British Columbia
Ministry of Forests, Lands and
Natural Resource Operations

Coast Area

2015-17 Coastal Timber Supply Areas Forest Health Overview

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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 many ecological principles. Recently, more emphasis has been placed on ecosystem management and application of proactive 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 Forest Health Overview provides background and strategic direction for forest health management in the Coast Area of British Columbia for both the West Coast (WCR) and South Coast Regions (SCR) by:

- Identifying damaging agents (and their inherent hazards and risks) that have the potential to impact forest and other resources;
- Outlining the recoverable and non-recoverable losses in managed forest 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 adaptability of forested ecosystems; and
- 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, Forest Health Stand Establishment Decision Aids and other existing forest health management practices guides and documents.

The aim and scope of the provincial forest health program is outlined in the *Provincial Forest Health Strategy 2013-16*. The content of this publication is summarized on the following page.

This overview 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 strategy. 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 *Forest and Range Practices Act* (FRPA) 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 based on the principle of professional reliance 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 biodiversity or timber, set by government. It also includes commitments and standards for harvesting and reforestation, including stocking standards, which may 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, Lands and Natural Resource Operations 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 2014/15 - 2016/17 Service Plan).

Ministry Service Plan

The Ministry makes timely and durable decisions on the land base, while balancing economic prosperity and environmental sustainability.

Ministry Goals:
2. Coordinated and sustainable management, use and stewardship of B. C.'s natural capital.

Objective 2.2:
Natural resource productivity is optimized through conservation, stewardship, and effective policy, legislation and external relationships.

Provincial Forest Health Strategy

Forest Health Mission Statement:
"Provide science-based, economically rationalized best management practices and implement treatment programs that prevent or mitigate the impact of forest health agents."

Forest Health Strategic Goals:

1. Pest impacts are monitored and assessed
   The evaluation of pest impacts on forest resource values is supported by forest health monitoring and assessments.
2. Practices are adapted to accomodate known forest health risks
   Forest practices are modified to minimize the impacts of forest health factors based on the best available information.
3. Resources are protected
   Forest resources are protected from pest damage through appropriately applied direct management actions.

Coastal TSA Forest Health Overview

Coast Area Forest Health Overview 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 Area (Figure 1). The Coast Area is composed of nine TSAs: Arrowsmith, Fraser, Kingcome, Mid-Coast, Pacific, Queen Charlotte, Soo, Strathcona, and Sunshine Coast (Table 1). The North Coast TSA was removed from the West Coast Region in 2010 and is now part of the Skeena Region. This strategy includes, but does not specifically address, parks, protected areas and TFL lands within the Coast Area. Individual TFL planning documents should be consulted for local information on pest history and risks within those tenures.

Figure 1. Location of West Coast and South Coast regional boundaries and office locations within the Coast Area.

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

Timber Supply Area	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)
Pacific	Shared between WCR and SCR
Queen Charlotte	Haida Gwaii (Queen Charlotte City)
Soo	Sea-to-Sky (Squamish)
Strathcona	Campbell River
Sunshine Coast	Sunshine Coast (Powell River)

Regional Forest Health Activities

The regional forest health program consists of three themes and 10 functions that support provincial and regional forest health goals. These functions are 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: Program Administration and Strategies

Function 1: Program Management.

- Manage budgets and projects, including performance measure management.
- Identify risks and set priorities for resource allocation.
- Implement and maintain internal policy and procedures.
- Develop, review and propose changes to policy and legislation.

Function 2: General Administration.

- Contract planning and managing partnering agreements.
- Communication, public liaison, public and First Nation consultation and FOI.
- Training (mandatory and corporate).

Function 3: Development of provincial, regional and TSA strategies.

- Determine government objectives and priorities for forest health and revise strategies, policies, practices and standard operating procedures.
- Participate in the determination of climate-change strategies for forest health and stewardship.
- Provide technical expertise to the development and implementation of best management practices and operational plans (e.g., Forest Stewardship Plans) and determination of non-recoverable pest losses.

Function 4: Participation in interagency efforts.

- Develop MOUs and partnering agreements with other agencies and organizations.
- Actively advocate strategic government objectives to other agencies, and participate in co-ordinated response planning for forest health issues.

Theme: Program delivery

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

- Set survey and treatment standards and procedures.
- Conduct forest health inventories, including detailed aerial and ground surveys.
- Investigate new infestations.
- Assess hazard and risk at multiple scales consistent with management objectives.
- Quantify social, economic and environmental impacts at multiple scales.

Function 6: Treatment of pest outbreaks and prevention of the establishment of some exotic pests.

- Define treatment and prevention standards and measures of success.
- Implement co-ordinated response to forest health outbreaks and prevent establishment of some introductions (e.g., gypsy moth).

Function 7: Management of endemic pests during forest operations.

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

Theme: Adaptive management

Function 8: Monitor forest health and management.

- Conduct provincial aerial overview survey.
- Develop protocols for resource stewardship monitoring and support surveys.
- Monitor natural and managed stands to determine pest impacts and report results.

Function 9: Professional development, training and extension.

- Maintain expertise through participation in workshops, conferences and through liaison with research agencies.
- Encourage innovative approaches to forest management that promote forest health.
- Update guidebooks and reference materials.
- Identify, develop, deliver and participate in training needs for Ministry staff and others (e.g., agreement holders, stakeholders, contractors, First Nations and the public).

Function 10: Operational forest health research.

- Design and conduct operational trials to enable science-based management.
- Develop and refine hazard and risk models.
- Communicate results of operational trials, inventories, and implications of management policies and practices.
- Advocate Ministry forest health research needs and priorities to research agencies.

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 subset of these agents are significant as measured in terms of their potential to cause appreciable damage or detrimentally affect management objectives. A list that focuses on the agents most significant to the Coast Area 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 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 1:100,000-1:150,000. Survey standards and annual results are available from the Ministry website[1]. 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. Thus, although under-reported, the overall distribution and impact of forest diseases in the Coast Area 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 accuracy of +/- 20 m. In addition, districts may conduct more detailed aerial and ground surveys when trying to assess the distribution and potential impact of some specific pests like defoliators.

Monitoring

Under FRPA the lead for monitoring within the Ministry has been the Forest and Range Evaluation Program[2] (FREP). This monitoring generates field data from inspections done on most of the values described in the FRPA, including the Timber value which encompasses forest health.

In 2006, a FREP pilot project was conducted on the Strathcona TSA as part of a larger provincial effort involving five TSAs. The pilot project evolved into the current FREP Stand Development Monitoring (SDM) protocol. This protocol outlines a procedure for sampling post-free growing inventory polygons to determine if stand attributes (e.g., density, leading species) are developing as assumed given the original management assumptions or if other attributes, like pests, are affecting tree growth. SDM has now been incorporated into the FREP monitoring schedule for most districts.

In addition to FREP monitoring, there are various forest health monitoring projects in the Coast Area that are specific to certain forest health concerns. For example, the South Coast Region has some whitebark pine monitoring plots tracking these high-elevation trees and both regions have plots monitoring the long-term development of blister-rust resistant western white pine and others tracking the impact of root diseases on second growth stands.

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 Coast Area). This is based almost solely on the provincial annual overview survey and is best applied at a landscape-level. This data is also available as GIS layers downloadable through GeoBC[3].

The second, more extensive repository is at the Pacific Forestry Centre[4] in Victoria. There the Canadian Forest Service operates an insectary and herbarium that collect insect and disease specimens from across the province and maintain a database that tracks their locations. Quite specific queries of

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[1] Web address is http://www.for.gov.bc.ca/hfp/forsite/overview/overview.htm.
[2] Web address is http://www.for.gov.bc.ca/hfp/frep/index.html.
[3] Web address is http://geobc.gov.bc.ca/.
[4] Web address is http://www.pfc.cfs.nrcan.gc.ca/index_e.html.

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 the RESULTS database operated by the Ministry, cover the province, the pest data they house is often incidental, difficult to access or not specifically organized for pest enquiries. Thus, extracting useful data for large scale forest planning is often difficult or requires a certain expertise with the database.

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

Assessment of Forest Health Hazard and Risk

The rhetoric of hazard and risk deserves some attention, as the terms are not synonymous. Hazard is usually referred to as a "source of danger" while risk is the "probability of loss". Hazard in the literature is often used as "the favourableness of the particular site for the development of the [pest]". The key points conveyed by hazard as a source of danger are: (1) a situation in space and time; (2) driven by environmental factors of climate and host distributions; and (3) a relative indication of the likelihood and severity of infestation.

Risk fundamentally refers to the probability of an undesirable outcome. Risk adds the idea that resource values or management investments are in jeopardy because damage from pests reduces host growth, reproduction and survival sufficiently to impact economic or ecological objectives.

A first approximation of hazard for most pests in the Coast Area is provided in Section 6.6 of Land management Handbook 28 (Green and Klinka 1994)[5]. 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 at this scale without observing the incidence of pests on or near the 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 (SEDA) published by FORREX in the *BC Journal of Ecosystems and Management.*

For use in conjunction with some host-specific SEDAs, a guide to hazard and risk specific to reforestation is provided in the *Reference Guide for FDP Stocking Standards* located on the Ministry website[6]. This guide was updated in February 2014 with climate-based species selection recommendations and in March 2013 to reflect changes in forest health considerations when certain species are used for reforestation in specific biogeoclimatic units.

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[5] 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.

[6] Web address is http://www.for.gov.bc.ca/hfp/silviculture/stocking_stds.htm

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[7] (VDYP) model that predicts yield for natural stands, and the Tree and Stand Simulator[8] (TASS)/Table Interpolation Program from Stand Yields[9] (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 available for complex and mixed wood stands in BC (e.g., PrognosisBC) may have an improved ability to account for the impact of damaging agents. However, these models are not always calibrated 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 the Ministry. Pest-specific forecasting models and extensions have been developed for independent use (Root Rot Tracker) or for use with existing models like TASS - Root Rot Simulator (ROTSIM) or the Spruce Weevil Attack Trial (SWAT), but these are not 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 FAIB staff and no longer help form future yield curves. The consensus amongst forest health and growth and yield specialists is that VDYP adequately accounts for endemic pest and decay losses.

TIPSY/TASS – Managed Stands

Volume estimates for single-species even-aged managed stands are based on TIPSY 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 stand conditions and constraints.

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 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;

7 Web address is http://www.for.gov.bc.ca/hts/growth/vdyp/vdyp.html.
8 Web address is http://www.for.gov.bc.ca/hts/growth/tass/tass_overview.html.
9 Web address is http://www.for.gov.bc.ca/hts/growth/tipsy/tipsy_description.html.

waste and breakage, and other factors that increase with age. Therefore, OAF 1 is a constant reduction factor that shifts the yield curve down (a Type 1 response), while OAF 2 losses start at zero and increase to its full value with age, modifying the shape of the yield curve as time passes (a Type 2 response).

The provincial default value for OAF 1 is 15% and for OAF 2 is 5%. OAF 1 values may be modified by using a survey to check the underlying assumptions for the area under question. OAF 2 is an estimate of the impact of decay, waste and breakage in second growth stands. Despite popular belief, it does not account for losses due to insects, diseases or other pests, even endemic ones, other than decay. 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 losses can be both increment loss and mortality. A NRL estimate is generally subtracted from yield projections. Often NRLs are 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 damage category and percent of AAC affected as accounted for in the most recent TSR for each TSA in the Coast Area

TSA (Effective date)	Fire m^3	Wind m^3	Pests[a] m^3	Total m^3	Current AAC m^3	% of AAC
Arrowsmith (2009)	1,000	1,000		2,000	420,000	0.5
Fraser (2015 proposed)	16,500	2,340	8,100	26,940	1,239,100	2.1
Kingcome (2009)	3,083	10,500		13,583	1,100,000	1.2
Mid-Coast (2011)	7,102	13,000		20,102	767,000	2.6
Pacific (2012)					1,507,119	
QCI (2012)			28,744	28,744	512,000	5.6
Soo (2011)	30,000		4,000	34,000	480,000	6.8
Strathcona (2015 proposed)	1,750	30,000	11,400	43,150	1,217,000	3.5
Sunshine Coast (2012)	500	6,900	5,250	12,650	1,197,949	1.1
Total				118,544	8,440,168	

[a] Pests does not include losses as determined by OAF reductions but does include losses to disease, insects, animals and abiotic factors other than fire and wind.

Operational Research Plan

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

Project	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. - 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.	- 30-year data collected from two sites, 15-year data from another. - Internal reports in 1991 and 1994. - Publication after 30 years data.	Final measurement in 2014. 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 resistance to WPBR found on trees from Texada Island.	- Fifteen years of continuous data. - Interim report in 2000. - Recommendations on use of Texada B+- seed and timing of pruning treatment(s). - Publication after 20 years data.	Final evaluations in 2014. Analysis pending.
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.	- Results published in 2010 WIFDWC proceedings.	Completed. Nursery sold, site destroyed.
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.	Some stands being harvested 10 years following treatment. Pilot assessment of some damaged trees done in 2009.
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	- Biennial data collection. - Recommendations on use of Texada half-sib seed for reforestation. - Publication after 15-years data.	Last assessed in 2013.

Project	Description	Product(s)	Timelines
	third in a series of trials testing Texada Island Pw.		
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 compared using the growth intercept method.	- To date, 51 stands have been assessed. - Interim report in 1999. - Publication after data collection complete.	Last group to be assessed in 2014. Analysis pending.
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 G&Y plot updates.
Whitebark Pine Monitoring Plots	Long-term monitoring plots to track health of whitebark pine. 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 mortality trend.	- Nine plots established to date. - Future plots required across range of Pa. - Refereed publication after sufficient data collected.	Assess 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.	- Seven small plots established in 3 districts in 2002. - Biennial data collection. - Refereed publication after 10-years data.	Last assessed in 2013.
Stumping Disturbance Trial	In conjunction with Paul Courtin (Research Section), evaluating the effect of stumping on soil disturbance and assessing seedling growth and development.	- Five sites established in 2007 and 2008. - Publication after 7-years data.	Assessed last in 2014. Analysis pending.
Yellow-cedar Decline	Multi-phase project looking at aspects of the decline of yellow-cedar predominantly on the north and mid-coasts. Currently building on initial results for hazard prediction model. Further work on assessing impact, ecological implications, and climatic factors is ongoing.	- Preliminary mapping of decline. - Dendrochronology pilot project complete. - UBC MSc thesis and publication. - UBC PhD dissertation and publications. - Hazard model for Yc decline under construction.	Dendro pilot results published in 2011.
Septoria canker of poplar	Introduction of non-native disease threatens susceptible hybrid poplar clones and native *P. trichocarpa*.	Risk evaluation for establishment of Septoria musiva in native poplar.	Distribution surveys complete.

Entomology (there is currently no entomology research planned)

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 Area, 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 better sources for this information that 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.
- Burleigh, J., Ebata, T., White, K. J., Rusch, D. and Kope, H. Eds. 2014. Field Guide to Forest Damage in British Columbia. Can. For. Serv. and BC MFLNRO. Joint Pub. No. 17. Third Ed. 355 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/hfp/meta/publications.htm#003

Abiotics

Yellow-cedar Decline

Yellow-cedar decline has been identified as a problem in southeastern Alaska for several decades but, until 2005, its occurrence and impact was poorly documented in BC. The decline can appear in small scattered 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 about 95,000 ha 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 quite readily. The frequency of widespread decline decreases as one travels south and virtually disappears south of Kingcome 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 long term climate change. The current model is that declining snow levels and early snow melt lead to increased susceptibility of the shallow fine roots to sudden late season frost events where upper layer soil temperature falls below -5° C. If this is correct, then any yellow-cedar is potentially subject to decline if snow packs recede early due to a change in climate patterns. We are currently working toward developing a predictive hazard model for coastal BC. However, early results indicate decline seems to most strongly occur in the CWHvm2 variant of the north and mid-coast.

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 suitable conditions for occurrence of the decline could be predicted.

Priority and Research

Assessing the impact of yellow-cedar decline is a high priority. This consists of two projects. One is to build on the landscape-level analysis completed in 2011 by expanding the physical attribute model beyond the test area across the range of yellow-cedar and testing its predictions. The other is to build on recent dendrochronology work that attempts to explain the climatic variables controlling the growth and mortality of yellow-cedar.

Resources

- Hennon, P.E., D.V. D'Amore, P.G. Schaberg, D.T. Witter and C.S. Shanley. 2012. Shifting climate, altered niche, and a dynamic conservation strategy for yellow-cedar in the North Pacific coastal rainforest. Bioscience 62(2): 147-158.
- Stan, A.B., T.B. Maertens, L.D. Daniels and S. Zeglen. 2011. Reconstructing population dynamics of yellow-cedar in declining stands: baseline information from tree rings. Tree-Ring Research 67(1): 13-25.
- Wooten, C.E. and B. Klinkenberg. 2011. A landscape-level analysis of yellow-cedar decline in coastal British Columbia. Can. J. Forest Research 41: 1638-1648.
- 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.

Adelegids

Balsam Woolly Adelgid

Balsam woolly adelgid (*Adelges piceae*) is a small aphid-like insect that was 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 BC in 1958 in the Vancouver area and on southern Vancouver Island. From there 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 Sea-to-Sky Natural Resource District; eastward to Hope and throughout the Fraser canyon as far north as the Nahatlatch and Mowhokam drainages. It has also crested the Coquihalla and 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 and was recently confirmed in the southern interior around Rossland.

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 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 BC Ministry of Agriculture and can be found online at: http://www.qp.gov.bc.ca/statreg/reg/P/PlantProtection/414_92.htm. Currently, the entire South Coast Region and West Coast Region (except Haida Gwaii) are included in the quarantine area for adelgid. The Cascades District of the Thompson-Okanagan Region is also included in the quarantine area.

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 endemic throughout the range of Douglas-fir where it normally breeds in trees that are stressed, recently windthrown, dead or dying from other causes. However, outbreaks occur periodically on the coast (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 Coast Area if conditions are suitable. The beetle is often associated with trees that are stressed or have been recently killed by root disease. However, within the Coast Area, Douglas-fir beetle generally only becomes a significant 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 usually build into large areas of attack on the coast, this beetle tends to attack the larger Douglas-fir in a stand and can kill substantial volumes of valuable timber when populations build.

Management
Control is via sanitation harvesting using trap trees (see *Bark Beetle Management Guidebook*). Use of the anti-aggregation pheromone MCH may be considered in certain situations.

Priority and Research
No research is occurring at this time.

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, on the coast lodgepole pine is a minor, and mostly a non-commercial, tree species. Most infestations of this bark beetle on the coast 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 Coast Area, 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. The large provincial MPB epidemic is winding down and, for the coast, populations have returned to their endemic level of occasional local attack where pine still exists. 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 Area, 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 coastal 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 spread. Falling and burning individual trees, 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 expensive and futile.

Priority and Research
No research is occurring at this time.

Resources

- Unger, L. 1993. Mountain pine beetle. Forest Pest Leaflet #76. Canadian Forest Service, Pacific Forestry Centre, Victoria.
- 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.

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.

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. The biological control agent *Bacillus thuringiensis var. kurstaki* (*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

No research is occurring at this time.

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 consistently occur on Haida Gwaii 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 Haida Gwaii. 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 Haida Gwaii, 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.

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. The biological control agent *Btk* will work but are not yet registered for this insect. As observed in 2001 on Haida Gwaii, thinned stands may be subject to greater mortality, possibly due to easier access to the crown. Therefore, post-thinning density targets should allow for this in areas at risk of budworm defoliation.

Priority and Research

No research is occurring at this time.

Resources

- 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.
- Koot, H.P. 1994. Western Blackheaded Budworm. Forest Pest Leaflet #24. Canadian Forest Service, Pacific Forestry Centre, Victoria.
- 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 on the coast. 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 of looper 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; two 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 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.

Priority and Research

No research is occurring at this time.

Resources

- Unger, L.S. 1995. Spruce budworms. Forest Pest Leaflet #31. 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.
- 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.
- Engelhardt, N.T. 1957. Pathological deterioration of looper-killed western hemlock on southern Vancouver Island. 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 2013 within the Coast Area were primarily light, this insect has caused significant damage here in previous years. In the past, western spruce budworm has had it largest impact in the Sea-to-Sky and Chilliwack Natural Resource Districts, particularly in the Pemberton/Birkenhead area and the Fraser Canyon area near Boston Bar. Outbreaks are periodic, occurring approximately every decade and last 3 to 5 years.

Hazard and Risk

Within the Sea-to-Sky and Chilliwack Natural Resource Districts, defoliation often occurs in an elevational band 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.

Defoliation is most common in the Boston Bar area of 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 on the coast but may occur after a number of years of severe defoliation.

Top-kill in immature trees can result in forks and crooks forming on the main stem of the tree (i.e., within the first 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 may be required to meet regeneration and stand objectives. Species for reforestation are limited in high hazard areas; however, using 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 levels and thin from below to maintain an even-aged structure. Ecosystem restoration treatments that thin and use prescribed fire in dense uneven-aged stands 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 region 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

No research is occurring at this time.

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.
- Unger, L.S. 1995. Spruce budworms. Forest Pest Leaflet #31. Canadian Forest Service, Pacific Forestry Centre, Victoria.
- Shepherd, R.F. 1994. Management strategies for forest insect defoliators in British Columbia. Forest Ecology and Management 68: 303-324.

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 within the Coast Area

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 the production and spread of seed.

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.

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. It is not a terribly aesthetic practice but it is effective in controlling dwarf mistletoe. The advent of partial cutting, 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 (Hawksworth rating 3+) infested trees should be removed unless they remain in reserves where there is little chance for their seed to disperse onto susceptible regeneration. Manage for non-susceptible tree species in the regeneration layer. 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.

Resources

- Muir, J.A., P.E. Hennon and R.W. Negrave. 2007. Biology, ecology and management of western hemlock dwarf mistletoe in coastal British Columbia: a synthesis of the literature. BC Ministry of Forests and Range, Nanaimo, BC. Technical Report TR-037.
- 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 the 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 a prolonged shift 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

The taxonomy of what was once referred to as the species complex *Heterobasidion annosum* (=*Fomes annosus*) has recently been redefined. What was once one species subdivided into five intersterility groups (ISG) is now five distinct species. Three species occur in Eurasia and two in North America. What was previous referred to as the S-type (ISG) found in western North America that is partial to non-pine conifers like *Abies*, *Picea, Tsuga* and Douglas-fir is now called *H. occidentale*. It occurs throughout the coast except in the driest parts of the CDF zone. What was previously referred to as the P-type (ISG) is now called *H. irregulare*. It 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 *H. occidentale*. It generally reflects the most susceptible hosts (in descending order) true firs, spruce, hemlock and Douglas-fir with the level of activity proposed. In pre-commercial 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. occidentale* increases 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. occidentale* 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 rotations no longer than 120 years. When conducting forest operations like partial cutting, minimize wounding to deny entry points for spores. For pre-commercial thinning, do not overly worry about colonization of fresh stump surfaces. While the incidence of *Heterobasidion* does increase in thinned stands, the impact appears limited in terms of volume loss over a rotation. Finally, unlike Scandinavia where *Heterobasidion* is the major root disease of plantation forests, treatment of stumps using a liquid or powder formulation of Borax or zinc chloride appears unnecessary. Biological control agents are used in Europe but are untested and not approved for use in BC. In areas where *Heterobasidion* occurs with *Armillaria* or *Phellinus*, management strategies for those diseases will usually suffice as a control.

Priority and Research

Considerable work was done regarding *H. occidentale* 20-30 years ago western North America. However, fears that it would cause considerable losses in managed (thinned) stands did not materialize. That, combined with the reluctance to practice intensive silviculture in hemlock on the coast, has led to a lack of interest in research of this fungus.

Resources

- Otrosina, W.J. and M. Garbelotto. 2010. *Heterobasidion occidentale* sp. nov. and *Heterobasidion irregular* nom. nov.: a disposition of North American Heterobasidion biological species. Fungal Biology 1: 16-25.
- 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 dozen similar 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 within in the Coast Area

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*[10]. 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.

[10] 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.

Impact
Armillaria root disease can cause substantial mortality in trees of any age. However, mortality on the coast is most pronounced by age 25. 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 disease 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.

Priority and Research
Armillaria is a 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. Ones that might be of use are:

- Cleary, M., B. van der Kamp and D. Morrison. 2008. British Columbia's southern interior forests: Armillaria root disease stand establishment decision aid. BC J. Ecosystem Management 9(2): 60-65.
- 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, multiplying and causing a vascular wilt as it effectively blocks the flow of water to the crown. This insect-driven dispersal also makes predicting disease spread 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

No research is occurring at this time.

Resources

- Jacobi, W.R., S. Zeglen and J.D. Beale. 2008. Black stain root disease progression in coastal Douglas-fir in British Columbia. Can. J. Plant Pathology 30: 339-344.
- 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 sulphurascens (= Phellinus weirii* Fd type*)*, 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 an important natural disturbance agent causing long-term change to Douglas-fir ecosystems in the Pacific Northwest. 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*. A recent taxonomic change has relegated the name *P. weirii* to describe the related fungus that is known to occur as a butt rot of western redcedar but this disease is rarely noted on the coast.

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 for the Coast Area

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. 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 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 infected 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 additional to the default OAF 2 of 5% resulting in a cumulative

OAF 2 of 12.5%. This OAF 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 rotation 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 individual families 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 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 incidences 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

No research is occurring at this time.

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 (WPBR), 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 lowest 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, most effectively 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 over a diverse landscape. One factor that is a reasonable predictor of potential infection is proximity to *Ribes* plants. Pines within 30 m of *Ribes* can 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 in 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 WPBR, 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. Nurseries are producing planting stocks that are crosses of resistant Cr2 pollen with local white pine of superior growth. The offspring are conferred at least 50% resistance (50% chance of not becoming infected) and field tests have noted survival of upwards of 80% depending on local rust conditions.

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 disease 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., J. Pronos and H. Merler. 2010. Silvicultural management of white pines in western North America. Forest Pathology 40: 347-368.
- Cleary, M. R. Ed. 2010. Proceedings of the 3rd Western White Pine Management Conference. June 17-18, 2008. Vernon, BC. BC Min. Forests and Range, Kamloops, BC. 116 pp.
- Zeglen, S., R. Hunt and M. Cleary. 2009. British Columbia's forests: White pine blister rust Forest Health Stand Establishment Decision Aid. BC J. Ecosystems and Management 10(1): 97-100.
- 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 on the coast 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 (Se) 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 Haida Gwaii, however, Sitka spruce from these islands has been shown to be highly susceptible to weevil attack.

Hazard zones for Sitka spruce 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 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

Manual control of established weevil infestations is not practical. 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.

When establishing new stands containing Sitka spruce, use weevil resistant planting stock. If improved class 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 Sitka spruce in areas considered to have moderate to high weevil hazard ratings. If class 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 spruce.

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

- In low hazard areas, spruce 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 spruce 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 spruce 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. Efforts are now focused on further refining the management around using weevil resistant spruce in reforestation.

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.
- Turnquist, R.D. and R.I. Alfaro. 1996. Spruce weevil in British Columbia. Forest Pest Leaflet #2. Canadian Forest Service, Pacific Forestry Centre, Victoria.
- McMullen, L.H. 1976. Spruce weevil damage, ecological basis and hazard rating for Vancouver Island. Canadian Forest Service, Info Report BC-X-288, 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 tree 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 old 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 known to be habitat for porcupine 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

2014 Aerial Overview Survey

Aerial overview surveys (AOS) have been conducted annually on the coast by the Ministry 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. The intent of these surveys is to provide an overview of forest health conditions. The AOS is generally not detailed enough for operational purposes but provides a landscape-level picture of pest activity and distribution that can be useful in the early detection of outbreaks or new occurrences. Table 9 summarizes the 2014 results for the Coast Area. 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 Area have not been undertaken with the same intensity as other parts of the province due to the relatively low level of insect activity. Note that TFL areas are neither completely nor consistently covered by the overview survey. As yet, the Pacific TSA is not recognized separately for the purposes of the AOS.

Table 9. Summary table of approximate area (ha) affected by pests and abiotic damaging agents at all severity levels in the Coast Area as reported from the 2014 aerial overview survey

	Timber Supply Area							
Damaging Agent	Arrowsmith	Fraser	Kingcome	Mid-Coast	QCI	Soo	Strathcona	Sunshine Coast
Douglas-fir beetle	0	949	11	186	0	240	1	404
Mountain pine beetle	0	83	0	45	0	195	0	0
Spruce beetle	0	188	19	99	0	0	0	0
Western balsam bark beetle	0	17,826	1014	12083	0	6220	0	516
Western blackheaded budworm	0	0	2789	86	1109	0	194	0
Western spruce budworm	0	0	0	0	0	3	0	0
Lodgepole pine sawfly	0	0	0	0	0	0	0	0
Aspen leaf miner	0	283	208	8174	0	0	0	0
Defoliators other	0	2206	0	0	0	0	0	0
Root diseases	218	18	4	0	0	1	10	176
Foliar diseases	0	0	0	6	6242	0	0	146
White pine blister rust	110	1	0	0	0	0	3	1693
Yellow-cedar decline	0	0	2227	11,674	14,064	0	0	0
Windthrow	0	0	11	7	1440	0	0	0
Drought	0	79	0	0	0	0	0	0
Flooding	57	25	224	349	180	8	65	82
Slides	0	0	53	130	632	24	310	0
Total	385	21,658	6560	32,839	23,667	6691	583	3017

Arrowsmith TSA

The Arrowsmith TSA is located on the southern half of Vancouver Island, south of the Strathcona TSA (Campbell River) and bordering on TFLs 25, 44, 46, 54, and 57 (Figure 2). In contrast to other TSAs in British Columbia, this TSA is made up of many disconnected parcels of land ranging in size from a few hectares to a few thousand hectares. These parcels are interspersed with private land, including TFLs, with urban and sub-urban areas, rural agricultural lands, and with parks and reserves. Although the district covers 1,574,719 hectares, the actual timber supply area covers only 122,445 hectares of productive forest land managed by the Province.

In 1993, the provincial government's Clayoquot Sound Land Use Decision established management practices for a 265,000-hectare area on the west coast of Vancouver Island. Of this area, 7347 hectares contribute to the Arrowsmith TSA timber harvesting land base (THLB) – the area of productive forest available for timber production.

Spanning Vancouver Island from the west to east coast, the terrain of the TSA varies from lowland valleys, with nutrient rich, moist sites to mountainous areas, with poorer, drier sites. Most of the productive forest land lies within the Coastal Western Hemlock (CWH) biogeoclimatic zone, where cool, wet summers and mild winters support stands with a significant proportion of western hemlock. The Coastal Douglas-fir (CDF) zone occurs on the eastern side of the southern portion of the TSA, which is comparatively drier with gentler topography than the western portions of the TSA. Here warm, dry summers and cool, wet winters result in stands dominated by Douglas-fir. At higher elevations, the Mountain Hemlock (MH) zone occurs and at the highest elevations, isolated occurrences of Coastal Mountain-heather Alpine (CMA) zone.

The forests of the TSA are diverse, and slightly more than half of the forests on the land base contributing to timber supply are considered to have medium or good site productivity. Major tree species include: Douglas-fir, hemlock and true firs, while other AAC species such as western redcedar, cypress, spruce, red alder, and maple also occur. The forests of the TSA have a relatively long history of harvesting, and as a result there are rapidly maturing second-growth forests on the lower elevation sites, that are accessible and highly productive. Almost half of the stands on the THLB are between 21 and 100 years of age.

Thirty-six First Nations and three treaty organizations have asserted traditional territories within the Arrowsmith TSA.

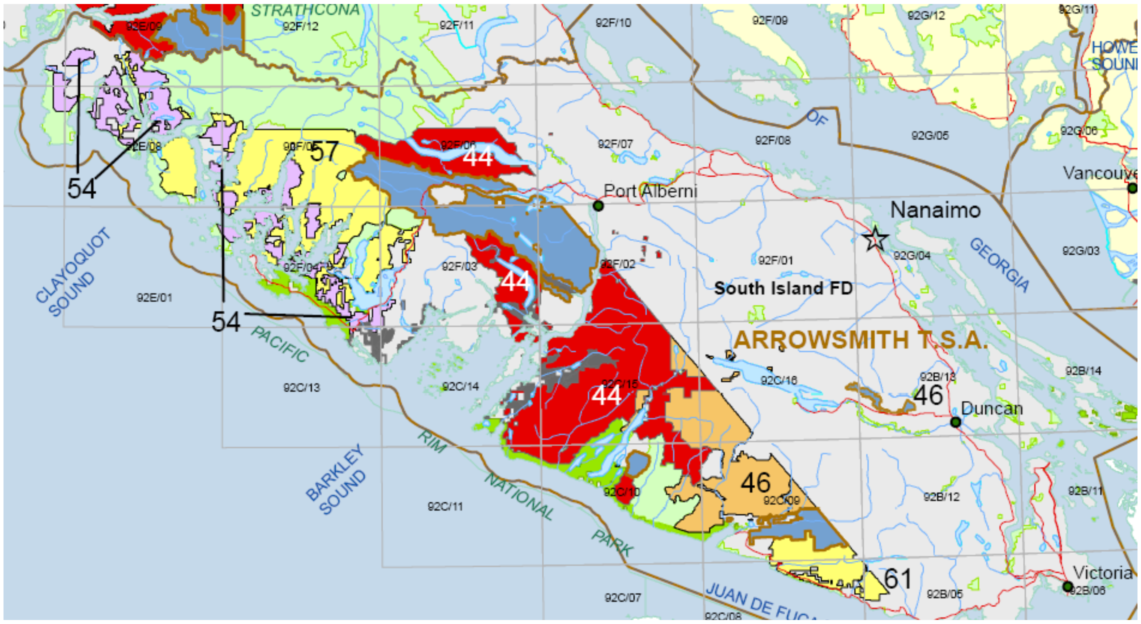

Figure 2. Arrowsmith Timber Supply Area.

Douglas-Fir Beetle

Very few records of early 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. A year later wind thrown trees were attacked in Cathedral Grove and in 1981 west of Shawnigan Lake. Douglas-fir beetle is endemic and often appears in scattered patches where mature Douglas-fir is present. It is often found associated with root diseases.

Drought

Over the last two decades, southern Vancouver Island and the Gulf Islands have experienced occasional prolonged periods of no or little precipitation during the summer months. These dry periods are sufficient to cause drought stress to all ages of trees growing on shallow or coarse textured soils with low moisture holding capacity. A single, exceptional long spell with no measureable precipitation, like the ones in 1998 and 2004, can lead to significant amounts of tree decline and mortality if conditions are severe enough. Local climate shifts suggest this may occur more frequently.

Gypsy Moth

In recent years accidental introductions of North American and Asian gypsy moths have been detected in southern British Columbia, including within the Arrowsmith TSA. The Ministry has taken the lead role in conducting mass trapping and aerial treatments for this pest, successfully preventing its establishment within the province. Baited traps are placed and assessed annually throughout the TSA to provide early detection of moths. Occasional captures are made every year, almost always in populated areas, and the last spray program using the biological control agent *Btk* for eradication of moths was in 2008 near Saltair and on Salt Spring Island.

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 have been incorporated since TSR II for this TSA through adjustment of the OAF2 to 12.5% for all managed Douglas-fir leading stands in the CDF and CWHxm1 & 2 variants. The TSA has both *Phellinus sulphurascens* (= *Phellinus weirii* Fd-type) and *Armillaria ostoyae* acting as mortality agents of immature and mature trees in these drier subzones.

Spruce Aphid

Spruce aphid has caused defoliation to Sitka spruce at various times, mostly between Victoria and Jordan River, and on 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. No recent occurrence of the insect has been reported for several years even though it outbreaks regularly on northern Vancouver Island.

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 by this insect has been recorded since in the Arrowsmith TSA.

Windthrow

Annual unsalvaged losses due to wind were estimated at only 1000 m^3.

Fraser TSA

The Fraser TSA covers approximately 1.4 million hectares and is located in the southern mainland portion of the South Coast Region (Figure 3). The TSA is the most densely populated TSA in the province, encompassing the major population centres of the Lower Mainland and the Fraser Valley. Although much of the timber processed in the TSA is harvested elsewhere, timber harvesting is an important part of the local economy, especially in the smaller communities. Primary sectors such as agriculture, forestry, fishing and mining are more important east of Metro Vancouver, especially in the Upper Fraser Valley and Fraser Canyon.

In the previous timber supply analysis, the total productive forest area in the TSA was reported to be approximately 636 000 hectares, of which less than half was considered suitable and available for timber harvesting. A significant number of large provincial parks are located partially or wholly within the boundaries of the TSA.

There is a diverse range of ecosystems in the TSA. Three broad physiographic units shape the area: the Coast Mountains border the TSA on the north and east; the Fraser lowland, a broad plain of riverine and glacial deposits, extends east from Vancouver to the community of Hope; and the Fraser estuary which includes the delta and tidal areas surrounding the outlet of the Fraser River. Within these physiographic units are five biogeoclimatic zones: Coastal Western Hemlock (CWH), Mountain Hemlock (MH), Interior Douglas-fir (IDF), Engelmann Spruce-subalpine fir (ESSF), and Alpine Tundra (AT).

The chief forester last determined the AAC for the Fraser TSA on July 27, 2004, setting it at 1,270,000 cubic metres effective August 1, 2004. On July 11, 2008, the chief forester postponed the next AAC determination to a date prior to August 1, 2014, which is 10 years since the last determination's effective date.

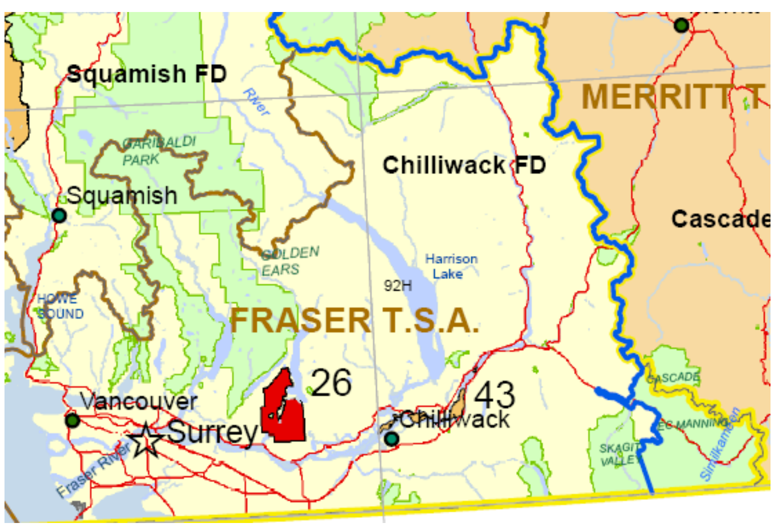

Figure 3. Fraser Timber Supply Area

Balsam Woolly Adelgid

This introduced pest has been found throughout the Fraser TSA. 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 is a native insect that attacks fresh wind throw 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. Over the last three years the mapped area of damage has varied between 500-1000 ha. The 2014 aerial survey delineated 949 ha of infested stands.

Douglas-fir Foliar Diseases

Swiss needle cast and Douglas-fir needle cast have been identified in young Douglas-fir plantations in the western part of the Fraser TSA. Swiss needle cast has been confirmed in the Alouette Lake/Stave Lake area and near Lake Errock. Douglas-fir needle cast has been identified on Vedder Mountain and in the Lake Errock area. Since these foliar diseases thrive during damp and mild spring conditions, there are likely more occurrences. Longer term impacts have not been determined. The district has installed monitoring transects in several young stands to measure defoliation levels over time.

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.

Drought

Over the last two decades, the South Coast has experienced occasional prolonged periods of no or little precipitation during the summer months. These dry periods are sufficient to cause drought stress to all ages of trees growing on shallow or coarse textured soils with low moisture holding capacity. A single, exceptional long spell with no measureable precipitation, like the ones in 1998 and 2004, can lead to significant amounts of tree decline and mortality if conditions are severe enough. Local climate shifts suggest this may occur more frequently.

Forest Tent Caterpillar

In 2014, this insect caused 2,205 ha of light to moderate defoliation, mainly around the Cultus Lake area. While the defoliation can be unsightly due the massive profusion of webs on trees and the migration of larvae across the landscape, it is not considered a serious forest pest and only repeated defoliation causes results in growth loss or mortality.

Gypsy Moth

In recent years accidental introductions of North American and Asian gypsy moths have been detected in southern British Columbia, including within the Fraser TSA. The Ministry has taken the lead role in conducting mass trapping and aerial treatments for this pest, successfully preventing its establishment within the province. Baited traps are placed and assessed annually throughout the TSA to provide early detection of moths. Occasional captures are made every year, almost always in populated areas, however, 197 moths were trapped near Cloverdale in 2014 resulting in a spray treatment program for 2015. Prior to this, an area south of Harrison Hot Springs was sprayed aerially in 2009 and from the ground in 2010 and an area in north Richmond was sprayed aerially in 2010.

Mountain Pine Beetle

Mountain pine beetle is a native insect that 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 4). 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. During the last mega outbreak, attack peaked at 31,921 ha of pine in 2007. Since then population levels have steadily declined to about 4000 ha in 2013. The majority of these areas showed light to moderate impact.

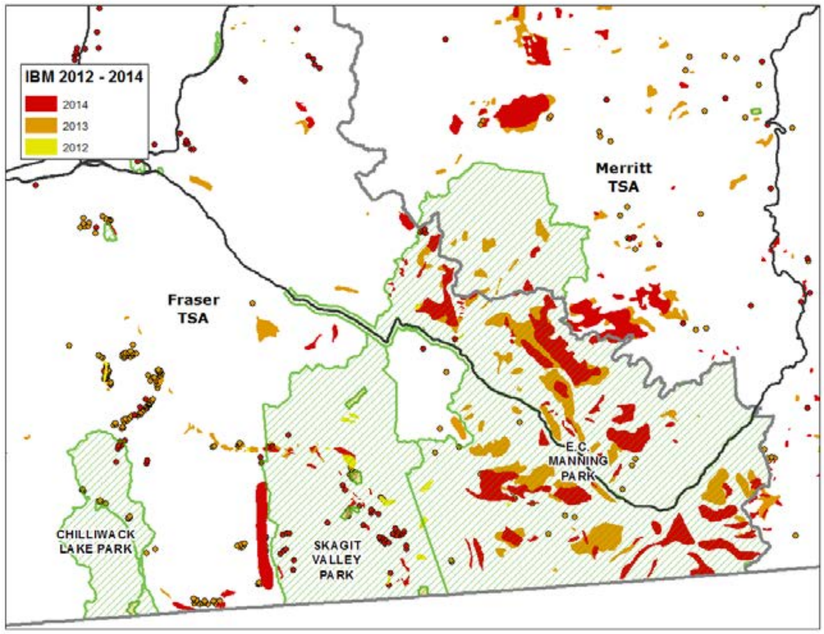

Figure 4. Area infested by mountain pine beetle in the Hope-Manning Park corridor of the Fraser TSA from 2012 to 2014.

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 (2008) TSR.

Septoria Canker

Septoria canker, caused by an introduced pathogen *Septoria musiva*, was positively identified for the first time in 2007 in the Fraser Valley on hybrid poplar. Foliar sampling and analysis in 2008 – 2009 and 2012 confirmed the presence of Septoria canker on native black cottonwood in locations from Hatzic, east of Mission, to Othello, just east of Hope (Figure 5). It has also been confirmed in numerous hybrid poplar plantations in the valley located on private land. Since the disease can transfer readily from hybrid to native poplar, the risk is that it will spread from native forest to plantations and back again as it expands its range. The spread rate and future impact of this disease is currently unknown but the use of some hybrid poplar strains should be avoided.

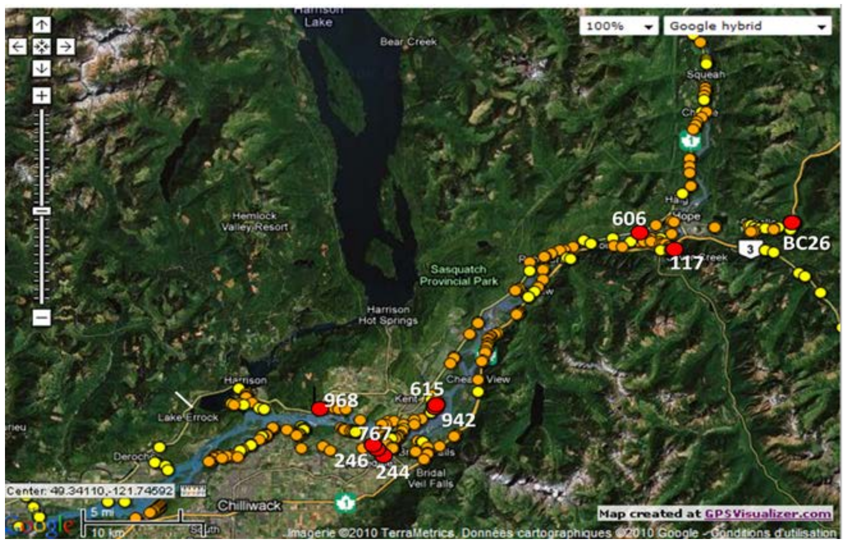

Figure 5. Distribution of sites in the Fraser Valley where Septoria canker was found (red spots) during sampling in 2008 and 2009.

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. Since 2004, areas attacked by spruce beetle have remained low with 188 ha mapped in 2014.

Western Balsam Bark Beetle

This beetle is usually found scattered, rather than clumped, at higher elevations within the ESSFmw. Historical records do not accurately reflect populations, as often funds were not available to survey high elevation stands. From 2005 to 2009, an average of 4420 ha per year was attacked, with a low of 681 hectares in 2010 following a high of 7775 ha in 2008. Recently, beetle activity has increased with 13, 506 ha mapped in 2013 and 17,826 of mostly trace and light damage mapped in 2014. 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. No detections have been recorded in recent years.

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. No detections have been recorded in recent years.

Western Spruce Budworm

Several outbreaks of this native insect have been recorded in the Fraser TSA. The first recorded 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 but collapsed by 1995. In 2001 populations began increasing near Boston Bar and along the Nahatlatch River, with 6600 ha of defoliation recorded in 2003. Populations were down slightly in 2004 and declined further in 2005. In 2006, however, budworm populations increased to a high of 24,337 ha in 2007. Levels have since declined steadily since then.

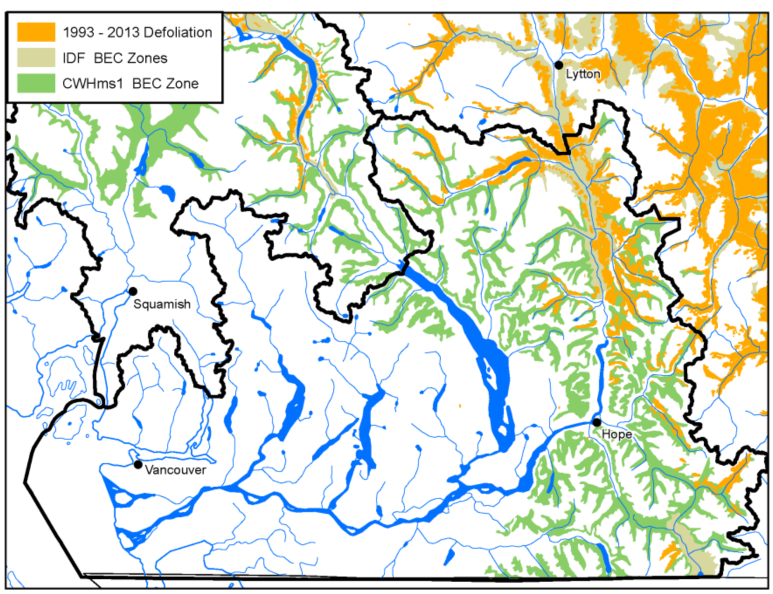

Figure 6. Areas defoliated by western spruce budworm from 1993-2013 in the Fraser TSA.

Control treatments have been carried out in 2008 and 2009 specifically targeting young Douglas-fir stands in the Fraser Canyon and Coquihalla areas. The objective of the treatments is to minimize top kill to 20 to 60 years old trees since defects to the leader can decrease the value of the timber at harvest. In 2008 and 2009, 833 ha and 1664 ha respectively were treated with *Bacillus thuringiensis* var. *kurstaki* (*B.t.k.*). Ground sampling conducted in the fall of 2009 and spring of 2010 indicated that infestation levels were light and further control treatments were not required.

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

Windthrow

According to TSR data, wind is estimated to account for a loss of 5200 m^3/year, 25% of which is considered recoverable.

Kingcome TSA

Created in 1980, the Kingcome TSA covers about 1.17 million hectares, mostly on mainland coastal BC adjacent to Queen Charlotte Strait, from Knight Inlet in the south, northwest to Cape Caution and northeast to Tweedsmuir Park, with the remainder of the TSA on northernmost Vancouver Island and the islands between Vancouver Island and the mainland (Figure 7)

The timber supply analysis report identifies the total area of the TSA as 1 172 428 hectares, of which 650 696 hectares are Crown Productive Forest, and 376 452 hectares are considered operable forest. The area of the TSA considered currently suitable and available for harvesting (the timber harvesting land base or THLB), net of exclusions associated with the ecosystem-based management (EBM) provisions of the CLUD, is identified as 189,179 hectares. The future THLB, subsequent to anticipated wildlife tree patches and future road construction, is identified as 184 163 hectares.

The AAC for the Kingcome TSA under Section 8 of the *Forest Act* prior to this determination is 1,284, 000 cubic metres, temporarily reduced by 52,000 cubic metres by order of the Chief Forester under Part 13, Section 173 of the *Forest Act* for an effective AAC of 1,232,000 cubic metres. The AAC includes a partition of 20 340 cubic metres for harvesting in deciduous forest stands.

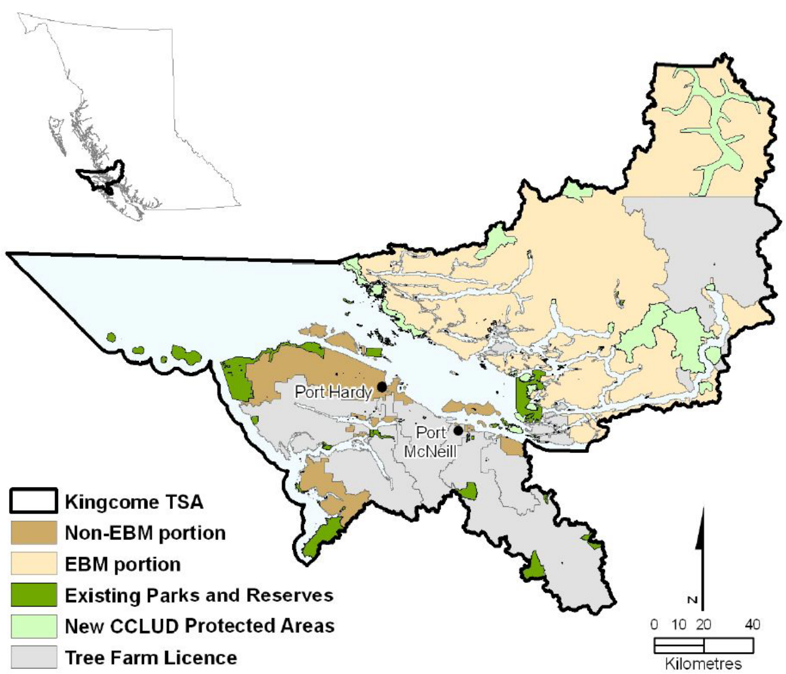

Figure 7. Kingcome Timber Supply Area.

Alder Sawfly

Defoliation of alder was noted in 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 all ages of hemlock is anticipated to rise significantly as we continue to move away from clear-cutting. Partial cutting systems now account for about half of all coastal harvesting, and Ecosystem Based Management involves leaving many trees and groups of 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 northeast corner of the TSA in the Klinaklini River Valley, just south of Tweedsmuir Provincial Park. The first outbreak was noticed in 1974 and continued until 1981. The latest outbreak was noted staring in 2000 and has continued throughout the last decade until ending in 2009 (Table 3).

Table 3. Comparison of hectares attacked annually by mountain pine beetle and balsam bark beetle in the Kingcome TSA.

	Area Attacked (ha)								
	2006	2007	2008	2009	2010	2011	2012	2013	2014
Mountain Pine Beetle	1697	3654	1964	1	38	0	0	0	0
Balsam Bark Beetle	786	1156	1332	12	116	194	118	224	1014

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 northeast 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. Recent attack has been increasingly modestly since 2013 (Table 3).

Western Blackheaded Budworm

In 1944 budworm defoliation was reported near Quatsino Sound and in 1954 near Holberg. Populations expanded significantly in 1955 to 400, 000 ha and doubled in 1956 to 800,000 ha. Defoliation occurred between Port McNeill and the Adam 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. 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. More recently, over 28,000 ha of light to severe budworm damage was reported annually in 2012 and 2013 mostly on TFL 6 (Figure 8) and stretching as far east as Bonanza Lake.. This most recent outbreak collapsed in 2014.

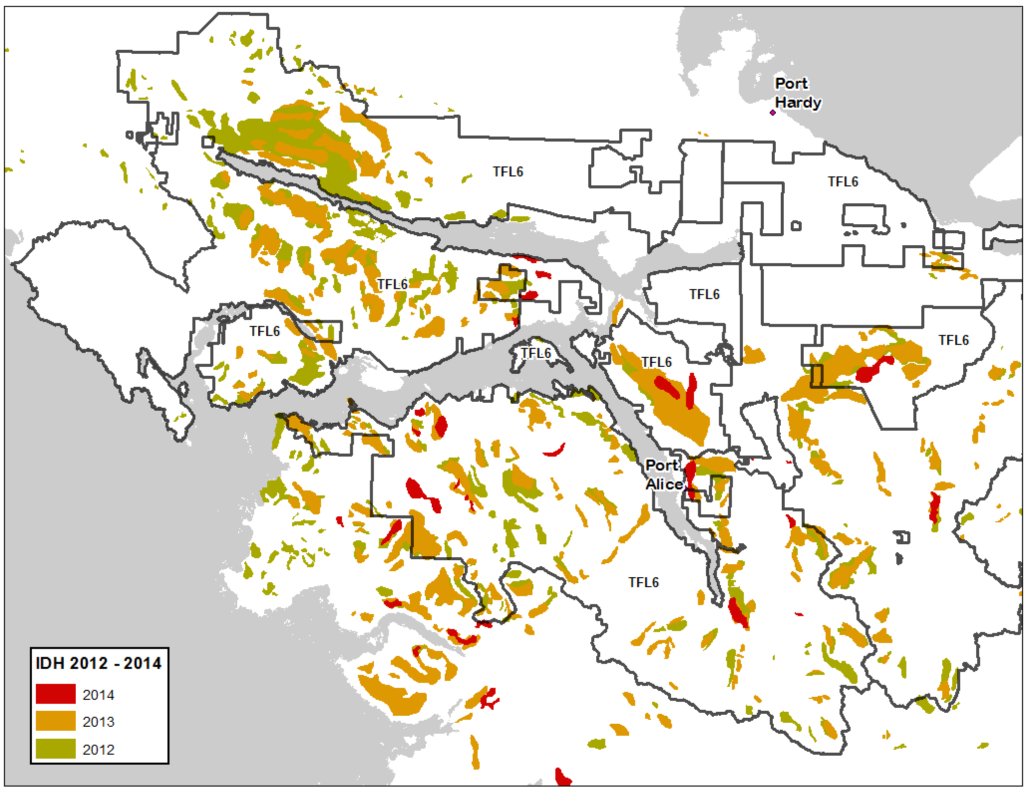

Figure 8. Distribution of western blackheaded budworm during the most recent outbreak in the Kingcome TSA.

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.

White Pine Blister Rust

White pine blister rust damage is not always visible during the aerial overview surveys, particularly if the infections have not killed the tree. However, surveyors often observe scattered damage throughout the range that the host trees grow. These are often recorded as spots or small scattered polygons. In 2010, several large polygons totalling 2,328 ha were mapped at trace intensity in the TSA. Although the damage occurred primarily as scattered single trees, damage was at a high enough level that recording spot infections was possible. These disturbances were located in the middle of Vancouver Island along the Nimpkish River north of Vernon Lake.

Windthrow

For TSR3, in the absence of any new studies, average annual losses to windthrow maintained the TSR2 assumption level at approximately 15 ha/yr with an average volume of 700 m^3/ha, for total un-salvaged loss of 10,500 m^3/year. Over the last four years, the AOS has mapped an average of 35 ha per year of windthrow. Although licensees are using windthrow assessments and extra care during block layout, it is possible that this estimate is now conservative considering the increased use of partial cutting and retention system harvesting, and the reality of increasing storm intensity related to climate change. There also remains some uncertainty as to how much windthrow can be salvaged.

Yellow-Cedar Decline

Yellow-cedar decline extends over 200,000 hectares in Alaska and the mortality has been mapped on over 95,000 ha of coastal BC. This decline is thought to be caused by changing climatic conditions, mainly early snowpack melt that leaves dehardening fine roots exposed to sudden late winter frost events. Yellow-cedar is susceptible to fine root mortality earlier than most other species and trees growing on shallow soils are particularly susceptible. Over recent years, the AOS of the mainland portion of the TSA has identified yellow-cedar decline in the several areas between Seymour and Kingcome Inlets, including the Parson Creek, Rainbow Creek and Clear River areas. In 2014, an additional 2227 ha of decline was mapped in the TSA. As the affected areas are not often suitable candidates for harvest or salvage, non recoverable losses should include an appropriate allowance for this in the next TSR.

Mid-Coast TSA

The Mid Coast TSA is situated on the central coast of BC and covers approximately 2.7 million hectares. It is bordered by the Kingcome TSA to the south, by Tweedsmuir Park to the east, and by the Fiordland Recreation Area, the Kitlope Heritage Conservancy Protected Area and Tree Farm Licence (TFL) 25 to the north.

The terrain in the Mid Coast TSA is variable and rugged. The outer coast portion of the TSA consists primarily of numerous low-lying islands and the outlying coastal mainland that support forests of relatively low productivity. The inner coast portion, further inland, consists of mountainous terrain, with very productive forests in the valley bottoms and along the many steep sided inlets, and with a large proportion of non-forested (alpine and subalpine) areas and ice fields at higher elevations.

Only a small portion of the total TSA area is forested (38 percent) and an even smaller portion is suitable for timber harvesting (12 percent). The productive forests are typically dominated by hemlock or balsam (65 percent) and western redcedar (25 percent), with minor proportions (about 5 percent each) of Sitka spruce and Douglas-fir. Most harvesting is confined to valley bottoms and valley sidewalls since much of the remaining land is either protected area or too rugged to support marketable timber.

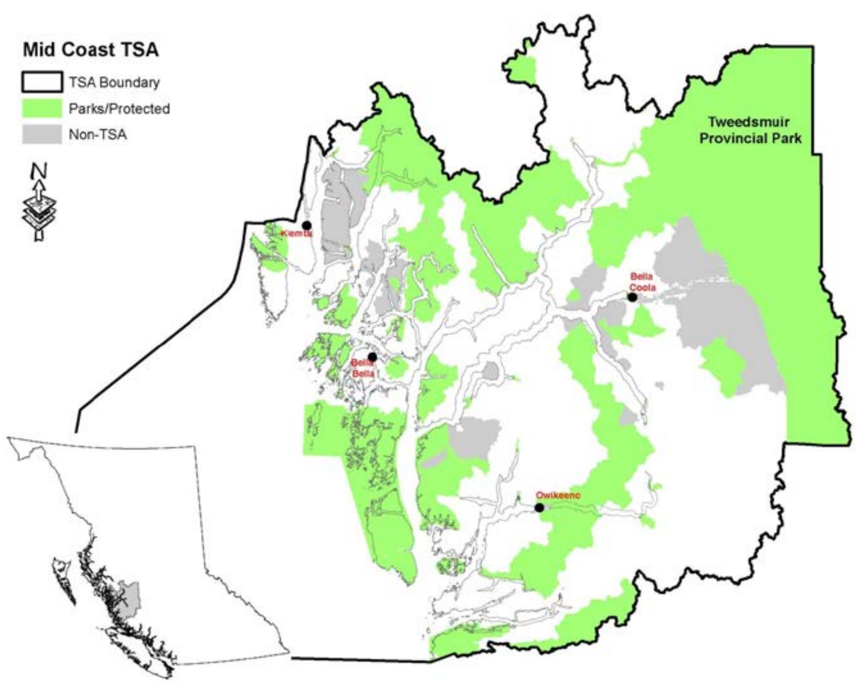

Figure 9. Mid-Coast Timber Supply Area

Aspen Serpentine Leaf Miner

This defoliator has been occurring more prominently in the TSA rising from 612 ha of mapped damage in 2012 to 8174 ha in 2014 with some of the defoliation being quite severe. Due to aspen being the most common species attacked, most of the damage is confined to Tweedsmuir Park and the far eastern portion of the TSA. Like most damage by defoliators, repeated attacks on the same tree will cause growth loss and, if persistent, mortality.

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, and Atnarko river valleys near Bella Coola. In 2003, 14 spots infestations were detected just southeast 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 all ages of hemlock is anticipated to rise significantly as the proportion of clearcut area is reduced. Partial cutting systems now account for about half of all coastal harvesting, and Ecosystem Based Management will likely mandate leaving many trees within cutblocks. Small clearcuts, helicopter logging, and dispersed retention are common practices in the Mid-Coast TSA. Unavoidably, a percentage of retained trees will be infected, and the parasite will have ideal conditions to spread to the surrounding understory. 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 activity 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. By 2003, populations decreased east of Dean Channel, with just over 8000 ha recorded. 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. Since 2008, the MPB has returned to endemic levels not considered problematic (Table 4, Figure 10).

Table 4. Annual comparison of hectares attacked by mountain pine beetle and balsam bark beetle in the Mid-Coast TSA

	Area Attacked (ha)			
	2011	2012	2013	2014
Mountain Pine Beetle	2803	208	0	45
Balsam Bark Beetle	4175	4210	8483	12,083

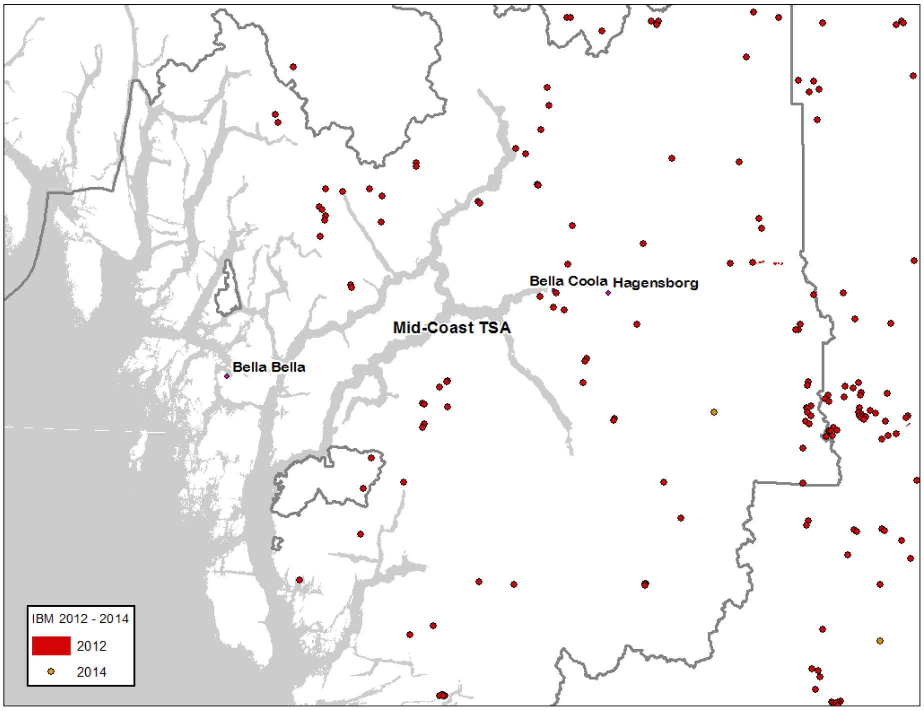

Figure 10. Recent infestation of mountain pine beetle in the Mid-Coast TSA.

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. Since, 2012 incidence levels have increased from around 4000 to over 12, 000 ha of mostly trace levels of endemic damage. Most of this loss is unsalvaged.

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 11).

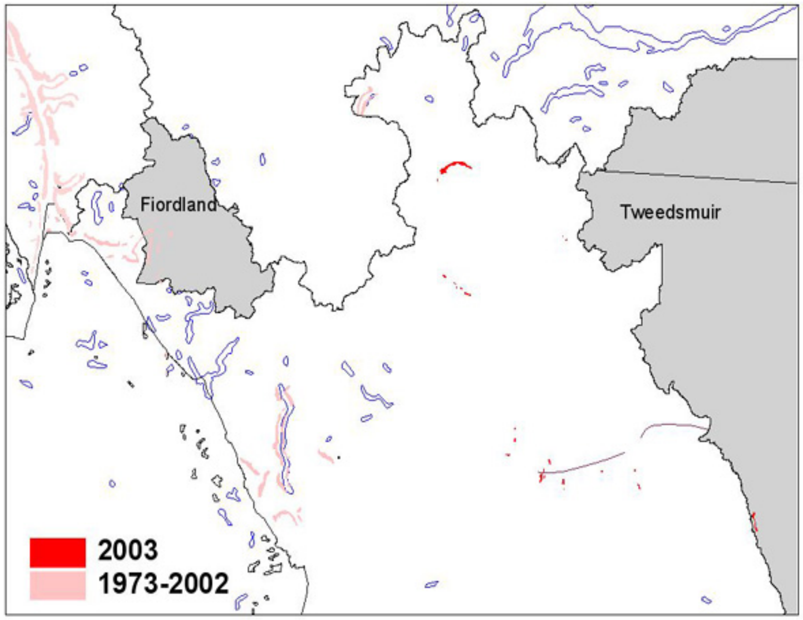

Figure 11. Area of historical blackheaded budworm defoliation and unknown 2003 defoliation in the Mid-Coast TSA.

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.

Yellow-Cedar Decline

Yellow-cedar decline extends over 200,000 hectares in Alaska and the mortality has been mapped on over 95,000 ha of coastal BC. This decline is thought to be caused by changing climatic conditions, mainly early snowpack melt that leaves dehardening fine roots exposed to sudden late winter frost events. Yellow-cedar is susceptible to fine root mortality earlier than most other species and trees growing on shallow soils are particularly susceptible. During a 2004 survey, yellow cedar decline was identified as far south as Cypress Lake on Banks Island in the North Coast Forest District. A follow-up 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. Further investigation has identified a band of mortality running through the TSA occurring roughly along the elevation boundary of the CWH vm1 and vm2 in the coastal maritime zone (Figure 12). For the most part salvage opportunities of the dead and dying material is limited, but could be undertaken where economically viable.

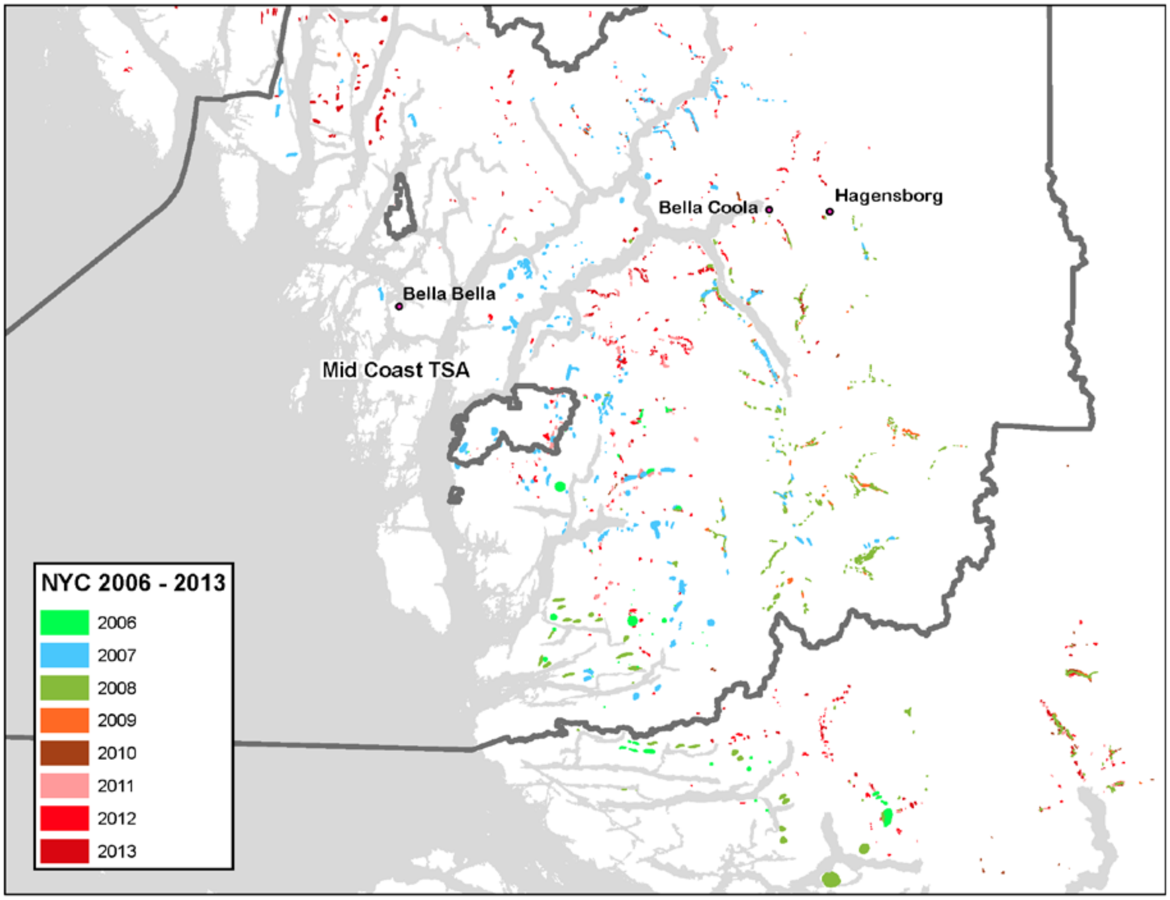

Figure 12. Annual record of occurrence of Yellow-cedar decline in the Mid-Coast TSA.

Queen Charlotte TSA

Haida Gwaii (formerly Queen Charlotte Islands) consists of more than 150 islands located approximately 90 kilometres west of British Columbia's north coast. The islands are divided into three physiographic units - the Queen Charlotte Ranges, the Skidegate Plateau and the Queen Charlotte Lowlands. The Islands have a total area of 1,018,000 hectares with parks and reserves accounting for 229,000 hectares (22%); tree farm license (TFL) areas, 324,000 hectares (32%); and the remainder, 465,000 hectares (46%) as TSA. The timber supply area is primarily located on the east and west sides of Graham Island, with a smaller portion on northwest Moresby Island.

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.

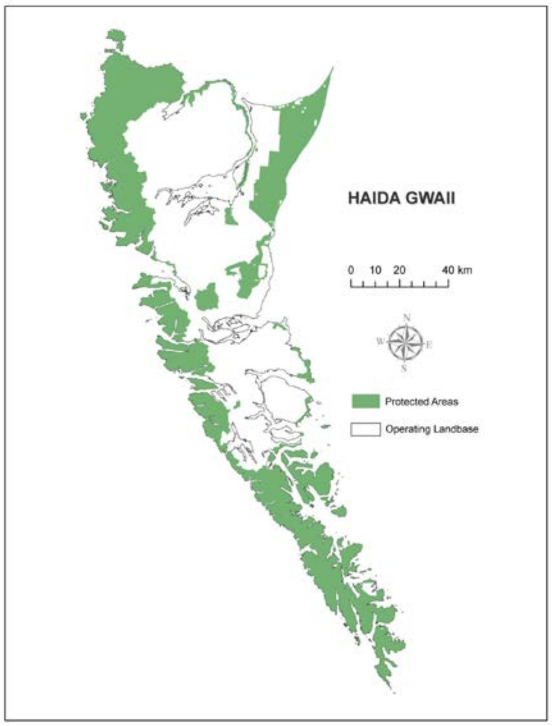

Figure 13. The Queen Charlotte Timber Supply Area.

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 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 Haida Gwaii, primarily on western redcedar. Recently, the lack of prompt removal of browse protectors on cedar saplings has resulted in increased stem defects as the protectors are not degrading quickly enough to guarantee unimpeded release of the tree. Efforts should be made to remove these protectors once trees are above browse height.

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. Losses to the aphid are assumed to result in a mortality rate of 10% based on Forestry Canada data.

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 14). 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 in 2001, with only 1500 ha mapped. It is interesting to note that many juvenile stands, especially those that had been thinned, were heavily defoliated which resulted in patch mortality. The most recent outbreak cycle ran from 2008 to 2012.

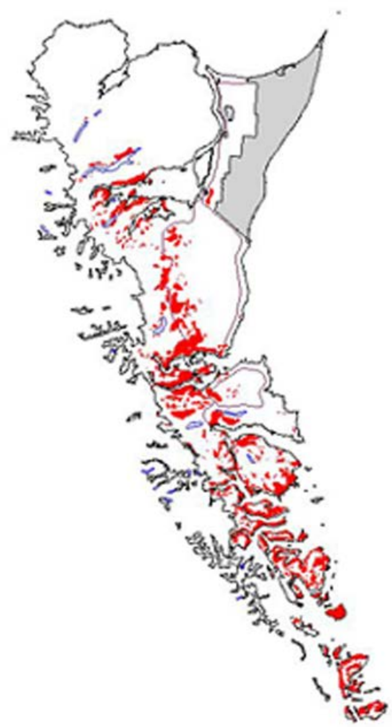

Figure 14. Area defoliated by western blackheaded budworm since 1973 in the Queen Charlotte TSA.

Cooley spruce gall adelgid

This insect has been introduced to Haida Gwaii on live Douglas-fir brought to the Islands. From the imported Douglas-fir it has spread to its alternative host, Sitka spruce, however, its occurrence on spruce is still very low. All Douglas-fir on Crown land have been removed but there are still live trees on private property.

Windthrow

Wind is a major disturbance agent in the TSA with an average of 1952 ha mapped each year from 2012-2014. However, a large portion of windthrow occurring on the operable land base is salvaged. A Ministry study of unsalvaged losses in the TSA estimate annual losses at 3800 m^3.

Yellow-Cedar Decline

Yellow-cedar decline extends over 200,000 hectares in Alaska and the mortality has been mapped on over 95,000 ha of coastal BC. This decline is thought to be caused by changing climatic conditions, mainly early snowpack melt that leaves dehardening fine roots exposed to sudden late winter frost events. Yellow-cedar is susceptible to fine root mortality earlier than other species and trees growing on shallow or wet soils are particularly susceptible. During a 2004 survey, yellow cedar decline was identified as far south as Cypress Lake on Banks Island in the North Coast Forest District. Until recently, the decline was not mapped on Haida Gwaii but the 2014 survey identified over 14,000 ha of trace to severe decline, mostly on the west side of Graham Island. For the most part salvage opportunities of the dead and dying material is limited, but could be undertaken where economically viable.

Soo TSA

The Soo TSA lies within the South Coast Region (Figure 15). The TSA closely corresponds to the drainages of the lower Squamish and Cheakamus Rivers, which flow into Howe Sound; and the Lillooet River, which flows into Harrison Lake. It is bounded on the west by TFL 38 and the Sunshine Coast TSA; on the north by the Lillooet TSA; and on the south and east by the Fraser TSA.

The total area of the Soo TSA is 909 519 hectares, of which 266 646 hectares are productive forest. The TSA includes many parks and protected areas, including nine new conservancies established since 2000 under the Sea-to-Sky Land and Resource Management Plan (LRMP). The terrain varies from rugged coastal mountains to the flat valley bottoms of the Lillooet River near Pemberton and the lower Squamish River. The major commercial tree species within the timber harvesting land base, in order of abundance, are Douglas-fir, amabilis fir (balsam), western hemlock, western redcedar, and Engelmann spruce.

The Soo TSA region has experienced one of the highest population growth rates in the province in recent years. Tourism is by far the largest employer; other important economic sectors include construction, forestry, and the public sector. One of the most significant changes in the Soo TSA since the last timber supply review was the April 2008 approval by the provincial government of the Sea-to-Sky LRMP. This plan provides current and future direction and guidance for the development of the entire district. Seven First Nations have asserted traditional territory that includes all or a portion of the Soo TSA.

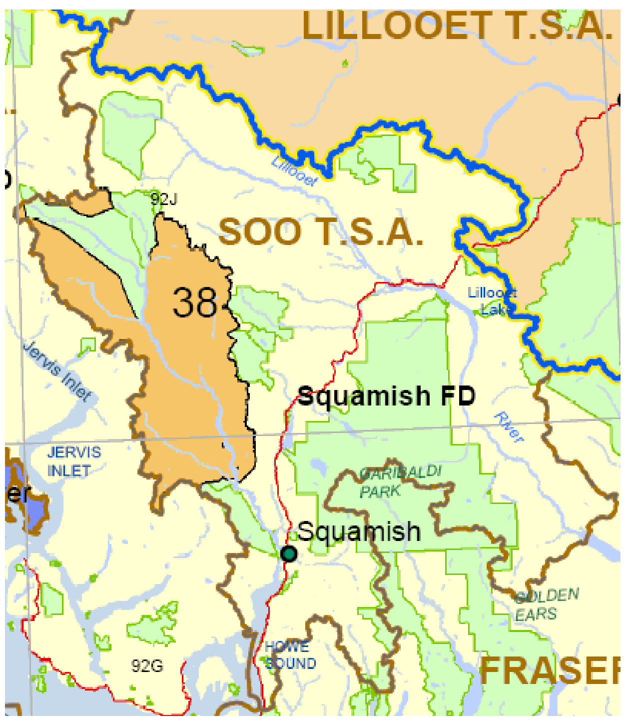

Figure 15. The Soo Timber Supply Area

Balsam Woolly Adelgid

An introduced pest, the balsam woolly adelgid has been recorded in the Whistler, Joffre and Hurley Pass areas. The Soo TSA is within the quarantine zone of the *Balsam Woolly Adelgid Regulation* that restricts movement of true firs to reduce the chance of spread to the interior of BC. Currently, there are no viable control treatments for forested areas.

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. Since 2004, the area affected by Douglas-fir beetle has been low but in 2014 240 ha were reported as attacked.

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 and 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). Areas affected by mountain pine beetle peaked at a high of 16,848 ha in 2007 and have decreased since. Total area attacked in 2014 was just under 200 ha.

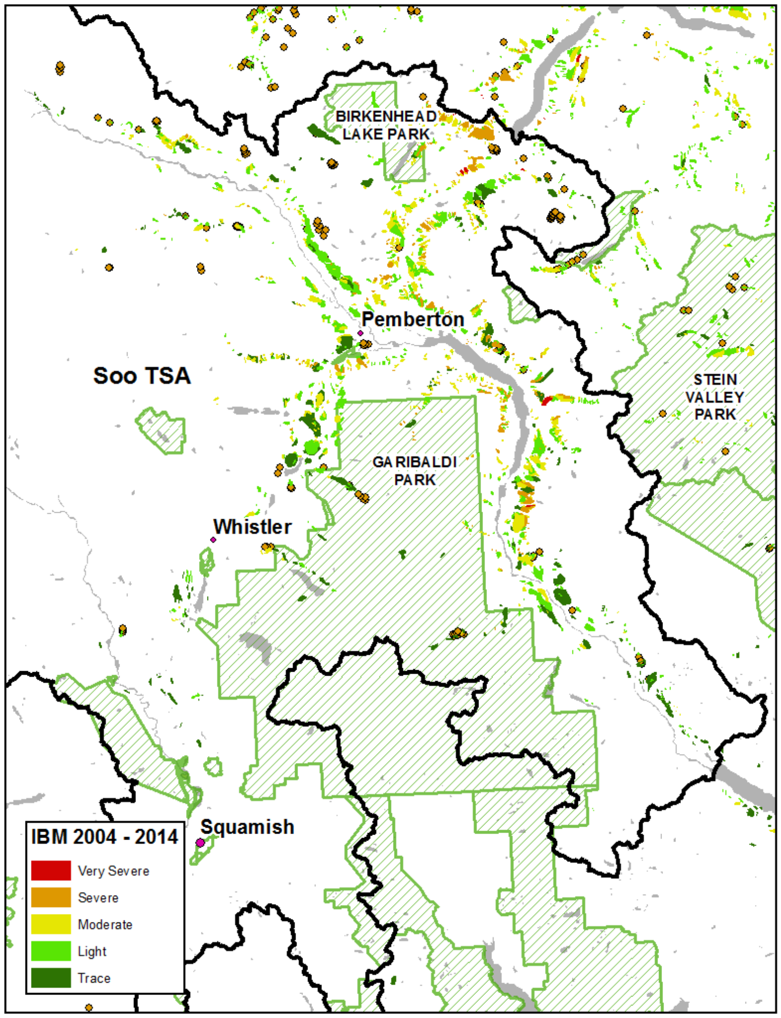

Figure 19. Area infested by mountain pine beetle in the Soo TSA from 2004 to 2014.

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 partially accounted for in the current TSR. The impact of root disease within transition zone forests is unclear. Some 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. In 2006, 832 ha of attack were recorded. The attack levels have since declined to a negligible amount.

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. Since then, a high level was recorded in 2007 (4545 ha) dropping to 434 ha by 2013 and rebounding to 6220 ha in 2014. Attack is usually scattered throughout forested areas and often is recorded as trace levels (<1% of the trees attacked). Control activities are not feasible for this insect.

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 occurring from 2003-2008. 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 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 4,000 ha of impact was noted in the 2006 survey, particularly in the Haylmore and Blackwater Creek areas. The amount of area recorded increased in 2007 to 18,702 ha then declined significantly, resulting in 708 ha recorded in 2009 and less than 100 ha since. As noted earlier, the historic elevational band ranges may change over time as a result of climate change. 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). More recent defoliation has occurred primarily in the CWHms1 (Figure 20).

Table 5. Total years and area (ha) of defoliation from 1943-2004 by biogeoclimatic unit 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

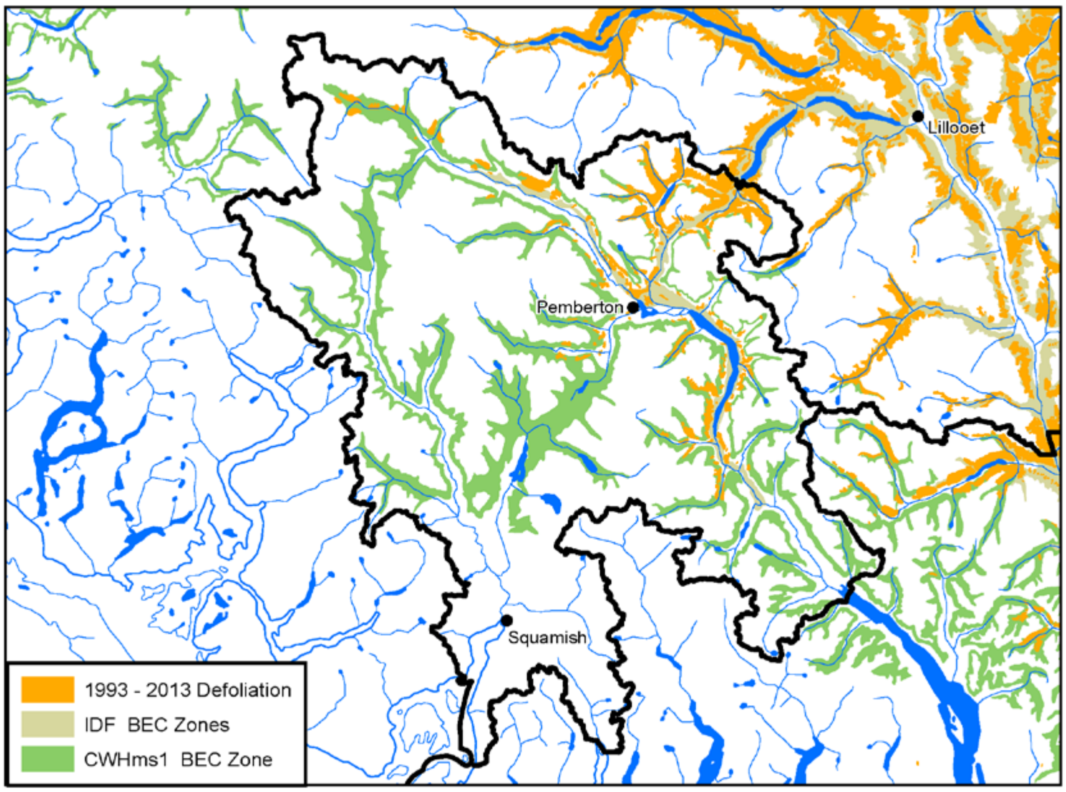

Figure 20. Area defoliated by western spruce budworm from 1993-2013 in the Soo TSA.

Strathcona TSA

Extending across central Vancouver Island from the west coast (Nootka Sound to the Brooks Peninsula) to the east coast (Fanny Bay to Sayward) and adjacent areas on the coastal mainland and islands of British Columbia, the Strathcona TSA covers approximately 407,000 hectares (Figure 16). In the previous timber supply analysis, the total productive forest area in the TSA was reported to be approximately 347,000 hectares, of which less than half was considered suitable and available for timber harvesting. The TSA comprises three timber supply blocks (TSB): the Kyuquot on western Vancouver Island, the Sayward on eastern Vancouver Island and the Loughborough on the mainland. A significant number of large provincial parks, including Strathcona, Tahsish-Kwois and Brooks-Nasparti are located partially or wholly within the boundaries of the TSA.

The TSA overlaps three biogeoclimatic zones: the Coastal Western Hemlock (CWH), Mountain Hemlock (MH) and Coastal Mountain-heather Alpine (CMA), in a mosaic of wet, mountainous terrain bisected by streams and rivers. Species of particular management concern are those that rely on the characteristics of old-growth forests because these stands may become fragmented as these forests are harvested and converted to younger stands and loss of habitat may occur.

The most recent economic dependency estimates show that the main sources of employment in the Strathcona TSA are the public sector, tourism and forestry. In 2006, the forestry and forest manufacturing sector accounted for about 16% of the employment in the district. Since then, there have been permanent closures of the Catalyst Elk Falls pulp and paper mill and the TimberWest Elk Falls sawmill in Campbell River and the Interfor Field sawmill in Courtenay.

The chief forester last determined the AAC on July 28, 2005, setting it at 1 217 000 cubic metres effective August 1, 2005. On December 9, 2005, he temporarily reduced the AAC by 16 000 cubic metres under Section 173 of the *Forest Act* to account for the establishment of the Maa-nulth Designated Area. On April 1, 2011 the Maa-nulth Treaty took effect and the Maa-nulth Designated Area was repealed to become Maa-Nulth Treaty Settlement Lands. The AAC reverted to 1 217 000 upon repeal of these designated areas.

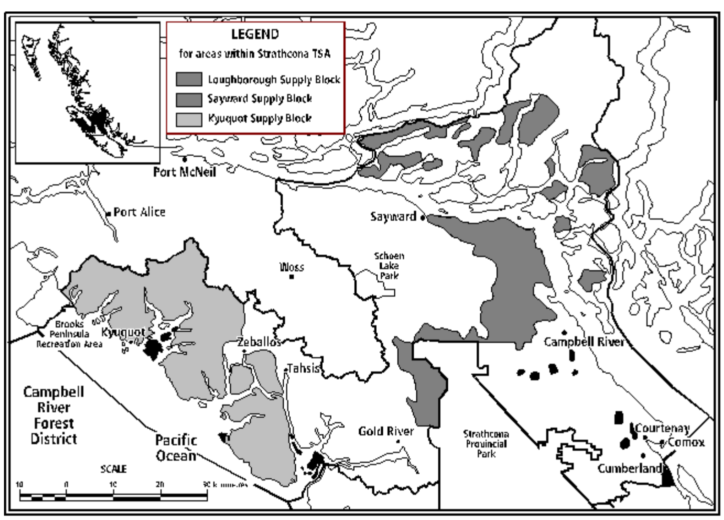

Figure 16. The Strathcona Timber Supply Area.

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 17). Approximately 330 ha were salvage harvested.

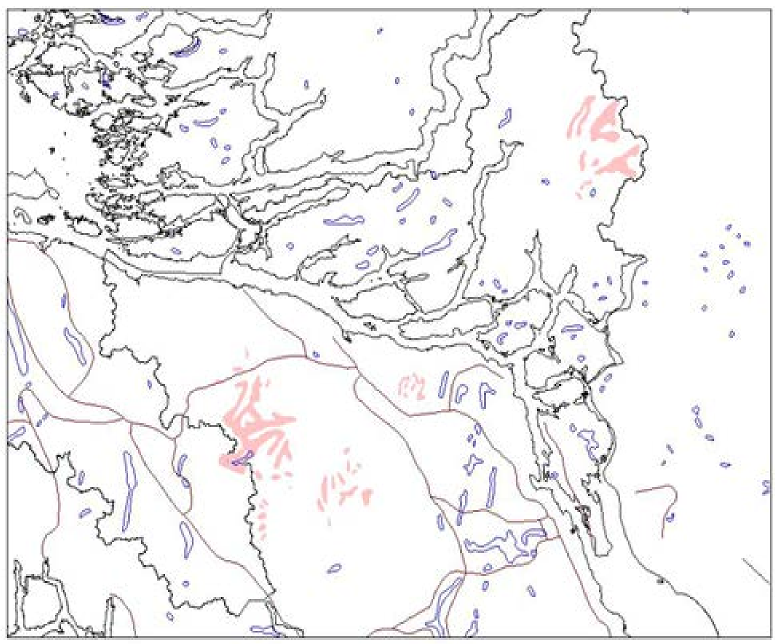

Figure 17. Area defoliated by conifer sawflies in 1996 near Schoen Lake Park and in the Phillips River drainage on the mainland.

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 but no further mortality was reported.

Root Disease

Laminated root rot occurs throughout the drier regions of the Strathcona TSA, primarily in young Douglas-fir stands 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 primarily 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 shoreline, 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 18). The resulting impacts however were considered to be minor. In 2103, 1330 ha of light to moderate budworm damage was noted, primarily in the Banks Peninsula area, but that has since dropped to less than 200 ha in 2014.

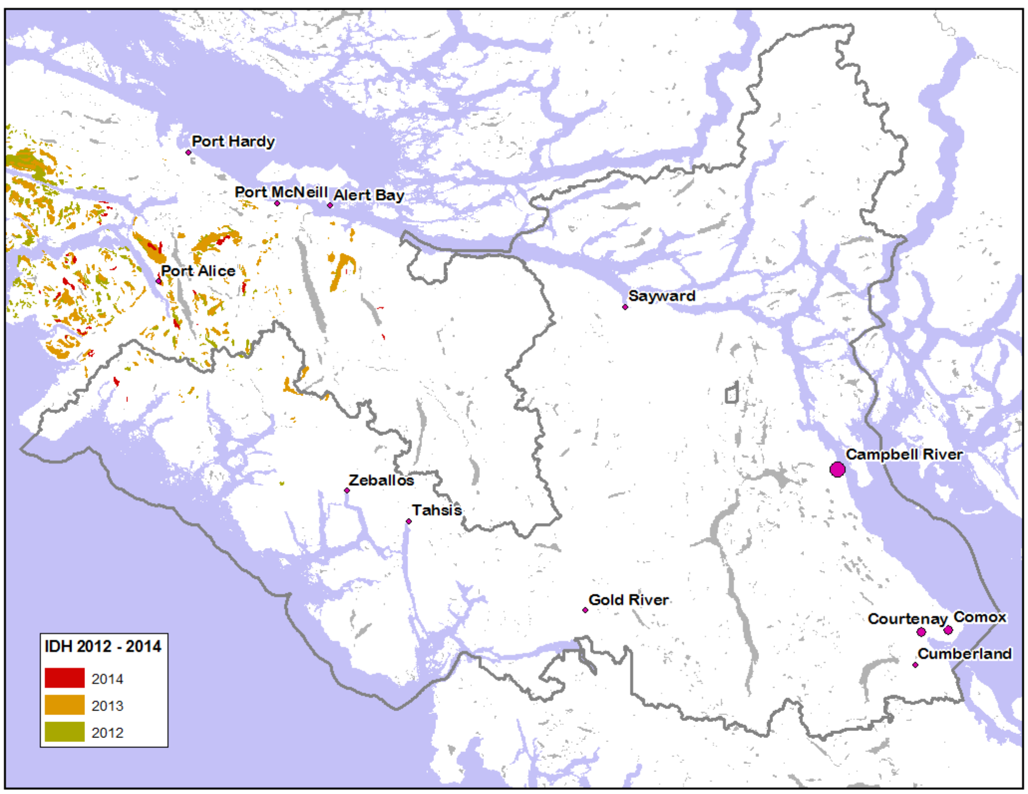

Figure 18. Area defoliated by western blackheaded budworm during the most recent outbreak on the northern Vancouver Island.

Windthrow

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

Sunshine Coast TSA

The Sunshine Coast TSA comprises approximately 1.5 million hectares along the southwest coast of British Columbia. The TSA is bordered by the Fraser TSA to the south, the Soo TSA to the east, the Strathcona and Kingcome TSAs to the west and the Williams Lake TSA to the north (Figure 19). It is also adjacent to portions of TFL 39 and TFL 43. The landscape of the Sunshine Coast TSA is dominated by the Coast Mountains and several coastal fjords, most notably Bute, Toba and Jervis Inlets. The landscape ranges from nutrient rich, moist floodplains in the valley bottoms to alpine meadows. About 28 percent of the land base of the TSA is considered to be productive forest land managed by the Province, of which just over half is considered to be available for timber harvesting.

The forests of the TSA are diverse, and about half of the forests on the THLB are considered to have medium or good site productivity. Major tree species include Douglas-fir, hemlock and amabilis fir (balsam), while other species such as western redcedar, spruce, pine, alder, and cottonwood also occur. The forests of the TSA have a long harvesting history, and as a result there are rapidly maturing second-growth forests on the lower elevation, more accessible and higher productivity growing sites. Nearly half of the stands on the THLB are between 21 and 100 years of age.

The chief forester last determined the AAC in November 2011 and it now is set at 1,197, 949 cubic metres effective January 16, 2012. The AAC contains a partition of 98 000 cubic metres for deciduous-leading stands and 1 121 949 cubic metres for conventional (coniferous) stands.

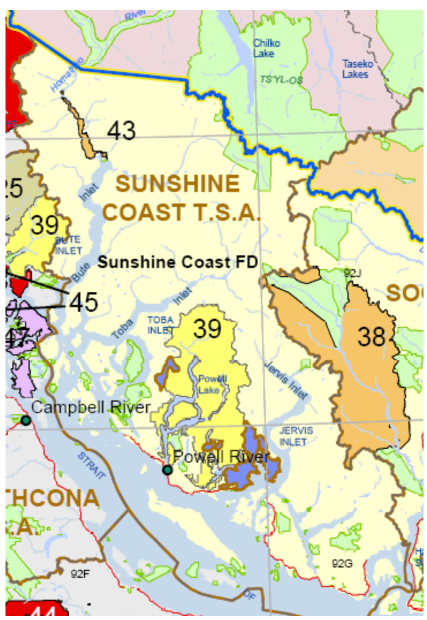

Figure 19. The Sunshine Coast TSA.

Balsam Woolly Adelgid

BWA has spread into the Sunshine Coast TSA. It has been confirmed in four sites north of Jervis Inlet. The TSA is included in the *Balsam Wooley Adegid Regulation* quarantine area along with the rest of the region.

Bear

Black bear damage and volume loss has increased within the Ramsay Arm, Quatam River and lower Toba Inlet over the past 10 years. Larger diameter Douglas-fir has been damaged and killed within the Quatam River area. A flight in 2011 revealed trees of over 40 centimetres in diameter and over 25 metres in height have been killed. Damage in younger managed stands has increased and mortality levels are over 40% in some plantations. Another consideration is decay within damaged trees and long term implications. Some of the early damaged juvenile spaced stands are showing mortality from decay. Wounding from bear damage has weakened the stem, with wind and snow resulting in breakage, killing the tree, projected to contribute future volume loss.

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. In the last few years, 400 to 800 ha of damage are reported annually. Since 2011, trap tree baiting and removal is used to reduce beetle populations near Powell River and on the Sechelt Peninsula.

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

Laminated root rot 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 and BC Timber Sales completed salvage of about 70,000 m^3 by 2007. A looper monitoring program was established in the Rainy River drainage in 2009 at the results to date show that the looper population remains at endemic levels.