British Columbia
Ministry of Forests and Range

Coast Forest Region

2008-10 Coastal Timber Supply Areas Regional Forest Health Overview

January 2008
(v. 1.01)

Stefan Zeglen, Forest Pathologist, Coast Forest Region, Nanaimo, BC

Janice Hodge, Consultant, JCH Forest Pest Management, Lumby, BC

Don Heppner, Forest Entomologist, Coast Forest Region, Nanaimo, BC

Jennifer Burleigh, Research Specialist, Research Branch, Victoria, BC

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1. INTRODUCTION

Forest health management requires knowledge of the temporal and spatial distribution of damaging forest health agents on the landscape as well as an understanding of their biological functions and ecological roles. Historically, forest health management was viewed as forest pest management and was often reactive in nature and did not acknowledge ecological principles. Recently more emphasis has been placed on ecosystem management and application of preventative or long-term strategies. Healthy forests are described as those which are resilient to disturbances, sustainable over the long-term and provide for a variety of resource needs and demands. This Regional Forest Health Strategy (RFHS) provides background and strategic direction for forest health management in the Coast Forest Region (CFR) by:

- Identifying damaging agents (and their inherent hazards and risks) that have the potential to impact the forest resource;
- Outlining the recoverable and non-recoverable losses in managed stands and applying them to timber supply reviews;
- Developing strategies and tactics to reduce both short and long-term forest health losses and thereby increase the resiliency of forested ecosystems;
- Determining management priorities and the future direction of operational research activities.

These points will be generally consistent with information currently available in Forest Practices Code guidebooks and other existing forest health management guidelines and documents.

Two complimentary documents outline the aim and scope of the provincial forest health program. They are the Forest Health Program 2007/10 document and the *Forest Health Implementation Strategy*[1]. The content of these two publications is summarized on the following page.

This RFHS outlines the regional activities that will be pursued as part of the Ministry's business and is intended to guide district priorities. These activities arise from the forest health business plan. Included is a synopsis of most coast-specific pests presented as a series of pest profiles and a brief history of major pest activity by timber supply area (TSA).

LEGISLATION PERTAINING TO FOREST HEALTH

The introduction of the *Forest and Range Practices Act* (FRPA) and the gradual transition away from the Forest Practices Code has altered the context in which forest management is conducted in British Columbia. The replacement of the previous "directive" regime with a "results-based" system has led to significant change in the manner forest health is dealt with in the planning phase of forestry operations.

The primary tool for planning and managing public forest lands is the Forest Stewardship Plan (FSP) mandated under FRPA for all public agreement holders. Within this plan, the holder specifies results or strategies to achieve the various objectives, such as timber, set by government. It also includes commitments and standards for harvesting and reforestation, including stocking standards, which may

[1] Document posted at http://icw.for.gov.bc.ca/hfp/ForestHealth/training/fhtrainingportal.htm. For internal use only.

directly influence forest health. Also, under FRPA section 26, the Minister may direct private land owners and public agreement holders to conduct remedial forest health control activities if he determines that damage is being done to the forest by pests.

HIERARCHY OF GOVERNMENT AIMS REGARDING FOREST HEALTH

The Ministry of Forests and Range is mandated to oversee forest health activities across the province. The direction for this mandate flows from both legislation and statements within the ministry's own Service Plan. The progression from overarching mandate to activities conducted at the regional level is as illustrated below (as excerpted from the Ministry 2006/07-2008/09 Service Plan).

Ministry Service Plan

Ministry Mission Statement:
"To protect, manage and conserve forest and range values through a high performance organization."

Ministry Goals:
1. Sustainable forest and range resources.

    Core Business Areas:
    1. Protection against fire and pests.

        Objective 1:
        Wildfire and pests are prevented and managed.

Forest Health Program

Forest Health Program Goal:
"To prevent and manage pests to ensure that forest management objectives are met."

Forest Health Program Themes and Functions:

A. Legislation and policy support
   - Development of strategies.
   - Participation in interagency efforts.
   - Support of statutory decision-makers.

B. Program delivery
   - Program planning and management.
   - Detection, assessment and prediction of pest damage.
   - Treatment of pest outbreaks and preventing establishment of exotic pests.
   - Management of endemic pests.

C. Adaptive management
   - Monitoring and evaluating treatment regimes.
   - Training and extension activities.
   - Operational research and monitoring.

Forest Health Implementation Strategy

FHIS Purpose:
"Monitor the health of Crown lands and respond appropriately in order to reduce the impacts of damaging agents."

FHIS Components:

a. Program emphasis areas.
b. Hazard and risk rating framework.
c. Program priorities.
d. Timber supply area strategy template.

Coast TSA Forest Health Overview

RFHS Components:

a. Regional forest health activities.
b. Forest health monitoring and inventories.
c. Assessment of hazard and risk.
d. Impact assessment on timber supply.
e. Pest profiles.
f. Pest history by TSA.

AREA COVERED BY THIS STRATEGY

This strategy covers forested crown land contained within the Coast Forest Region (Figure 1). The CFR is composed of nine TSAs: Arrowsmith, Fraser, Kingcome, Mid-Coast, North Coast, Queen Charlotte, Soo, Strathcona, and Sunshine Coast (Table 1). This strategy includes, but does not specifically address, parks, protected areas and TFL lands within the region. Individual TFL planning documents should be consulted for local information on pest history and risks.

Figure 1. Location of forest district boundaries and office locations within the Coast Forest Region (green).

Table 1. The nine timber supply areas within the Coast Forest Region and their respective administrative forest districts

Timber Supply Area	Forest District (Office location)
Arrowsmith	South Island (Port Alberni)
Fraser	Chilliwack
Kingcome	North Island – Central Coast (Port McNeill)
Mid-Coast	North Island – Central Coast (Port McNeill)

North Coast	North Coast (Prince Rupert)
Queen Charlotte	Queen Charlotte Islands (Queen Charlotte City)
Soo	Squamish
Strathcona	Campbell River
Sunshine Coast	Sunshine Coast (Powell River)

2. REGIONAL FOREST HEALTH ACTIVITIES

The *Forest Health Implementation Strategy* outlines the three themes and 11 functions that support the provincial forest health goal. Some of these functions are shared with the Ministry's invasive plants program which is housed in the same business area but is managed by Range Branch. These functions can be overlaid at the regional level to provide context for the various activities that are conducted annually as part of the forest health program. Regional activities include district involvement.

THEME: LEGISLATION AND POLICY SUPPORT

Function 1: Development of provincial, regional and TSA strategies.

Regional activities:

- Determine government objectives and priorities for forest health and revise strategies, policies, practices and standard operating procedures.
- Advocate regional MOFR forest health objectives and priorities to research agencies.
- Participate in the determination of climate-change strategies for forest health, silviculture, and invasive plants.
- Provide technical expertise to the development and implementation of legislation, policy, best management practices, and operational plans (e.g., Forest Stewardship Plans).
- Review FRPA legislation, objectives and priorities and provide long-term analysis of, and refinement to, management strategies, practices, and policies.

Function 2: Participation in interagency efforts.

Regional activities:

- Develop MOUs and partnering agreements with other agencies and organizations.
- Maintain liaison with other agencies to develop co-ordinated responses to forest health issues (e.g., Canadian Forest Service, Canadian Food Inspection Agency, BC Parks).

Function 3: Support of statutory decision-makers.

Regional activities:

- Advise internal (regional and district) staff, joint (IAMC, JSC and JMC) and delegated decision-makers.
- Keep current with applied research through participation at workshops and conferences and through liaison with research agencies.
- Maintain expertise to provide best advice to all decision-makers for forest health.
- Provide technical expertise and input to the development and implementation of legislation, policy, best management practices, and operational plans.

THEME: PROGRAM DELIVERY

Function 4: Program planning, management and partnering.

Regional activities:

- Develop eligibility criteria for accessing sources of funding.
- Set priorities for response to forest health issues (e.g., funding allocation.).

- Define resource requirements and allocations annually and plan management activities accordingly (e.g., detection, treatment, extension, operational research and monitoring).

Function 5: Detection, assessment and prediction of pest damage.

Regional activities:

- Set survey and treatment standards and procedures.
- Conduct regional portion of provincial aerial overview survey.
- Do detailed aerial and ground surveys.
- Investigate new infestations.
- Conduct forest health inventories other than aerial overview survey (e.g., yellow cedar decline, pests of young stands, defoliators, etc.). Includes population sampling.
- Quantify pest impacts at multiple scales (related to tree growth and to timber supply). Includes establishment, re-measurement, and assessment of Permanent Sample Plots (PSPs).
- Assess hazard and risk at multiple scales consistent with management objectives.
- Monitor natural and managed stands (after free-growing declaration) to determine pest impacts and report results.

Function 6: Treatment of pest outbreaks and prevention of the establishment of some exotic pests (e.g., gypsy moth).

Regional activities:

- Maintain liaison with other agencies to develop co-ordinated responses to forest health issues (e.g., gypsy moth, mountain pine beetle, climate change).
- Define treatment regimes for control purposes and implement them for native and exotic pests (e.g., defoliators and bark beetles).
- Investigate and respond to new infestations and introductions (e.g. gypsy moth).

Function 7: Management of endemic pests during forest operations.

Regional activities:

- Provide technical input to and support for the implementation of best management practices.
- Advocate treatment and management regimes for preventive purposes (endemic pests and invasive plants).

Function 8: Development of agents for biological control of invasive plants.

Regional activities:

- Development of biological control agents for invasive plants is the responsibility of Forest Practices Branch. Distribution of agents is done through the invasive plants program of the Range Branch. Regional and district staff may be asked to assist.

THEME: ADAPTIVE MANAGEMENT

Function 9: Monitoring and evaluation of delivery and treatment regimes.

Regional activities:

- Develop monitoring framework and maintain monitoring programs.
- Monitor natural and managed stands (after free-growing declaration) to determine pest impacts and report results.

- Identify indicators for effectiveness evaluations of treatments and participate in effectiveness evaluations.

Function 10: Facilitation or provision of training and extension activities.

Regional activities:

- Encourage innovative approaches to forest management that promotes forest health.
- Update guidebooks and reference materials.
- Identify, develop and deliver training for MOFR staff.
- Identify, develop, and deliver training for non-MOF staff (e.g., agreement holders, stakeholders, contractors, First Nations, and public).

Function 11: Operational research and monitoring of pest behaviour and populations (natural and managed).

Regional activities:

- Design and conduct operational trials to enable science-based management.
- Develop and refine hazard and risk models.
- Communicate results of operational trials, inventories, and management policies.

3. FOREST HEALTH MONITORING AND INVENTORIES

DAMAGING AGENTS

The list of biotic agents that cause damage to forest trees is quite extensive. In reality, only a fraction of these agents are significant as measured in terms of their potential to cause appreciable damage or alter management objectives. A summary list for the province is found in Appendix I of the provincial *Forest Health Program* document. An abbreviated list that focuses on the agents most significant to the Coast Forest Region is found in Appendix A of this document.

DETECTION

Detection, often mistakenly referred to as monitoring, applies to both aerial and ground surveys. The Ministry of Forests and Range conducts an annual aerial overview survey of much of the province for all detectable forest pests. This survey is usually conducted across Crown forest land, including parks and protected areas, at a scale of 1:100,000-1:125,000. Survey standards and annual results are available from the Ministry website[2] and include those for conducting the survey as well as for manipulation and presentation of the data. Aerial survey results are incorporated into the annual provincial report *Summary of Forest Health Conditions in British Columbia.*

It should be noted that due to the relative ease of mapping insect infestations from the air, especially those created by bark beetles and defoliating insects, there is dramatically more information on their incidence and severity relative to diseases. Therefore, although under-reported, the overall distribution and impact of diseases in the Coast Forest Region usually exceeds that of insects.

In areas with designated Suppression Bark Beetle Landscape Units detailed aerial surveys are also conducted. These are generally conducted at a scale of 1:20,000-1:40,000, with a required horizontal

[2] Web address is http://www.for.gov.bc.ca/hfp/forsite/overview/overview.htm.

accuracy of +/- 20 m. In addition, districts may conduct more detailed aerial and ground surveys when trying to assess the potential impact of some specific pests.

MONITORING

It is expected that with the continued implementation of the FRPA Resource Evaluation Program[3] (FREP) within the Ministry that the amount and scope of field monitoring will increase rapidly within the term of this strategy. This monitoring will generate field data that will be made available for review by delegated decision makers and forest planners.

In 2006, a FREP pilot project was conducted on the Strathcona TSA as part of a larger provincial effort involving three TSAs. The project examines post-free growing stands in order to evaluate three broad areas: a) that unforeseen pest problems are not affecting stands after they are declared free-growing; b) that stand composition and structure are developing as intended by the forest management objectives and; c) that stand growth is progressing in accordance with the assumptions in the timber supply analysis. The results of this pilot will be reported out in a FREP report in 2007. Depending on the results, it is anticipated that other TSAs in the province will also be assessed as part of this project.

INVENTORY

There are two main repositories for historical forest health information. The first is the provincial forest health website that contains pest incidence and distribution information (back to 1999 for the CFR). This is based almost solely on the provincial annual overview survey and is best applied at a landscape-level. This data is also available through the Land & Resource Data Warehouse[4] run by the Ministry of Agriculture and Lands.

The second, more extensive repository is at the Pacific Forestry Centre[5] in Victoria. Here the Canadian Forest Service operates an insectary and herbarium that collect specimens from across the province and maintain a database that tracks their locations. Quite specific queries of insect pests can be made through the pest data archives while those for fungi can be accessed through the DAVFP database maintained by the herbarium. Records go back as far as 1901.

There are also several minor repositories for forest health data. While large databases, like RESULTS, cover an extensive geographic area, the pest data they house is often incidental, difficult to access or not specifically organized for pest queries. Thus, extracting useful data for forest planning is often difficult or requires a certain expertise with the database. Examination of such data can lead to much more detailed indications of pest activity on a specific opening or limited geographic area.

A brief summary of the historical information regarding pest outbreaks for each TSA in the CFR is available in Appendix B.

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3 Web address is http://www.for.gov.bc.ca/hfp/frep/index.html.
4 Web address is http://www.lrdw.ca/.
5 Web address is http://www.pfc.cfs.nrcan.gc.ca/index_e.html.

4. ASSESSMENT OF FOREST HEALTH HAZARD AND RISK

The rhetoric of hazard and risk deserves some attention, as the terms are not synonymous. In the literature, the terms are often undefined or used so poorly, on occasion, so as to appear contradictory to the intent. We define hazard as the probability of pest occurrence for a given area. This may be interpreted as the favourableness of the particular site for the development of a pest. For example, anywhere in BC that 5-needle pines grow there is a potential hazard for white pine blister rust. The hazard rating will change depending on the presence and interaction of certain physical and environmental variables (i.e., moisture, slope, presence of alternate host, etc.).

We define risk as a relative rating for the potential failure of a management objective due to a pest. The risk rating is the product of the hazard rating and the incidence of the pest. For example, a stand rated as high hazard but with no incidence of white pine blister rust is at low risk to the intended management objective of growing white pine. Conversely, a stand rated as low hazard but with rust present is assigned a high risk rating given the same management objective.

A first approximation of hazard for most pests in the Coast Forest Region is provided in Section 6.6 of Land management Handbook 28 (Green and Klinka 1994)[6]. This reference can be considered the "default" value when more recent information (e.g., in a FPC guidebook or other published reference) is not available for a specific pest. Note that while the section is titled "Pest Risks of Major Conifer Species", as discussed above, it is really describing hazard. Risk cannot be assessed on this scale without observing the incidence of pests on or near that area of interest.

For some pests (e. g., spruce leader weevil, laminated root disease), more detailed second approximation hazard ratings exist. These are usually found in Forest Practices Code guidebooks or, more recently, within pest-specific reference publications like the Stand Establishment Decision Aids published in the *BC Journal of Ecosystems and Management*.

5. IMPACT ASSESSMENT ON TIMBER SUPPLY

Predicted future yield is at the foundation of timber supply modelling in British Columbia. Most timber supply reviews (TSR) are based on the Variable Density Yield Prediction (VDYP) model that predicts yield for natural stands, and the Tree and Stand Simulator (TASS)/Table Interpolation Program from Stand Yields (TIPSY) programs that predict yield for managed stands. The yield estimates from both of these models currently incorporate endemic levels of volume loss from damaging agents. Other yield tables/models are currently being developed for complex and mixed wood stands in BC (e.g., PrognosisBC and MGM), that may have an improved ability to account for the impact of damaging agents; however, these models are not ready for operational application on the coast.

Non-recoverable losses (NRL), however, are not included in any of these models, and are accounted for separately in TSR. These NRLs are based on estimates developed by district and regional staff. Pest-specific forecasting models and extensions have been developed for independent use (Root Rot

[6] Green, R.N. and K. Klinka. 1994. A field guide to site identification and interpretation for the Vancouver Forest Region. BC Ministry of Forests. Land Management Handbook 28.

Tracker) or for use with existing models like TASS - Root Rot Simulator (ROTSIM) or the Spruce Weevil Attack Trial (SWAT), but these have not been widely used.

VDYP – NATURAL (UNMANAGED) STANDS

VDYP is used to produce yield tables for natural unmanaged stands based on measurements from extensive sampling of temporary and permanent sample plots. Decay losses are inherent to the model, while waste and breakage factors are applied to the analysis in the development of VDYP yield curves. These decay, waste and breakage estimates were developed based on sampling in different areas of the province, and therefore different factors exist for different areas.

In addition to decay, other damaging agents are presumably accounted for in VDYP since they would have naturally occurred in the measurement plots. These include endemic levels of hemlock dwarf mistletoe, root disease, and defoliators. The caveat is that obviously pest-affected plots are discarded by inventory staff and no longer help form future yield curves. The consensus though amongst forest health and growth and yield specialists is that VDYP adequately accounts for endemic pest and decay losses, therefore VDYP losses have not been reviewed.

TIPSY/TASS – MANAGED STANDS

Volume estimates for single-species even-aged managed stands are based on the TIPSY model which uses growth and yield tables derived from TASS. TASS is based on fully stocked, relatively pest-free sample plots, and is therefore considered to represent the full potential of the site. Adjustments to the model yield projections are used to reflect actual conditions.

OPERATIONAL ADJUSTMENT FACTORS

Operational adjustment factors (OAF) are used to adjust the potential yields generated from TIPSY to reflect actual yields under operational conditions. OAF 1 reduces the potential yield by a constant percentage to reflect small stocking gaps within stands that are incapable of growing trees (e. g., swamps, rocky areas). OAF 2 reduces potential yields to reflect losses due to tree maturity, including decay; waste and breakage, and other factors that increase with age. Therefore, OAF 1 is a constant reduction factor that shifts the yield curve down, while OAF 2 starts at zero and increases to its full value with age, modifying the shape of the curve as time passes.

The provincial default value for OAF 1 is 15% and OAF 2 is 5%. OAF 1 values may be modified by using a survey to check the underlying assumptions for the area under question[7]. OAF 2 is an estimate of the impact of decay, waste and breakage in second growth stands. It does not account for losses due to insects, diseases or other pests, even endemic ones. Any impacts from these damaging agents are additional to the default value of 5% and should be applied for the specific timber types, biogeoclimatic zones, and age classes as appropriate in the next TSR. Where they exist, recommended adjustments to OAF 2 values are described in the pest profiles in Appendix A.

NON-RECOVERABLE LOSSES

Non-recoverable losses (NRL), or unsalvaged losses, are the amount of volume lost annually to damaging agents that is not harvested. This represents losses above and beyond those already accounted for in existing growth and yield models, often as a result of unpredictable events. These

[7] BC Ministry of Forests. 1998. OAF 1 Project. Reports 1 & 2. Forest Practices Branch, Victoria. Web address is http://www.for.gov.bc.ca/hfp/meta/publications.htm.

losses can be both increment loss (e.g., defoliation, defect) and mortality. NRL's are generally subtracted from yield projections. The majority of NRLs are generally the result of abiotic factors like fire or wind. Catastrophic or sustained events (e.g., prolonged defoliation) or those which are not well-suited to either OAF (e.g., drought, windthrow) may also qualify. The most recent NRL estimates for each TSA are provided in Table 2.

Table 2. Summary of non-recoverable (unsalvaged) losses by damaging agent and percent of AAC affected as accounted for in the most recent TSR for each TSA in the Coast Forest Region

TSA (Effective date)	**Fire** m^3	**Wind** m^3	**Pests**[a] m^3	**Total** m^3	**Current AAC** m^3	**% of AAC**
Arrowsmith (2004)	1,000	1,000		2,000	391,796	0.5
Fraser (2004)	15,925	2,500		18,425	1,270,000	1.5
Kingcome (2002) [8]	3,083	10,500		13,583	1,240,000	1.1
Mid-Coast (2002)	7,102	13,000		20,102	795,000	2.5
North Coast (2007)	2,034	8,050		10,084	494,000	2.0
QCI (2003)		3,800	3,300	7,100	361,000	2.0
Soo (2000)	30,000		4,000	34,000	503,000	6.8
Strathcona (2005)	1,750	30,000		31,750	1,201,000	2.6
Sunshine (2001)	5,946	5,490	775	12,211	1,143,000	1.1
Total	66,840	66,290	8,075	141,205	7,452,196	1.9

[a] Pests does not include losses as determined by OAF reductions.

6. OPERATIONAL RESEARCH PLAN

The following Table 3 outlines the key projects comprising the operational trial portion of the regional forest health program.

Project Name	**Description**	**Product(s)**	**Timelines**
Pathology (Stefan Zeglen)			
CFS Root Disease Plots	Long-term (45+ years) root disease plots established to track extent and spread of disease over time. Of the three plots, one was logged and one is scheduled for logging.	· Part of legacy of sites used to calibrate root disease models (oldest continuous dataset from coastal stands). · Past CFS publications. · Possible refereed FS publication after latest measurements.	Remeasured 2002 (Tsable) and 2003 (Campbell River). Analysis pending.
Pw Low Branch Pruning Trial	Three sets of plots – two established in 1983, the other in 1988 – as long-term tests of unimproved white pine survival following pruning. Longest running trial of its type on the coast.	· 20-year data collected from one site, 15-year data from another. · Internal reports in 1991 and 1994. · Recommendations on utility of pruning. · Refereed publication after 20-years data.	Last remeasured in 2003. Analysis pending.
Texada Pw Outplanting Trial (Sx 94404V)	Large trial testing four seedlots of Pw (three from Texada plus control) for survival under two pruning regimes at nine locations throughout region. This is the baseline trial in a series testing various aspects of resistance to WPBR found on trees from Texada Island.	· Fouteen years of continuous data. · Interim report in 2000. · Recommendations on use of Texada bulk-collected seed and timing of pruning treatment(s). · Refereed publication after 15-years data.	Annual evaluations until 2009. Periodic monitoring afterward.

[8] Currently under review. Chief Forester's determination scheduled for late 2008.

Project Name	Description	Product(s)	Timelines
Pw Nursery Screening Trial (Sx 95201V)	Large trial testing whether nursery source (interior vs coast) or stocktype (plug vs bareroot) makes any difference in survival of five Pw seedlots (three Texada plus two controls). This is the second in a series of trials testing Texada Island Pw.	· Nine years of continuous data. · Recommendations for choice of stocktype or nursery source. · Refereed publication after 10-years data.	Last remeasured in 2004. Nursery sold, site destroyed. Analysis pending.
Tree Wounding & Decay Permanent Sample Trees (Sx 97802V)	Extensive long-term trial involving 25 partial cut stands across region. Each stand has 15-20 tree pairs (wounded tree and non-wounded partner) of various species damaged during harvesting activities. Only trial testing nature and extent of tree damage on standing residuals and the resulting wood products on coast.	· No data to date as trial requires harvest of stands. · Recommendations on tolerance to tree damage as described in *Tree Wounding & Decay Guidebook*. · Quantification of volume loss due to location and size of various wounds. · Refereed publication after sufficient data collected.	Some stands being harvested 10 years following treatment. Capturing data when harvesting occurs.
Texada Pw Families Progeny Trial (Sx 98101V)	Large trial testing the survival of wild-pollinated, half-sib Pw progeny from known Texada Island families against Pw families from other sources (e.g., CFS, Dorena, Westar) at four sites. This is the third in a series of trials testing Texada Island Pw.	· No data collected to date. · Recommendations on use of Texada half-sib seed for reforestation. · Refereed publication after 10-years data.	Biennial evaluations to start in 2003.
Retrospective Evaluation of Stumped Areas	Assessment of earliest stands treated for root disease by stumping (1977-87). Stands are surveyed for presence of root diseases 15-20 years post-treatment and tree growth for treated and untreated areas (where possible) is measured using the growth intercept method.	· To date, 24 stands have been assessed. · Interim report in 1999. · Refereed publication after 2007 data collection complete.	Assessments completed in 2007 on 34 stands.
Regional TSA Root Disease Netdowns	In tandem with 10-year remeasurement by Inventory, assessment of permanent sample plots for root disease and other pests. Evaluation of plots allows extension of OAF2 factors to other coastal subzones for timber supply review purposes.	· Currently have 7.5% netdown for *Phellinus* and *Armillaria* for CDF and CWH xm subzones. · Recommendations for OAF2 adjustments for all coastal subzones.	Ongoing evaluation of plots in tandem with inventory remeasurements.
Whitebark Pine Monitoring Plots	Long-term monitoring plots to track health of whitebark pine, a pioneer and indicator species in high-elevation ecosystems. Surveys to date (Zeglen 2002) indicate 50% of whitebark pine in BC is dead or infected by white pine blister rust. The rate is quite variable across the province. Monitoring is required to determine the population trend.	· Nine plots established to date. · Future plots required across range of Pa in BC. · Refereed publication after sufficient data collected.	Assessment of plots every 5 years following establishment.
MGR Pw Field Test	Field trial of major gene resistant (MGR) western white pine from Dorena, OR versus Texada seedlots. MGR trees show excellent resistance (80+%) in preliminary trials.	· Six small plots established in 3 districts in 2002. · Refereed publication after 10-years data.	Last assessed in 2006.
Stumping Disturbance Trial	In conjunction with Paul Courtin (Research Section), evaluating the effect of stumping on soil disturbance survey measures and assessing seedling growth and development.	· Two sites established in 2007 with three more planned. · Refereed publication after 5-years data.	Assessed annually.
Yellow-cedar Decline Monitoring	Multi-phase project looking at various aspects of the decline of yellow-cedar predominantly on the north and mid-coasts. Initial work around mapping extent of decline and studying timing of decline is ongoing. Further work on assessing impact on TSR, ecological and silvicultural implications, fire history, and climate factors is planned.	· Preliminary mapping of decline started. · Dendrochronology pilot project started in 2007. · Various reports and papers will result.	Initial mapping completed in 2007. Dendro pilot complete in 2008. Aerial photo mapping in 2008.
Entomology (Don Heppner)			
MCH Trail/ Douglas-fir Beetle	MCH is a anti-aggregation pheromone that does not yet have federal registration for use. This trial tests the efficacy of MCH to control Df beetle within coastal Df stands.	· Initial beetle survey completed · MCH bubble caps deployed · Attack check survey completed · Final results survey to be completed · Result report to be submitted PheroTech	Summer 2006 April 2007 June 2007 Early summer 2008 Summer 2008

APPENDIX A: PEST PROFILES

The following pest profiles are derived from a regional list of damaging agents. These damaging agents are the most relevant to the Coast Forest Region, although their significance can vary greatly from TSA to TSA. Not all pests identified in the region are profiled. They are grouped by common association (e.g., root diseases, defoliators) and then alphabetically within each group.

For each damaging agent a brief background is provided. It is not intended that detailed information on the biology of these organisms be presented here. There are far better sources for this information which may be accessed through the references provided. Historical information on pest occurrence by TSA is provided in Appendix B. Following this are entries on hazard and risk and impact that are adapted specifically for the coast. This includes recommendations for FSP developers and reviewers on forecasting possible management constraints and identifying potential implications for TSR. Similarly, a brief summary of current management strategies and tactics to mitigate pest damage is provided for those creating site plans in areas where these risks are identified. Finally, the relative ranking of the damaging agent in the provincial research priority matrix is given and any relevant ongoing or planned research is described.

The information provided is meant to be neither exhaustive nor complete for any pest or group of damaging agents. It is provided as a starting point for planners and statutory decision makers to ensure that plans incorporate sufficient detail to ensure that the agents of most obvious concern to proper forest management are adequately addressed.

General references for field identification of these damaging agents include:

- Allen, E., Morrison, D. and Wallis, G. 1996. Common Tree Diseases of British Columbia. Canadian Forest Service, Victoria, BC. 178 pp.
- Henigman, J., Ebata, T., Allen, E., Westfall, J. and Pollard, A. 2001. Field Guide to Forest Damage in British Columbia. Can. For. Serv. and BC Min. For. Joint Pub. No. 17. Second Ed. 370 pp.

General references for management of some of the major pest groups include the Forest Practices Code guidebooks including:

- Bark Beetle Management,
- Defoliator Management,
- Dwarf Mistletoe Management,
- Management of Terminal Weevils,
- Pine Stem Rust Management,
- Root Disease Management,
- Tree Wounding and Decay.

These and other guidebooks can be downloaded from the Ministry website at http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/guidetoc.htm.

Abiotics

Yellow-cedar Decline

Yellow-cedar decline has been identified as a problem in southeastern Alaska for several decades but, until recently, its occurrence and impact was poorly documented in BC. The decline can appear in small patches or extend over a large area. Identification of dead or dying trees can be difficult due to the visual similarities to western redcedar and the tendency for the two species to commingle in coastal forests. The spike-top mortality common to western redcedar can hide the dead or symptomatic crowns of yellow-cedar, especially when the latter is infrequent in occurrence. Individual declining trees can die quickly, exhibiting red or brown crowns, or slowly with gradually thinning crowns. Regardless of the speed of death, root systems are always in an advanced stage of deterioration with the smallest roots dying first. Necrotic lesions are often found on the lower bole under the bark. Dead trees can remain standing for decades.

Recent assessments along the coast indicate that large areas within the range of yellow-cedar are exhibiting the effects of the decline and this may be affecting the future range of this species. The most noticeable areas are on the north and mid-coasts where landscape-level occurrence can be observed. The frequency of widespread decline decreases as one travels south and virtually disappears around the Kingcomb Inlet. Individual or small group mortality may still occur south of this point but the infrequent distribution of yellow-cedar makes it difficult to detect.

Hazard and Risk

Currently, yellow-cedar decline is considered to be a result of climate change. The hypothesis is that declining snow levels at lower elevations of the range of yellow-cedar is leading to increased susceptibility of the fine roots to late season frost events. If this is correct, then any yellow-cedar is potentially subject to decline if snow packs recede due to a prolonged change in climate.

Impact

There is no current assessment of the extent or impact of yellow-cedar decline for the region.

Management

Since the decline appears to be climate driven and since we still do not understand fully the process that is unfolding, management options are limited. In time guidelines may be developed around the suitability of yellow-cedar for reforestation in areas where a sufficient hazard of the conditions favourable for occurrence of the decline would exist.

Priority and Research

Quantifying the extent of yellow-cedar decline in BC is a high priority. This consists of two projects: one to map the extent of the decline and the other to investigate the likely impact on timber supply of the loss of standing yellow-cedar inventory. Complementing this will be projects investigating the ecological and silvicultural implications of decline on coastal forests.

Resources

- Hennon, P.E., D.V. D'Amore, S. Zeglen and M. Grainger. 2005. Yellow-cedar decline in the North Coast Forest District of British Columbia. USDA For. Serv., Pac. NW Res. Stn. Research Note PNW-RN-549.

- Hennon, P.E. and C.G. Shaw III. 1997. What is killing these long-lived defensive trees? J. Forestry 95(12): 4-10.

Adelegids

Balsam Woolly Adelgid

Balsam woolly adelgid (*Adelges piceae*) is a small aphid-like insect that was accidentally introduced to North America from Europe. It feeds on all species and all ages of true fir (*Abies* species) and can cause deformity, die-back and mortality. In BC, amabilis and grand firs are attacked most frequently. Grand fir is the most tolerant of attacks; sub-alpine fir is the most easily damaged; and amabilis is intermediate. Damage is caused by substances injected by the adelgid during feeding. These substances cause abnormal tissue growth that disrupts normal translocation processes within the tree.

It was first detected in B.C. in 1958 in the Vancouver area and on southern Vancouver Island. From here it continues to spread northward and eastward. Currently, its known distribution within BC ranges northward on Vancouver Island to near Sayward (but has not been found north of the Alberni Inlet on the west side of Vancouver Island); to the Loughborough Inlet on the mainland coast; northward to Birkenhead and Anderson lakes within the Squamish Forest District; eastward to Hope and throughout the Fraser canyon as far north as the Nahatlatch and Mowhokam drainages. It has not been found in the Coquihalla or along Highway 3 to Manning Park. It has been on the east side of the Cascade Mountains in Washington since 1961 and is now well established in northern Idaho.

Hazard and Risk
Any *Abies* species within the currently infested area is potentially susceptible and may be at risk. The infested area continues to expand.

It appears there is a range of susceptibilities within the *Abies* population. Some individuals die within a few years of becoming infested, some survive with chronic infestations for many years, some with minimal effects, while others appear to be unaffected.

The Whistler area is particularly heavily infested. The incidence of this adelgid declines with elevation.

Impact
Impacts have not been well studied. Infestations within grand fir can be chronic for decades however the trees often succumb eventually. Their decline in health may be taken advantage of by the fir engraver beetle, *Scolytus ventralis*, especially following dry summers, as is common on the east coast of Vancouver Island. Impacts in amabilis fir are variable. Some trees will die within a few years of becoming infested while others remain chronically affected for many years, however a significant proportion does not seem to be affected. From information from Idaho, sub-alpine fir appears to die after only a few years of infestation.

In Idaho, 100% mortality of sub-alpine fir stands has occurred within 10 years of the stand becoming infested. In Oregon, infestation and damage were found to be most severe on good sites and at lower elevations; tree damage was most severe in the first decade; infestation and further tree killing were observed 40 yrs after the initial infestation. Grand fir is slowly being eliminated from the forests there.

Management

The *Balsam Woolly Adelgid Regulation* was developed to help prevent or limit the spread of this introduced insect from the area of infestation. It regulates the growing of *Abies* spp. and the movement of trees, foliage and logs. It is administered by the Ministry of Agriculture and Lands and can be found online at: http://www.qp.gov.bc.ca/statreg/reg/P/PlantProtection/414_92.htm.

If relying on *Abies* species for reforestation within or near an area of known infestation, be aware that a portion of these trees may become infested and killed. The use of insecticides in the forest setting is not considered to be practical at present.

Priority and Research

No research is occurring at this time.

Resources

- Turnquist, R. and J.W.E. Harris. 1993. Balsam woolly adelgid. Forest Pest Leaflet #1. Pacific Forestry Centre, Forestry Canada, Victoria.

Bark Beetles

Douglas-fir Beetle

Douglas-fir beetle (*Dendroctonus pseudotsugae*) is a bark beetle that attacks Douglas-fir. It is common throughout the range of Douglas-fir where it normally breeds in trees that are stressed, windthrown, recently dead or dying from other causes. However, outbreaks occur periodically in the CFR (approximately once every decade) and tend to last 3 to 4 years before subsiding.

Hazard and Risk

Douglas-fir can be attacked anywhere in the CFR if it becomes stressed. It is often associated with trees that are stressed or have been killed by root disease. However, within the region, Douglas-fir beetle generally only becomes a pest within the coast/interior transition area (i.e. IDFww, CWHds1). During outbreaks, scattered patches of apparently healthy Douglas-fir can be killed across extensive areas.

Impact

Endemic mortality can normally be seen on the landscape, however because it is widely scattered it may not have significant impacts. Although outbreaks do not build into large areas of attack in the CFR, because this beetle tends to attack the larger Douglas-fir in a stand it can kill substantial volumes of valuable timber.

Management

Control is via sanitation harvesting using trap trees (see *Bark Beetle Management Guidebook*).

Priority and Research

MCH, a beetle pheromone that repels attacking beetles, shows promise for protecting high value trees, such as those in parks, residential areas, OGMAs, etc. It may also prove to be an effective technique to deal with small patches of infested trees.

Resources

- Humphreys, N. 1995. Douglas-fir beetle in British Columbia. Forest Pest Leaflet #14. Canadian Forest Service, Pacific Forestry Centre, Victoria.

Mountain Pine Beetle

Mountain pine beetle (*Dendroctonus ponderosae*) is BC's most well known forest pest. This bark beetle attacks all pine species but is primarily associated with lodgepole pine. Its population dynamics allow it to develop into extensive outbreaks. Fortunately in the Coast Forest Region lodgepole pine is a minor, and mostly a non-commercial tree species. Most infestations of this bark beetle in the CFR are in stands considered to be inoperable economically. There may however be scenic, recreational or wildfire related reasons for dealing with this beetle.

Hazard and Risk

Within the CFR, pine stands in the coast/interior transition zone have the highest hazard for attack by mountain pine beetle (i.e. IDFww, CWHds1, ds2, and ESSFmw). During outbreaks virtually any pine stand within 10 km of currently infested trees could be at risk. Mountain pine beetle is now infesting lodgepole pine along ocean inlets in the mid-coast and it appears to be working its way southward toward Squamish from the Whistler area. There has also been a small outbreak detected recently on Vancouver Island, where it is a native species. The *Bark Beetle Management Guidebook* provides methodologies to assess hazard and risk based on stand age, density, elevation, longitude and latitude.

Impact

The impacts of this beetle can be extreme. During outbreaks all mature pine within an area can be killed. Immature pine can also be killed during large outbreaks. Within the Coast Forest Region, pine only composes a very small portion of the timber supply. So, even though a large number of pine trees can be killed, the impact on the timber supply is limited. However this beetle can impact the scenic viewscape and may impact recreational experiences and wildlife habitat. The increase in fire fuels as a result of beetle-killed trees can also be of concern.

Management

When outbreaks are at the incipient stage, single tree treatments can be effective at controlling its spread. Falling and burning, or small patch harvesting of currently infested trees can be practical. The use of pheromone baits can facilitate control efforts. See the *Bark Beetle Management Guidebook* for detailed procedures. However, once initial outbreaks grow and spread, control efforts can quickly become futile. 3

Priority and Research

This beetle is probably the most researched forest insect in North America and currently it is also the most funded. Current work into the use of verbenone, a beetle pheromone that repels attack, looks promising.

Resources

- Safranyik, L., D.M. Shrimpton and H.S. Whitney. 1976. Management of lodgepole pine to reduce losses from the mountain pine beetle. Forestry Technical Report #1. Canadian Forestry Service, Pacific Forest Research Centre, Victoria.
- Unger, L. 1993. Mountain pine beetle. Forest Pest Leaflet #76. Canadian Forest Service, Pacific Forestry Centre, Victoria.

Defoliators

Conifer Sawfly

The conifer sawfly (*Neodiprion abietis*) is a defoliator of amabilis fir and western hemlock on the BC coast. Outbreaks by this insect are relatively rare and short-lived but can have significant impacts if the defoliation is severe. It is a unique defoliator in that it is from the insect Order *Hymenoptera* (wasps) rather than the usual defoliator Order *Lepidoptera* (moths). The sawfly is actually a wasp whose larval stage feeds on tree needles. The most recent outbreak was from 1995 to 1998 in the Philips River area on the mainland coast and in the general Sayward area on Vancouver Island.

Hazard and Risk
A hazard rating system has not been developed; however, outbreaks appear to re-occur in the same areas each episode; probably involving the same stands. Outbreaks have occurred in the following areas: Philips River, Apple River, Stafford River and Paradise Creek on the mainland coast; and Kunnum Creek, Compton Creek, Memekay River and Bigtree Creek on Vancouver Island. Defoliation tends to occur on mid- to upper-slopes and at the back-end of drainages at elevations from 600m to 900m. The biogeoclimatic units that appear to be involved are: CWHvm1, vm2, mm1, mm2; MHmm1; with CWHvm2 and mm2 the most severely affected.

Trees stressed by defoliation may be at risk of attack by *Pseudohylesinus* bark beetles.

Impact
Impacts have not been well quantified but can be significant in severely defoliated stands of old growth amabilis fir (15 to 20% mortality in severely defoliated stands). Mortality could potentially be worse if bark beetle populations take advantage of the defoliation stress.

Management
Control treatments have not been developed for BC. Treatments utilizing common insecticides would probably be effective; however, environmental concerns will likely preclude their use. Btk will not affect this insect. Treatments utilizing a nucleopolyhedrovirus (NPV) show promise on outbreaks in Eastern Canada, but is still in the developmental stages.

Management actions are limited to monitoring and mapping defoliation, and quantifying impacts. Identify severe defoliation for priority salvage harvesting where necessary or possible.

Priority and Research
Nucleopolyhedrovirus may have potential, but needs development work. Trials would be required to test it here. The taxonomy of the *Neodiprion* genus is not clear, more work is required.

Resources

- Ingram, J.D. 2005. The 1995-1998 outbreak of *Neodiprion abietis* on the coast of British Columbia. Unpublished graduating essay, Faculty of Forestry, UBC, Vancouver.
- Westfall, J. 2002. Conifer sawfly outbreak, Vancouver Forest Region 1995 – 1998. Unpublished internal report, Vancouver Forest Region, Ministry of Forests, Nanaimo.

Western Blackheaded Budworm

The western blackheaded budworm (*Acleris gloverana*) is a defoliator of western hemlock. Outbreaks periodically occur on the coast of BC every 8 to 15 years, defoliate extensive areas and last three to five years. The most serious outbreaks occur on the Queen Charlotte Islands and on Northern Vancouver Island.

Hazard and Risk

Although this budworm is found throughout hemlock forests, outbreaks on the coast are most common in the following biogeoclimatic subzone variants: CWHvm1, vm2, vh1, vh2, wh1 and wh2. Significant impacts, however, seem to be limited to the CWHvm1 and wh1. All age classes can be affected. Defoliation tends to reoccur in the same stands during each outbreak episode, thus maps of previous outbreaks provide a good indication of the hazard of budworm defoliation.

Impact

Most impacts are minimal and the majority of stands recover well, however, stands that receive severe defoliation for a number of years will have mortality and top-kill. Impacts are higher in the Queen Charlotte Islands. Severe defoliation of immature stands seems to result in higher mortality rates than in mature/old growth. Stands that have received >50% defoliation for a number of years can show up to 30% to 60% mortality.

Immature, second growth stands that have been thinned seem to be more impacted by defoliation from this budworm. Following an outbreak that lasted 6 years in the Queen Charlotte Islands, mortality in severely defoliated immature stands averaged <10%. However, top-kill was significant and frequent (45%) with very poor recovery 6 years post-outbreak. It appears that growth reductions in some second growth stands may be worse than originally anticipated. The Canadian Forest Service is continuing to assess the budworm damaged stands in the Queen Charlotte Islands.

Management

A survey method for egg mass sampling to forecast defoliation severity can be found in the *Defoliator Management Guidebook*. There is currently no operational control treatment for this defoliator. *Btk* formulations will work but are not yet registered for this insect. As observed in 2001 in the QCI, thinned stands may be subject to greater mortality, possibly due to easier access to the crown. Therefore, thinning targets should allow for this in areas at risk of budworm defoliation.

Priority and Research

There is a need to get Btk registered for western blackheaded budworm. A pheromone based trap to monitor budworm populations is under development.

References

- Koot, H.P. 1994. Western Blackheaded Budworm. Forest Pest Leaflet #24. Canadian Forest Service, Pacific Forestry Centre, Victoria.
- Nealis, V.G., R.. Turnquist, and R. Garbutt. 2004. Defoliation of juvenile western hemlock by western blackheaded budworm in Pacific coastal forests. Forest Ecology and Management 198:291-301.
- Wood, P.M. and D.G. Heppner. 1986. Blackheaded budworm in the Vancouver Forest Region: 1985/86 situation report. Forest Service Internal Report PM-V-8. BC Ministry of Forests, Burnaby.

Western Hemlock Looper

The western hemlock looper (*Lambdina fiscellaria lugubrosa*) is another serious defoliator of western hemlock that occasionally reaches outbreak proportions in the Coast Forest Region. Seven outbreak episodes have occurred on the coast of BC since 1911. While western hemlock is the preferred host, almost any foliage including broad-leaved trees and shrubs will be fed upon during outbreaks. All ages are susceptible. A closely related sub-species defoliates Gary oak.

Hemlock looper outbreaks on the coast are sporadic; however, populations can increase rapidly and quickly cause severe defoliation. Within areas of severe defoliation, 80% of hemlock trees can be killed during the second year of the outbreak. Outbreaks also decline rapidly following two to four years of defoliation.

Hazard and Risk

On the BC coast, outbreaks are most common in the Howe Sound area and within the Vancouver watershed area (Seymour River, Capilano and Coquitlam lakes areas). It has also occurred on Vancouver Island (Neroutsos Inlet and Nitinat Lake areas) and in Jervis Inlet. The CWH vm1 and CWHdm are the BEC zone variants most at risk.

Impact

Severe mortality of western hemlock can occur following one year of moderate to severe defoliation. The killed timber deteriorates quickly; 2 years following mortality 20% of the wood will be affected with advanced decay. Beyond the second year of deterioration, radial penetration by decay fungi will increase rapidly and, as a result, the sawlog volume will be reduced below the point of economic recovery by the fifth year, with only small volumes of relatively low quality sound wood remaining in the basal logs of the larger trees.

Management

Foray 48B (a commercial formulation of *Btk*) is now registered for use on western hemlock looper. Spray treatments should be applied during the spring following the first year of detected defoliation. Delay will likely result in significant hemlock mortality.

Although looper populations can be monitored via egg and larva sampling and with pheromone traps; the sporadic nature of outbreaks on the coast makes them difficult to forecast. High indices of moisture stress have recently been found to be significantly correlated with looper outbreaks.

Resources

- Unger, L.S. 1995. Spruce budworms. Forest Pest Leaflet #31. Canadian Forest Service, Pacific Forestry Centre, Victoria.
- Koot, H.P. 1994. Western Hemlock Looper. Forest Pest Leaflet #21. Canadian Forest Service, Pacific Forestry Centre, Victoria.
- Turnquist, R. 1991. Western Hemlock Looper in British Columbia. FIDS Report 91-8. Canadian Forest Service, Pacific Forestry Centre, Victoria.

- Parfett, N., I.S. Otvos and A..V. Sickle. 1995. Historical western hemlock looper outbreaks in British Columbia: input and analysis using a geographical information system. FRDA Report 235. Canadian Forest Service, Pacific Forestry Centre, Victoria.
- Engelhardt, N.T. 1957. Pathological deterioration of looper-killed western hemlock on southern Vancouver Isalnd. Forest Science 3(2): 125-136.

Western Spruce Budworm

Western spruce budworm (*Choristoneura occidentalis*) is a defoliator of Douglas-fir throughout the tree's range in British Columbia. Although infestation levels recorded for 2004 within the Coast Forest Region were primarily light, this insect has caused significant damage here in previous years. In the past, western spruce budworm in the CFR has had it largest impact in the Squamish and Chilliwack Forest Districts, particularly in the Pemberton/Birkenhead area and the Fraser Canyon area near Boston Bar. Outbreaks in the CFR are periodic occurring approximately every decade and last 3 to 5 years.

Hazard and Risk

Within the Squamish and Chilliwack Forest Districts, defoliation often occurs in elevational bands across mountain sides, particularly on south and west facing slopes. Warm, dry sites with greater than 80% Douglas-fir are most commonly affected. Douglas-fir is the principle host; amabilis and grand fir are secondary hosts; and spruce is occasionally fed upon. Historically budworm defoliation reoccurs in the same general sites each outbreak episode. Stand hazard can be estimated from maps of previous outbreaks.

In the CFR, defoliation is most common in the general Boston Bar area in the Fraser Canyon, the D'Arcy/Birkenhead area north east of Pemberton and the mountain slopes on the north side of the Lillooet River, northwest of Pemberton. Defoliation occasionally expands beyond these areas, but seldom causes significant damage.

Impact

Impacts caused by this defoliator are variable and depend on the severity of defoliation and the number of years of defoliation. Defoliation reduces incremental growth, and can cause top-kill and mortality. Mortality is rare in the CFR but may occur after a number of years of severe defoliation. Top-kill in immature trees can result in forks and crooks in the main stem of the tree (i.e. within the most valuable log).

Stand mortality, even after 7 consecutive years of moderate to severe defoliation, averages about 1% of the trees. However, individual stand extremes can reach 50% mortality. Forks, crooks and creases caused by up to three previous infestations were found on 11% of standing Douglas-fir but ranged from 0 to 70% in individual stands. The combined effect of four budworm outbreaks that occurred during the life of a Douglas-fir stand amounted to a loss of about 12% in radial growth. Cumulative stand volume losses following an outbreak can range as high at 19%.

Management

Re-establishing Douglas-fir in high budworm hazard areas assumes a risk of future damage from budworm defoliation. Spray treatments (*Btk*) may be required to meet regeneration and stand objectives. Species for reforestation are limited in high hazard areas; however, utilizing non-host species (e.g. ponderosa pine, lodgepole pine) within a mixed planting with Douglas-fir will help reduce impacts, especially along edges of mature timber. Spruce can be used at higher elevations as an alternative to Douglas-fir.

Dense stands are more susceptible; manage density to target stocking standard and thin from below to maintain an even-aged structure. Ecosystem restoration treatments that thin and underburn dense uneven-aged stand should reduce budworm populations and damage. Commercial thinning should also reduce budworm damage.

Thinning and fertilization, through improving tree vigour, may help trees withstand repeated attacks and compensate for growth losses. However, these treatments are unlikely to reduce stand susceptibility.

Spray treatments are indicated for young stands of Douglas-fir in the CRF when moderate to severe defoliation is predicted for the following year (as determined by predictive egg sampling surveys – refer to the *Defoliator Management Guidebook*). The biological control agent *Bacillus thuringiensis* var. *kurstaki* (*Btk*) (e.g. Foray 48B) is the product of choice for budworm control (refer to the *Defoliator Management Guidebook*).

Priority and Research

Canadian Forest Service researchers are studying the phenology of bud break and the emergence of budworm larvae in the spring and the influence this has on budworm populations. They are also studying the population dynamics (survival/mortality) of the larvae populations from emergence in the spring to pupation in mid-summer.

Resources

- Heppner, D. and J. Turner. 2006. British Columbia's coastal forests: Spruce weevil and western spruce budworm forest health. Stand Establishment Decision Aids. BC J Ecosystems and Management 7(3):45–49.
- Shepherd, R.F. 1994. Management strategies for forest insect defoliators in British Columbia. Forest Ecology and Management 68:303-324.
- Unger, L.S. 1995. Spruce budworms. Forest Pest Leaflet #31. Canadian Forest Service, Pacific Forestry Centre, Victoria.

Dwarf Mistletoe

Hemlock Dwarf Mistletoe

Hemlock dwarf mistletoe (*Arceuthobium tsugense*) is an obligate parasitic plant that affects tree growth and leads to the production of "brooms", stem deformities and occasional mortality. Breakage of branches holding brooms can provide potential entry sites for wood-decaying fungi. While the primary host is western hemlock, *A. tsugense* can also be found on mountain hemlock, Pacific silver fir, grand fir, Sitka spruce and lodgepole (shore) pine. Like most plants, dwarf mistletoes produce flowers which are pollinated by insects and produce seeds that spread within the same canopy (intensification) or to adjacent canopies. This process is slow and often difficult to observe, especially in young trees, as there may be up to a four year lag from the time of infection until the first aerial shoots are produced. On older trees the results of prolonged infection are more readily observed.

Hazard and Risk

The *Dwarf Mistletoe Guidebook* states that all forests within the CWH are considered high hazard to hemlock dwarf mistletoe. A more refined hazard rating is provided by Muir *et al.* (2004) and is summarized in Table 4.

Table 4. Hazard rating for hemlock dwarf mistletoe in the Coast Forest Region

BEC Subzone	Hazard Rating
CDF[a]	Low
CWH mm2, ms1, vm[b], ws2	Low
CWH ds, mm1	Moderate
CWH xm[a], dm[a], ms2[c], vh, wh	High

[a] Shore pine may be infected in these subzones.

[b] Where subzones are not split numerically, both have the same rating.

[c] This rating applies only up to 600 m elevation. Above that, hazard is low.

The risk of hemlock dwarf mistletoe typically manifests in two ways. First, the risk to susceptible regeneration growing within 10-15 m of infested residual trees along cutblock boundaries or adjacent to single-tree or group reserves is high. Second, the risk to uninfected residual trees remaining after partial cutting is dependent on the amount of infested neighbouring trees left behind. The opening of infested canopies stimulates the formation of mistletoe aerial shoots and increases spread of the parasite.

Impact

Although not primarily a mortality agent, it has been estimated that for coastal BC hemlock dwarf mistletoe is responsible for over 1 million m^3 in annual growth loss. Moderately and severely infested trees have demonstrated growth reductions of 20-40%, respectively, compared to uninfested trees. Trees initiating under infested canopies can undergo decades of suppressed growth and creation of stem deformities (swellings) that result in unmerchantable stem form and occasionally death. While individual tree growth effects have been quantified, currently there is no OAF reduction to account for stand-level infestation for use in TSR.

Management

Being obligate parasites, management of dwarf mistletoes should be easy: kill the host and you kill the pest. For years, application of this principle formed the basis for dwarf mistletoe management in BC. Infested stands were clearcut, with straight edged boundaries and strict adherence to the "3-m knockdown rule", on the coast. This led to sanitation of large areas which were successfully regenerated to western hemlock and other susceptible hosts. Not terribly aesthetic but effective in controlling dwarf mistletoe. The advent of partial cutting to the coast, with its emphasis on irregular cutblock shape and tree retention, has resulted in corresponding increase in concern over perpetuation of dwarf mistletoe in harvested areas. While it will be difficult to eradicate dwarf mistletoe from infested stands that are partially cut, reducing the risk to regeneration and residual trees is possible. Try to reduce the perimeter edge of the cutblock and use natural barriers in placing cutblock boundaries. All severely and moderately infested trees should be removed unless they remain in reserves where there is little chance for their seed to disperse onto susceptible regeneration. Leaving infested trees, including advanced regeneration > 3 m tall, in a dispersed retention system should be avoided. When opening closed canopies through commercial thinning or uneven-aged stand management, remove as many infested trees as possible to reduce the proliferation of new aerial shoots and consequent spread of seed. If conducting pre-commercial thinning along cutblock or reserve edges, identify and remove any infested young trees.

Priority and Research
A great deal of work on dwarf mistletoes was done in the 1950's through 1970's in BC. Since the biology was well understood and forest management practices at the time were effectively dealing with the pest, further research was gradually discontinued. With the implementation of variable retention systems, interest in dwarf mistletoe impact in these harvested stands has been rekindled. Recent questions regarding tree retention and regeneration in partial cut western hemlock stands require resolution. Some recent work has been initiated on quantifying the impact of dwarf mistletoe in these stands and applying the results for use with current growth and yield models.

Resources

- Muir, J., J. Turner and K. Swift. 2004. Coast Forest Region: Hemlock dwarf mistletoe stand establishment decision aid. BC J. Ecosystems and Management 5: 7-9.
- Unger, L. 1992. Dwarf mistletoes. Can. For. Serv., Pac. For. Centre. Forest Pest Leaflet 44.

Foliar Disease

Cedar Leaf Blight (Keithia)

Cedar leaf blight (*Didymascella* (formerly *Keithia*) *thujina*) is a widespread, native foliar disease of western redcedar in BC. It infects new foliage and kills one-year leaves in such a manner that the pattern of foliar discolouration produced is quite distinct from that of annual leaf mortality (cladaptosis) that affects older foliage. A distinct symptom is the presence of dark brown to black fruiting bodies on the surface of the leaf. After the leaf dies, the fruiting body drops out leaving a pit or hole in the leaf.

Hazard and Risk
Disease incidence tends to be highest in dense stands with high humidity. This disease, while occurring in mature stands, is often regarded as more of a problem in nurseries where an improper watering regime can result in rapid infection of seedlings. Since environment plays a strong role in facilitating infection, this disease could become more noticeable with prolonged change toward wetter weather.

Impact
Impact in mature stands is minimal. The greatest impact is usually to planting stock that has been infected in the nursery. Infection and mortality of a large proportion of cedar foliage can result in the rapid death of young trees. This is particularly evident when infected one-year old stock is planted. In the past, some plantations have experienced widespread failure of planted cedar.

Management
Changes in nursery practices for growing western redcedar has made the sale of infected stock rare. On one-year old stock the disease is often not evident until the following summer when mortality occurs. Two-year old stock may have evident symptoms visible and should be carefully checked prior to planting.

Priority and Research
Since management practices around reducing the risk of this pest exists, its priority is low and little research is ongoing.

Resources
- Russell, J.H., H.H. Kope, P. Ades and H. Collinson. 2007. Variation in cedar leaf blight (*Didymascella thujina*) resistance of western redcedar (*Thuja plicata*). Can. J. For. Res. 37: 1978-1986.

Root Disease

Annosum Root Rot

Annosum root disease is part of a complex of several distinct types or groups of fungi that currently are labelled under one species name, *Heterobasidion annosum* (=*Fomes annosus*). The distribution of these groups is extensive with three types occurring in Europe and two in North America. Each type is preferential to a certain group of host species. For example, the S-type found in western North America is partial to non-pine conifers like *Abies*, *Picea, Tsuga* and Douglas-fir. It occurs throughout the coast except in the driest parts of the CDF zone. The P-type is more widespread in North America and prefers primarily pine hosts, but is not found in BC. Most damage is done as either a heart rot or as a root and butt rot, consequently detection of the disease can be difficult until the tree is cut or windthrown. The fungus is adept at invading new hosts via airborne spores and entry through fresh stump surfaces or stem wounds is common. Once colonized, growth of mycelia along root systems to neighbouring trees facilitates spread.

Hazard and Risk
A first approximation hazard rating exists for the S-type of *H. annosum*. It generally reflects the most susceptible hosts (in descending order) *Abies*, *Picea, Tsuga* and Douglas-fir with the level of activity proposed. In precommercial thinning, a high hazard for infection exists for amabilis fir and Sitka spruce but the hazard is low for western hemlock and Douglas-fir. This rating also applies for damage to residual stems caused by partial cutting. However, two other factors should be considered. For mature trees, the risk of rot caused by *H. annosum* increases markedly in trees >120 years old. Also, the risk for new infections decreases markedly if activities are performed during winter or summer when spore dispersal is inhibited by cold temperatures or dry conditions, respectively.

Impact
While *H. annosum* spreads readily and through varied pathways and is a major mortality agent of conifers in Europe, its impact in coastal BC is less dramatic. While the disease is endemic to coastal forests, its impact in mature stands is not considered as significant as that of laminated root rot on Douglas-fir. This may be because the disease is considered more as a grade loss factor rather than a mortality agent. As such, its impact on timber supply is muted by being combined with all other decay, waste and breakage factors and it is likely included in these calculations.

Management
It is rare to single out *H. annosum* for management in mature stands since usually does not occur extensively enough or it is often found with other root diseases like *Armillaria* or *Phellinus*. As such, most recommendations regarding the disease are preventive in nature aiming to reduce the risk of creating new infections. The following four recommendations are typical. First, manage stands, especially western hemlock and amabilis fir, to short rotations (<120 years). When conducting forest

operations like partial cutting, minimize wounding to deny entry points for spores. For precommercial thinning, do not overly worry about colonization of fresh stump surfaces. While the incidence of *Annosum* does increase in thinned stands, the impact appears limited in terms of volume loss over a rotation. Finally, treatment of stumps using a liquid or powder formulation of Borax or zinc chloride appears unnecessary. In areas where *Annosum* occurs with *Armillaria* or *Phellinus*, management strategies for those diseases will usually suffice to control *Annosum*.

Priority and Research

Considerable work was done regarding *H. annosum* 20-30 years ago western North America. However, fears that it would cause considerable losses in managed (thinned) stands did not materilize. That, combined with the reluctance to practice intensive silviculture on the coast, has led to a lack of interest in research of this fungus. In Europe, where Annosum causes significant difficulties in forest management, research into chemical (urea, borax) and biological control (*Phlebiopsis gigantea*) measures is active.

Resources

- Morrison, D.J., M.D. Larock and A.J. Waters. 1986. Stump infection by *Fomes annosus* in spaced stands in the Prince Rupert Forest Region of British Columbia. Can. For. Serv., Pac. For. Centre. BC-X-285.
- Otrosina, W.J. and R.F. Scharpf (Eds.). 1989. Research and management of Annosus root disease (*Heterobasidion annosum*) in western North America. USDA For. Serv., Pac. SW For. and Range Exp. Stn. General Technical Report PSW-116.

Armillaria Root Disease

Armillaria root disease is a complex of up to three dozens fungal species found across forest types worldwide. Seven species of *Armillaria* occur in Western Canada but only one, *Armillaria ostoyae*, is considered pathogenic on a range of hosts including conifers. The remainder act primarily as saprophytes or are very rarely found. On the coast, *A. ostoyae* is found south of the Dean Channel except for an isolated occurrence in the driest part of the Queen Charlotte Islands. It is mostly visible in young stands or plantations <20 years old where mortality can be readily identified. In older stands its effect tends to be diluted and the occurrence of dead trees more difficult to spot, especially in stands dominated by coastal climax species. *Armillaria* is more obvious in the coast/interior transition and a more dramatic problem east of the Coast Range in southern Interior forests.

Hazard and Risk

A second approximation of disease hazard exists for *Armillaria* within BC. Table 5 is extracted from the relevant table in the *Root Disease Management Guidebook*.

Table 5. Landscape level hazard rating for *Armillaria* by biogeoclimatic unit in the Coast Forest Region

Forest Region	BEC unit	Hazard Rating
Coast	CDF mm	High[a]
	CWH dm	High[a]
	CWH ds1	High[a]
	CWH ds2	High[a]
	CWH mm1	High[a]
	CWH ms1	High[a]
	CWH ms2	High[a]

CWH xm1	High[a]
CWH xm2	High[a]
IDF ww	High

[a] This high hazard rating applies primarily to juvenile stands being regenerated to highly susceptible species in these subzones.

Essentially, this hazard rating is meant as a warning that *Armillaria* mortality can occur in juvenile stands, particularly those reforested heavily to Douglas-fir. An assessment of pre free-growing stands found that, in the CWH, *Armillaria* was a far more common cause of young tree mortality in plantations than *Phellinus weirii*[9]. This mortality has appeared even when there was no Douglas-fir in the original stand. As such, care should be taken pre-harvest to ensure that mature tree mortality is not caused by *Armillaria* prior to prescribing reforestation options.

Impact

Armillaria root disease can cause substantial mortality in trees of any age. However, mortality on the coast is most pronounced by age 20-25. Coast transitional stands suffer greater losses than purely coastal forests. Quantification of impact across subzones is continuing and currently the prescribed OAF 2 of 7.5% for root disease in the CDF and CWH xm1 & 2 accounts for losses to Armillaria. More detail on this OAF can be found in the profile of laminated root disease.

Management

Guidelines for managing *Armillaria* are similar to those for laminated root disease with the added complication that the suitable host list for *Armillaria* is larger, making choice of species suitable for reforestation more difficult. Simply put, the thresholds for treatment decisions break at three points illustrated in Table 6.

Table 6. Disease incidence and treatment thresholds for *Armillaria* in coastal forests

Disease incidence	Treatment level	Description
<2%	Minimal	Conduct harvesting and reforestation with no specific constraints.
2-15%	Alternate	Ensure good knowledge of disease distribution. If possible, stratify opening to avoid high incidence areas. Reforest with mix of mostly alternate species.
>15%	Intensive	Avoid partial cutting. Consider inoculum removal (stumping, push falling) if site suitable. If not, implement alternate strategy that avoids or minimizes most susceptible species.

For the most part, intensive treatments are suitable only on productive sites that will benefit most and that are amenable to machinery and some amount of disturbance. Chemical and biological controls have either not been registered or not proven easy to apply. Broadcast burning has no effect on buried inoculum. In some studies, the application of nitrogen fertilizers has increased the incidence and mortality rate of *Armillaria*, likely by enhancing cambial growth and providing a more developed food base. Conversely, it is suggested that fertilization with potassium fertilizers may enhance resistance by stimulating root development.

[9] Nevill, R., N. Humphreys and A. Van Sickle. 1996. Five-year overview of forest health surveys in young managed stands in British Columbia, 1991-1995. Canadian Forest Service and BC Ministry of Forests. FRDA Report 262.

Priority and Research
Armillaria is the top priority forest pathogen for research in BC. However, most of the work is being done in the southern interior. Work on the coast is limited, mainly to studies on the efficacy of stumping as a treatment and its relationship with laminated root disease in maturing stands.

Further Reading
Most references are not specific to the coast or are dated. Some that might be of value are:

- Morrison, D. and K. Mallet. 1996. Silvicultural management of Armillaria root disease in western Canadian forests. Can. J. Plant Pathology. 18: 194-199.

Black Stain Root Disease

Black stain root disease (BSRD) is composed of three varieties of fungus, only two of which are present in BC. *Leptographium wageneri* var. *ponderosum* occurs mainly on lodgepole pine and *L. wageneri* var. *pseudotsugae* on Douglas-fir. Only the latter is found on the coast. BSRD is also unique in that, unlike other root diseases, it neither kills the cambium nor decays roots. Instead, the fungus is brought into the host by root-feeding beetles and spreads into the sapwood, causing a vascular wilt as it effectively blocks the flow of water to the crown. This insect-driven dispersal also makes predicting spread of the disease difficult.

Hazard and Risk
The unique insect-fungal mutualism makes predicting the occurrence of BSRD difficult in that not all vector insects carry spores and even spore carriers may not attack a host tree in sufficient numbers to cause mortality. The insects are attracted to trees stressed by a variety of agents, including human-caused activities like road building, harvesting and thinning. In areas where BSRD has been noted, the risk of attack by beetles may be stimulated along road or skid trail edges as roots are disturbed or trees are physically damaged. Harvesting can also push emerging adults into surrounding stands or plantations in a search for suitable new habitat. Such displacement can temporally elevate the local vector population and cause an "outbreak" of mortality, especially in younger trees already suffering from other effects (e.g., competition, drought, root disease, etc.). It is possible that with climate change the occurrence of BSRD could increase in areas where Douglas-fir is a marginal species.

Impact
The impact of BSRD is usually localized and rarely exceeds a few dozen trees in a stand unless circumstances are exceptional. The usual pattern is for the sudden appearance of a few dead trees in a stand followed by additional but gradual mortality for several years following. The pattern of occurrence can appear random since nearest neighbours often do not succumb to the disease. No specific net down is applied for BSRD.

Management
In areas where BSRD may be a concern, low mortality levels can be encouraged by minimizing site disturbance and avoiding tree injury associated with road building and harvesting in areas predominant to young Douglas-fir. The survival of the fungus in stumps is short-lived so they are not considered important in spreading the disease. One point to consider is that since the vectors are attracted to weakened trees other root diseases may be present on these sites.

Priority and Research
A recent long-term study of BSRD on the coast essentially confirmed our understanding of this disease in Douglas-fir[10]. This disease has a low priority for further research. However, it may serve as a useful indicator of the effects of climate change in future studies.

Resources
- Hunt, R.S. and D.J. Morrison. 1995. Black stain root disease. Can. For. Serv., Pac. For. Centre. Forest Pest Leaflet 67.

Laminated Root Disease

Laminated root disease, caused by *Phellinus weirii*, is the most damaging root disease in coastal forests. Its ability to kill primarily Douglas-fir and *Abies* species at any age makes this a most notable and economically significant pathogen. It is also the most important single natural disturbance agent causing long-term change to forest ecosystems in the Pacific Northwest. Another strain of *P. weirii* is known to occur as a butt rot of western redcedar but this disease is rarely noted on the coast. The distribution of *Phellinus* on the coast follows that of Douglas-fir through the CDF and drier CWH subzones. *Phellinus* can create very noticeable mortality in coastal forests since almost all conifers are susceptible to some extent. Juvenile stand mortality can start as early as age 5 and continues throughout stand development, often culminating in large, obvious mortality centres filled with non-susceptible host species of trees or shrubs. *Phellinus* is also quite extensive throughout the southern Interior but its presence is often overshadowed by that of *Armillaria*.

Hazard and Risk
A second approximation of disease hazard exists for *Phellinus* within BC. Table 7 is extracted from the relevant table in the *Root Disease Management Guidebook*.

Table 7. Landscape level hazard rating for *Phellinus* by biogeoclimatic unit in the Coast Forest Region

Forest Region	BEC unit	Hazard Rating
Coast	CDF mm	High
	CWH dm	High
	CWH ds1	High
	CWH ds2	High
	CWH mm1	High
	CWH mm2	High
	CWH ms1	High
	CWH xm1	High
	CWH xm2	High
	IDF ww	High

Essentially, this hazard rating indicates that there is a high risk of *Phellinus* occurring in stands that were previous predominant to Douglas-fir, particularly if they are being reforested with Douglas-fir.

Impact
Phellinus root disease can cause substantial mortality in Douglas-fir and *Abies* of any age. It is estimated that 1.4 million m^3 are lost annually in BC through mortality and growth reduction.

[10] Jacobi, W.R., S. Zeglen and J.D. Beale. 200X. Black stain root disease progression in coastal Douglas-fir in British Columbia. Can. J. For. Res. XX: XXX-XXX.

Mortality is typically observed from age 6-10 and continues throughout the rotation culminating in the creation of large openings and ingress of less susceptible climax species. The occurrence of *Phellinus* is closely tied to the presence of Douglas-fir. For example, while western hemlock is susceptible to *Phellinus*, infected trees are rarely found in stands that aren't substantially mixed with Douglas-fir. Quantification of impact across subzones is continuing and currently the prescribed OAF 2 of 7.5% for root disease in the CDF and CWH xm1 & 2 accounts for losses to all root diseases, including *Phellinus* and *Armillaria*. This OAF should be applied to any Douglas-fir-leading stand type >10 years old within the three subzones. It is added to the default OAF 2 of 5% resulting in a cumulative OAF 2 of 12.5%. This value has been applied in the latest TSR for the Arrowsmith, Strathcona, and Sunshine Coast TSAs.

Management

Guidelines for managing *Phellinus* are similar to those for *Armillaria*. Simply put, the thresholds for treatment decisions break at three points illustrated in Table 8.

Table 8. Disease incidence and treatment thresholds for *Phellinus* in coastal forests

Disease incidence	Treatment level	Description
<2%	Minimal	Conduct harvesting and reforestation with no specific constraints.
2-15%	Alternate	Ensure good knowledge of disease distribution. If possible, stratify opening to avoid high incidence areas. Reforest with mix of mostly alternate species.
>15%	Intensive	Avoid partial cutting. Consider inoculum removal (stumping, push falling) if site suitable. If not, implement alternate strategy that avoids or minimizes most susceptible species.

For the most part, intensive treatments are suitable only on productive sites that will benefit most and that are amenable to machinery and some amount of disturbance. Chemical and biological controls have either not been registered or not proven easy to apply. Broadcast burning has no effect on buried inoculum. Application of nitrogen fertilizers has no effect on disease incidence or the rate of mortality. Fertilization of mature stands can delay culmination age and extend rotations for a few years but has little effect on final stand volume.

Priority and Research

The biology and action of laminated root disease has been extensively studied over the last few decades. Current research is focussed on the efficacy of various treatment options (e.g., stumping) and the search for resistant individuals in field trials.

Resources

- Sturrock, R., S. Zeglen, and J. Turner. 2006. British Columbia's coastal forests: Laminated root rot Forest Health Stand Establishment Decision Aid. BC J. Ecosystems and Management 7(3):41–43.
- Thies, W.G. and R.N. Sturrock. 1995. Laminated root rot in western North America. USDA Forest Service, Pac. NW Res. Stn. Research Bulletin PNW-GTR-349.

Rhizina Root Disease

Rhizina root disease, caused by the fungus *Rhizina undulata*, is primarily a mortality agent of seedlings planted after fire has occurred on a site. On the coast, *Rhizina* was a problem in some plantations in the late 1960's and through the 1970's but it has faded with the reduced use of broadcast burning for site preparation.

Hazard and Risk

Since *Rhizina* spores require a certain amount of soil heating to stimulate germination, any occurrence of fire can cause appearance of the fungus. On the coast, *Rhizina* was confined to the CWH exclusively following fire, either natural or man-caused. As such, any use of fire may stimulate the appearance of *Rhizina* and care should be taken when planting into these high hazard burned areas.

Impact

The incidence of Rhizina tends to disappear two seasons following burning. For example, a fall burn followed by a spring planting would create a hazard for Rhizina. Incidence of the fungus would appear that year and persist into the next before exhausting itself by the third season. Mortality can be patchy since infection is dependent on proper heating of the soil but rates of up to 80% have been observed in some plantations.

Management

If planting into a burned area that has no history of *Rhizina*, conduct a seedling survival survey the season following planting to ensure no mortality has occurred. If the area has a history of *Rhizina*, then delaying planting for two seasons may be preferable. This will ensure that the disease has exhausted itself on the site and infection risk is minimal.

Priority and Research

Due to its infrequent occurrence, research into *Rhizina* is a very low priority.

Resources

- Callan, B.E. 1993. Rhizina root rot of conifers. Can. For. Serv., Pac. For. Centre. Forest Pest Leaflet 56.

Stem Rusts

White Pine Blister Rust

White pine blister rust, caused by the introduced fungus *Cronartium ribicola*, is a devastating pathogen of five-needle pines across North America. In BC, it affects western white, limber and whitebark pines and has removed the former from being a conspicuous component in forests. While WPBR may infect trees of any age, the greatest impact on western white pine is to young trees since the zone of highest infection incidence is the lower two metres of the bole. Infection occurs through foliage and progresses to the branch (or main stem in the case of direct stem needle infections) where swellings (cankers) appear after a year or two. Most cankers are conspicuous in the spring when the blisters holding masses of orange aeciospores open and spores spread to the alternate host, primarily *Ribes* spp. In the fall, basidiospores return to infect pine needles, usually best during humid warm periods, and the cycle starts anew.

Hazard and Risk

Site hazard for WPBR is considered high in BC anywhere that five-needle pines grow. Some hazard rating systems exist in the US but to date no one has produced a reliable system for use in BC, mainly due to the problem of correlating various site and tree factors to the incidence of rust. One factor that is a reasonable predictor of potential infection is proximity to *Ribes* plants. Pines within 30 m of *Ribes* will usually suffer higher levels of infection. Recently, species of *Pedicularis* and *Castelleja* have been identified as alternate hosts for WPBR but, so far, this has only been confirmed Idaho. As a general rule of thumb for the coast, areas above 1000 m may be considered less hazardous. This may make them feasible for use of resistant, interior-source planting stock.

Impact
Since its introduction, WPBR has decimated the proportion of white pine in natural forests. The high mortality rate associated with the disease has resulted in the nearly discontinued use of western white pine in reforestation due to doubt regarding its likely survival. WPBR, along with mountain pine beetle, has severely impeded the reproductive capability of whitebark and limber pines threatening the survival of these high-elevation species in some areas.

Management
Despite its handicap, western white pine is still a desirable species primarily because of its wood characteristics and its utility in replacing Douglas-fir in areas where laminated root disease occurs. Over the decades numerous attempts have been made to control this disease. The most significant was the widespread attempt to eradicate *Ribes* across the US from the 1930's to the 1960's. This attempt was largely unsuccessful due to the impossible task of locating and eradicating every *Ribes* plant across the landscape. Some success can be obtained in controlling Ribes establishment by altering harvesting regimes to limit canopy openings and restrict the increase in light levels to the forest floor. Other cultural efforts have included using chemical and biological control agents (largely ineffective or impractical), thinning (ineffective), pruning (variable effectiveness), and scribing cankers (effective but expensive). Since the 1960's, the most actively pursued strategy is tree breeding to try and identify and reinforce whatever resistance to WPBR exists in the natural population and use the resulting offspring for reforestation. On the coast, the most common practice has been to prune potential white pine crop trees in order to increase the odds of survival. The recommended treatment regime is outlined in Appendix 3 of the *Pine Stem Rust Management Guidebook*. The recent introduction of resistant stock (carrying the Cr2 gene) has opened the window on using western white pine more extensively in plantations without requiring pruning to ensure better survival.

Priority and Research
WPBR has been studied since shortly after its discovery on the west coast. This includes 25 years of testing and breeding for resistant stock in BC and twice that long in the US. This remains a high profile pest on the coast with ongoing projects testing cultural (i.e., pruning) and genetic (i.e., resistance) management techniques. The most recent work involves testing the offspring of both major and minor gene resistant parents with the hope of combining both attributes.

Resources

- Zeglen, S., R.. Hunt and M. Cleary. 200X. British Columbia's forests: White pine blister rust Forest Health Stand Establishment Decision Aid. BC J. Ecosystems and Management (submitted).
- Hunt, R.S. and M.D. Meagher. 1992. How to recognize white pine blister rust cankers. Forestry Canada. Pacific Forestry Centre, Victoria, BC.

Weevils

Spruce Weevil

The spruce weevil, *Pissodes strobi*, is the major insect pest of Sitka spruce in the Coast Forest Region where it seriously limits the use of Sitka spruce for reforestation. Repeated weevil attack of the leading shoots of young Sitka spruce leads to suppressed height growth and stem deformities.

Young Sitka spruce become susceptible at about age 5 and will continue to be attacked for the next 3 decades. Dense stands have slightly lower attack rates and less deformity.

Hazard and Risk
Weevil hazard zones are based on climate; warmer sites are more susceptible. Spruce plantations adjacent to stands that have heavy attack are at risk. Englemann spruce is also susceptible to attack but due to the higher elevation and cooler climate of Se sites, weevil attack is usually much less intense, and generally not a concern. Spruce weevil has not been found on the Queen Charlotte Islands, however, Ss from these islands has been shown to be highly susceptible to weevil attack.

Hazard zones for Ss have been correlated to biogeoclimatic subzone variants:

- High hazard: CWHxm, dm, ds1, ds2, mm1, ms2, vm1; CDFmm; IDFww.
- Moderate hazard: CWHvh1, vm2.
- Low hazard: remaining variants within coastal zones [see page 229 of Green and Klinka (1994)]
- Hazard ratings within these variants declines as one moves northward, for example in the North Coast Forest District the CWHvm1 has a low hazard and the hazard in the vm2 is negligible.

Impact
Repeated attack by the weevil can result in unacceptable losses of height growth and stem deformation as lateral braches turn upward and compete for dominance. Forks, crooks and heavy branching can result. In severe cases, little commercial volume is produced with many of the attacked trees becoming overtopped and suppressed by competing, less valuable tree species.

Management
Control of established weevil infestations is currently not practical.

When establishing new stands containing Sitka spruce, utilize weevil resistance planting stock. If improved "A" seed is used (from selected orchard grown weevil resistant trees, R+87), it is suggested that possibly up to half of the stand composition could be planted with Ss in areas considered to have moderate to high weevil hazard ratings. If "B" seed is used (from naturally resistant stands, R+64), caution is recommended and it is suggested that only about a third of the stand composition be Ss [Further research is required to refine theses recommendations].

If weevil resistant stock is not available, plant Sitka spruce as follows:

- In low hazard areas, Ss can be planted in accordance with normal species selection guidelines. Low levels of weevil attack can be tolerated at the stand level (e.g. ≤10% stems attacked per year considered to have a moderate hazard, it is recommended that Ss only be planted to compose up to 20% of the stand composition.

- In areas considered to have a moderate hazard, it is recommended that Ss only be planted to compose up to 20% of the stand composition.
- In high hazard areas, alternative non-host tree species should be planted, and limit spruce to 10% of the total stocking.
- Plant Ss with other tree species at higher densities (greater than 1600 stems per hectare) and delay thinning (or don't thin). Weevil attack rates decline when stand height reaches approximately 12 m.

Priority and Research
This insect has received a significant amount of research over the past three decades, starting with many years of leader clipping trials trying to develop a control method. The weevil's complex of predators and parasites has also been studied in an attempt to develop ways to control it. Pesticide injection treatments were also attempted as was overstorey shading. Unfortunately no practical method has yet been developed to control established infestations. However, the identification of naturally resistant individual spruce, and subsequent research trials have now brought this to the point where weevil resistant seedlings can be utilized operationally. Research efforts are now focused on further developing and implementing weevil resistant Ss.

Resources

- Green, R.N. and K. Klinka. 1994. A field guide to site identification and interpretation for the Vancouver Forest Region. BC Ministry of Forests, Victoria. Land Management Handbook #28.
- Heppner, D. and J. Turner. 2006. British Columbia's coastal forests: Spruce weevil and western spruce budworm forest health Stand Establishment Decision Aids. BC J Ecosystems and Management 7(3):45–49.
- McMullen, L.H. 1976. Spruce weevil damage, ecological basis and hazard rating for Vancouver Island. Canadian Forest Service, Info Report BC-X-288, Victoria.
- Turnquist, R.D. and R.I. Alfaro. 1996. Spruce weevil in British Columbia. Forest Pest Leaflet #2. Canadian Forest Service, Pacific Forestry Centre, Victoria.

Wildlife

Porcupine

Porcupines are primarily herbivores with a winter diet that consists almost exclusively of the cambium, phloem and foliage of woody shrubs and trees. The wounding caused by feeding ranges from small patches of bark removed to complete stripping and girdling of trees. Along with outright mortality, feeding damage can cause reduced tree growth and structural defects that lower wood quality and serve as entry points for decay fungi. Porcupines prefer different species in different areas of their range.

Hazard and Risk
There is a hazard that exists to second-growth, even-aged, hemlock-dominated stands on the north and mid-coast where porcupines may be present. Immature western hemlock is by far the preferred food source for porcupine on the coast with trees in the 10 to 30 cm dbh range most commonly suffering feeding damage. Small trees are rarely attacked since they are often too small to offer the

porcupine protection from predators or a sufficiently high perch in the canopy. Larger trees that have developed thicker bark are less desirable as well due to the increased effort required to climb and feed higher in the canopy.

Impact
The results of a study done in the North Coast Forest District showed that while overall stand volume does not appear to be greatly affected, there is a considerable shift in stand species composition due to porcupine damage. Due to their preference for western hemlock, porcupine feeding kills, or causes to be killed by other factors (e.g., decay), or renders less valuable due to defect (e.g., crooks, scars, etc.) hemlock trees. This favours the growth of Sitka spruce, amabilis fir and western redcedar which are not preferred by porcupines.

Management
Since porcupines seem to key on openings stocked with large amounts of even-aged western hemlock, increasing species diversity in large openings is a good risk reduction strategy. This may not lessen the amount of feeding damage but it will ensure that sufficient stocking of non-host trees exists to carry stand volume expectations to rotation. Most active efforts to reduce local porcupine populations, by hunting or introducing predators, have failed to have any lasting effect.

Priority and Research
There is no research ongoing at this time.

Resources

- Woods, A. J. and S. Zeglen. 2003. Impact of feeding damage by the porcupine on western hemlock-Sitka spruce forests of north-coastal British Columbia: 15-year results. Can. J. Forest Research 33: 1983-1989.

APPENDIX B: PEST HISTORY BY TSA

2006 AERIAL OVERVIEW SURVEY

Aerial overview surveys have been conducted annually in the Coast Forest Region by the Ministry of Forests since 1998. Prior to this, the Forest Insect and Disease Survey (FIDS) unit of Forestry Canada (now the Canadian Forest Service) was responsible for conducting large-scale aerial and ground surveys. As a minor exception to this, the Canadian Forest Service continues to survey the Queen Charlotte Islands. The intent of these surveys is to provide an overview of forest health conditions. These surveys are generally not detailed enough for operational purposes but provide a landscape-level picture of pest activity and distribution that can be useful in creating a preliminary hazard and risk assessment for managed areas. Table 9 summarizes the 2006 results for the Coast Forest Region. Annual updates are available on the Ministry website and through the *Summary of Forest Health Conditions in British Columbia.*

It is important to note that aerial surveys in the Coast Forest Region have not been undertaken with the same intensity as other parts of the province due to the relatively low level of insect activity. As such, forest health histories may not be reflective of actual conditions. Also, note that TFL areas are usually not covered by the overview survey.

Table 9. Summary table of approximate area (ha) occupied by pests in the Coast Forest Region, by forest district, as detected during the 2006 aerial overview survey

	Forest District[11]							
Damaging Agent	**DCK**	**DCR**	**DNC**	**DNI**	**DQC**	**DSC**	**DSI**	**DSQ**
Douglas-fir beetle	1093	1		44		1	2	266
Mountain pine beetle	19257			185765				11920
Spruce beetle	115			222		2		832
Alder sawfly				180				
Satin moth				292				
Western balsam bark beetle	3262			7949		28		360
Western spruce budworm	10925			2234				7832
Defoliators other	30			32		10		33
Spruce aphid					195			
Drought			1052					
Yellow-cedar decline				3789	349			

[11] DCK = Chilliwack Forest District; DCR = Campbell River Forest District; DNC = North Coast Forest District; DNI = North Island – Central Coast Forest District; DQC = Queen Charlotte Forest District; DSC = Sunshine Coast Forest District; DSI = South Island Forest District; and DSQ = Squamish Forest District.

ARROWSMITH TSA

The Arrowsmith TSA covers approximately 200,000 ha of southern Vancouver Island and extends from the Gulf Islands to central Vancouver Island (Figure 2). It encompasses the cities of Victoria, Duncan, Ladysmith, Nanaimo, Parksville, Qualicum Beach and Port Alberni. The TSA bounds many Tree Farm Licences (TFLs), including TFL 25, 44, 46, 54 and 57. The productive forest land accounts for only 56% of the TSA and the timber harvesting landbase accounts for only 30%. The majority of the forested TSA is within the Coast Western Hemlock (CWH) biogeoclimatic zone. The forests are dominated by Douglas-fir, western redcedar, western hemlock and true firs. While the eastern side of the island has a high proportion of second growth and now areas of third growth, the western portion is less developed and forests tend to be older. Some of the TSA's best growing sites will see up to 10m^3/ha growth per year, making them some of the most productive forests in Canada.

The current AAC is 391,796 m^3, which includes 6,300 m^3 of red alder stands and 13,700m^3 for harvest in Clayoquot Sound.

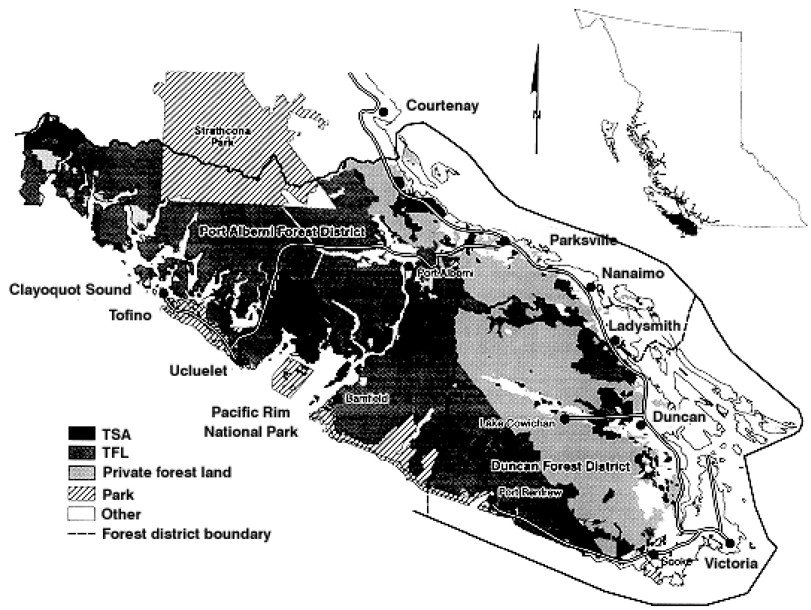

Figure 2. Arrowsmith Timber Supply Area.

Douglas-Fir Beetle

Very few records of Douglas-fir beetle activity exist for the Arrowsmith TSA. The first record was for 1914 near Cowichan Lake. In 1953 trees predisposed by drought were attacked near Victoria and North Pender Island, and in some windthrow near Gordon River. In 1974 attacked trees were found near Port Alberni, East Saanich, Chemainus, and Coombs. In 1975 blowdown was attacked in Cathedral Grove and in 1981 west of Shawnigan Lake.

Mountain Pine Beetle

From 1940-1960 mountain pine beetle was recorded on western white pine near Port Renfrew, San Juan Valley, Carmanah and Englishman River areas. This infestation on Vancouver Island is estimated to have covered over 135 300 ha and killed close to 4 million trees.

Root Diseases

Losses to root disease were incorporated into the last TSR for the TSA through adjustment of the OAF2 to 12.5% for all existing managed Douglas-fir leading stands in the CDF and CWHxm1 & 2 subzones, and 10% for future managed Douglas-fir leading stands.

Spruce Aphid

Spruce aphid has caused defoliation to Sitka spruce at various times, mostly between Victoria and Jordan River, and a few of the Gulf Islands.

Western Black Headed Budworm

A number of outbreaks of blackheaded budworm have occurred within the Arrowsmith TSA over the past 100 years, however significant impacts have been limited. Figure 3 outlines areas which have been historically defoliated by western blackheaded budworm.

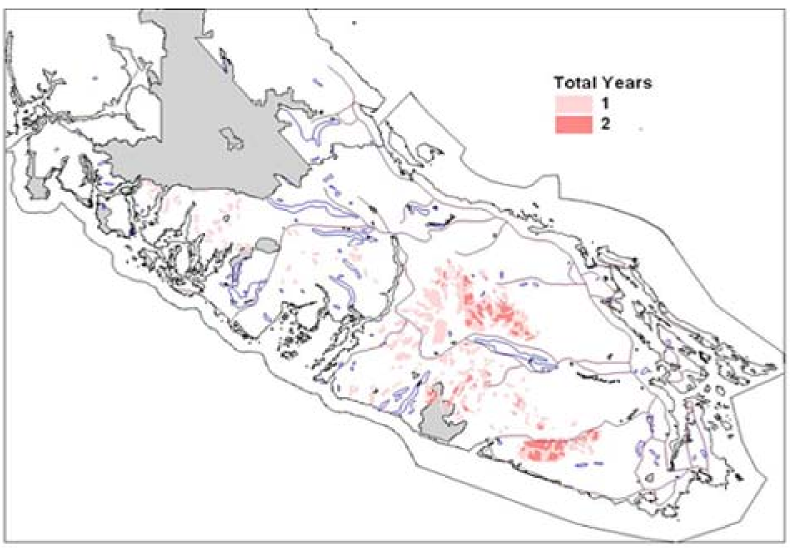

Figure 3. Area historically defoliated by western blackheaded budworm by total years of defoliation in the Arrowsmith TSA.

Western Hemlock Looper

A large outbreak of western hemlock looper was recorded on southern Vancouver Island from 1945-1947, in the Cowichan and Nitinat lakes area. This outbreak was over 20,000 hectares in size and mostly within the CWHvm1. It resulted in severe defoliation and mortality, and much salvage harvesting.

Western Spruce Budworm

The first recorded defoliation by western spruce budworm in British Columbia occurred near Victoria (including Saltspring Island), and Duncan in 1909 and 1910 in the Coastal Douglas-fir biogeoclimatic zone. No other defoliation has been recorded since in the Arrowsmith TSA.

Windthrow

The last TSR estimated total losses to windthrow at 2500 m^3/year, but the annual unsalvaged losses were only 1000 m^3.

Other Important Pests

In recent years accidental introductions of North American gypsy moth has been detected in southern British Columbia, including within the Arrowsmith TSA. The Ministry of Forests and Range has taken the lead role in conducting mass trapping and aerial treatments for this pest, successfully preventing its establishment within the province.

FRASER TSA

The Fraser TSA roughly encompasses the Lower Fraser River Basin and is the most densely populated TSA within the Province (Figure 4). It is bounded by the Coast Mountains on the north and east, the Fraser lowlands east to Hope, the Fraser estuary at the outlet of the Fraser River to the west and the United States to the south. The Fraser is a biologically diverse region, with 13 commercial tree species and 5 biogeoclimatic zones within its boundaries. The Coastal Western Hemlock (CWH) biogeoclimatic zone is the most widespread and is dominated by western hemlock, amabilis fir and minor components of Douglas-fir and western redcedar.

The total TSA area is 1.4 million ha and the timber harvesting landbase is 260 918 ha (18% of the total TSA area). A large portion of the timber processed within the TSA is harvested outside the TSA. The TSA has an AAC of 1.27 million m^3, which includes harvesting of deciduous dominated stands for a volume up to 32 500 m^3.

The spotted owl is a very high profile endangered species found within the TSA. Spotted owl special resource management zones occupy approximately 135 500 ha, in which management activities are limited to those which create, maintain or enhance spotted owl habitat.

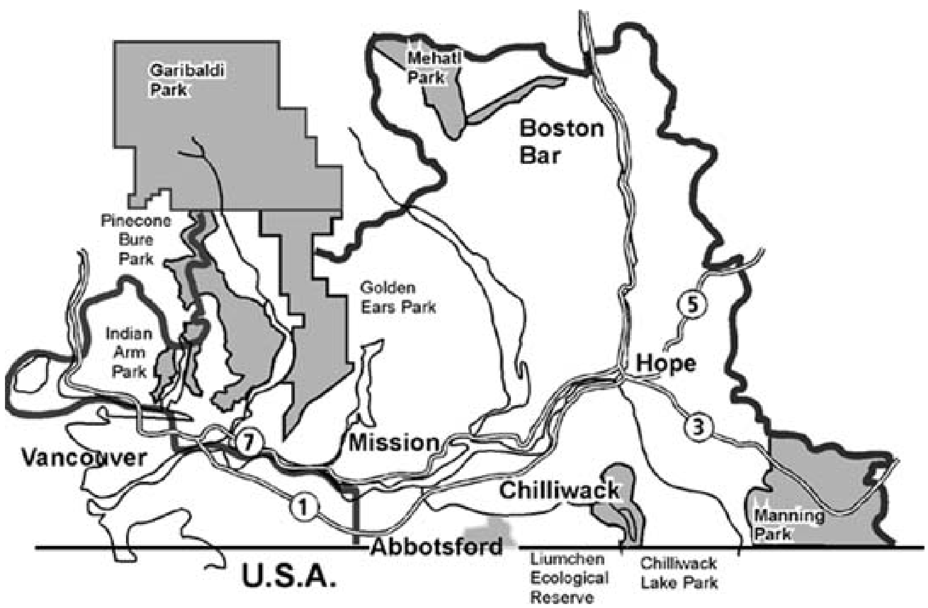

Figure 4. Fraser Timber Supply Area

Balsam Woolly Adelgid

This introduced pest has been found throughout the Fraser TSA, except along the Highway 3 corridor east of Hope into Manning Provincial Park. It can cause significant damage, including mortality, to *Abies* species; however within this TSA its impacts have not yet been found to be significant. The TSA is included within the regulated quarantine area which restricts the movement of true firs (see Balsam Woolly Adelgid Regulation).

Douglas-fir beetle

Douglas-fir beetle attacks fresh windthrow and/or trees predisposed by other factors, such as drought, defoliation or root diseases. Instances of Douglas-fir beetle attacked root-diseased trees are common for the Fraser TSA.

Douglas-fir beetle was first recorded in 1952 in the Skagit and Anderson River valleys. Populations continued at low levels until 1956, with no recorded damage from 1957-1959. In 1960 infestations were noted again in these areas, and by 1961 populations expanded to include small patches in the Nahatlatch River valley. In 1967 and 1968, populations increased in the Fraser Canyon, with infestations totalling, 1960 ha and 1677 ha, respectively. Small patches continued until 1972 throughout the Fraser Canyon. In 1974 dead trees were noted in the Silver-Skagit valley. Small pockets of attacked trees continued annually and sporadically throughout the TSA, until 1980 when 1300 ha were reported in the Fraser Canyon and thru Sunshine Valley. Populations have remained active since then at low levels, with a peak of 870 ha in 2000 in a large infestation near Nahatlatch River. In 2003, 250 ha were recorded in 17 separate patch infestations, 3 of which were near the Nahatlatch River and the remainder in protected areas along Highway 3 between Sunshine Valley and the west gate of Manning Park. In 2004, populations increased substantially along the Fraser Canyon corridor and Nahatlatch River with approximately 2590 ha infested, and also in Manning Park where 155 ha were infested. Populations declined again in 2005 to attack 685 ha; 1093 ha were attacked in 2006 and in 2007, 796 ha were attacked.

Douglas-Fir Tussock Moth

Douglas-fir tussock moth has caused occasional defoliation of ornamental spruce and Douglas-fir in urban situations (i.e., golf courses, boulevards etc.). It is not considered a serious pest of coast managed forests.

Fire

Fire damaged an estimated 17,000 m^3 of timber per year. A large portion of this timber is not recovered and unsalvaged losses are estimated to be 15,925m^3/year.

Mountain Pine Beetle

Mountain pine beetle was first recorded from the 1940's to 1960's in the Skagit River Valley and side drainages of the Fraser River. In 1972 several patches were noted in Manning Park, in 1973 in the Nahatlatch River Drainage. The infestation continued in both of these areas in 1974. In 1975 populations near Nahatlatch decreased, while those in the Manning Park corridor remained sporadic from 1976-1998, and expanded significantly in 1999 to 1577 ha. This infestation has increased annually with approximately 9300 ha recorded in Manning Park and Skagit valley, and 3300 ha outside park boundaries along Highway 3, in 2004 (Figure 6). This is a significant increase from 2003 when approximately 4300 infested ha were found in Manning Park and 690 ha outside the park In the Fraser Canyon small spot and patch infestations have also occurred sporadically, with slight increases from 1977-1978, 1980, 1985-1986, and 2002-2003. In 2004 populations increased to 10,252 ha and continued to increase with 31,921 ha of pine under attack in 2007.

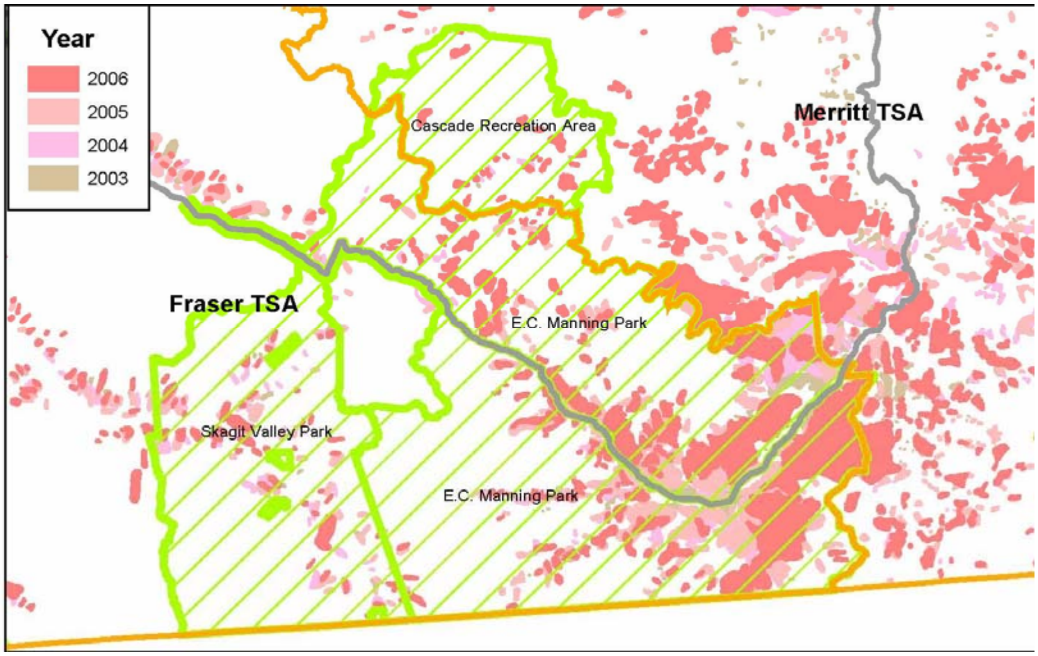

Figure 6. Area infested by mountain pine beetle in the Hope-Manning Park corridor in the Fraser TSA between 2003 and 2006.

Root Diseases

The TSA contains areas with extensive amounts of root disease, primarily laminated root disease of Douglas-fir and Armillaria root disease on many conifer hosts. Root disease losses have been not been accounted for in the last (2003) TSR. Losses to root diseases are proposed for the next TSR. This will involve an adjustment for OAF 2 to 12.5% for all existing managed Douglas-fir leading stands in the CDF and CWHxm1 & 2 subzones.

Spruce Beetle

Very little spruce beetle activity has been noted in the Fraser TSA. In 1988, 84 ha were lightly infested in Manning Provincial Park, and in 1994-1995 approximately 50 ha were infested near the Coquihalla Summit. In 2002, 160 ha were reported south of Nahatlatch and Pitt rivers, and in 2003, 120 ha NE of Boston Bar and 20 ha in Manning Provincial Park. In 2004 approximately 55 ha of infested spruce were detected south of the Nahatlatch River. Only 11 ha were detected in 2007.

Western Balsam Bark Beetle

Historical records do not accurately reflect populations, as often funds were not available to survey high elevation stands. This beetle is usually found scattered, rather than clumped, at higher elevations within the ESSFmw. In 2005, 1780 hectares were mapped; with 3261 ha in 2005 and 6816 ha in 2007. It is considered to be impractical to attempt to manage this beetle on the coast.

Western Black-Headed Budworm

In 1941 light defoliation occurred from Vancouver to Surrey. In 1967, approximately 3000 ha of western hemlock and true fir were defoliated near Hope and the Coquihalla Valley. This population decreased by half in 1968, but increased in 1969 to over 6000 ha stretching from the North Shore Mountains to Howe Sound and Harrison Lake. Populations collapsed by 1972. In 1985 over 2300 ha near Harrison Lake were defoliated. Historically defoliation has been light to moderate and has not had significant impacts.

Western Hemlock Looper

Six outbreaks of western hemlock looper have been recorded in the Fraser TSA. The first occurred from 1911-1913 causing severe defoliation and mortality near Stanley Park. The second outbreak occurred from 1926-1930 and covered over 4600 ha in total. This outbreak led to severe defoliation and extensive top-kill and tree mortality in the lower Fraser Valley, west of Hope, and in the Howe Sound and Port Mellon areas. From 1944 to 1947 defoliation occurred near, and in, the City of Vancouver watersheds, covering over 12,000 ha. From 1958-1959 light to severe defoliation occurred once again in Stanley Park. From 1969-1972 light defoliation was recorded near Coquitlam Lake. In 2002 defoliation was noted near Port Moody. In 2003 populations increased with approximately 2100 ha defoliated noted near Stave and Harrison Lakes. These populations collapsed in 2004 with only 18 ha defoliated near Stave Lake.

Western Spruce Budworm

Six outbreaks of western spruce budworm have been recorded in the Fraser TSA (Figure 7). The first outbreak occurred from 1943-1944 along the Skaist River and defoliated approximately 7000 ha per year. From 1953-1958 extensive defoliation occurred along the Fraser Canyon, including Nahatlatch and Anderson Rivers. In 1971 populations began building again in the Fraser Canyon, and near Hope and Tashme on the Hope-Princeton Highway. This infestation expanded annually along the Fraser Canyon and Skagit and Skaist corridors until 1977, and collapsed by 1981. In 1989-1990 small pockets of defoliation were noted near Boston Bar. From 1992-1994 populations expanded in the Nahatlatch River area and collapsed by 1995. In 2001 populations began increasing again near Boston Bar and along the Nahatlatch River, with 6600 ha of defoliation recorded in 2003. Populations were down slightly in 2004 with 4708 ha recorded and declined further in 2005 to 2643 ha. In 2006, however budworm populations increased again to 10,925 ha affected by defoliation, and increased further in 2007 to 24,337 ha.

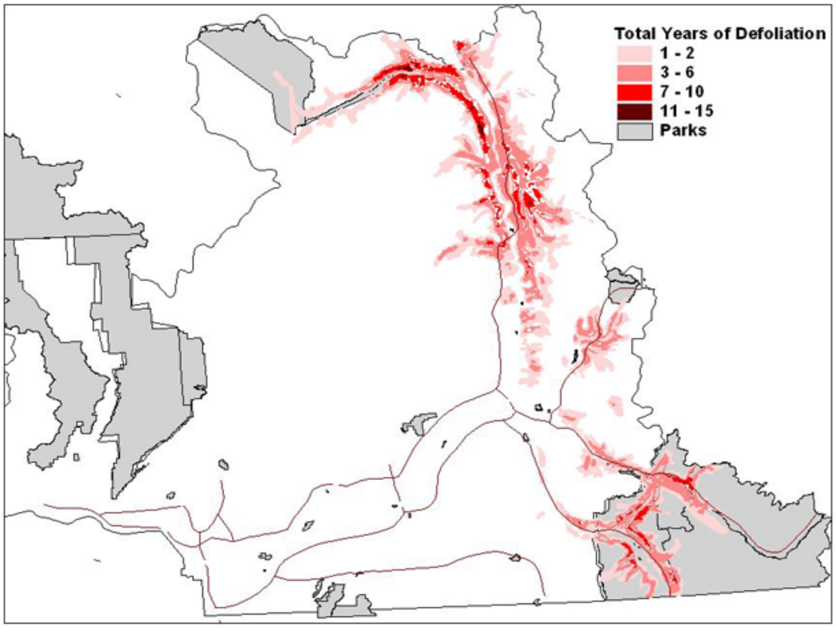

Figure 7. Area defoliated by western spruce budworm since 1943 in the Fraser TSA by total years of defoliation.

Areas which have sustained chronic infestations are located along the Nahatlatch River and south to Boston Bar, with 45% of the defoliation occurring in the CWHms1, followed by the IDFww at 28% (Table 10).

Table 10. Summary of western spruce budworm defoliation in the Fraser TSA since 1943, by biogeoclimatic zone and total years of defoliation

	Total Years of Defoliation					
	1-2	3-6	7-10	>10	Total	% of Total
IDFdk2	0	57	20	0	77	0
IDFww	10,730	21,114	5,935	579	38,358	28
CWHds1	10,075	6,317	1,134	5	17,531	13
CWHms1	34,161	24,529	6,873	118	65,681	48
ESSFmw	9,384	1,709	50	0	11,143	8
MHmm2	6,105	1,702	0	0	7,807	6
Total	70,455	55,428	14,012	702	140,597	100

Spruce Aphid

Sporadic defoliation of Sitka spruce has been reported for this introduced pest, mostly in the Fraser Valley.

Windthrow

Wind damage is estimated to account for a loss of 31,500 m^3/year according to TSR 3 data. However, only 2,500 m^3 were considered unsalvaged.

KINGCOME TSA

The Kingcome TSA encompasses northern Vancouver Island, the Queen Charlotte Straights and the adjacent mainland (Figure 8). The bulk of the TSA lands stretch from Knight Inlet northwest to Cape Caution and northeast to Tweedsmuir Park. The TSA covers approximately 1.14 million ha, of which 51% is considered productive forest and 15% is available for harvest under 2001 management practices. The TSA has an AAC of 1.284 million m^3, which is an 8.2% reduction from the 1996 AAC. This harvest level includes 1,263,660 m^3 of coniferous stands and 20,340 m^3 of stands dominated by deciduous species. The Coastal Western Hemlock (CWH) biogeoclimatic zone dominates the TSA, with the Mountain Hemlock (MH) zone occurring at higher elevations. The CWH is dominated by western hemlock, and also includes Douglas-fir, western redcedar, Sitka spruce, yellow-cedar, amabilis fir, mountain hemlock, shore pine, bigleaf maple and red alder.

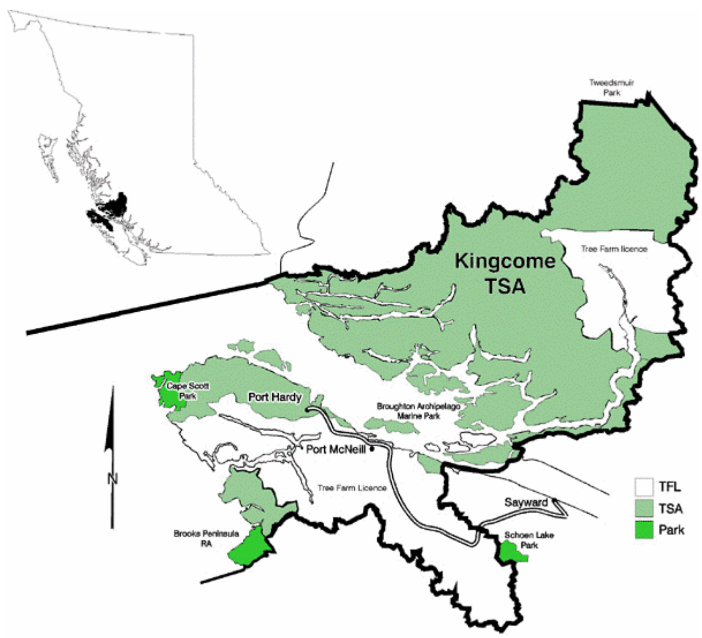

Figure 8. Kingcome Timber Supply Area.

Alder Sawfly

Defoliation of alder was noted in July 2006 on the Klinaklini Estuary (about 40 ha) and mouth of Ahnuhati River (about 25 ha). No control action was required.

Hemlock Dwarf Mistletoe

The incidence of dwarf mistletoe on hemlock is anticipated to rise significantly as we continue to move away from clear-cutting. Partial cutting systems now account for more than half of all coastal harvesting, and Ecosystem Based Management will likely mandate leaving many trees within cutblocks. Unavoidably, a percentage of retained trees will be infected, and the parasite will have ideal conditions to spread to the surrounding regeneration. Losses associated with dwarf mistletoe include growth loss, premature breakage and mortality, reduced lumber quality and value, and impacts on regeneration.

Mountain Pine Beetle

Mountain pine beetle infestations have been confined to the NE corner of the TSA in the Klinaklini River Valley, just south of Tweedsmuir Provincial Park (Figure 9). The first outbreak was noticed in 1974 and continued until 1981, followed by 1989 and 2000 (Table 11). As this timber is inaccessible and excluded from the timber supply, no control action was warranted.

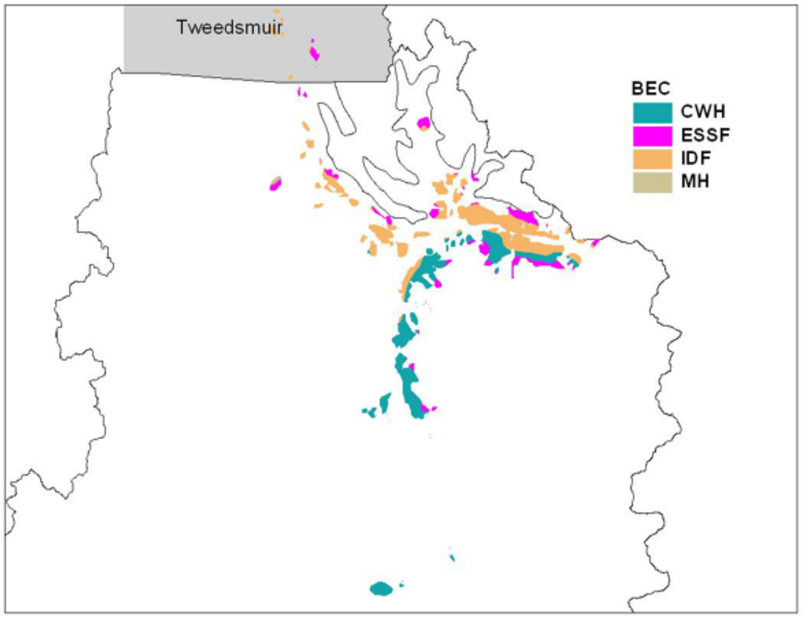

Figure 9. Area infested by mountain pine beetle since 1975 in the Klinaklini River of the Kingcome TSA.

Table 11. History of mountain pine beetle in the Klinaklini River Valley since 1974, in the Kingcome TSA

	1975	1976	1977	1978	1979	1980	1981	1989	2000	Total
CWH ds 2	403	532	890	185	0	46	0	1	39	2,096
CWH ws 2	181	138	437	107	0	57	3	0	72	994
ESSFmw	73	230	516	15	0	161	54	0	108	1,156
IDF ww	1,366	1,098	1,043	72	1	357	0	0	132	4,070
MH mm 2	0	0	0	0	0	0	26	0	0	26
Total	2,023	1,998	2,886	379	1	622	82	1	351	8,343

Root Diseases

Losses to root diseases are proposed for the next TSR. This will involve an adjustment for OAF 2 from the default 5% to 12.5% for all existing managed Douglas-fir leading stands in the CDF and CWH xm1 & 2 subzones.

Spruce Weevil

The impact of spruce weevil (aka white pine leader weevil) is becoming more of a legacy problem due to the avoidance of spruce in the 1990's and the increased use of weevil resistant stock in recent plantations. Nonetheless, significant growth loss associated with the insects wide ranging destruction has been experienced in areas where spruce was a high component of the plantations established in the 1970's and 1980's.

Western Balsam Bark Beetle

Western balsam bark beetle activity has been noted in the NE corner of the TSA, just south of Tweedsmuir Provincial Park, in the upper Klinaklini River drainages including Colwell, Dorothy, and Frontier Creeks. These areas are not considered part of the timber supply due to their remote location.

Western Blackheaded Budworm

In 1944 defoliation was reported near Quatsino Sound, and 1954 near Holberg. Populations expanded significantly in 1955 to 400, 000 ha and doubled in 1956 to 800,000 (GIS files not available). Defoliation occurred between Port McNeill and the Adams River, between Port Hardy and Holberg, north of Zeballos, and Quatsino Sound. Populations collapsed in 1957. In 1971 defoliation was noted near Victoria Lake and increased dramatically to approximately 35,000 ha in 1972 that included areas west of Victoria Lake to Brooks Peninsula and north to Quatsino Sound (Figure 10). The population collapsed in 1973, with no defoliation noted until 1988 when approximately 5000 ha were infested near Port Hardy. This population persisted until 1990. In 1997-9, approximately 38,000 ha were lightly to moderately defoliated in a broad area of northern Vancouver Island extending from Brooks Peninsula to north of Holberg Inlet, and as far east as Victoria Lake. This outbreak affected mainly old growth hemlock-balsam stands, but younger regenerating hemlock stand damage was also noted. In 2003, 152 ha were defoliated between Victoria Lake and Neroutsos Inlet.

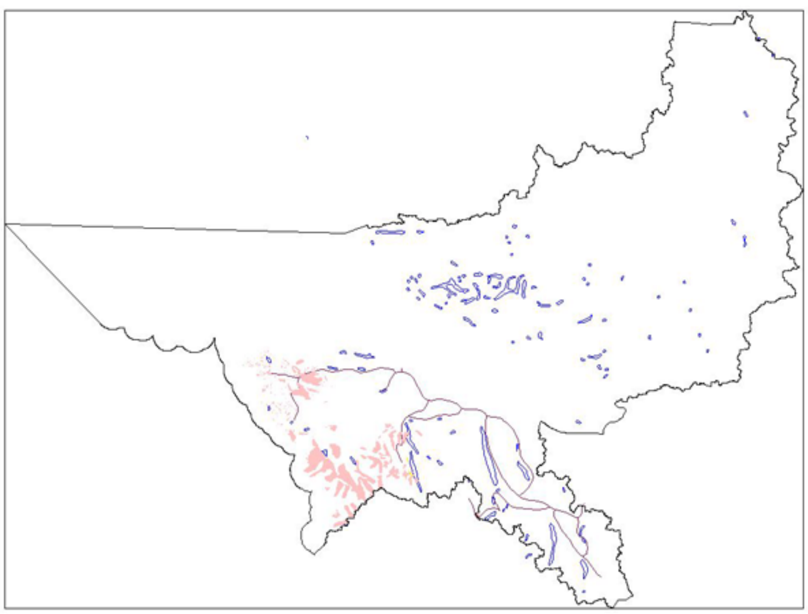

Figure 10. Area defoliated by western black headed budworm since 1971 in the Kingcome TSA.

Western Hemlock Looper

Between 1926 and 1927 approximately 1500 ha were defoliated at the mouth of Neroutsos Inlet. This is the only record of western hemlock looper activity in the Kingcome TSA.

Windthrow

In the last TSR, average annual losses to windthrow were estimated at approximately 15ha with an average volume of 700 m^3/ha, for total unsalvaged loss of 10,500 m^3/year. It is likely that this estimate is now too conservative with the increased use of partial cutting and retention system harvesting.

Yellow-Cedar Decline

Yellow-cedar decline extends over 200,000 hectares in Alaska and the extensive mortality has recently been mapped in parts of coastal BC. This problem is thought to be caused by changing climatic conditions. Yellow-cedar is thought to be susceptible to spring frost injury in areas where root systems are not protected by snow, resulting in fine root death. An aerial survey of the mainland portion of the TSA in 2006 identified yellow-cedar decline in the several areas between Seymour and Kingcomb Inlets, including the Parson Creek, Rainbow Creek and Clear River areas.

MID-COAST TSA

The Mid-Coast TSA occupies 2.2 million ha, covering B.C.'s central coast. It is bordered by Tweedsmuir Park on the east, Cape Caution on the south and Sheep Passage in the north (Figure 11). About 819,000 hectares, or 37 percent of the area of the Mid Coast TSA, are considered productive forest, and currently a maximum of about 23 percent of that productive forest, or 8.6 percent of the total TSA, are considered available for harvesting. The allowable annual cut was set in 2000 at 1 million m^3/year by the Chief Forester. However, the current AAC is 768,000 m^3/year due to a temporary AAC reduction under Part 13 of the Forest Act.

Mixed hemlock and true fir stands in the Coastal Western Hemlock (CWH) biogeoclimatic zone dominate the TSA (65%), with western redcedar occupying approximately 25% and then about 5% for each of Sitka spruce and Douglas-fir. The Mid-Coast TSA has some of the largest coast temperate rainforests.

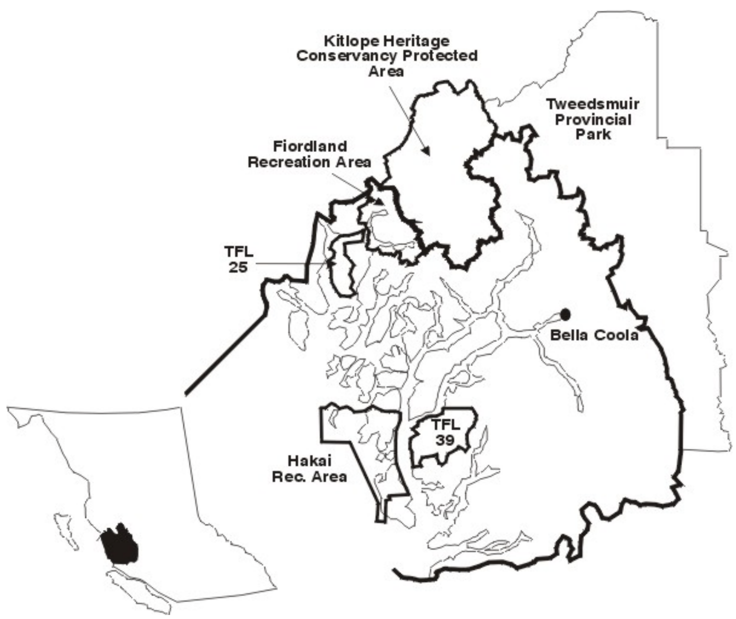

Figure 11. Mid-Coast Timber Supply Area.

Douglas-fir beetle

Spot infestations were noted in 1993 near Bella Coola, and once again in 1994 with approximately 140 ha recorded. This outbreak decreased in 1995 with only 25 ha recorded in the Dean, Talchako, Atnarko river valleys near Bella Coola. In 2003, 14 spots infestations were detected just SE of Bella Coola and east of Kimsquit. In the late 1980's and early 1990's there was significant beetle activity in the Talchako and Atnarko drainages mostly within Tweedsmuir Provincial Park. This area has a high climatic hazard for DFB; however, much of the susceptible timber has been harvested.

Hemlock Dwarf Mistletoe

The incidence of dwarf mistletoe on hemlock is anticipated to rise significantly as we continue to move away from clear-cutting. Partial cutting systems now account for more than half of all coastal harvesting, and Ecosystem Based Management will likely mandate leaving many trees within cutblocks. Unavoidably, a percentage of retained trees will be infected, and the parasite will have ideal conditions to spread to the surrounding regeneration. Losses associated with dwarf mistletoe include growth loss, premature breakage and mortality, reduced lumber quality and value, and impacts on regeneration.

Mountain Pine Beetle

The following describes mountain pine beetle outside of Tweedsmuir Provincial Park.

The first record of mountain pine beetle activity covered approximately 700 ha, from 1975-1983 just west of Tweedsmuir Provincial Park, in the Dean River drainage. Small patch infestations were recorded from 1984 to 1986. In 1999, 391 ha were infested near the mouth of the Dean River and south of Hagensborg. In 2000 the infestation near Hagensborg collapsed but expanded to 1796 ha along the Kimsquit River, Dean River, and Dean Channel. Populations doubled in 2001 with 3774 ha infested mostly in previously infested areas, and near Hagensborg. In 2002, significant expansions occurred with approximately 13, 800 ha infested along the Dean and Kimsquit rivers and along the highway corridor between Bella Coola and Hagensborg. In 2003 populations decreased east of Dean Channel, with just over 8000 ha recorded (Figure 12). Area infested in 2004 amounted to approximately 3400 ha along the Bella Coola River west of Tweedsmuir to Bella Coola, south along South Bentinck Arm and North along Dean Channel.

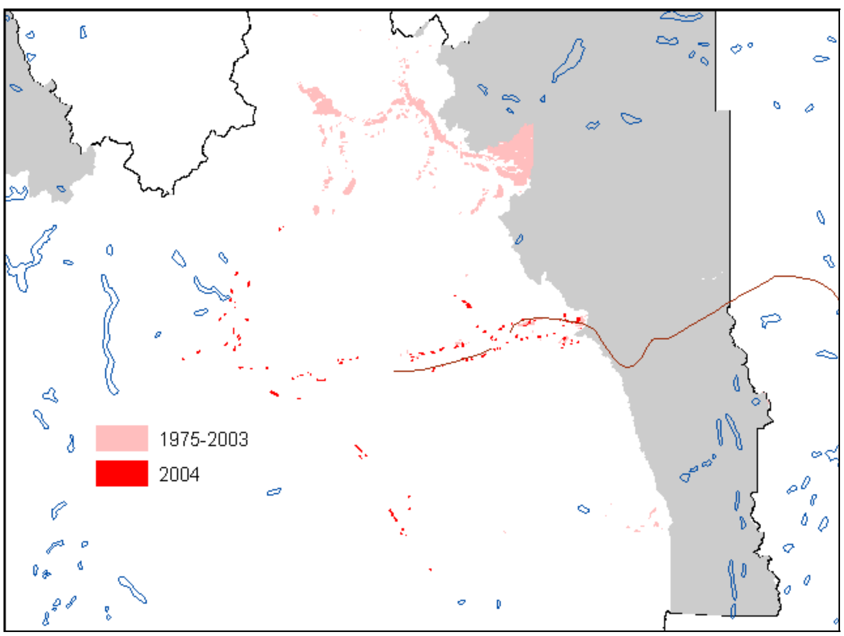

Figure 12. Area infested by mountain pine beetle in the Mid-Coast TSA, from 1975-2004.

Spruce Beetle

Small patches of spruce beetle were recorded from 1989-1992 near Bella Coola. Populations increased to 1683 ha in 2004 with patches recorded along the shores of Owikeno Lake and scattered south to Seymour inlet, with a patch to the north near Bentinck Arm.

Western Balsam Bark Beetle

Western balsam bark beetle infestations are ubiquitous in stands containing suitable hosts. From 1994 to 2001 the area infested fluctuated between 900-1500 ha, and decreased to 580 ha in 2002. In 2003, populations increased 2384 ha (or aerial survey coverage increased) mostly south of Dean River to the TSA boundary.

Western Black-Headed Budworm

Defoliation by blackheaded budworm was recorded from 1973-1974 when approximately 8400 ha were recorded near Ocean Falls, Fiordland and Kitlope River (Figure 13).

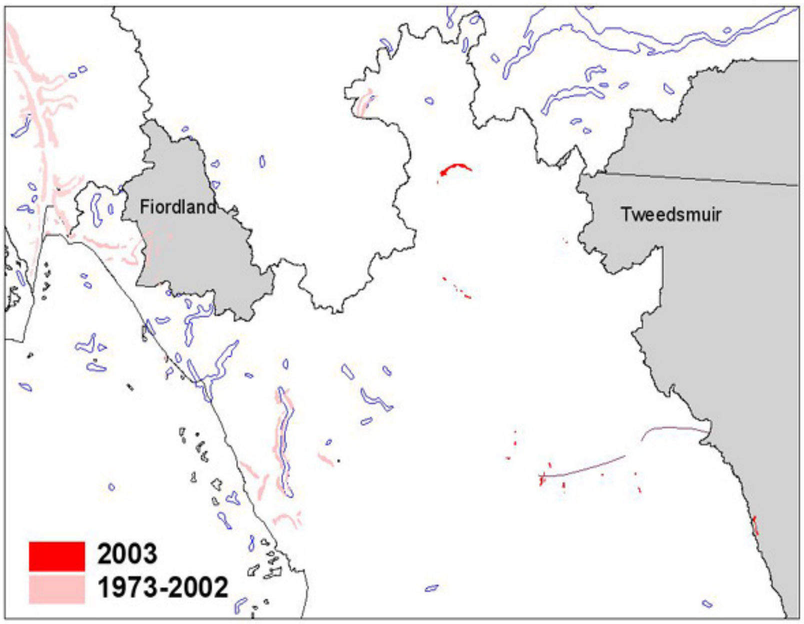

Figure 13. Area of historical blackheaded budworm defoliation and unknown 2003 defoliation in the Mid-Coast TSA.

Western Spruce Budworm

Approximately 500 ha of moderate and 1000 ha of light defoliation noted in 2006 in the Knot Lakes area south of Tweedsmuir Provincial Park is suspected to be due to western spruce budworm. This defoliation was first noted in 2004.

Windthrow

The last TSR included 13,000 m^3/year of unsalvaged losses due to windthrow. It is likely that this estimate is too conservative with the increased use of partial cutting and retention system harvesting, as well as the advent of Ecosystem Based Management on the mid-coast.

Yellow-Cedar Decline

Yellow-cedar decline extends over 200,000 hectares in Alaska and the extensive mortality has recently been mapped in parts of coastal BC. This problem is thought to be caused by changing climatic conditions. Yellow-cedar is thought to be susceptible to spring frost injury in areas where root systems are not protected by snow, resulting in fine root death. During a 2004 survey, yellow cedar decline was identified as far south as Cypress Lake on Banks Island in the North Coast Forest District. An aerial survey of the mainland portion of the TSA in 2006 identified yellow-cedar decline in the several areas south of Burke Channel, including the Ambach Creek and Kilbella River areas. Most of the 22 areas mapped occur in remote or inactive harvesting regions of the mid coast. A few areas have had recent helicopter logging adjacent to the yellow-cedar decline. For the most part salvage opportunities of the dead and dying material is limited, but could be undertaken where economic.

NORTH COAST TSA

The North-Coast Timber Supply Area covers 1.83 million ha on B.C.'s coast (Figure 14). Productive forests account for 48% of the TSA but only 8% of the total landbase is classified for timber harvesting. The allowable annual cut was set at 494,000 m^3/year in 2007, which was a decrease of 14% from the previous determination. The decrease in AAC is in part due to the allocation of forest land to the Nisga'a as part of their land claim settlement and due to reductions under Part 13 of the Forest Act. Tree Farm License 25 is located in the southeast corner of the TSA, while the world renowned grizzly bear reserve, Khutzeymateen Provincial Park, is located on the eastern portion.

The Coastal Western Hemlock (CWH) biogeoclimatic zone dominates the lower to mid elevations of the TSA. The CWH contains some of the most productive ecosystems in Canada. Western hemlock is the most abundant commercial tree species within the TSA, followed by western redcedar, amabilis fir, Sitka spruce and yellow-cedar.

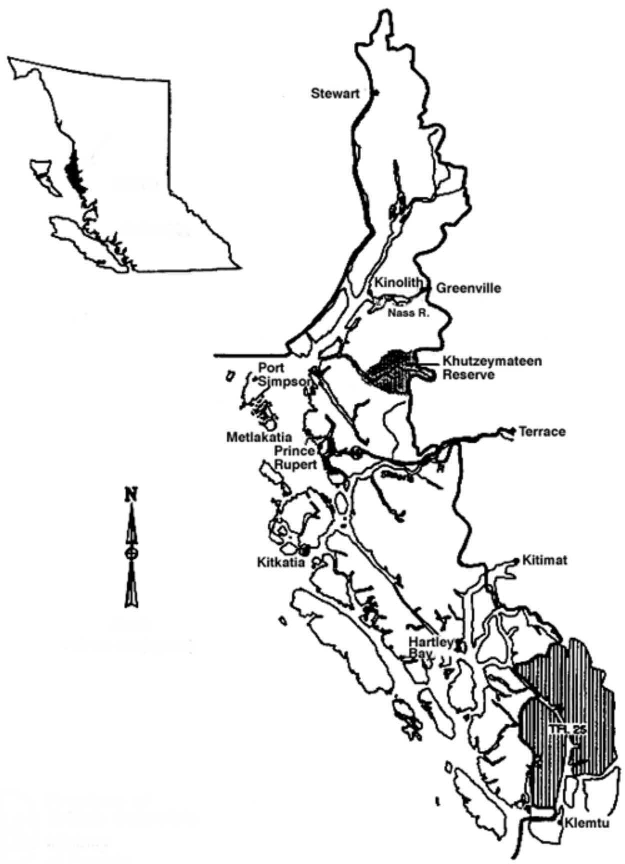

Figure 14. North-Coast Timber Supply Area

Blackheaded Budworm

In 1973-1974, approximately 20,000 ha were defoliated annually and once again in 1985 covering 1150 hectares. The majority of this defoliation occurred in TFL 25.

Dwarf mistletoe

Dwarf mistletoe has been identified throughout the district however it has not been observed in all operating areas. This pest may be exacerbated by the recent trends in silviculture system prescriptions which favour partial harvesting.

Porcupine

Porcupine damage to maturing second growth trees has been a noted problem in many portions of the TSA for decades. Porcupines tend to feed mainly on western hemlock, with a lesser preference for Sitka spruce and true fir. An extensive study conducted in the Khutzeymateen Inlet showed that stand composition could be dramatically affected by porcupine feeding (damage and resulting mortality of hemlock, with an increase in the growth of neighbouring spruce and fir), overall net stand volume was not greatly different than that projected by existing stand growth models. In the last Chief Forester rational for the district TSR the following statement was made: "While porcupine damage is evident in some second-growth stands, the long-term effect on timber production is not fully understood. Possible effects include lengthened regeneration delays, lower stocking, and lower volume yields. Unsalvaged losses due to porcupine damage have not been quantified, and as such, no unsalvaged losses were attributed to this pest in the analysis".

Spruce Aphid

In 1961 a large outbreak of spruce aphid caused damage to Sitka spruce in the Prince Rupert area. The most recent peak in damage occurred in 1998 and there has been some limited mortality.

Spruce Beetle

Some mortality due to spruce beetle was found near Gitnadoix Park in 2001.

Spruce weevil

The hazard for spruce weevil attack in this TSA is very low. Very low levels of weevil attack have been observed in some spruce stands within the CWHvm1. The attack incidence is spotty with minimal impact. This pest should continue to be monitored for changes in incidence and impact.

Unidentified defoliation

In 2003, 1386 ha were defoliated near Butedale (Figure 15). This has been tentatively identified as hemlock looper, but the causal agent is unknown.

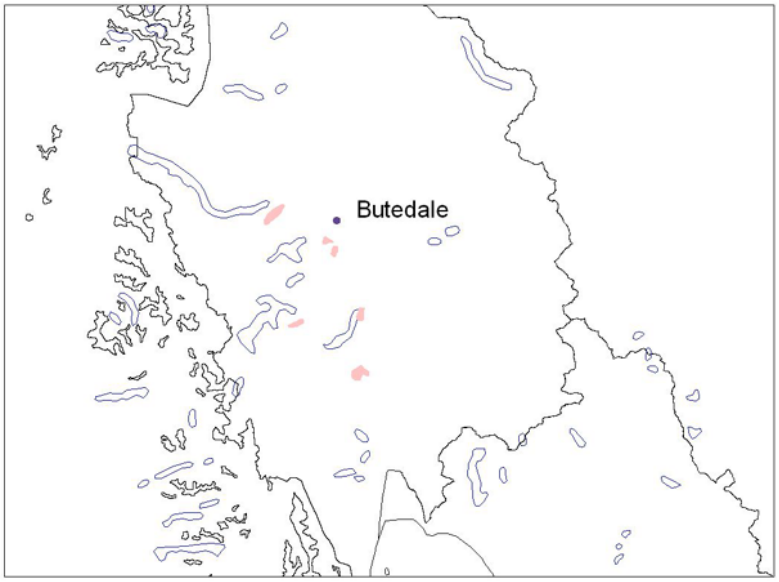

Figure 15. Area defoliated near Butedale in 2003 in the North Coast TSA.

Western Balsam Bark Beetle

A few small patches of western balsam bark beetle were noted near Kitimat in 2001 and 2002.

Windthrow

A report estimating windthrow losses in the North Coast TSA was completed in 1998. This study estimates the annual un-salvaged losses to wind to be 13,417 m3 on the operable land base. MoFR staff reviewed this report, and adjusted the blow-down estimate to 8050 m3/year to reflect un-salvaged losses on the timber harvesting land base.

Yellow-cedar decline

Recently a phenomenon called yellow-cedar (Yc) decline has been documented in this TSA. In many areas throughout the district yellow cedar appears moribund or dead. This has not been accounted for in the TSR analysis, however dead Yc still retains significant value as a standing dead tree (documented up to 80 years post mortality). This phenomenon continues to need monitoring and research to determine the cause.

QUEEN CHARLOTTE TSA

The Queen Charlotte Timber Supply Area encompasses the group of more than 150 islands that make up the Queen Charlotte Islands or Haida Gwaii (Figure 16). The majority of the TSA land is located on Graham Island and it accounts for approximately 45% of the 1 million hectares within the Queen Charlottes. Parks and reserves account for 22% while 32% is located within a TFL. Approximately 354 000 ha of the TSA is considered productive forest land and only 18% is currently available for harvest. The AAC was set 475 000 m^3 in 2000. However, this was reduced to the current level of 361,000 due to the designation of the Duu Guusd in March 2003.

The dominant biogeoclimatic zone is the Coastal Western Hemlock, which covers 97% of the TSA. Dominant species include western and mountain hemlock, western redcedar and Sitka spruce.

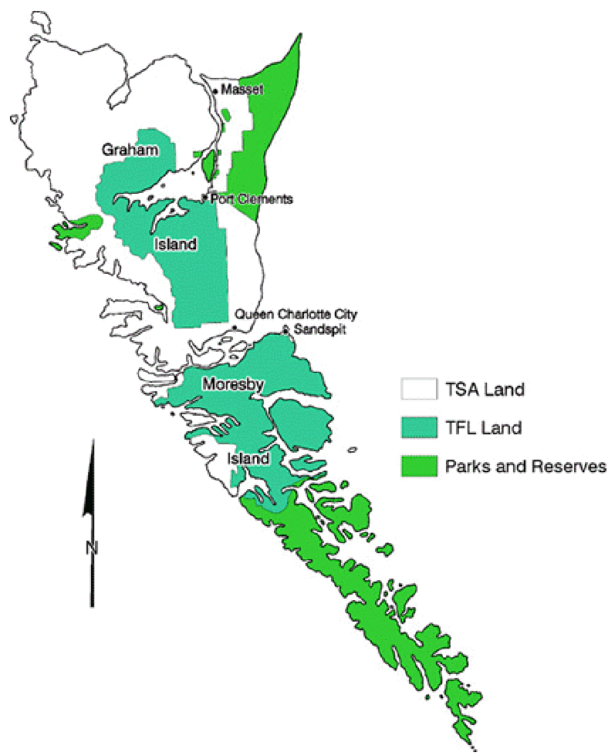

Figure 16. Queen Charlotte Islands Timber Supply Area

Armillaria Root Disease

This root disease caused by *Armillaria ostoyae* was discovered on the TSA, well outside of its previously identified range, by district staff in 1996. Its range appears restricted to the very driest portions of Graham Island, mainly around Tlell. To date its primary impact has been to kill some trees in plantations in that area. Saprophytic species of *Armillaria*, often quite difficult to visually differentiate from the pathogenic variety, are very commonly found in the TSA on dead trees.

Conifer Sawflies

Although larval counts of sawflies are often high, defoliation is not always noticeable. In 1984, however, over 200 ha of shore pine were defoliated by pine sawfly near Nadu creek. Hemlock sawfly populations typically increase with western blackheaded budworm populations however their impact during outbreaks is minor compared to blackheaded budworm.

Green-striped Forest Looper

This looper has reached outbreak populations in the past in the Queen Charlotte TSA. On Graham Island in 1963 over 14,000 ha of western hemlock and western red cedar were defoliated. This infestation moved to the west side of Masset Sound, causing further defoliation to 2430 ha. No other outbreaks have been recorded.

Mammals

Deer browse is the most significant and costly plantation pest on the Queen Charlotte Islands, primarily on western redcedar.

Spruce Beetle

Spruce beetle has only been reported a few times in the Queen Charlotte TSA. No extensive damage has been recorded.

Spruce Aphid

In 1961 a severe and extensive outbreak was recorded in the Queen Charlotte TSA. Infestations decreased in intensity in 1962, but caused defoliation once again in 1963. Increases in populations have occurred periodically since throughout the Queen Charlotte Islands but tends to only be significant within a fringe along the coastline.

Western blackheaded budworm

The first recorded defoliation by this pest occurred in 1931 from Lyell Island to Masset Inlet. However, blackheaded budworm outbreaks have most probably been a component of island ecology here for a long time. Outbreaks have since occurred in 1943-1944, 1952-1955, 1957-1960, 1972-1975, 1985-1988, and 1996-2001 (Figure 16). Defoliation tends to reoccur in the same stands each outbreak episode. Typically the outbreaks start on the south east coast of Moresby Island and move northward in each successive year. Most stand recover from the defoliation however there is usually some patchy mortality and top-kill. Approximately 12, 000 ha were aerially sprayed with DDT in 1960. An experimental application of an early formulation of Btk was also successfully carried out in 1960. The most recent outbreak started in 1996 with almost 6300 ha defoliated in the southern portion of the islands. In 2000, then outbreak covered over 31,100 ha and covered most of the mid-central to southern portion of the islands. The population collapsed by 2002, with only 1500 ha recorded in 2001. It is interesting to note that many juvenile stands were heavily defoliated, which resulted in patch mortality.

Cooley spruce gall adelgid

This insect has been introduced to the Queen Charlotte Islands by people who have brought live Douglas-fir to the Islands. From the imported Douglas-fir it has spread to its alternative host, Sitka spruce, however, its occurrence on spruce here is still very low. All Douglas-fir on crown land have been removed but there are still live firs on private property.

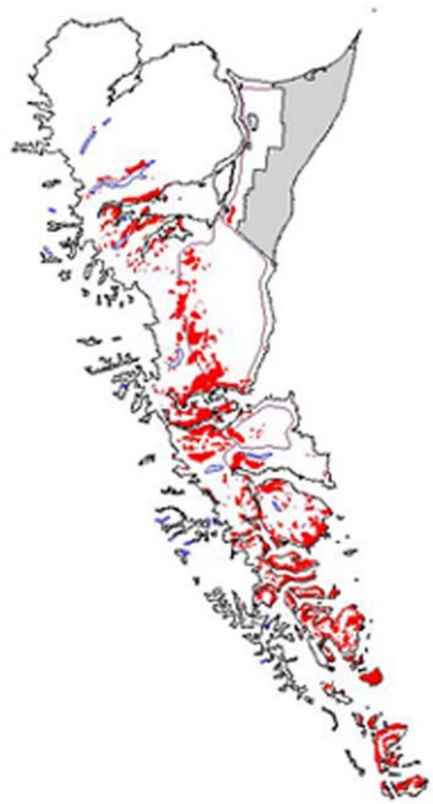

Figure 17. Area defoliated by western blackheaded budworm since 1973 in the Queen Charlotte TSA.

Windthrow

Wind is a major disturbance agent in the TSA, however a large portion of windthrow occurring on the operable landbase is salvaged. A MoF study of unsalvaged losses in the QCI estimate annual losses at 3800 m^3.

SOO TSA

The Soo TSA covers approximately 826,000 ha, of which 299,000 ha are considered productive forests and 123,400 ha are available for timber production, harvest and management (Figure 18). The harvestable landbase is dominated by Doulgas-fir, western redcedar, Pacific silver fir and western hemlock. There are smaller areas dominated by Sitka spruce, lodgepole and western white pines and black cottonwood.

The TSA is primarily in the Coastal Western Hemlock (CWH) biogeoclimatic zone along the valleys, with a band of Mountain Hemlock (MH) at high elevations before moving to the Alpine Tundra (AT). The northwestern portion of the TSA also has small areas of Interior Douglas-fir (IDF) and Engelmann spruce subapline fir (ESSF). The TSA has an annual allowable cut (AAC) of 503,000 m^3/year, which is predominately made up of Douglas-fir, western hemlock, Pacific silver fir, and western redcedar. The TSA is adjacent Tree Farm License (TFL) 38, held by Northwest Squamish Forestry Ltd. (NWSF). TFL 38 occupies a total area of 189,287 ha, of which 29% is considered productive forest.

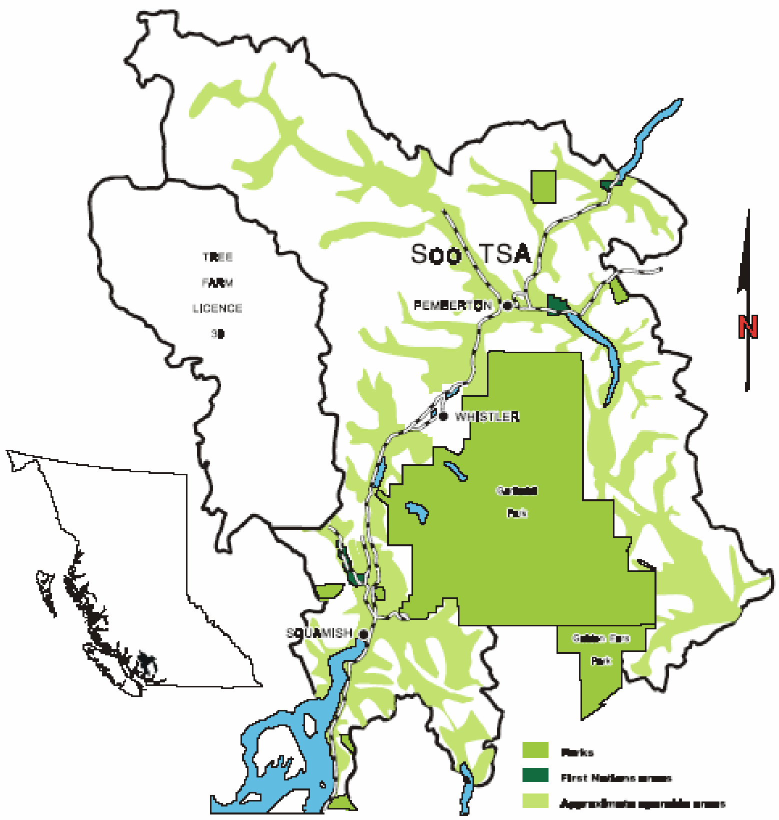

Figure 18. Soo Timber Supply Area.

Douglas-Fir Beetle

Trees previously defoliated by western spruce budworm were attacked by Douglas-fir beetle in the Pemberton Valley in 1953. Scattered attacks occurred annually until 1956, and then again in 1960, 1967, 1975-1981 and 1983-1985. In 1989, 11 separate infestations totaling 77 ha were noted on the east side of Lillooet Lake, between Billygoat Creek and Ure Creek. Douglas-fir beetle activity was noted annually until 1995 in many of the areas which had been defoliated by western spruce budworm or where laminated root disease was found. In 2004, populations increased substantially to approximately 1124 ha between Lillooet River and Pemberton, Pemberton to D'arcy, Birkenhead Lake, south between Lillooet Lake and Harrison Lake, including Snowcap Creek.

Mapping and sampling of mortality resulting from Douglas-fir beetle was done in winter 2006/07 in and around Glacier Lake. An understanding of the decomposition rate of the standing dead Fd will guide any salvage decisions in this area. Significant mortality was identified within Garibaldi Provincial Park but there are no plans to salvage here. There was relatively little red attack noted in the mapping of this mortality.

Mountain Pine Beetle

The first recorded infestations of mountain pine beetle occurred on mostly white pine in the Squamish River Valley in the 1940's, with extensive white pine mortality noted in 1960. The small spot infestations continued sporadically until the early 1970's. Larger infestations were recorded throughout the 70's near Birkenhead and Lillooet lakes, and Haylmore and Blackwater creeks. In 1978 and 1979 white pine was attacked near Joffre Creek. Beetle populations increased in the early 1980's, specifically near Haylmore Creek and Birkenhead Lake. In 1985, populations began increasing significantly with a peak of over 58,000 trees newly attacked in the Soo TSA in 1986. The populations decreased thereafter with only 525 ha noted in 1989 near Birkenhead and Lillooet Lakes. In 1992, populations increased again in the Birkenhead/Gates rivers and the north side of Blackwater creek. Area infested declined once again from 1993-1994 but doubled in the Birkenhead River area in 1995. In 2004, approximately 7100 ha of mountain pine beetle were recorded along most highway corridors in the Soo TSA: from Whistler to D'Arcy, NE along Lillooet River, east along Birkenhead Lake and south of Pemberton from Lillooet Lake to Harrison Lake (Figure 19).

A fall and burn program at the north edge of Whistler was undertaken in 2004 in an effort to slow the spread of this insect at a "pinch point" in the valley. While the program was well implemented, these efforts were not successful due to extreme beetle pressure. A localized trap tree program was implemented at in 2004 Brandywine Provincial Park (Don, please confirm dates) and has been successful in protecting the Pl to date, but future infestations are anticipated.

Due to extreme beetle pressure, there have been many attacks on Ponderosa Pine in the D'Arcy area in 2005/06. Much of this timber should now be considered at high risk. This may impact some ecosystem restoration strategies implemented in that part of the district in 1999 – 2004.

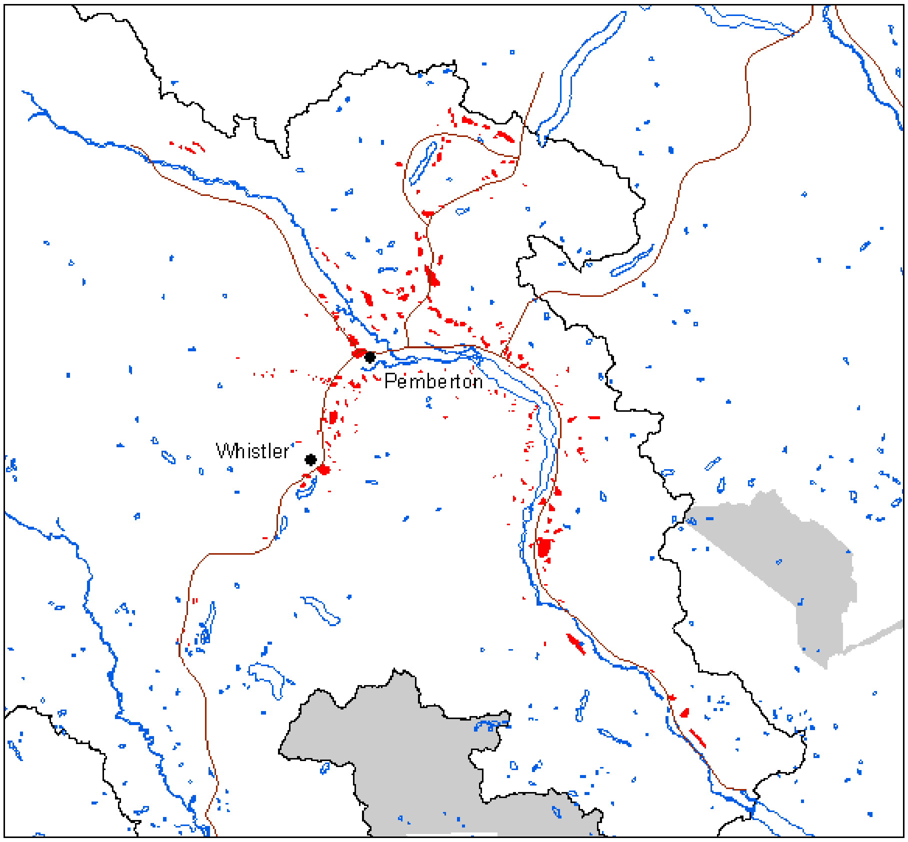

Figure 19. Area infested by mountain pine beetle in the Soo TSA in 2004.

Pine Needle Sheathminer

In 1989-1990, this insect pest of lodgepole pine caused widespread light defoliation from Texada Island, east to Mowhokam Creek, and as far north as D'arcy.

Root Diseases

The TSA contains areas with extensive amounts of root disease, primarily laminated root disease of Douglas-fir and Armillaria root disease on many conifer hosts. Root disease losses have been not been accounted for in the last TSR. Losses to root diseases are proposed for the next TSR. The impact of root disease within transition zone forests is unclear. Local stands show significant impacts from *Armillaria*, and some studies imply risk to future timber supply if these stands are left untreated.

Spruce Beetle

In 1995 spruce beetle mortality was noted over 5 ha in the Birkenhead River Valley. In recent years, extensive mortality has also occurred in the Haylmore and adjacent drainages. In 2004 approximately 255 ha were recorded near Salamander Mountain SE of Lillooet Lake and NE of Harrison Lake.

Western Balsam Bark Beetle

Western balsam bark beetle is ubiquitous throughout the range of sub-alpine fir. Upper elevation stands of spruce/sub-alpine fir generally have some activity. In 1987 infestations were first recorded in the Haylmore and Cayoosh drainage. Activity has been noted annually thereafter with a peak of 375 ha in 1991.

Western Spruce Budworm

Five outbreaks of western spruce budworm have been recorded in the Soo TSA in 1943-1944, 1953-1959, 1968-1979, 1986-1992, and most recently commencing in 2003. The first record of western spruce budworm in the Soo TSA occurred in 1943 between Pemberton and Anderson Lake. In 1953 light defoliation occurred along the Lillooet River between Harrison and Lillooet lakes. Populations expanded in previously infested stands in 1954 and from Gowan Creek to Pemberton and near Haylmore Creek. The infestation continued to expand in 1955 along the Lillooet River, with new defoliation recorded between Pemberton, Birkenhead Lake and D'arcy. Populations continued to increase in 1956 and 1957 and moved southward to Alta Lake in 1958. In 1959 populations collapsed. The next outbreak commenced in 1968, once again near Pemberton. This outbreak continued to increase and expanded into the Lillooet River and Lillooet Lake area until 1974 when defoliation area and intensity began decreasing. In 1976 tree mortality and top-kill were noted at Rutherford and Railroad creeks. Populations continued to decline with a slight increase noted in 1977 near Lillooet and Birkenhead rivers. By 1979 populations had collapsed. An assessment conducted in 1980 found that within stands previously defoliated, up to 39% of the Douglas-fir had top-kill and 28% were dead from either repeated defoliation or bark beetle attack. A small infestation was noted in 1981 near Halymore creek. The third outbreak commenced in 1986 with over 1225 ha defoliated in the Blackwater and D'arcy creek drainages. This infestation expanded into the Haylmore drainage the following year. Populations continued to expand annually with a peak in 1992 of almost 21 000 ha defoliated. In 1993 populations collapsed. Defoliation was recorded once again in 2003 near D'arcy and once again in 2004 when approximately 4200 ha were defoliated.

In 2006, defoliation in the Whistler – Pemberton area (Shadow lake Interpretive forest) was very obvious from the highway, and some egg mass sampling was done. Levels were not high enough to warrant treatment. Over 4,000ha of impact was noted in the 2006 aerial overview survey, particularly in the Haylmore and Blackwater Creek areas. As noted earlier, the historic elevational band ranges may change over time as a result of climate change impacts. An overlay analysis of western spruce budworm defoliation since 1943 found that the CWHms1 and CWHds1 have incurred the greatest amount of defoliation, with the majority sustaining 3-10 years of defoliation (Table 12, Figure 20).

Table 12. Total years and area (ha) of defoliation from 1943-2004 by biogeoclimatic zone in the Soo TSA.

	Total Years of Defoliation					
Subzone	1-2	3-6	7-10	>10	Total	% of Total
IDFww	973	19,392	6,183	1,569	28,117	21
CWHds1	8,381	31,325	9,983	3,519	53,208	39
CWHms1	35,392	20,249	3,166	318	59,125	44
ESSFmw	5,116	2,803	596	0	8,515	6
MHmm2	10,727	1,702	2	0	12,431	9
Total Area	60,589	75,471	19,930	5,406	161,396	100

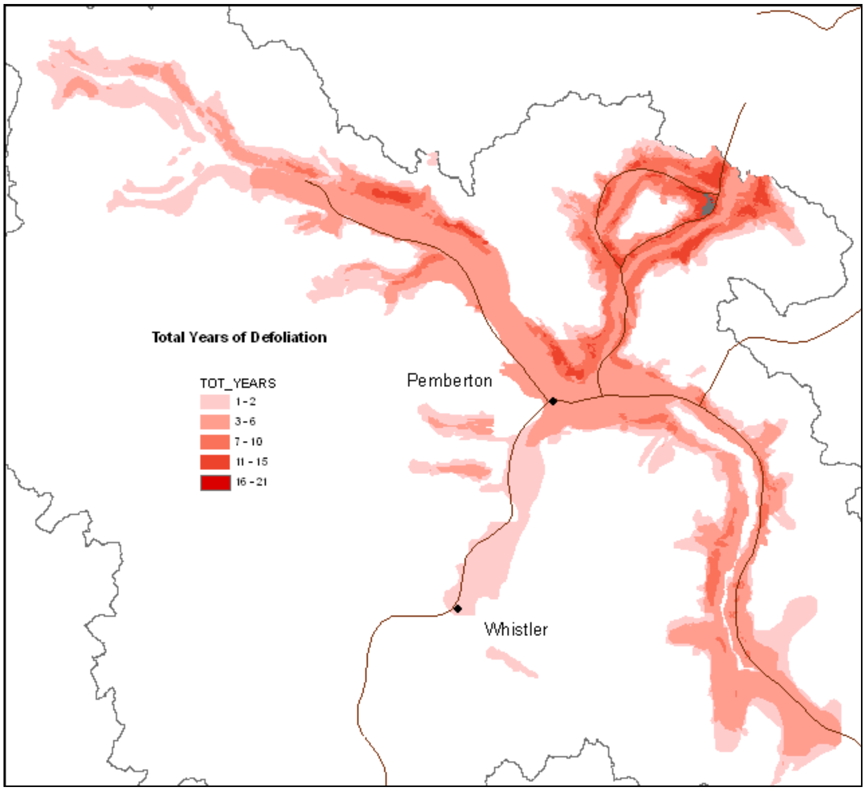

Figure 20. Area defoliated by western spruce budworm from 1943-2004 in the Soo TSA.

STRATHCONA TSA

The Strathcona TSA occupies 705,071 ha of central Vancouver Island and portions of the southwestern mainland BC (Figure 21). The TSA is broken down into 3 timber supply blocks, the Kyuquot, Sayward and Loughborough. Productive forests account for 353,144 ha, while only one half of this area is available for timber harvest. The current AAC of 1,278,000 m^3/year was established in 1999 and is a 10% reduction relative to the previous TSR. The reduction is due primarily to the implementation of the Forest Practices Code and approval of the Vancouver Island Land Use Plan.

The Coastal Western Hemlock (CWH) biogeoclimatic zone dominates the Timber Harvesting Land Base. Western hemlock is the dominant species, while Douglas-fir, western redcedar, Sitka spruce, yellow cedar, amabilis fir, mountain hemlock, shore pine, big-leaf maple and red alder will occur in specific local conditions.

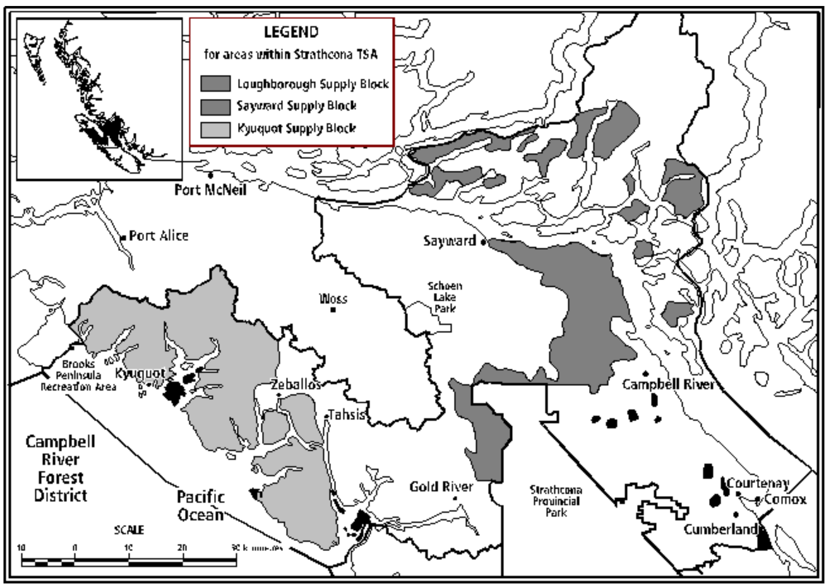

Figure 21. Strathcona Timber Supply Area.

Conifer Sawflies

Populations of conifer sawfly (*Neodiprion* spp.) periodically reach outbreak levels within this TSA in the general Adam, White and Memekay river areas and in some of the mainland river drainages such as the Stafford and Phillips. The conifer sawfly's principle host is amabilis fir and it primarily feeds on older foliage. In severely defoliated stands, up to20% of amabilis fir can be killed. 1952, spot activity was noted between Salmon River and Great Central Lake. The first major outbreak recorded in the TSA occurred in 1978 – 1980 over 4,470 ha in the general Sayward area. Significant salvage harvesting followed as *Pseudohylesinus* bark beetles apparently attacked the stressed trees. The most recent outbreak occurred in 1995 – 1998 in the same general areas. At the peak of the outbreak in 1996, approximately 29,445 ha were defoliated, with 38% in the CWHvm2, 34% in the MHmm1, 20% in the CWHvm1, 7% in the CWHmm2 and 1% in the CWHmm1 (Figure 22). Approximately 330 ha were salvage harvested.

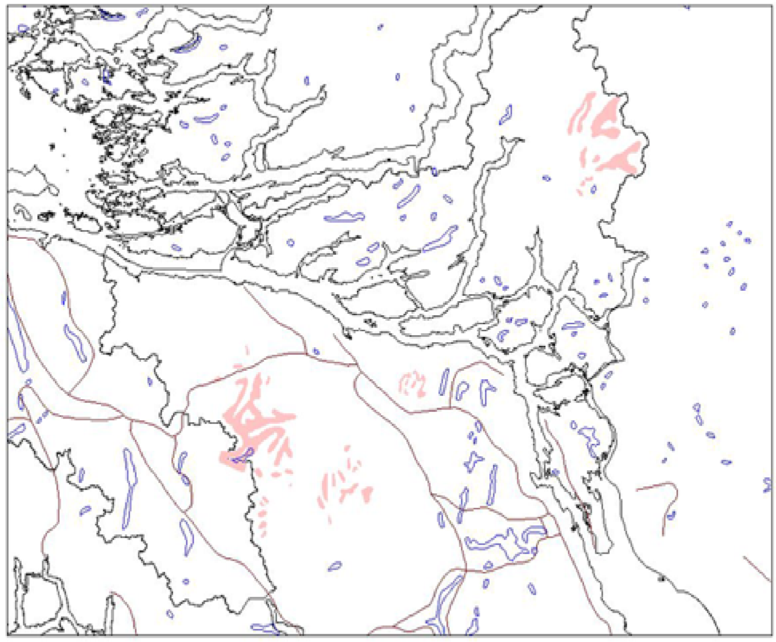

Figure 22. Area defoliated by conifer sawflies in 1996 near Schoen Lake Park and in the Phillips River drainage on the mainland.

Douglas-fir Beetle

Very few records of Douglas-fir beetle activity exist for the Strathcona TSA. The first recorded activity was in 1938 near Comox Lake, followed in 1953 near Cumberland, and 1954-1955 and 1974 near Buttle Lake. Beetle activity is generally at an endemic level, and usually associated with trees affected with root disease. However, it is commonly found in trees that die due to other causes.

Mountain Pine Beetle

From 1940-1960 mountain pine beetle was recorded on western white pine near Buttle Lake and Forbidden Plateau. This infestation on Vancouver Island is estimated to have covered over 135 300 ha and killed close to 4 million trees. In 2006, a small patch of beetle-killed lodgepole pine was located south of Sayward.

Root Disease

Laminated root rot occurs throughout the drier regions of the Strathcona TSA, primarily in young Douglas-fir forests in the Sayward forest, Quadra Island and in the Gold River area. The last TSR accounted for 11,400 m^3 of annual unsalvaged losses due to laminated root rot.

Spruce Aphid

The accidentally introduced spruce aphid has caused severe damage to Sitka spruce in the Campbell River area and on adjacent islands. Although commonly found on spruce along the coastline, it is not generally considered a forestry pest.

Western Blackheaded Budworm

In 1955, populations of budworm on northern Vancouver Island exploded and by 1956 had expanded into the headwaters of Tahsish and Kashutl river valleys. In 1972, western blackheaded budworm defoliated approximately 54,000 ha of which 56% was in the CWHvm1, 22% in the CWHvm2, 18% in the CWHwh1, and 4% in the MHmm1 (Figure 23). The resulting impacts however were considered to be minor.

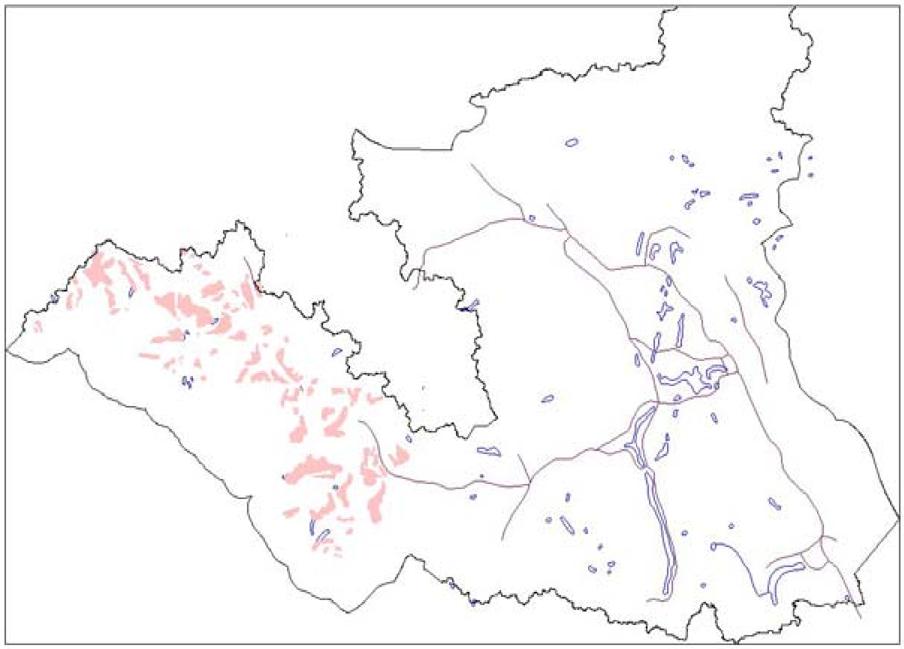

Figure 23. Area defoliated by western blackheaded budworm in 1972 in the Strathcona TSA.

Windthrow

The last TSR estimated annual losses to windthrow at 60 000 m^3/year, with the annual unsalvaged portion at 30,000 m^3/year. These losses are due to endemic windthrow and are based on forest district windthrow records and district staffs experience.

SUNSHINE COAST TSA

The Sunshine Coast TSA covers approximately 1.6 million ha along the south coast of BC and includes the communities of Powell River, Sechelt and Gibsons (Figure 24). Approximately 224,000 ha are considered available for timber production, harvest and management. Douglas-fir, western hemlock and Pacific silver fir dominate the harvestable landbase; however, western redcedar, yellow cedar, red alder, and black cottonwood are present in locally high densities.

The southeastern sections of the TSA are dominated by the Coastal Douglas-fir (CDF) biogeoclimatic zone, moving to CWH, with patches of MH in the higher elevations as it transitions to AT. The TSA has an AAC of 1.143 million m^3/year, mainly Douglas-fir, western hemlock, red alder and western redcedar. It is situated around TFLs 10, 39 and 43. TFL 10, held by InterFor, occupies 229,677 ha, of which 23% are covered by productive forests and an AAC of 170 950 m^3/year. TFL 39, held by Weyerhaeuser, is the largest in the Province and occupies 801 393 ha (68% classified as productive forest). The TFL is composed of 7 separate blocks, located in the Sunshine Coast, Mid Coast and Queen Charlotte TSAs and has a total AAC of 3.639 million m^3/year.

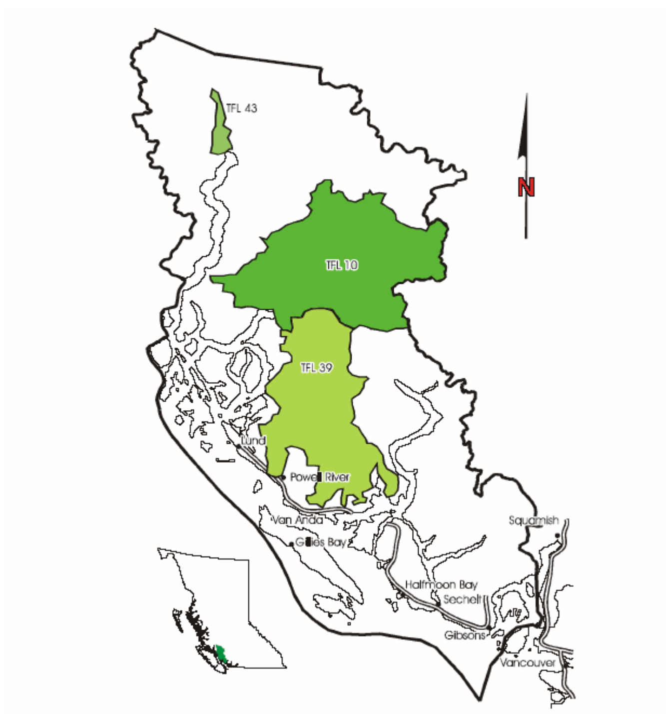

Figure 24. Sunshine Coast TSA.

Bear

Stem mortality from bear damage has become increasingly common in the last 10 years in managed stands in the Sunshine Coast TSA, particularly at Elizabeth Island near the mouth of Toba Inlet, Ramsay Arm and the north side of Quatam River. Stands which have undergone juvenile spacing appear to be most at risk as the increased sugar levels in the cambium are a good food source for bears at certain times of the year.

Recent black bear damage was detected in April 2007 in a 15 year old planted stand near Elizabeth Island at the mouth of Toba Inlet. During a ground survey fresh damage less than one week old was noted on about 15 trees. Plots were established and 80% of stand had some degree of damage, with 26% of trees killed. The bear-damaged juvenile spaced stand at the head of Ramsay Arm was revisited in April. Large wounds have significant decay and in some cases the trees have broken at the base due to rot. Recalculation of the original plots in the Ramsay Arm block has 48% mortality with 83% of stems having some damage.

Douglas-fir Beetle

In 1960 two small infestations were reported on the Sechelt Peninsula. Douglas-fir beetle populations have been increasing in recent years within TFL 39 due to recent windfall events and selective harvesting operations. In 1994, salvage harvesting of Douglas-fir beetle attacked trees occurred in conjunction with wind fall salvage in the Okeover area.

Mountain Pine Beetle

In 1964 a small patch of white pine was attacked at Cairn Ridge on the Sechelt Peninsula. From 1982-1988 small scattered infestations were noted in the Homathko River and at unspecified locations in the TSA. The Homathko & Southgate valleys were flown in 2006 and mountain pine beetle populations are at endemic levels, with scattered patch mortality occurring in over mature pine stands.

Root Diseases

Phellinus weirii is the main concern with high levels of infection occurring in the Okeover Inlet area near Powell River and on the Sechelt Peninsula near Homesite Creek. Losses to root disease were incorporated into the last TSR through adjustment of the OAF2 to 12.5% for all existing managed Douglas-fir leading stands in the CDF and CWHxm1 & 2 subzones.

Spruce Beetle

In 1995, 30 ha of infestation were recorded between Powell River and Filer Creek.

Western Hemlock Looper

Defoliation by western hemlock looper was first recorded from Port Mellon to Woodfibre in 1928, and in 1946 near Sechelt. In 1969 larval counts increased from Jervis Inlet to Harrison Lake but no defoliation was recorded. In 1987 over 90 ha of western hemlock, western redcedar and broadleaf maple were defoliated on the west side of Jervis Inlet.

Hemlock looper defoliation was noted in the Rainy River drainage in 1999 over less than one hectare. The population increased dramatically by 2002 with about 800 ha being defoliated in Rainy River and McNab Creek in Howe Sound. In 2002, Canadian Forest Products proposed salvage of about 145 ha of the most severely attacked stands containing about 87,000 cubic metres of timber. Salvage operations were curtailed when Canadian Forest Products surrendered their Forest License. Howe Sound Pulp & Paper has expressed an interest in salvaging the remaining 40,000 cubic metres and are working with BC Timber Sales to complete salvage operations in 2007.