British Columbia Ministry of Forests

Forest Health Strategy

2024-27 Coast Area

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Cover photo: Windthrow Robson Bight 2021

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Introduction

Healthy forests are described as those which are resilient to disturbances, sustainable over the long-term, and able to provide for a variety of resource needs and demands. This Forest Health Strategy provides background and advice for forest health management in the Coast Area of British Columbia incorporating both the West Coast and South Coast Natural Resource Regions by:

- Identifying damaging agents by bio-geoclimatic subzone (BEC) that have the potential to impact forest resources;
- Outlining strategies and tactics to mitigate both short and long-term forest health risks for high hazard forest health factors;
- Outlining the recoverable and non-recoverable losses (NRLs) used in the last timber supply reviews (TSRs);
- Discussing forest health in the context of climate change;
- Outlining regional forest health activities and priorities; and
- Describing historical forest health factor trends based on annual aerial overview surveys.

Provincial Forest Health Program

The aim and scope of the provincial forest health program is outlined in the *2023-2026 Forest Health Strategic Plan*[1]. The plan vision is to "remain leaders in proactive and targeted reactive forest health management". The six goals of the plan are to:

1) Promote healthy forests;
2) Incorporate forest health principles and knowledge into guidance, policy and legislation;
3) Modernize forest health data management knowledge and decision support tools;
4) Deliver effective and efficient management of forest pathogens and insects, and of climate change impacts;
5) Adopt a business model that supports proactive and reactive program priorities and operational activities;
6) Foster a learning culture of professional development and continuous improvement.

This regional forest health strategy outlines the regional activities that will be pursued as part of the Ministry of Forests' (the Ministry's) business plan and is intended to inform district priorities. These activities arise from the provincial forest health strategy and local priorities. Included is a synopsis of most coast-specific forest health factors presented as a series of profiles and a historical summary of major abiotic, insect and pathogen activity by timber supply area (TSA).

BC Forest Health Legislation and Policy

Forest Health legislation is summarized on the government website[2]. The *Forest and Range Practices Act* (FRPA) sets the context in which forest management is conducted in British Columbia. In 2002, the

[1] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/fh-strategies/fh_strategic_plan_2023_final.pdf
[2] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-health-legislation

replacement of the previous "directive" regime under the *Forest Practices Code Act* with a "results-based" system under FRPA which is based on the principle of professional reliance, lead to significant changes in the planning for forest health in
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. FRPA has recently undergone significant changes, whereby FSPs will eventually be replaced by Forest Landscape Plans (FLPs), currently being negotiated for some areas of the Province between government, indigenous peoples and forest and range license holders. Under an FLP, forest license holders will be required to develop forest operational plans (FOPs) that are consistent with FLPs and higher level plans. FLPs must consider 5 legal objectives[3], one of which is "preventing, mitigating and adapting to impacts caused by significant disturbances to forests and forest health including wildfire, insects, disease, and drought".

Currently the only approval test for forest health in an FSP is with regards to stocking standards. This has not always proven to be a very effective tool for ensuring forest health concerns are adequately addressed in forest operational plans. Under FRPA section 26, the Minister has sweeping powers to direct private landowners and public agreement holders to conduct remedial forest health control activities if the Minister determines that damage is being done to the provincial forest. However, this section has rarely if ever been officially exercised.

Provincial forest health policy requires each resource district to produce a forest health strategy[4] that covers each TSA within their district or region. These strategies specify forest health conditions, issues, and options to:

- shape TSRs and operational plans;
- guide forest health investments;
- link to higher level strategies;
- provide current estimates of NRLs;
- identify key forest health issues; and
- provide recommendations for adapting to potential forest health risks driven by climate change.

These plans have no legal status under current BC forest legislation. This document is the regional strategy for the West Coast and South Coast Natural Resource Regions.

Area Covered by this Strategy

This strategy covers forested Crown land contained within the Coast Area (Figure 1). The Coast Area consists of two Natural Resource Regions (South Coast and West Coast) and is composed of nine TSAs: Arrowsmith, Fraser, Great Bear Rainforest (GBR) North, GBR South, North Island, Haida Gwaii, Pacific, Soo and Sunshine Coast (Table 1). The GBR North and Pacific TSAs are shared with the Skeena Natural Resource Region. This strategy includes, but does not specifically address, parks,

[3] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-landscape-plans/flp_faq.pdf
[4] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-health-strategies

protected areas and Tree Farm Licence (TFL) lands within the Coast Area. Individual TFL planning documents should be consulted for local information on forest health history and risks within those tenures.

Figure 1. West Coast and South Coast Natural Resource Regions and Ministry 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	Natural Resource District (Administrative office locations)
Arrowsmith	South Island (Port Alberni)
Fraser	Chilliwack
GBR North	North Island (Port McNeill) and Coast Mountains (Terrace)
GBR South	North Island (Port McNeill) and Campbell River
Haida Gwaii	Haida Gwaii (Daajing Giids)
North Island	North Island (Port McNeill) and Campbell River
Pacific	Shared between West Coast, South Coast and Skeena Natural Resource Regions (covers BC Timber Sales operating areas)
Soo	Sea-to-Sky (Squamish)
Sunshine Coast	Sunshine Coast (Powell River)

High hazard forest health factors by BEC variant

Most recent forest health survey data for the coast comes from Reporting Silviculture Updates and Land Status Tracking System (RESULTS) forest health data, Forest and Range Evaluation Program (FREP) Stand Development Monitoring (SDM) surveys, Change Monitoring Inventory surveys (CMI), and Annual Aerial Overview Surveys (AOS). The method of forest health data collection in each one of these surveys is discussed below.

RESULTS forest health data

The percentage of live and dead total trees that do not meet the appropriate free growing damage criteria are recorded for silviculture survey plots[5]. This information ensures that trees counting towards free growing meet the definition of a healthy well spaced tree. The damage criteria were developed with the intent that damaged trees would not likely contribute to merchantable volume at rotation age. The ability of surveyors to identify forest health damage agents is highly variable and generally lacking good quality control checks to ensure the accuracy of the reported forest health data.

Stand Development Monitoring Surveys

SDM surveys record forest health damage as part of the timber value as part of FREP. Older surveys (SDM1.0) used damage criteria developed for post-free growing stands, but more recent surveys (SDM2.0[6]) record incidence and severity similarly to CMI plot data covered in the next section. These surveys are usually completed by resource district staff. Unfortunately, few SDM surveys have been completed for the Coast. Both RESULTS and SDM surveys are examples of stand level surveys which are designed to provide information on a stand.

CMI forest health data

CMI plots[7] are intended to provide landscape-level inventory data. They are not meant to evaluate conditions within an individual stand. These permanent sample plots use systematic sampling to collect inventory and growth and yield information. They are selected based from the National Forest Inventory[8] (NFI) 20 km x 20 km plot grid. Young stand monitoring (YSM) plots are a subset of CMI plots that target stands 15-50 years old. They use a grid formed by subdividing the NFI grid into smaller grid cells (usually 5x10 km) to increase the number of samples. These surveys record both forest health incidence and severity. The surveys are contracted out by the Forest Analysis and Inventory Branch (FAIB) and have the advantage of stable funding, good quality control and data management standards. Because systematic sampling is used, confidence intervals for forest health incidence may be calculated. In the past, the forest health data collected by FAIB was not always well summarized, but the forest health program is actively working with FAIB to provide better summaries of forest health data. Appendix B shows a summary of YSM forest health data by BEC

[5] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/silviculture/silviculture-surveys/2023-silv_survey_procedures_manual-_final.pdf
[6] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/frep/frep-docs/sdm_v2_protocol_september_11_2018.pdf
[7] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-inventory/ground-sample-inventories/provincial-monitoring
[8] https://open.canada.ca/data/en/dataset/35c3556c-e48d-41a7-ac50-652257b0a8e8

subone and variant for the coast. This survey data supports estimates of forest health impacts for a TSA or BEC unit.

AOS Survey

The Ministry undertakes an annual AOS of the province for all detectable forest health agents. This survey is usually conducted across all 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[9]. Aerial survey results are incorporated into the annual provincial report *Summary of Forest Health Conditions in British Columbia*[10].

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 tree diseases. However, although under-reported, the overall distribution and impact of diseases in the Coast Area usually exceeds that of insects. A summary of the historical information regarding forest health outbreaks for each TSA in the Coast Area based on AOS data is available in Appendix A.

Other Forest Health Surveys

There are various forest health monitoring projects in the Coast Area. For example, the South Coast Natural Resource Region has white bark pine monitoring plots tracking these high-elevation trees and baited traps are deployed to track Douglas-fir beetle activity following large wildfires. 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. There is also a network of plots in some Coastal Western Hemlock (CWH) subzones that monitor the impact of Swiss needle cast disease.

Forest health data from each of these sources has its own specific uses and limitations based on the age of the stands sampled, the survey methodology used, and the way in which forest health data was collected (Table 1). The associated forest health data is sometimes incomplete, difficult to access or not specifically organized for forest health enquiries. Thus, extracting useful data for large scale forest planning is often difficult or requires familiarity with data bases.

Table 1. Comparison of different types of surveys that collect forest health monitoring information.

Survey	Sample Population, and selection method	Strengths	Weakness
RESULTS	all regenerated stands for which ground	-large data source -stand level survey	-Some licensees use ocular assessments from roadsides, drones

[10] https://www.for.gov.bc.ca/ftp/hfp/external/!publish/aerial_overview/data_stds/aos%20standards%202019.pdf

[10] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/aerial-overview-surveys/summary-reports#Forest-health-conditions

	surveys were conducted -stands generally between 7-20 years of age	-data collected on species, density, and forest management activities	or helicopters to conduct free growing survey, which prevents the collection of detailed forest health information -Incidence is based on the number of trees that had severity above a predefined threshold -concerns over reliability of forest health information -difficult to access forest health information from multiple stands
SDM	Varies based on specific survey objectives and when surveys were done.	-allows Ministry staff to become familiar with forest health conditions in the field	-reliant on availability of in-house Ministry staffing resources -limited number of surveys conducted on coast
CMI/YSM	Systematic sampling based off the 20x20 km NFI grid -YSM plots are 15-50 years of age and use a smaller grid size than that used for NFI plots (usually 5x10 km)	-standardized program with stable funding, and good quality control and data management protocols -good for collecting landscape level forest health data -repeated measurements over time -both incidence and severity recorded	-most surveys on the coast require helicopter access (expensive) -not good for assessing forest health at the individual stand level
AOS	80-100% of all forested land	-good record of mortality agents visible from an airplane over time - stable funding	Only good for detecting forest health factors visible from the air -limited ground verification and quality control -requires good visibility

Defining hazard and risk

The terms hazard and risk deserve attention, as they are not synonymous. Hazard in the literature is often used as the favourableness of the particular site for the development of the forest health factor.

It is the probability that a tree in a broad geographic area will be affected by a particular forest health factor.

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 forest health factors reduces host growth, reproduction and survival sufficiently to impact economic or ecological objectives. Risk takes into account proximity in time and space to a particular forest health factor. For some forest health factors such as root diseases and dwarf mistletoes, determining risk requires a site assessment for the presence of these factors. For some forest insects risk assessment may require knowledge about the timing and frequency of outbreaks.

Current high hazard forest health factors are listed by BEC (Table 2). Table 3 indicates which BEC variants are present in each TSA. These hazard ratings are based on a combination of currently available forest health survey data in published and nonpublished reports and other data sources, combined with expert opinion. Hazard for biotic factors is based on the most susceptible tree species affected. These ratings do not always agree with other hazard ratings available in earlier publications. What constitutes low, moderate, or high hazard is somewhat subjective. The hazard ratings in the table were based on the best available current survey data which may change as new high hazard forest health factors emerge or better forest health monitoring data becomes available.

The hazard ratings presented here supersede earlier hazard ratings available in Section 6.6 of Land management Handbook 28 (Green and Klinka 1994)[11] and within forest health-specific reference publications like the Stand Establishment Decision Aids (SEDA) published by FORREX in the *Journal of Ecosystems and Management*[12]. For use in conjunction with some host specific SEDAs, some information about hazard and risk in reforestation is provided in the *Reference Guide for FDP Stocking Standards* located on the Ministry website[13]. This guide is updated periodically to reflect changes in forest health considerations when certain species are used for reforestation in specific BEC units. Forest health hazard by trees species and BEC can also be found on the By-BEC portal[14]. These tables take into account forest health hazard by tree species.

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11 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. https://www.for.gov.bc.ca/hfd/pubs/docs/Lmh/Lmh28.pdf

12 https://jem-online.org/index.php/jem/issue/archive.

13 Stocking Standards - Province of British Columbia (gov.bc.ca).

14 https://thebeczone.ca/shiny/bybecmap/

Table 2. High hazard forest health factors by BEC variant.

FH factor	CDFmm	CWHdm	CWHds1	CWHds2	CWHmm1	CWHmm2	CWHms1	CWHms2	CWHvh1	CWHvh2	CWHvh3	CWHvm1	CWHvm2	CWHwh1	CWHwh2	CWHws2	CWHxm1	CWHxm2	ESSFdc2	ESSFmc	ESSFmk	ESSFmw	ESSFmw1	ESSFmw2	ESSFxv1	IDFdk2	IDFdw	IDFww	IDFww1	MHmm1	MHmm2	MHdm2	MHwh	MHwh1	MSdc2	MSxv	SBPSmc	SBPSmc2
Deer											H			H	H																							
Snow or Ice Breakage			H				H												H	H		H																
Yellow-cedar Decline								H		H		H	H	H	H															H				H				
Drought	H	H															H	H																				
Frost Crack																														H								
Windthrow									H		H			H	H	H																						
Snow or Ice Damage			H				H	H																						H								
Dothistroma Needle Blight		H	H	H	H	H	H	H	H	H	H	H	H	H	H	H																						
Cedar Leaf Blight									H	H	H		H	H	H			H																				
Swiss Needle Cast		H															H	H																				
Poplar Leaf Blight																H																						
Hemlock Dwarf Mistletoe		H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H																				
Armillaria	H	H	H		H	H	H	H									H	H								H		H										
Black Stain																	H	H																				
Laminated Root Rot	H	H	H		H	H	H	H									H	H										H										
Rhizina Root Disease		H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H																				
White Pine Blister Rust		H	H		H	H	H					H	H				H	H					H															
Balsam Wooly adelgid					H																																	
Spruce Aphid											H			H																								
Basam Bark Beetle			H	H	H			H								H			H	H	H	H	H	H	H													
Douglas-fir Beetle			H				H																					H	H									
Spruce Beetle																H					H	H																
Mountain Pine Beetle			H	H																			H	H				H										
Black Army Cutworm						H							H																									
Black Headed Budworm									H	H		H		H		H																						
Hemlock Looper		H										H																										
Conifer Sawfly						H							H																									
Western Spruce Budworm			H				H																					H										
Spruce Terminal Weevil	H	H	H	H	H		H	H				H					H	H					H	H				H			H							

Table 3. BEC variant by TSA.

TSA	CDFmm	CWHdm	CWHds1	CWHds2	CWHmm1	CWHmm2	CWHms1	CWHms2	CWHvh1	CWHvh2	CWHvh3	CWHvm1	CWHvm2	CWHwh1	CWHwh2	CWHws2	CWHxm1	CWHxm2	ESSFdc2	ESSFmc	ESSFmk	ESSFmw	ESSFmw1	ESSFmw2	ESSFxv1	IDFdk2	IDFdw	IDFww	IDFww1	MHmm1	MHmm2	MHdm2	MHwh	MHwh1	MSdc2	MSxv	SBPSmc	SBPSmc2
Fraser	x	x	x				x					x	x				x		x				x	x		x		x	x	x	x	x						
Soo		x	x				x					x	x											x				x		x	x							
Sunshine Coast	x	x	x		x		x					x	x				x	x				x								x	x							
Haida Gwaii											x			x	x																		x					
GBR North WCR				x				x	x	x		x	x			x				x	x	x			x		x	x		x	x			x	x	x	x	x
GBR South		x		x	x				x			x	x			x	x	x				x						x		x	x							
North Island					x	x			x			x	x				x	x												x	x							
Arrowsmith	x				x	x			x			x	x				x	x												x								

Strategies for dealing with forest health factors

The following management strategies are recommended for the mitigation of losses from forest health factors listed as high hazard in Table 2. They are grouped by common association (e.g., root diseases, defoliators) and then alphabetically within each group.

For each damaging agent a brief description of recommended management strategies is provided with more detailed references on the biology (for biotic disturbance agents) and management listed in the References. Additional detailed forest health information is available on the Ministry forest health website[15]. Historical information on forest health factor occurrence by TSA based on historical annual aerial overview survey data is provided in Appendix A.

General references for field identification of damaging agents includes:

- 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.[16]

Additionally, there have been revisions to guidance around managing dwarf mistletoes (Land Management Handbook 73 2019)[17] and root diseases (Managing root disease in British Columbia. 2018)[18].

Abiotics

Drought and Heat Stress

Impact

In recent years, high levels of drought mortality and foliage loss have been detected in the annual AOS (see link under forest health monitoring surveys), particularly on eastern Vancouver Island and the Gulf Islands. Poor planting survival is beginning to become a problem in some coastal areas during drought years. Drought can cause foliage loss, top and branch dieback, mortality, and predispose trees to attack by biotic forest health factors such as bark beetles. Heat stress from heat domes, although often associated with droughts, has different physiological effects on trees. Heat stress can occur even in the absence of drought conditions. Temperatures above a critical temperature threshold (the thermal tolerance threshold) will cause irreversible damage to the photochemistry

[15] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health

[16] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/forest-health-docs/field_guide_to_forest_damage_in_bc_web.pdf

[17] https://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/LMH73.pdf

[18] Root diseases — Management - Province of British Columbia (gov.bc.ca).

involved in photosynthesis. Following the 2021 heat dome, needle mortality was observed on many conifers. On Douglas-fir, most of this needle loss was on the previous year's needles.

The standardized precipitation evapotranspiration index (SPEI) is a widely accepted method of summarizing drought conditions that is calculated based on current and historical precipitation and temperature. You can view current and historical maps of drought index for different parts of the world using the global drought monitor[19] available on the internet.

Management

Strategies for managing for drought include selecting more drought resistant species, managing to lower densities, thinning, and switching to alternative silviculture systems to provide greater shading and promote natural regeneration. Planting strategies include using larger stock types with increased root to shoot ratios. Avoiding clear cutting on drought sensitive sites with shallow soils and southern exposures or retaining these areas as wildlife tree patches could potentially avoid future regeneration problems and reduce potential soil loss. Most drought tolerance mechanisms tend to lower yield potential (Pita 2005). This suggests that genetically improved stock and pioneer species with fast growth rates may be more susceptible to drought. Facilitated migration of trees from drier to wetter climates may increase future drought tolerance but comes with the potential for increasing susceptibility to certain diseases which are less of a problem in drier habitats. Trees that can tolerates summer drought may not be well adapted to areas that experience high amounts of winter precipitation. Fertilizer treatments that promote above ground growth over root growth could have a potentially negative impact on drought tolerance.

Priority and Research

There is a need for tree improvement programs to put more emphasis on screening for drought tolerance particularly for some of the more drought tolerant tree species. There is also a need to set up permanent plot network (with weather stations) specifically designed to study the long-term impacts of drought across a variety of BEC units. More work is also needed to study the effects of thinning and managing to lower densities on drought tolerance and the interaction between drought stress and secondary biotic forest health factors such as wood bores and some canker pathogens.

Further Reading

Clark, J.S., L. Iverson, C.W. Woodal and C.D. Allan. 2016. Impacts of increasing drought on forest dynamics, structure, diversity, and management. In Effects of Drought on Forests and Reangelands in the United States: A comprehensive Science Synthesis pp.59-96.

Marias, D.E., F. Meinzer, D.R. Woodruff and K.A. McCulloch. 2017. Thermotolerance and heat stress responses of Douglas-fir and ponderosa pine seedling populations for contrasting climates. Tree Physiology 37(3):301-315.

Pita, P., I. Canas, F. Soria, and G. Toval. 2005. Use of Physiological traits in tree breeding for improved yield in drought-prone environments. The case Of *Eucalyptus globulus*. Invest Agrar: Sist Recur For 14(3) 383-393.

[19] https://spei.csis.es/index.html

Fire

Fire has become one of the most important forest health factors in recent years. British Columbia is experiencing a serious and sustained increase in extreme wildfire behaviour and fire events particularly in the wildland-urban interface. At the same time, the impacts of climate change are increasing, fire size and severity are increasing, and fire seasons are becoming longer.

Fire hazard assessments and hazard abatement are key activities in reducing the potential threat of wildfires arising from fuels left on the land base following industrial activities. Under the *Wildfire Act* a person carrying out an industrial activity or prescribed activity is required to assess and abate fire hazards as necessary.

In conjunction with Natural Resources Canada, the BC Wildfire Service has developed A Guide to Fuel Hazard Assessment and Abatement in British Columbia[20] to assist those carrying out industrial activities to determine whether fuel hazard abatement is necessary, and if so, the threshold necessary to comply with the legislated obligations.

The guide provides a procedure to determine fuel hazards created by an industrial or prescribed activity on forest land and contains step by step instructions to enable a person to determine when fuel hazard abatement is needed in relation to the fire risk, proximity to interface, and fuel loading and arrangement.

Fuel management practices are the planned manipulation and (or) reduction of living or dead forest fuels for forest management and other land use objectives (such as hazard reduction, silvicultural purposes, wildlife habitat improvement) by prescribed fire, mechanical, chemical or biological means, and (or) changing stand structure and species composition. Best management practices for fuel management on the coast are provided in Wildfire Risk Reduction best management practices[21] .

Cultural and prescribed fire is one of many land stewardship practices that can help reduce the intensity of naturally occurring wildfires while returning an integral and culturally significant process to the land base.

Frost Cracks

Frost cracks are associated with rapid freezing events that cause outer bark and wood layers to contract more quickly than the underlying layers and the formation of ice lenses that split the wood apart (Kubler 1983). They are sometimes more common on the south side of the tree due to rapid freezing and contraction of tissues warmed by direct exposure to low angle sunlight during the day. Frost cracks can also be associated with wounds or decay. Trees form reaction wood in response to injury that contracts at a different rate than surrounding wood as a result anatomical and chemical differences. Trees growing on wet sites or having a higher wood moisture content are more susceptible to frost cracking. Frost cracks can serve as entry points for insects or decay. Frost cracks formed in previous years are susceptible to reopening in future years. In YSM surveys, frost cracks

[20] https://www2.gov.bc.ca/assets/download/665F3A4A01F6490999F606C8E6118E07

[21] https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/wildfire-status/prevention/fire-fuel-management/fuels-management/wrr_bmps_-_coast_and_mountains_georgia_depression.pdf

were most prevalent in the MHmm1 (Appendix B) on western hemlock, amabilis fir and yellow-cedar. Cracks unrelated to frost can also sometimes occur after severe drought, especially in Douglas-fir and grand fir (Pacques, 2021).

Further Reading

Kubler, H. Mechanisms of frost crack formation in trees – review and synthesis. For. Sci. 1983 29(3) 559-568.
Pacques, L.E., F. Millier and D. Vellise. 2021. Longitudinal stem cracks in larch: what makes trees vulnerable? New For. 54:813-832

Snow and Ice Damage

Snow and ice damage can take the form of breakage or snow press. Ice damage hazard is highest the Mountain Hemlock zone and the submaritime CWH zones. We can expect to see more snow press damage in the future as a result of rapid fluctuations in winter temperatures associated with climate change and warmer winter temperatures in higher elevation stands. Higher elevation species such as engelmann spruce, subalpine fir, and whitebark pine are less susceptible to snow and ice damage than other species. In YSM surveys, most of the damage occurred on mountain and western hemlock and yellow-cedar. Higher density stands with high height to diameter ratios are at greater risk of snow press damage. In uneven aged stands, the position of understory trees relative to the crowns of larger trees can also be important as snow is shed off the crowns of larger trees on to the smaller regenerating trees below.

Wind

Windthrow events can be considered catastrophic or endemic. Catastrophic wind events generally occur at more than 20-year intervals, generally cause breakage, and are unpredictable. Endemic wind events occur every 1-3 years, generally result in uprooting and are predictable. Harvesting activities can make remaining trees much more susceptible to endemic winds. Most damage occurs within 1-3 years of harvesting with the majority occurring within a year. During the 1980s and 90s, repeated blowdown around the edges of clearcuts followed by salvage, resulted in ever expanding clear cuts in some areas of the coast. This led to research and trials on how to design cut blocks to minimize future wind damage and the development of wind firming treatments such as topping, pruning, and feathering. Feathering involves thinning out the most vulnerable trees along the edges of multi-storied stands. A number of these techniques are now standard practices that are considered a necessary and standard part of forest harvesting operations on the coast.

Windthrow is a result of complex interactions between tree, stand and landscape level features. Local wind and topography are usually the most important factors determining windthrow hazard but other factors such as stand structure, soil characteristics, and tree species can be just as or more important in some cases. BEC variant is not a good predictor of windthrow hazard, but at the landscape level, some areas of the coast experience more windthrow than others. BEC variants associated with these areas are rated as high hazard in Table 2. In broad geographic terms, Haida Gwaii experiences significantly more wind damage than other parts of the coast. Western Vancouver Island also experiences high levels of wind damage followed by northern Vancouver Island which has moderate levels of wind damage.

Ridges experience the most wind exposure and valley bottoms can experience high wind exposure when they are parallel to the wind direction. On the coast, southern exposed edges tend to experience the most damage from the predominantly southerly winds. Dense even height stands that promote trees with high height to diameter ratios (>60) are particularly prone to wind damage following harvesting. Western hemlock and true fir stand edges generally suffer the most damage.

Management

Windthrow management involves assessing windthrow hazard and consequence to determine windthrow risk. Consequence could include potential impacts of windthrow to non timber values such as visual quality objectives, fish bearing streams or stand level biodiversity. Windthrow prediction maps have been developed for some parts of the coast to help in determining local hazard. Examination of existing blocks in the general area with similar designs can be useful for assessing windthrow hazard when laying out new cut blocks. Field procedures for assessing planned blocks include assessing soil, topography and stand characteristics to come up with an overall windthrow hazard for the stand.

Risk can be reduced by planning for windthrow and salvage, changing the block layout by adjusting the size and shape of retention or individual leave tree criteria, reducing the amount of distance where the wind can flow unobstructed following harvest (fetch), using an alternate silviculture system or wind firming (topping, pruning or feathering).

Further Reading

Stathers, R.J., T.P. Rollerson and S.J. Mitchell. 1994.Windthrow Handbook for British Columbia Forests. Research Program Working Paper 9401. Ministry of Forests.

Zielke, K., K. Byrne and B. Bancroft. 2022. Windthrow Manual for Coastal British Columbia. Report prepared for BC timber Sales. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/bc-timber-sales/ems-sfm-certification/business-area/chinook/tch-tsg-windthrow-manual.pdf

Yellow-cedar Decline

Yellow-cedar decline has been a problem in southeastern Alaska for several decades, but its occurrence and impact were poorly documented in BC until 2005. The decline can appear in small, scattered patches or extend over a large area. Identification of dead or dying yellow-cedar can be difficult due to its visual similarity with western redcedar and the tendency for the two species to commingle in coastal forests. The spike-top mortality found in western redcedar can hide the dead or symptomatic crowns of intermixed yellow-cedar. Individual declining trees can die quickly, showing 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.

Aerial assessments along the coast show over 150,000 ha of yellow-cedar stands afflicted by decline which may be constricting the future range of this species. The most noticeable areas are on Haida Gwaii and the north and mid-coasts where landscape-level occurrence can be seen quite readily. The frequency of 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. Decline is most evident at higher elevation in the south and decreases in elevation as you move north.

Yellow-cedar decline is a result of long-term climate change since the late 1800s. Warming winter temperatures result in declining snow levels and early snow melt leads to increased susceptibility of the shallow fine roots to sudden late season frost events where upper layer soil temperature falls below minus 5° C. As has been recently illustrated on Haida Gwaii, yellow cedar of all ages is subject to decline given these risk factors. Areas where rooting depth is restricted by high water tables or shallow rocky soil are particularly susceptible.

Impact

A 2019 analysis of losses detected by the annual aerial overview survey shows over 2.2 million m^3 of yellow cedar volume has been mapped as killed by decline, primarily in the GBR North TSA. Much of this mortality is at higher elevation or outside the timber harvesting land base (THLB).

Management

Since the decline appears to be climate driven and since we do not yet understand fully the drivers involved, management options are limited. In time local guidelines may be developed around the suitability of yellow-cedar for reforestation in areas where conditions for occurrence of the decline can be predicted. Until then, a publication from Alaska (Hennon et al. 2016) may offer guidance in managing yellow cedar on the north coast and Haida Gwaii. Suggested strategies for Alaksa include shifting timber production to decline impacted areas, protecting yellow cedar in unaffected areas and planting yellow cedar and favouring yellow cedar through thinning. Yellow cedar is often outcompeted by other species on sites with better drainage, deeper soils, and medium to rich nutrient regime, as opposed to the open poorly drained sites where yellow cedar has historically had a competitive advantage over other tree species and appears to be most susceptible to decline.

Priority and Research

Dendrochronology work on the north coast and Haida Gwaii has increased our understanding of how the decline manifests in BC. A collaborative research project exploring the recovery and ecological succession of declining stands on the north coast was started in 2019. Due to the difficulty and cost associated with helicopter access, the focus of this research will be shifting to Graham Island in 2024, where the road access is better.

Further Reading

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Comeau, V.M., L.D. Daniels, G. Knochenmus, R.D. Chavardes and S. Zeglen. 2019. Tree-rings reveal accelerated Yellow-cedar decline with changes to winter climate after 1980. Forests 10: 1085 **https://doi.org/10.3390/f10121085**

Hennon, P.E., McKenzie, C.M., D'Amore, D.V., Wittwer, D.T., Mulvey, R.L., Lamb, M.S., Biles, F.E., and Cronn, R.C. 2016. A climate adaptation strategy for conservation and management of yellow-cedar in Alaska. USDA Forest Service, Gen. Tech. Rep. PNW-GTR-917. https://www.fs.usda.gov/pnw/pubs/pnw_gtr917.pdf

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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.

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Adelgids

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 often. Grand fir is the most tolerant of attacks, sub-alpine fir is the most easily damaged, and amabilis fir has intermediate susceptibility. 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.

The adelgid 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 throughout Vancouver Island, to the Loughborough Inlet on the mainland coast, northward into the Cariboo, and eastward into the Kootenays.

Impact

The affects of adelgid have not been well studied. Infestations within grand fir can be chronic for decades however the trees often succumb eventually. Their decline in vigour 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. Effects on amabilis fir are variable; some trees will die within a few years of becoming infested while others may remain chronically affected for many years and yet others do not seem to be affected.

In Idaho, sub-alpine fir appears to die after only a few years of adelgid infestation, where data shows 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 years after the initial infestation. As a result, grand fir is slowly being eliminated from Oregon forests.

Management

The province encourages limiting the movement of seedlings from the southern interior or coast into the north.

Further Reading
Davis, G.A., L. Lowry, T. Eckberg, J.A. Hickey and E. Smirnova. 2022. Characterizing balsam woolly adelgid infestations and associated tree mortality in Idaho J. of Forestry 120(4):361-378.

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

Spruce Aphid

Spruce aphid, *Elatobium abietinum*, is a chronic forest health factor of sitka spruce on Haida Gwaii and has caused severe defoliation in some years. Occasionally, it also shows up in other areas of the south coast. Severe defoliation is usually located but not restricted to trees close to the ocean. Feeding is usually limited to older needles and current years needles are only rarely affected. Aphid populations are highest during the winter months and drop off during the summer and severe defoliation generally occurs in years with mild winters.

Management
There are no effective strategies for managing for spruce aphid. Ornamental spruce are particularly susceptible and people with ocean front property should avoid planting ornamental spruce or sitka spruce on their properties.

Further Reading
Koot, H.P. 1992. Spruce Aphid. Forest Pest Leaflet 16. FRDA II.
https://cfs.nrcan.gc.ca/publications?id=2202

Bark Beetles

Susceptibility ratings maps for all the major bark beetles are available for both the West Coast (RWC) and South Coast (RSC)[22]. These maps are very good at predicting which areas will be most impacted when bark beetle outbreaks occur and are useful for assessing local bark beetle hazard and providing a basis for planning for future outbreaks. Targeting highly susceptible stands for priority harvest can help mitigate the impacts of bark beetle outbreaks.

Douglas-fir Beetle

The Douglas-fir beetle (IBD), *Dendroctonus pseudotsugae*, is endemic throughout the range of Douglas-fir where it normally breeds in trees that are stressed, recently windthrown, recently dead or dying from other causes such as wildfire. However, outbreaks occur periodically on the coast (about once every decade) and tend to last 3 to 4 years before subsiding.

[22] https://www.for.gov.bc.ca/ftp/HFP/external/!publish/barkbeetles/New_Susceptibility_Ratings/2023_Ratings/

Impact
Endemic mortality can normally be seen on the landscape; however, because it is widely scattered it may not have significant impacts. Although large outbreaks on the coast are relatively uncommon, this beetle can kill significant volumes of timber when outbreaks occur.

Management
Control is through one or a combination of sanitation harvesting, trap trees, fall and burn, funnel trapping, or use of anti-aggregates[23]. Use of the anti-aggregation pheromones (MCH) works best when beetle populations are low or in conjunction with other treatments as part of a push-pull strategy. Sanitation harvesting and use of trap trees can be difficult on the coast due to steep terrain, poor access and high winter snowfall. Spillover (attack of adjacent live Douglas-fir) can sometimes be a problem when trying to attract bark beetles using funnel traps. These are best deployed 100 m from any live mature Douglas-fir. In areas with high levels of beetle, wood from new access roads can be used as trap trees provided that the wood is removed before the beetles emerge. Section 41 of the Forest Planning and Practices Regulation[24] requires that licensees who use trap trees to concentrated beetles must ensure the insect brood is destroyed before the insects emerge.

Forest management activities have the potential to lead to increased beetle populations. There are recommended procedures that should be followed during harvesting and road building, particularly in the coast transition zone, to limit the spread of IBD. These include keeping stump heights low, prompt removal or burning of green wood over 20 cm diameter before beetle emergence in the spring, using funnel traps around log yards, and prompt removal or use of anti-aggregates to keep beetles out of windthrow along roads and recent cut blocks. In the past, licensees operating on the coast could ignore these recommendations with little or no IBD consequences, but with climate change and increased summer droughts and fires, IBD is expected to become an increasingly important problem on the coast and the coast-interior transition zone.

Priority and Research
The regional staff is working with the director of bark beetle management to assess the effectiveness of post-Douglas fir beetle mitigation treatments after fires.

Further Reading
FLNRORD. 2019. A guide to managing Douglas-fir beetles in BC's coastal region. Factsheet. 3 pp. Available at A Guide to Managing Douglas-fir Beetles in B.C.'s Coastal Region (gov.bc.ca).

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 infamous forest insect. This bark beetle attacks all pine species but is primarily associated with mature lodgepole pine. Its population dynamics allow it to develop into extensive outbreaks. Fortunately, on the coast, shore pine is a

[23] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-pests/bark-beetles/douglas-fir-beetle/management
[24] https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/14_2004

minor commercial species. Low levels of mountain pine beetle are still present in high elevation stands along the eastern boundary of the GBR.

Impact

The impacts of this beetle can be extreme. However, once populations grow and spread, control efforts can quickly become expensive and less effective. During outbreaks, all mature pine within an area can be killed. Immature pine can also be killed during severe outbreaks. The impact on timber supply from Mountain pine beetle is limited on the coast due to a low percentage of pine in the timber harvesting land base (THLB). However, this beetle can affect the scenic view scape and may affect recreational experiences, wildlife habitat and fire hazard.

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 help control efforts. Refer to the government website for more information on management[25].

Further Reading

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.

Spruce Beetle

Spruce beetle (*Dendroctonus rufipennis*) is endemic throughout the range of spruce where it normally breeds in trees that are under stress or recently windthrown, and in freshly cut logs. Localized outbreaks occur periodically in the coast-interior transition areas and on Haida Gwaii.

Impact

Although outbreaks on the coast are rare and do not build into large areas of attack, this beetle tends to favour both stressed and mature spruce trees in a stand and can kill valuable timber when populations build.

Management

Control options include sanitation harvesting, salvage harvesting and trap trees[26]. This beetle is often managed by harvesting infected stands. However, because the beetles over winters in the lower bowl

[25] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-pests/bark-beetles/mountain-pine-beetle/management#Tactics
[26] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-pests/bark-beetles/spruce-beetle/management

or duff it is important to use trap trees before and after harvesting occurs. Unlike in standing trees, spruce beetle remains in downed trees and trap trees over the winter.

Further Reading

Province of British Columbia. Spruce beetle management in B. C. https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-pests/bark-beetles/spruce-beetle/management

Western Balsam Bark Beetle

Western balsam bark beetle (*Dryocoetes confuses*) is one of the most destructive insects affecting subalpine fir and is a primary driver of succession in high elevation subalpine fir stands. The balsam bark beetle is endemic throughout the range of subalpine fir, where it causes scattered mortality over large areas of its host range.

Impact

Western balsam bark beetle populations are chronic in mature, high elevation subalpine fir stands, but the area mapped in the AOS can vary considerably from one year to the next. This is the most significant bark beetle on the coast in terms of area mapped. Most of the balsam bark beetle on the coast occurs in the GBR North TSA. The mapped areas are usually trace or low severity.

Management

Western balsam bark beetle populations are not usually managed due to its complex biology (endemic) and difficulty in harvesting access and operability. Trap trees are not an effective control treatment but pheromone baiting can concentrate beetle attack in standing trees intended for harvest (Maclauchlan & Brooks, 2021). to reduce spread. No proactive measures are appropriate and the only viable option for managed stands is to limit subalpine fir stands to a shorter rotation or target harvesting of stands with dead and dying trees.

Priority and Research

The provincial entomologists have set up permanent sample plots at several locations in BC. No plots have been established on the coast due to the inaccessibility of most of the subalpine fir stands which occur at higher elevations in difficult to access locations.

Further Reading

Furniss, R.L. and V.M. Carolin. 1977. Western Forest Insects. Miscellaneous Publication No. 1339. U.S. Department of Agriculture, Forest Service.

Maclauchlan, L.E. and J.E. Brooks 2021. Comparison of tow treatment regimes for managing western balsam bark beetle. J. of Ecosystems and Man.21(1)1-10.

Defoliators

Conifer Sawfly

The conifer sawfly (*Neodiprion abietis*) is a defoliator of amabilis fir and mountain and western hemlock on the BC coast. Outbreaks by this insect are rare and short-lived but can have significant impacts if the defoliation is severe. Unlike most defoliators which are from the Order *Lepidoptera* (moths), the conifer sawfly is uniquely from the insect Order *Hymenoptera* (wasps). The sawfly is a wasp whose larval stage feeds on year old and older needles. On Haida Gwaii outbreaks are often associated with black headed budworm outbreaks.

Hazard and Risk

A hazard rating system has not been developed; however, outbreaks appear to re-occur in the same areas 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 and Horseshoe Creek on Vancouver Island. Defoliation tends to occur on mid- to upper-slopes and at the back end of drainages at elevations ranging from 600m to 900m. The BEC units that appear to be involved are: CWHvm1, vm2, mm1, mm2, and Mountain Hemlock (MH)mm1, with CWHvm2 and mm2 being 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 may increase if bark beetle populations take advantage of the defoliation stress.

Management

Control treatments have not been developed for BC. Treatments using common insecticides would be effective; however, environmental concerns will likely prevent their use. The biological control agent *Bacillus thuringiensis var. kurstaki* (Btk) will not affect this insect. Treatments using 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. Salvage harvest is often difficult or impossible because of old growth constraints on harvesting.

Further Reading

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 eight to 15 years and last three to five years. The most serious outbreaks consistently occur on Haida Gwaii and on northern Vancouver Island.

Impact

Most impacts are minimal, and most stands recover well; however, stands that receive severe defoliation over consecutive 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 or old growth. Stands that have received >50% defoliation for several consecutive years can show 30% to 60% mortality.

Immature, second growth stands that have been thinned seem to be more affected by defoliation from this budworm. Following an outbreak that lasted six years on Haida Gwaii, mortality in severely defoliated immature stands averaged <10%. However, top-kill was significant and frequent (45%) with very poor recovery six years post-outbreak. It appears that growth reductions in second growth stands may be worse than originally expected.

Management

A survey method for egg mass sampling to forecast defoliation severity can be found in the *Defoliator Management Guidebook*[27]. Additional information can be found on the government website[28]. There is currently no operational control treatment for this defoliator. The biological control agent Btk will work but is not yet registered for this insect. As seen in 2001 on Haida Gwaii, thinned stands may be subject to greater mortality, due to greater exposure of the upper crown. Therefore, post-thinning density targets should allow for this in areas at risk of budworm defoliation.

Further Reading

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.

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

[27] https://www.for.gov.bc.ca/ftp/hfp/external/!publish/FPC%20archive/old%20web%20site%20contents/fpc/fpcguide/defoliat/defoltoc.htm
[28] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/forest-pests/defoliators/blackheaded

years of defoliation. On the BC coast, outbreaks are most common in the Sunshine Coast and Howe Sound areas and within the Metro Vancouver watersheds (Seymour, Capilano and Coquitlam).

Impact

Severe mortality of western hemlock can occur following one year of moderate to severe defoliation and mortality of other hosts can occur following one or more years of severe defoliation. Drought stress and the presence of other forest health factors (i.e., hemlock dwarf mistletoe or root disease) will also affect survival. The killed trees deteriorate 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 in high value stands. Delay will result in significant hemlock mortality. In 2021, the Ministry started annual monitoring of western hemlock looper in historical outbreak locations using pheromone traps. The Vancouver watersheds conduct their own monitoring during outbreaks.

Further Reading

McCloskey, S.P.J., L.D. Daniels and J.A. McLean. 2009. Potential impacts of climate change on western hemlock looper outbreaks. Northwest Science 83: 225-238.

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: 125-136.

Western Spruce Budworm

Western spruce budworm (*Choristoneura occidentalis*) is a defoliator primarily of Douglas-fir throughout the tree's range in BC. True firs such as subalpine fir, and to a lesser degree spruce, are also affected. Historically, western spruce budworm has had it largest impact in the coastal-interior transition areas of 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 every decade, and last 3 to 5 years. 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 affected. Budworm defoliation reoccurs on the same general sites for each subsequent outbreak.

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 consecutive years of severe defoliation. Top-kill in immature trees can result in forks and crooks forming on the stem of the tree (i.e. within the first log).

Stand mortality, even after seven 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 all live Douglas-fir but varied from 0 to 70% across individual stands. The cumulative effect of four separate budworm outbreaks that occurred during the life of one 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 needed 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 impact, 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 stands from below to keep 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 and given the marginal economics of these treatments, they are generally not recommended for high hazard budworm areas.

Spray treatments are suggested for young stands of Douglas-fir when moderate to severe defoliation is predicted for the following year (as found from predictive egg sampling surveys). The biological control agent (Btk) (e.g., Foray 48B) is the product of choice for budworm control.

Further Reading

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Dwarf Mistletoe

Hemlock Dwarf Mistletoe

Hemlock dwarf mistletoe (*Arceuthobium tsugense*) is an obligate (requiring a live host) parasitic plant that affects tree growth and leads to the production of foliar "brooms," stem deformities and occasional mortality. Plants are either male or female. Breakage of branches holding brooms can supply potential entry sites for wood-decaying fungi. While the primary host is western hemlock, hemlock dwarf mistletoe can also be found on mountain hemlock, Pacific silver fir, grand fir, Sitka spruce and lodgepole (shore) pine. Recent taxonomic work proposes three subspecies of *A. tsugense* based on host affinity: *A. tsugense* subsp. *tsugense* on western hemlock, *A. tsugense* subsp. *contorta* on shore pine and *A. tsugense* subsp. *mertensiana* on mountain hemlock. However, there is considerable host overlap between these three subspecies. Like most plants, dwarf mistletoes produce flowers which are pollinated by insects and produce seeds that spread within the same tree canopy (intensification) or to adjacent canopies. Infections require sufficient light to grow shoots and produce seed. The infection process is slow and often difficult to see, 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 seen.

Impact

Hemlock dwarf mistletoe typically manifests in two ways: first, the risk to susceptible regeneration growing within 10-15 m of infested mature residual trees along cutblock boundaries or next to single-tree or group reserves is high; second, the risk to uninfected residual trees left 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 which increases the production and spread of seeds. Although not primarily a mortality agent, hemlock dwarf mistletoe accounts for an estimated 0.8 million m^3 in annual growth loss for coastal BC. This loss may decrease as mature stands are converted to plantations. However, poor sanitation practices when harvesting leaves regeneration susceptible to early infection when the impact is greatest. Moderately and severely infested trees have showed growth reductions of 20-40%, respectively, compared to uninfested trees. Young trees starting out under infested canopies can undergo decades of suppressed growth, creating stem deformities (swellings) that result in unmerchantable stem form and occasionally death. While individual tree growth effects have been quantified, currently there is no Operational Adjustment Factor (OAF) reduction accounted for in timber supply reviews (TSRs). More about OAF factors can be found in the section titled "Accounting for Forest Health in Timber Supply."

Management

Being obligate parasites, management of dwarf mistletoes should be easy, kill the host and you kill the parasite. 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. Partial cutting harvest systems, with an increased emphasis on visual quality using irregular cut block shape and higher tree retention, often result in a corresponding increase in dwarf mistletoe survival in regenerating areas.

While it may difficult to eradicate dwarf mistletoe from infested stands that are managed under a retention system (more than half of the total cut block area is within one tree length from the base of a live tree), reducing the risk to regeneration and residual trees is possible. Reducing the perimeter edge of the cut block and the use of natural barriers (such as non host timber types) helps limit exposure to infested edges. All severely and moderately (Hawksworth[29] rating 3+) infested trees should be removed unless they are 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 infested trees where possible to reduce the proliferation of new aerial shoots and consequent spread of seed within canopies. If conducting pre-commercial thinning along cut block or reserve edges, find and remove any infested young trees.

Priority and Research

Significant dwarf mistletoes research was done in the 1950s through 1970s in BC. Since the biology was well understood and forest management practices at the time were effectively reducing risk, research gradually stopped. With the implementation of variable retention systems, interest in dwarf mistletoe impact in post-harvest stands has been rekindled. Questions remain about susceptible tree retention and regeneration in partial cut western hemlock stands and the impact on stand volume. To this end Hanno Southam, a master's student at UBC, is conducting research looking at the rate of spread over time of hemlock dwarf mistletoe from infected edges into hemlock leading stands between 30-45 years old. None of the study sites contain over topping infected residual trees within the block. This information will provide a better understanding of the risk of mistletoe spread within partial retention areas that do not contain dispersed infected hemlock residual trees over 3m in height immediately after harvest.

Further Reading

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[29] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/managed-stand-pests/figure_5_the_hawksworth_six-class_dwarf_mistletoe_rating_system.pdf

Foliar Diseases

Cedar Leaf Blight (Keithia)

Cedar leaf blight (DFU), or *Didymascella* (formerly *Keithia*) *thujina*, is a widespread, native foliar disease of western redcedar. It infects the current year's foliage and kills these new leaflets, which produces a patchy pattern of foliar discolouration on younger material. This pattern is distinct from flagging (yellow branches), which results in foliage shedding of all ages of leaf material. Another distinct, close-up sign of DFU is the presence of golden to dark brown pin cushion-like fruiting bodies on the upper surface of a leaflet. These infected leaflets will die and then change to a grey colour, leaving a pit or hole when the fruiting body subsequently falls out.

Hazard and Risk
Disease incidence tends to be highest for most CWH subzones, particularly in dense stands with high humidity, although variability is high among individual trees. Often nursery culture conditions can intensify this disease on seedlings. Environmental conditions (temperature and moisture) help disease infection and spread. Seedlings infected in nurseries will carry the disease into plantations, and where condition are suitable, the disease will expand. DFU could become more noticeable with a prolonged shift toward warmer and wetter weather. In some cases, the use of the enclosed type of seedling protectors may function as a mini "greenhouse" which increases the development of DFU. This has been noted in wet environments like Haida Gwaii.

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 substantial proportion of cedar foliage can result in rapid foliage loss and death of young trees. This is particularly clear when infected one-year old stock is planted. In the past, 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 noticed until the following summer when fruiting bodies form, and leaflet mortality occurs. Infected two-year old stock will show signs of DFU and thus seedlings should be carefully checked prior to planting.

Further Reading
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.

Shoot-tip Blight of Western Red Cedar

Shoot-tip blight has been recently causing significant damage in western red cedar plantations on southern Vancouver Island. The causal fungus is *Truncatella angustata*. It infects red and yellow cedar and causes grape vine trunk disease in some areas where commercial grapes are grown. It also causes canker and twig dieback on blueberries. Shoot tip blight damages the leaf scales which affects photosynthetic capacity and growth. The symptoms are often confused with cedar leaf blight.

Symptoms appear as circular to oval brownish black spots (2-3 mm) scattered at the tip margins. Disease incidence is highest in the CWHxm1 and xm2. Screening has shown that some families have relative resistance to the disease.

Further Reading

Noshad, D., L. Van Der Merwe and A. Yanchuk. 2024. First Report of *Truncatella angustata* causing leaf blight on Thuja plicata. Plant Disease 108(3):785.

Swiss Needle Cast

Swiss needle cast (SNC), *Nothophaeocryptopus gaeumannii*, is not an introduced disease but a native foliar pathogen. Its name comes from being first identified by Swiss researchers who were examining it on imported Douglas-fir growing in Switzerland in 1925. SNC can be found worldwide everywhere Douglas-fir grows and it is the only host for this fungus. SNC was rarely noticed in the past, usually overshadowed by another foliar disease of Douglas-fir, Rhabdocline needle cast (*Rhabdocline pseudotsugae*). However, in the 1990s Oregon began reporting large areas of Douglas-fir plantations defoliated by SNC and that trend has continued with over 250,000 ha being mapped to date and an additional 100,000 ha mapped in Washington state. SNC ascospores infect newly flushing needles via the stomata. The fungus develops internally but causes no reaction or necrosis of tissue that would lead to visible symptoms like banding or foliar discolouration. The only visible sign is the production of black fruiting structures that appear a few months after infection and block leaf stomates, leading to lowered CO_2 uptake and hindering metabolic processes like photosynthesis. Once the leaf becomes a net liability to the tree, it is dropped, usually as two or three-year-old foliage. This premature foliar drop leads to growth loss and occasionally mortality.

Hazard and Risk

The occurrence of SNC is correlated to weather. During flush and early leaf development, mild moist weather that promotes leaf wetness increases the chance of successful infections. Mild winter temperatures allow continued fungal development in the leaf that increases stomatal blocking and disease severity. Planting Douglas-fir into wetter coastal areas than its historical range in Oregon encouraged the development of SNC while more inland areas remained unaffected. Since BC does not share the same coastal geography as Oregon, our increased incidence is more likely due to changing weather patterns that have increased the amount of spring moisture during some years. The north side of the Fraser River between Stave and Harrison Lakes are most severely affected, but the disease can be found at varying levels on regenerating Douglas-fir throughout the BC coast. There is evidence that moving seed lots from high elevation or dry site sources to the coast can increase risk. Foliar diseases disproportionately affect genetically maladapted seed sources.

Impact

Monitoring plots in Oregon average 23% growth reductions in epidemic areas. Severely infected stands may suffer up to 60% reductions in growth. The value of this growth loss has been estimated at US $128 million annually. Mortality is rare but has been documented in stands with repeated annual infections especially on younger trees.

Management

There is evidence of family tolerance to the disease, but such families are still being assessed for tree improvement purposes. The relative tolerance of different families appears to vary depending on the site. Fertilization (N, Ca, P or blends) does not seem to compensate for needle loss. Infected trees respond to thinning more slowly (thin early and from below) but it does not help needle retention. There is no evidence that mixed species stands reduce infection, but loss of basal area may be compensated for by other species. Fungicides are effective, and used extensively in the Christmas tree industry, but would need to be applied one to three times during the infection window and every year that weather conditions are suitable for the disease.

Priority and Research

SNC has come to the fore in the last decade primarily because of its appearance in young stands prior to free growing. An extensive network of monitoring plots was set up starting in 2017 in the CWH dm, xm and vm subzones to collect information on stand infection and weather attributes and to determine an impact estimate for the disease. Starting in 2023 the Ministry of Forests began asking silviculture surveyors to collect needle retention data in stands being managed for Douglas-fir. While there are many factors that can affect needle retention, this data will be helpful in defining high hazard areas for SNC so new stocking standards can be implemented in areas most impacted by SNC.

Further Reading

Ritokova, G., D. Shaw and D. Mainwaring. 2020. Silvicultural decision guide for Swiss needle cast in coastal Oregon and Washington. Swiss Needle Cast Co-operative, Corvallis, OR. Download at: http://sncc.forestry.oregonstate.edu/sites/default/files/SilvGuide_July2020.pdf

Root Diseases

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 earlier 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 Coastal Douglas-fir (CDF) zone. What was previously referred to as the P-type ISG is now called *H. irregulare*. While *H. irregulare* has been detected around lower mainland plant nurseries using spore traps, it has not yet been documented in any native BC forests. Most damage from *H. irregulare* is either heart rot or root and butt rot, so 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 helps spread the disease.

The most susceptible hosts (in descending order) are true firs, spruce, hemlock and Douglas-fir. 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 creating 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. 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 its contribution to volume loss is included in these calculations.

Management

It is rare to single out *H. occidentale* for management in mature stands since it usually does not occur extensively, or it is often found with other root diseases like *Armillaria* or *Phellinus*. As such, most recommendations about 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 of less than 120 years. When conducting forest operations like partial cutting, minimize wounding to deny entry points for spores. For pre-commercial thinning, do not worry about colonization of fresh western hemlock stump surfaces; while the incidence of *H. occidentale* can increase in thinned stands, the impact appears limited in terms of volume loss over a rotation. Finally, unlike in Scandinavia where *Heterobasidion* is the major root disease of plantation forests, in BC treatment of stumps using a liquid or powder formulation of Borax or zinc chloride appears unnecessary. Further, 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 latter diseases will usually suffice as a control.

Priority and Research

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

Further Reading

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.

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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.

Armillaria Root Disease

Armillaria root disease is a complex of up to three dozen similar fungal species found across forest types worldwide. Up to seven species of *Armillaria* occur in Western Canada but only one, *Armillaria ostoyae* (= *A. solidipes*), is considered pathogenic on a range of hosts including conifers. The others (including *A. sinapina, A. gallica* and *A. nabsnona*) act primarily as saprophytes or are very rarely found. On the coast, *A. ostoyae* is found from the Dean Channel south to the US border. *Armillaria* is more obvious in the coast-interior transition zones and presents a more dramatic problem east of the Coast

Range in southern Interior forests. It is mostly visible in young stands or plantations <20 years old where mortality can be readily seen. 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. This can make it difficult to assess the risk of *Armillaria* in silviculture prescriptions when stands are being regenerated predominantly to Douglas-fir. Local experience is often needed to assess the risk of *Armillaria* in future young Douglas-fir stands.

An assessment of pre free-growing stands found that, *Armillaria* was a far more common cause of young tree mortality in CWH plantations than laminated root rot (*Coniferiporia sulphurascens*)[30]. This mortality has appeared even when there was no Douglas-fir in the previous mature stand.

Impact

Armillaria root disease can cause mortality in trees of any age but the amount of mortality and growth loss is a function of host vigour and the amount of *Armillaria* infected roots present in the soil. Visible mortality in stands on the coast is most pronounced by age 20-25 after which mortality drops off. Quantification of impact across subzones is continuing and currently the prescribed OAF 2 of 7.5% for root disease in the CDFmm and CWH xm1 & 2 accounts for losses to *Armillaria*. More detail on this OAF can be found in the profile of laminated root disease. We may start to see *Armillaria* having a larger impact in coastal forests and continuing to cause mortality in older Douglas-fir stands with increased frequency of droughts due to climate change.

Management

Guidelines for managing *Armillaria* are like those for laminated root disease with the added complication that the susceptible host list for *Armillaria* is larger, making choice of species suitable for reforestation more constrained. When *Armillaria* is identified in a preharvest walkthrough, a more detailed survey may be required to quantify and map the disease to determine severity and need for for remedial treatment. The most common management strategy is to regenerate with less susceptible species; however, *Armillaria's* extensive host list means that most commercial conifer and even hardwood species are susceptible to a degree. More intensive treatments like stump removal are effective in reducing disease inoculum between rotations but are limited by economic, site, and machinery constraints.

Intensive treatment is suitable only for productive sites 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.

Priority and Research

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

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[30] 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.

Further Reading

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Black Stain Root Disease

Black stain root disease (DRB) is composed of three varieties of fungus, only two of which are present in BC. *Leptographium wageneri* var. *ponderosum* occurs on lodgepole and ponderosa pines and *L. wageneri* var. *pseudotsugae* on Douglas-fir. Only the latter is found on the coast. DRB 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 weevils (at least three different ones, including *Hylastes* spp., have been identified) and spreads into the sapwood, multiplying and causing a vascular wilt by effectively blocking 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 DRB difficult since not all vector insects carry spores and even spore carriers may not attack a host tree in enough numbers to cause mortality. The insects are attracted to trees stressed by a variety of agents, including human-caused activities like road building, soil compaction, harvesting and thinning. In areas where DRB has been noted, the risk of attack by beetles may be stimulated along roads, transmission lines, or skid trail edges as roots are disturbed or trees damaged. Harvesting can also push emerging adults into surrounding stands or plantations in a search of suitable new habitat. Such displacement can briefly elevate the local vector population and cause an "outbreak" of mortality, especially in younger trees already suffering from other factors (e.g., competition, other root diseases, drought, etc.). An increase in summer droughts due to climate change may increase the occurrence of DRB.

Impact

DRB is one of the most difficult diseases to diagnose because it requires cutting into the sapwood near the root collar or in the roots. The stain often disappears within a couple years of the trees being killed. For this reason, it often goes undiagnosed. The impact of DRB is usually localized and patchy in a stand. New mortality may pop up suddenly and then gradually decrease over time. The pattern of occurrence can appear random since nearest neighbours are not necessarily attacked or do not succumb to the disease. No specific OAF net down is applied for DRB.

Management

In areas where DRB 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. Spread is by insect only. The survival of the fungus in stumps is short-lived and is not considered important in spreading the disease. Because the vectors are attracted to root rot weakened trees DRB is often associated with other root diseases.

Further Reading

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 (DRL), caused by *Coniferiporia sulphurascens (= Phellinus sulphurascens, = P. weirii* Fd type*)*, is the most damaging root disease in coastal Douglas-fir forests. Its ability to kill primarily Douglas-fir and *Abies* species of any age makes DRL a 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 DRL on the coast follows that of Douglas-fir through the CDF and drier CWH subzones. DRL can create very noticeable mortality in coastal forests since many 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. DRL is also quite extensive throughout the southern Interior, but there 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.

Impact

DRL can cause substantial mortality to Douglas-fir and *Abies* sp. of any age. An estimated 1.4 million m^3 are lost annually in BC through mortality and growth reduction. Mortality typically starts at age 6-10 and continues throughout stand development culminating in the creation of large openings or gaps in stands that are filled by less susceptible species. The occurrence of DRL is closely tied to the presence of Douglas-fir. For example, while western hemlock is susceptible to DRL, infected hemlocks are rarely found in stands not mixed with infected Douglas-fir, and on wetter sites, hemlock may colonize root rot centres. Quantification of impact across BEC 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 DRL and *Armillaria*. In addition, the default OAF 2 of 5% results in a cumulative OAF 2 of 12.5% for CDF and CWHxm 1 & 2.

Management

Guidelines for managing DRL are similar to *Armillaria* guidelines, with the exception that the susceptible host list for DRL is shorter. Although many conifers are less effective hosts, all pines are tolerant and cedars are resistant while hardwoods are immune. These species can be reliably chosen as alternates to highly susceptible species like Douglas fir and *Abies* species. When DRL is identified in a preharvest walkthrough, a more detailed survey may be required to identify areas for treatment. The most common treatment is to regenerate with less susceptible species including white pine, red or yellow cedar, and hardwoods. More intensive treatments like stump removal are effective for reducing disease inoculum between rotations but are limited by economic, site and machinery constraints.

Intensive treatments are suitable only on productive sites that will benefit most and that are amenable to machinery and some amount of disturbance. 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 negligible 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., stump removal) and the search for resistant individual families in field trials.

Further Reading
Zeglen, S. and P.J. Courtin. 2019. Soil disturbance and juvenile Douglas-fir growth following stump removal on moderately coarse textured soils in southwestern British Columbia: 10-year results. Can. J. For. Res. 49: 767-774.

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Rhizina Root Disease

Rhizina root disease, caused by the fungus *Rhizina undulata*, is primarily a mortality agent of seedlings planted after fire. On the coast, *Rhizina* affected CWH plantations in the late 1960s and through the 1970s but that has faded with the elimination 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 wildfire or broadcast burning for site prep. As such, any use of fire may stimulate the appearance of *Rhizina* and care should be taken when planting into 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 risk 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 seen in 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.

Further Reading
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Stem Rusts

White Pine Blister Rust

White pine blister rust (DSB), 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 its historical representation in forests. While DSB may infect trees of any age, the greatest impact occurs on young western white pine, since the zone of highest infection incidence is the lowest two metres of the bole. Infection occurs via spores infecting foliar stomata and mycelia progressing into 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.

Recently, species of *Pedicularis* and *Castelleja* have been named as alternate hosts for DSB but so far this has only been confirmed in areas east of the Cascades. As a rule of thumb for the coast, areas above 1000 m elevation may be considered less hazardous.

Hazard and Risk
Site hazard for DSB 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.

Impact
For over a century, DSB has decimated white pine in BC forests. The high mortality rate associated with the disease had resulted in largely discontinuing the use of western white pine in coastal reforestation due to doubt about its survival. DSB, along with mountain pine beetle, has severely impeded the reproductive capability of whitebark and limber pines, threatening the continued survival of these high-elevation species in areas of the province.

Management
Despite DSB, 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. It is also less susceptible to damage form elk. Over the decades, several attempts have been made to control this disease. The most significant was the widespread attempt to eradicate *Ribes* across the US from the 1930s to the 1960s. This was unsuccessful due to the impossible task of locating and eradicating all *Ribes* plants 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 (ineffective or impractical), thinning (ineffective), pruning (variable effectiveness), and scribing

cankers (effective but expensive). Since the 1960s, the most actively pursued strategy is tree breeding to try to identify and reinforce whatever resistance to DSB exists in the natural population and use the resulting offspring for reforestation.

On the coast, the most widespread practice has been to prune potential white pine crop trees to increase the odds of survival. Recent work, however, shows over the long-term sanitation pruning (treatment of older, already infected trees to increase survival) does not work. The recommended preventative pruning treatment regime is outlined in the 2009 Stand Establishment Decision Aid listed below and requires initial treatment early in the tree's development. The recent introduction of resistant stock (carrying the Cr2 or major gene resistant gene) has opened the window on using western white pine more extensively in plantations without requiring pruning to ensure survival. Seed orchards are producing class A seed from crosses of resistant Cr2 pollen with local white pine families of superior growth. The offspring are conferred at least 50% resistance (50% chance of not becoming infected on average) and field tests have noted survival of over 80% depending on local rust conditions. Natural regeneration survival of native trees is 5-15% in most areas.

Priority and Research

DSB has been studied since shortly after its discovery on the west coast. This includes 30 years of testing and breeding for resistant stock in BC and twice that long in the US. This is still a high-profile disease on the coast with ongoing projects testing cultural (i.e., pruning) and genetic (i.e., resistance) management practices. The most recent work involves evaluating the offspring of both major and minor gene resistant parents with the hope of combining both resistance attributes and genomics work on the fungus and host.

Further Reading

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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 Journal 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 five and will continue to be attacked for the next three decades. Dense stands have slightly lower attack rates and less deformity. Englemann spruce is also susceptible to attack but due to the higher elevation and cooler climate where Engelmann spruce grows, weevil attack has historically been less of a concern. Climate change appears to be increasing the hazard in these areas. Spruce weevil has not been found on Haida Gwaii, but Sitka spruce originating from there has been shown to be highly susceptible to weevil attack.

Impact

Repeated attack by the weevil can result in unacceptable losses of height growth and stem deformation as lateral branches turn upward and compete for dominance, often causing crooks and resulting in forked or dwarfed trees. In severe cases, little commercial volume is produced, with 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 to develop ways to control it. Pesticide injection treatments were also tried 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 later research trials have now resulted in weevil resistant seedlings that can be planted operationally.

Use improved weevil resistant planting stock (from selected orchard grown weevil resistant trees, R+87) to establish new Sitka spruce stands. If seed availability is limited, 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 following normal species selection guidelines. Low levels of weevil attack can be tolerated at the stand level (e.g., ≤10% stems attacked per year).
- In areas considered to have a moderate hazard, it is recommended that spruce only be planted 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 ha) and delay brushing competing hardwoods.
- Weevil attack rates decline when stand height reaches 12 m.

Priority and Research

This insect has received a significant amount of research over the past three decades, starting with years of leader clipping trials trying to develop a control method. Since Class A weevil-resistant seed is now available little new research is being undertaken on the coast.

Further Reading

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

Deer

Deer browsing of western red cedar and yellow-cedar seedlings is a problem throughout the coast area. It is especially a problem on Haida Gwaii. Sitka mule deer were first introduced to Haida Gwaii in 1880 with devastating affects on many understory herb and shrub species. Widespread deer browsing on Haida Gwaii is also believed to be a contributing factor to baby bird predation by another introduced species, the red squirrel.

Management

Deer protectors are highly recommended for consideration in all coastal areas where western red cedar is planted. Several types of commercial deer protectors are available. Deer protectors should extend at least 1.5-1.75 m in height from the ground. Stakes need to be at least 2 cm square, by 1.5m and should be free of knots, especially at ground level. Rocky soil may require 2.5cm diameter Douglas-fir or pine stakes that are less likely to split.

Metal cages require two stakes. Finger jointed stakes should not be used. Deer protectors need to be firmly attached to their stakes. For collapsible deer protectors, the stake should be located inside the protector. A study by Henigman & Martinez (2002) found that metal cage barriers provided the best browse protection and 1m plastic mesh barriers provided the worst. However, metal cage barriers required better support than plastic barriers, were the most expensive to purchase and install, and required removal once the trees reached the required height. There was some concern that plastic cone and tube barriers reduced recovery of seedlings infected with cedar leaf blight. The plastic cone barriers required the most maintenance and had the highest overall costs. Leaders and side branches often emerged from the sides of the plastic mesh barriers which led to browsing, shrub-like trees, and additional damage to the barriers from feeding. The plastic mesh type barriers need to be attached to the stakes to prevent them from bending over. Deer repellents are also available and may provide some protection at the time of planting but require continuous re-application to be effective over longer periods of time.

Further Reading

Henigman J. and M. Martinez. 2002. Evaluation of Deer Browse Barrier Products to Minimize Mortality and Growth Loss to Western Redcedar. Final Report.

Elk

Successfully regeneration in areas frequented by Roosevelt Elk can be very difficult. Damage includes browsing, tramping, antler rubbing and pulling out freshly planted seedlings. High hazard areas are sites in rich valley bottoms and riparian areas close to elk seasonal ranges or migratory routes with available winter thermal and snow cover. Douglas-fir, western red cedar, and yellow-cedar are preferred browse species. Western white pine, sitka spruce, western hemlock, grand fir and red alder are less preferred by elk. Harvest scheduling can be an important factor in determining the availability of alternate food sources over time.

Management
The Silviculture Working Group Coast Forest Region FRPA Implementation Team provided recommendations for minimizing elk damage. They include planting less desirable species, avoiding small openings or long narrow blocks, maintaining high slash loads, using cage protectors, planting with larger stock at higher densities, grass seeding roads and landings or planting later in the spring when there are other alternate food sources, encouraging recreational and road access, and using deer repellents prior to planting.

Further Reading
Silviculture Working Group. 2011. Roosevelt Elk impacts on reforestation: mitigation options
Ministry of Forests, Lands, Natural Resource Operations and Rural Development. 2018. Roosevelt Elk current condition report. Howe Sound cumulative effects project.

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
Hazard to second growth, even-aged, hemlock-dominated stands exists 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 also less desirable due to the increased effort required to climb and feed higher in the canopy.

Impact
The results of a study done in the North Coast 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 favours the growth of sitka spruce, amabilis fir and western redcedar. Damage occurs by girdling, exposing the wood to decay, or causing defects (e.g., crooks, scars, etc.).

Management
Since porcupines seem to prefer openings stocked with substantial 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 enough 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.

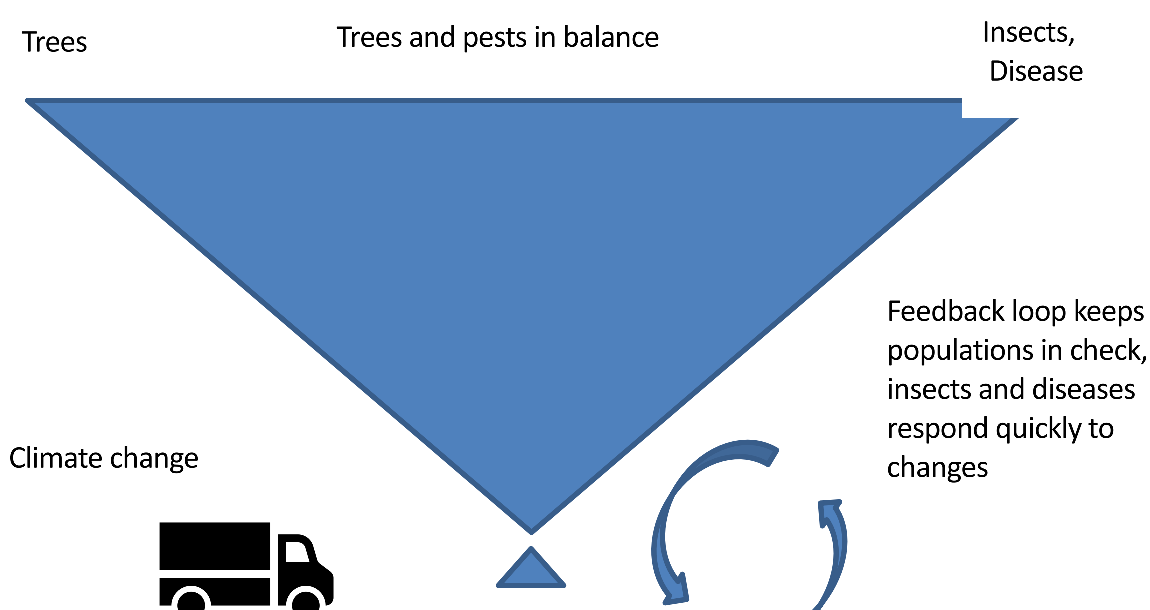
Further Reading

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.

Climate Change and Forest Health

Historically, the coast has not been affected to the same degree by forest health compared to the rest of the province. Within the Coast Area, some of the largest forest health impacts have been in the coast-interior transition area. Climate change is having a growing effect on forest health and will be a major driver when it comes to forest health in the future. The most visible immediate impacts are the increase in fires and drought mapped in the AOS.

One of the key concepts in forest health is the forest health triangle (Fig. 2). Forest health is the interaction between trees, biotic and abiotic forest health factors, and the environment. When these factors remain constant tree health is relatively stable. Changes to any one of these factors, such as rapid changes to the environment caused by climate change, will affect forest health. Diseases and insects undergo natural fluctuations in population levels even when the environment is relatively stable but with climate change these changes are expected to be larger, more frequent, and less predictable. Insects and diseases have short generation times and adapt quickly to changes in the environment. Trees have long generation times and even small changes in the environment can cause trees to become maladapted to their environment resulting in less vigorous trees that re more susceptible to forest health factors.



Environment

Figure 2. Forest Health Triangle.

Recent coastal examples of how climate change can negatively impact forest health include SNC and yellow-cedar decline. A warming climate also brings with it higher frequency of abiotic forest heath factors resulting from extreme weather events. Biotic and abiotic factors often act together to negatively impact forest health. Some examples include increased IBD attacks following fire and wind, increased drought mortality of trees with root disease, tree declines, and increases in secondary insects and disease following periods of drought.

We may be able to slow the impact of climate change by increasing forest resilience through:

- better forest health monitoring,
- mitigating forest health problems through hazard reduction and proactive treatments both in our managed forests and protected areas,
- paying attention to forest health trends happening to the south,
- increasing the diversity of trees species and management regimes,
- shifting timber harvest more towards dead and damaged timber, and
- realizing that growth forecasts based on past and current conditions may no longer be accurate predictors of future conditions.

However, climate mitigation is a band-aid solution at best. The more we can do to reduce green house gas emissions sooner the more likely climate mitigation efforts will have a positive effect on forest health outcomes under climate change. In order to mitigate against these climate impacts, it is imperative that we drastically and immediately reduce green house gas emissions.

Accounting for Forest Health in Timber Supply

Predicted future yield is at the foundation of timber supply modelling in British Columbia. Most timber supply reviews (TSR) are based on output from three models: the Variable Density Yield Prediction (VDYP) model that predicts yield for natural stands, and the Tree and Stand Simulator (TASS)/Table Interpolation Program from Stand Yields (TIPSY) models that predict yield for managed stands[31]. These models may or may not account for the impact of damaging agents. Target release dates for the next scheduled TSR by TSA are available on the BC government web site[32].

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. Some forest health specific forecasting models and extensions have been developed for use with TASS/TIPSY like the Spruce Weevil Attack Trial (SWAT) or the Gall Rust Impact Module (GRIM).

[31] Growth & Yield Modelling - Province of British Columbia (gov.bc.ca).

[32] Timber Supply Areas target release dates - Province of British Columbia (gov.bc.ca)

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 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 forest health affected plots are discarded and no longer help form future yield curves. The consensus amongst forest health and growth and yield specialists is that VDYP accounts for endemic forest health factors 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, forest health factor 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; 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 at age 100, 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 forest health factors, even endemic ones, other than decay. Any impacts from these damaging agents are added to the default value of 5% and should be applied for the specific timber types, BEC, and age classes as appropriate in the next TSR. Where they exist, recommended adjustments to OAF 2 values are described in the forest heath factor profiles.

Non-Recoverable Losses

Non-recoverable losses , 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 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 TSAs and TFLs are provided in Table 4 and Table 5, respectively. Links to TSA data packages and tentative TSA target release dates are available on the government AAC TSA website.[33] The way these NRLs are calculated varies widely across different TSR processes but efforts are being made to standardize how these NRLs are calculated in the future based on AOS and vegetated resource inventory data.

[33] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/timber-supply-review-and-allowable-annual-cut/allowable-annual-cut-timber-supply-areas

Table 4. Summary of annual 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 (data package yr.)	Drought m³/yr.	Fire m³/yr.	Flood m³/yr.	Slides m³/yr.	NCY m³/yr.	Wind m³/yr.	Root Rot m³/yr.	IBB m³/yr.	IBD m³/yr.	IBM m³/yr.	IBS m³/yr.	Total[a] m³/yr.	Current AAC m³	% of AAC
Arrowsmith (2020)		1,067					4,159	32	3,845		2	9,105	320,230	2.8
Fraser (2019)		16,500				3,120		3,100	8,800	400	200	32,120	1,220,808	2.6
GBR North[b] (2017)													803,000	
GBR South[b] (2017)													830,500	
Haida Gwaii (2021)				26 ha[c]	40 ha[c]	70 ha[c]						195 ha[c]	272,061	
North Island (2020)	116	2,592	93						117		3	2,921	1,248,100[f]	0.2[f]
Pacific (2018)												18,057[e]	859,176	2.1
Soo (2023)		30,000										34,000[d]	368,276	9.2
Sunshine Coast (2021)	360	500	791			6,900		6	2,114	1467	199	12,650	1,197,466[f]	1.0[f]
Total													4,674,051	

[a] sum of all forest health factors
[b] There were no data packages for these TSAs created in 2017.
[c] For Haida Gwaii, the unsalvaged losses were presented as non-contributing areas for use in the SELES spatial timber supply model.
[d] Includes 4,000 m3/year for Western spruce budworm and Douglas-fir beetle
[e] Total unsalvaged losses were obtained by prorating the NRLs from surrounding TSAs based on the percentage of Pacific TSA area represented by the blocks surrounded by a particular TSA.
[f] Awaiting final determination when table created. Current AAC and % of AAC is based on the previous AAC determination (2017 for North Island, 2018 for Sunshine Coast).

Table 5. Summary of annual non-recoverable (unsalvaged) losses by damage category as accounted for in the last data package available on the government website for each of 17 TFLs in the Coast Area.

TFL	Licensee	Resource District	Fire m^3/yr.	Wind m^3/yr.	Abiotic m3/yr.	Defoliator m^3/yr.	Biotic m^3/yr.	Insects m^3/yr.	Total[a] m^3/yr.	Data Package Year[c]	Current AAC m^3/yr.	AAC yr.
TFL 6	Western Forest Products	North Island		7,000					7,000	2011	1,362,000	2015
TFL 19	Western Forest Products	North Island		6,335					6,335	2008	728,837	2012
TFL 25	Western Forest Products	various		3,700					3,700	2003	234,300	2017
TFL 26	District of Mission	Chilliwack	10	112					122	2019	60,000	2020
TFL 37	Western Forest Products	North Island							8,470	2017	847,000	2018
TFL 38	Northwest Squamish	Sea to Sky	2,084					1,071	3,200[b]	2002	250,500	2007
TFL 39	Western Forest Products	Sunshine Coast							5,105	2014	510,500	2024
TFL 43	Homalco Forestry	North Island							0	2009	18,450	2021
TFL 44	Tsawak-Qin Forestry	South Island		8,380					8,380	2009	642,800	2023
TFL 45	Interfor	North Island	10				10		20	2001	140,000	2017
TFL 46	Teal Cedar Products	South Island							3,754	2009	375,442	2022
TFL 47	TimberWest	North Island GBR south							0	2012	630,000	2017
TFL 54	Ma-Mook	South Island							2,410	2018	46,000	2020
TFL 58	A&A Trading	Haida Gwaii							0	2012	99,000	2020
TFL 60	Taan	Haida Gwaii			8,300	36,613			44,913	2012	279,000	2020
TFL 61	Pacheedaht Andersen	South Coast							0	2003	121,000	2019
TFL 64	Western Forest Products	Sunshine Coast							9,058[d]	2014	905,800	2024
Total									102,467		7,250,629	

[a] sum of all forest health factors

[b] rounded up to 3,200

[c] total forest health loss data was taken from values found in management reports available on the government website when the table was compiled. In some cases the current AAC may be based on more current NRL data than shown.

[d] Block 2 of old TFL39. In 2014, TFL 39 used 1% of AAC

Regional Forest Health Activities

1. Training, Advocacy, Extension, Professional Development

Forest health training and extension are key components of the forest health program in the Coast Area (West Coast and South Coast Natural Resource Regions). For help with identification or management of forest health factors or to set up forest health training contact your regional forest health staff. Regional staff stay up to date with current research and share information with forest health specialists at universities and in other jurisdictions.

2. Program Delivery

The coast area receives land based investment strategy (LBIS) money to carry out forest health monitoring on a number of projects (2.1-2.6).

2.1 Spongy Moth

The region puts out and collects spongy moth traps not accessible via paved roads in the West Coast Region and supports the provincial entomologist with control sprays or grid trapping if required. Resource Districts in the South Coast region are responsible for putting out their own monitoring traps. Early detection is critical for ensuring this invasive moth does not become established in BC. Not only does spongy moth pose a threat to native tree species, the province risks trade restrictions being placed on wood exports and other trade goods. European spongy moth is established in eastern Canada and makes its way into BC in the form of egg masses laid on boats and recreational vehicles. Asian spongy moth occasionally makes its way into BC on cargo ships. The Asian spongy moth poses a greater threat because the females can fly and disperse more quickly and they are more likely to feed on conifers. When infestations are detected, they are controlled through grid trapping or through aerial application of Btk, a naturally occurring bacterial spray for the control of moths. More information on Btk can be found on the BC government website[34].

2.2 Aerial Overview Survey Monitoring

The region is responsible for tendering, awarding, administering, managing, and summarizing the annual regional aerial overview (AOS) survey (see section on AOS for more information).

2.3 Forest Health Monitoring

The region is responsible for conducting forest health monitoring surveys and summarizing forest health information collected from a variety of sources. At the present time, the region has a series of permanent sample plots and weather monitoring stations for determining the impacts from Swiss needle cast (SNC). Data collected from these plots will be used to determine the impacts of SNC and provide management recommendations for managing the disease in the coast area.

2.4 Defoliator Monitoring

The region monitors hemlock looper populations using pheromone traps located in areas of historical outbreaks and conducts egg mass surveys for western spruce budworm annually. The results from

[34] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/invasive-forest-pests/spongy-moth/what-is-btk

these surveys are used to predict outbreaks the following year. The region also oversees monitoring of black army cut worm in areas being replanted after fires.

2.5 Douglas-fir Beetle

The region provides advice and expertise to districts to carry out proactive Douglas-fir beetle (IBD) treatments. Because of the steep terrain and high winter snowfalls, reactive treatments are seldom possible. Treatment has mostly been focused on post-fire use of funnel traps and anti-aggregates.

2.6 Administration

The region is currently without a fulltime entomologist. To help manage the workload, the region spends 10% of its land based investment dollars to help deliver its programs.

3. Supporting Districts, BCTS, Regional Stewardship staff and other government staff on forest health related matters

Resource district LBIS funds and reporting are coordinated through the regions. Regional forest health staff also assist regional staff with forest health related questions.

4. Assessing Forest Health Hazard and Risk Maintaining the Regional Forest Health Strategy

The region assesses current hazard and risk for forest health factors and updates the coast area forest health strategy.

5. Help Develop Forest Health Policy and Best Management Practices

Regional forest health staff along with regional forest health specialists from other regions work with provincial forest health staff to advise the office of the chief forester on forest health policy for the province.

6. Research and Collaboration

The region applies for provincial research dollars to fund forest health research projects and collaborates with universities, the federal government, and other partners to carry out operational forest health research (Table 5).

7. Climate Change Strategies

Region forest health staff work with other regional and provincial government staff to develop climate change strategies to deal with forest health. Climate change is currently having a major impact on the health of BCs forests and is expected to be a major driver of forest health in the years to come.

Table 6. Current Research Projects.

Project	Description	Product	Timelines
Texada BSO White Pine Trial	White Pine Blister Rust Progeny Trial	-rating 33 families for blister rust resistance	-Last assessed in 2019.
Whitebark Pine Monitoring Plots	Long-term monitoring plots to track health of whitebark pine. Surveys to date show 50% of whitebark pine in BC is dead or infected by white pine blister rust. The rate varies across the province. Monitoring is needed to find the mortality trend.	- Nine plots set up to date. - Future plots required across range of whitebark pine	-Assess plots every 5 years following establishment.
Septoria canker of poplar	Introduction of non-native disease threatens susceptible hybrid poplar clones and native *P. trichocarpa*.	- Risk evaluation for establishment of *Septoria* in native poplar. - Chief Forester guidance on use of poplar hybrids in BC[35].	-Follow up survey completed in 2020.
Yellow-cedar Decline ecological succession	Collaborative work with regional research, UBC and partners on assessing ecological implications of decline sites on the north and mid-coasts.	- Research proposal funded. - Summary of pilot field season.	-Pilot completed 2019. -Next collection planned 2024.
Swiss needle cast	Monitoring plot network tracking the severity and impact of SNC on young Fd stands in CWH subzones. Collaborative project with SNC Co-op plot network in OR and WA states.	- Network of 43 plots set up 2017-19 across three subzones. - Initial plot data capture and analysis of tree foliage and soils and genomic profiling of disease in BC. - BCIT student projects.	-Annual monitoring of 14 weather station sites. -Ten-year assessment starts late 2027.
Foliar retention in young coastal Douglas-fir stands	Voluntary reporting of needle retention and leader growth as part of silviculture survey data collection	-assessment of annual trends in needle retention resulting from SNC and other causes of needle loss across a variety of coastal ecosystems and geographic locations	-Data collection started in 2023
Rate of hemlock dwarf mistletoe spread from an infected edge	Rate of hemlock dwarf mistletoe spread into 35-year old western hemlock leading stands	-MSc. Thesis -permanent sample plot network	-Data collection started in 2023
Armillaria ostoyae on Haida Gwaii	Investigation of distribution and pathogenicity of *A. ostoyae*	-Management of *A. ostoyae* on Haida Gwaii in collaboration with UBC and Pacific Forestry Centre	-Data collection in 2024
Effectiveness of Douglas-fir beetle post fire mitigation	Investigation of post-fire Doulgas-fir beetle spread with and without mitigation treatments using satellite imagery	-Funding recommendations for Douglas-fir beetle post-fire mitigation projects	-Test effectiveness of treatments carried out between 2022-2024

[35] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/forest-health-docs/septoria_guidance.pdf

Appendix A: Pest History by TSA

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) conducted large-scale aerial and ground surveys. The intent of these surveys is to provide an overview of forest health conditions. The AOS is not detailed enough for operational purposes but supplies a landscape-level picture of pest activity and distribution that can be useful for the early detection of outbreaks or new pest occurrences. Table 6 summarizes the 2020 results for the Coast Area. More recent annual updates are available on the Ministry website and through the *Summary of Forest Health Conditions in British Columbia*.

Root disease has been left out of the table because it is difficult to map root disease from a fixed wing aircraft and the numbers recorded in the AOS survey grossly underestimate the amount of root disease present across the landscape. Note that Tree Farm Licence (TFL) areas are neither completely nor consistently covered by the overview survey. The Pacific (TSA) is not recognized separately for the purposes of the AOS because the small blocks that make up the Pacific TSA are scattered across a wide geographic area. Instead of summarizing the forest health factors in the Pacific TSA, this appendix just provides a broad overview map and a table that indicates which blocks are lumped in with other TSAs in the AOS summaries.

Table 7. Summary of annual average area (ha) affected by major pests and abiotic damaging agents at all severity levels in the Coast Area as reported by the aerial overview survey. Figures are 10-year averages from 2010-2020 except for GBR North, GBR South and North Island TSAs which are four-year averages form 2017-2020 and Pacific which is a ten year average from 2010-2019.

	Timber Supply Area									
Damaging Agent	Arrow smith	Fraser	GBR North	GBR South	Haida Gwaii	North Island	Pacific	Soo	Sunshine Coast	Rank based on ha
Douglas-fir beetle	1690	1566	485	432		109	339	240	434	5
Mountain pine beetle		1544	2965		28			1125	217	3
Spruce beetle		1093	3581	132	134	28		185	260	4
Western balsam bark beetle	589	6534	64268	1169		188		9904	1649	1
Western black headed budworm					4680					7
Western hemlock looper		602							654	15
Western spruce budworm		372						72		16
Aspen leaf miner		101	3463							10
Balsam woolly adelgid	9	50	4	93		1615			18	11
Foliar diseases			3632					19		9
White pine blister rust	2122	13		13		1842			712	6
Bear	31	42								17
Yellow-cedar decline			21997	4170	3045		144			2
Windthrow	40	6	74		1285	57	213	15	3	12
Drought	1044	635	390	129	60	517	58	65	1283	8
Flooding	18	22	198	69	476	78	540	111	43	14
Slides		17	248	64	1230			21	6	13
All	5,543	12,597	101,305	6,271	10,938	4,434	1,294	11,757	5,279	
Approximate Size of TSA	1,574,719	1,400,000			308,000	1,749,460	434,000	826,000	1,500,000	

Arrowsmith TSA

The Arrowsmith TSA is located on the southern half of Vancouver Island and borders on TFLs 44, 46, 54, 57, and 61. 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, TFLs, urban and sub-urban areas, rural agricultural lands, parks and reserves. The Arrowsmith TSA is administered by the South Island Natural Resource District. Although the TSA encompasses 1 574 719 hectares, the actual productive forest land managed by the district is only 122 445 hectares.

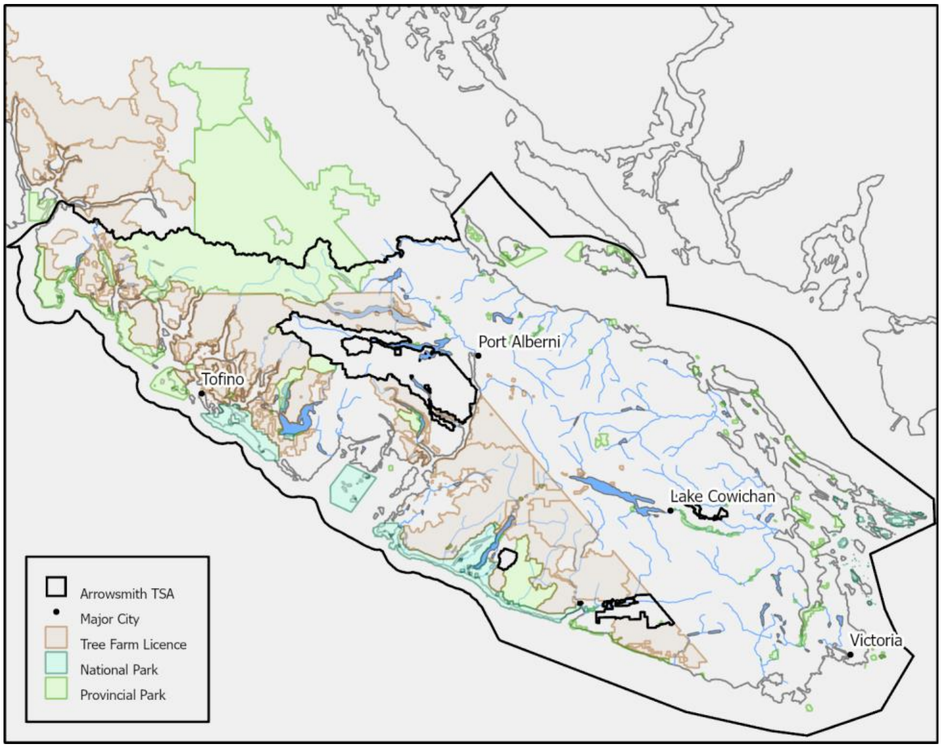


Figure 2. Arrowsmith Timber Supply Area.

Spanning southern 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 sizable proportion of western hemlock. The Coastal Douglas-fir (CDF) zone occurs on the eastern side of the TSA, which is comparatively drier with gentler topography than the western part. 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, there are isolated occurrences of Coastal Mountain-heather Alpine (CMA) zone.

The forests of the TSA are diverse, and slightly more than half of the land base contributing to timber supply is considered to have medium or good site productivity. Major tree species include Douglas-fir, western redcedar, western hemlock and true firs, while other species such as yellow-cedar, spruce, red alder, and maple also occur. The forests of the TSA have a 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 timber harvesting land base (THLB) are between 21 and 100 years of age.

Thirty-six First Nations have asserted and/or established Aboriginal interests within the traditional territories that overlap the Arrowsmith TSA.

Effective September 11, 2020, the new AAC for the Arrowsmith TSA is 320 230 cubic metres. This AAC is about 10 percent lower than AAC in place prior to this determination (originally set in 2009 and adjusted in 2016).

Douglas-Fir Beetle

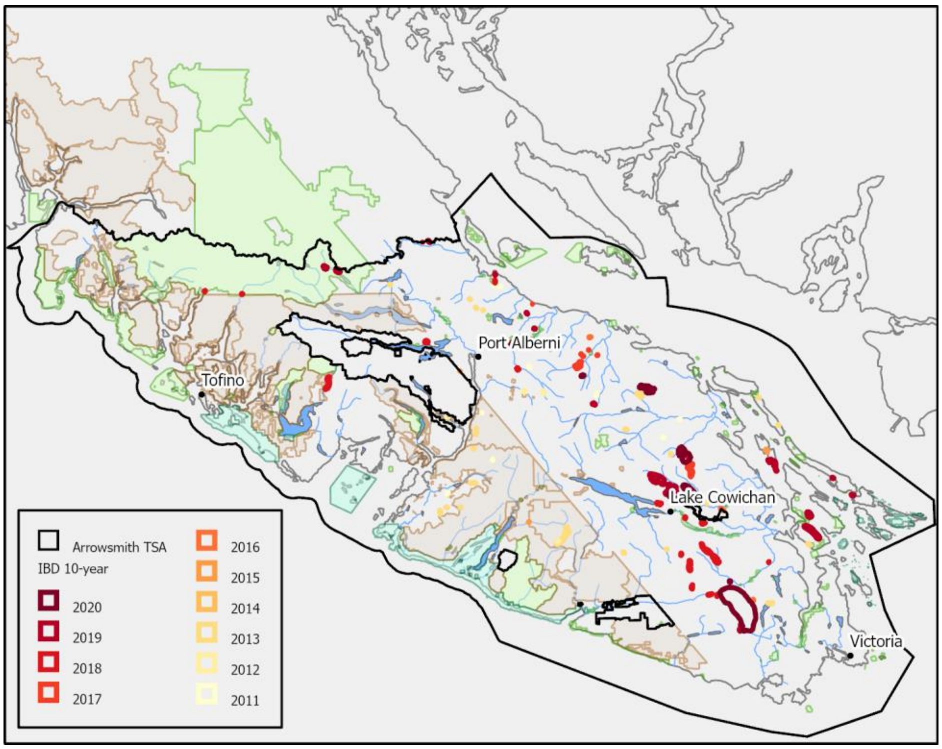


Figure 3. Annual occurrence of Douglas-fir beetle over the last decade in the Arrowsmith TSA.

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 suffering from 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. It can also appear after large windthrow events when populations expand by colonizing recently killed trees. The occurrence of beetle has trended upward between 2017 and 2020 from 598 to 8995 ha a result of increased attack on drought-stressed trees.

Drought

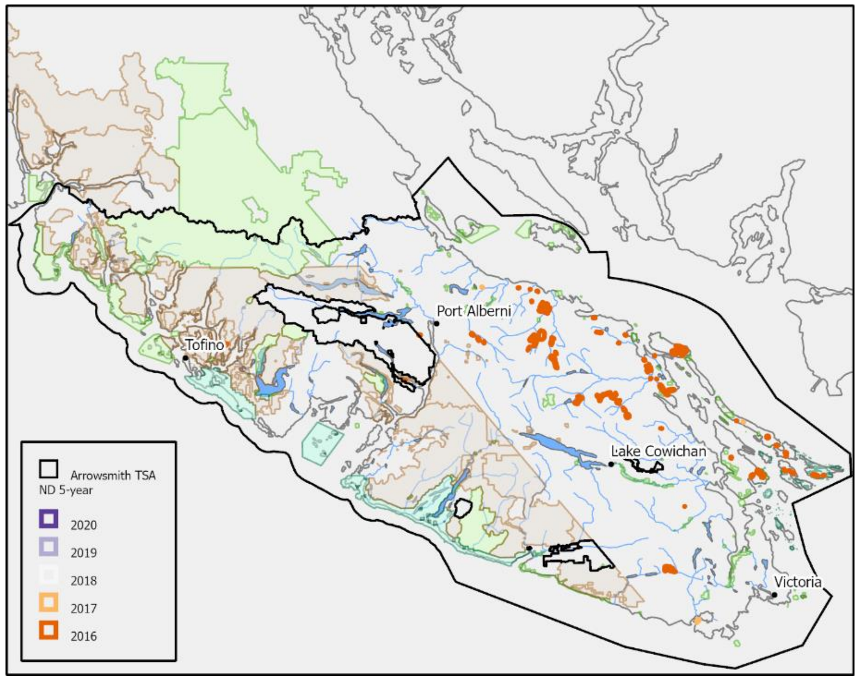


Figure 4. Annual occurrence of drought mortality in the Arrowsmith TSA.

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 enough 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 summer dry spell with little measurable precipitation, like the ones in 1998, 2004, 2017, 2018, 2022 and 2023 can lead to significant amounts of tree decline and mortality if conditions are severe enough. Local climate shifts suggest this may occur more often. Recent drought is especially noticeable on eastern Vancouver Island and the Gulf Islands especially in areas where dead and declining western redcedar are present.

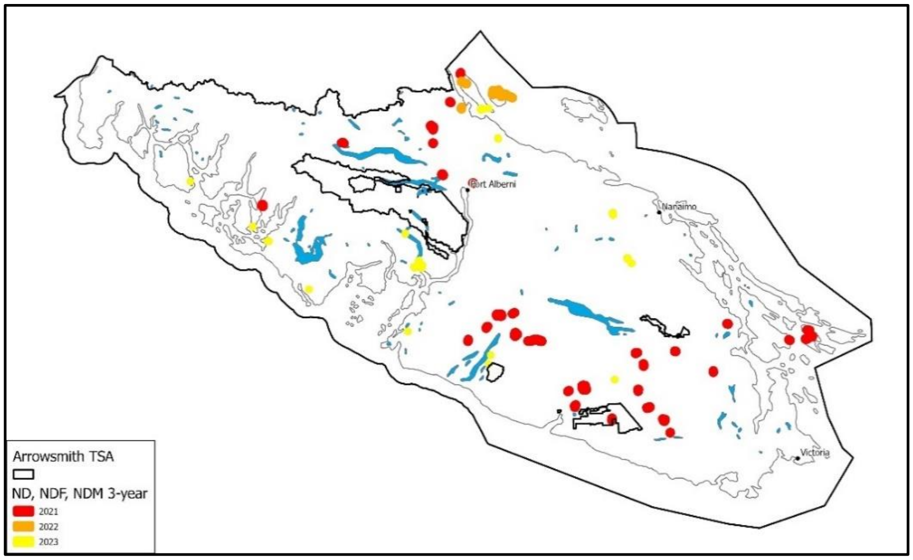


Figure 5. Annual occurrence of Drought from 2021-2023 in the Arrowsmith TSA.

Spongy 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 a partnership role with the Canadian Food Inspection Agency in monitoring for this pest and a lead role in conducting aerial and ground eradication treatments, 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, mostly in populated areas. The most recent spray applications using the biological control agent Btk for eradication of moths in the TSA was in 2024. The largest total spray was in 2023 with 3,040 ha sprayed between Campbell River and Victoria[36].

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. Since then, this beetle has rarely been reported.

Root Diseases

Losses to root diseases 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 *Coniferiporia sulphurascens* (= *Phellinus weirii* Fd-type) and *Armillaria ostoyae* acting as mortality agents of immature and mature trees, primarily Douglas-fir, in these drier subzones.

[36] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/invasive-forest-pests/spongy-moth/treatment-history

Spruce Aphid

Spruce aphid has caused defoliation to Sitka spruce at various times, mostly between Victoria and Jordan River, and on the Gulf Islands. In some years it is more noticeable than others even though it probably occurs annually in the same areas.

Western Black Headed Budworm

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 recently even though outbreaks occur 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 ha in size and mostly within the CWHvm1. It resulted in severe defoliation and mortality and later 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 CDF biogeoclimatic zone. No other defoliation by this insect has been since recorded in the Arrowsmith 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 see scattered damage throughout the range that the host grows. These are often recorded as spots or small scattered polygons. In 2020, polygons totalling 11,769 ha were mapped at trace to moderate intensity throughout the TSA. Although the damage occurred primarily as scattered single trees, damage was at a high enough level that recording polygons was possible. This mortality was primarily in the drier subzones of eastern and central Vancouver Island and was mostly natural white pine regeneration.

Windthrow

There was a large wind event on December 18/19, 2019 that struck parts of southern Vancouver Island. Extensive windthrow was noted in the Whiskey Creek area, Little Qualicum Falls Provincial Park and on neighbouring private lands. Much of the material was salvaged and no uptick in Douglas-fir beetle was noted in 2020.

Fraser TSA

The Fraser TSA, located in the southern portion of British Columbia's South Coast Natural Resource Region, covers approximately 1.4 million hectares and is administered from the Chilliwack Natural Resource District office. It is the most densely populated TSA in the province, encompassing major population centres in the Lower Mainland and Fraser Valley. There are 34 first nation communities that reside in the District, 27 communities that reside outside the TSA for a total of 61 communities that assert territories over the Fraser TSA and there are 11 tribes/councils which include a combination of the individual communities.

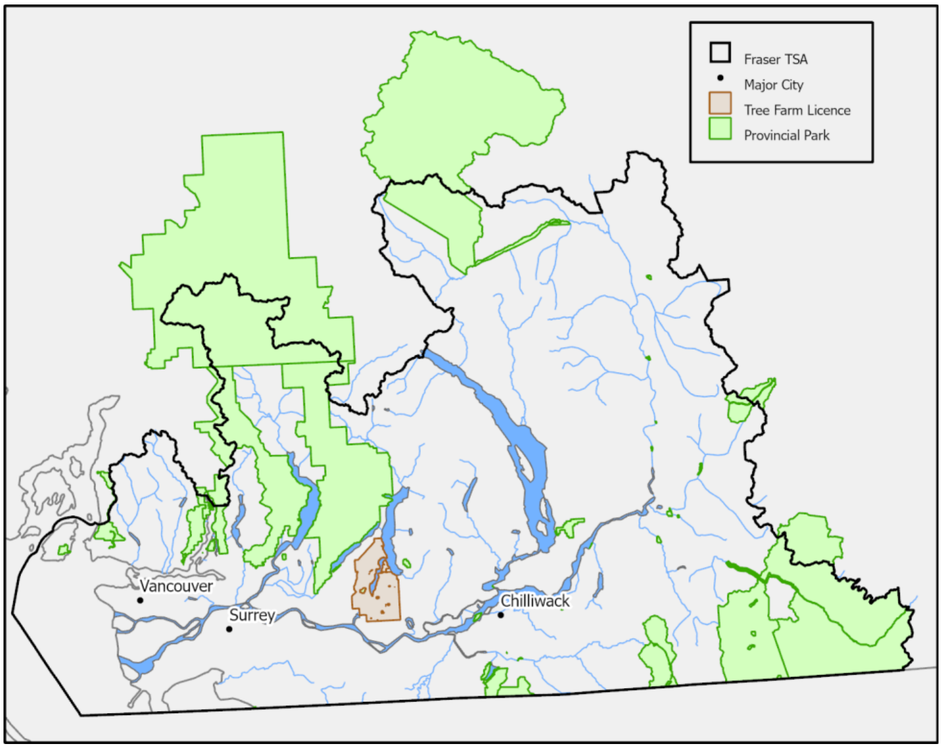


Figure 6. Fraser Timber Supply Area.

The Fraser TSA is a biologically diverse region, with five biogeoclimatic zones providing habitat for more than 300 species of resident and migratory birds, 45 species of mammals, 11 species of amphibians, and 5 species of reptiles. The TSA is bordered by the Coast Mountains to the north and to the east. Tributaries and lakes drain from this area into the Fraser River, flowing through the broad, riverine plain lying between the community of Hope to the east and the city of Vancouver to the west, on toward the extensive delta of the Fraser estuary and into the saltwater of Georgia Strait. While the coastal western hemlock zone is the most abundant zone in the TSA, the diverse landscapes support 13 commercial tree species.

The TSA includes both major urban population centres, where various service sectors combine to provide about 70 percent of the region's employment, and smaller rural communities, where primary sectors including forestry provide important sources of employment and economic activity.

Effective August 6, 2019, the new AAC for the Fraser TSA is 1 220 808 m^3.

Balsam Woolly Adelgid

This introduced pest has been found throughout the Fraser TSA. It can cause considerable damage, including mortality, to *Abies* species; however, within this TSA its impacts have not yet been found to be significant. The TSA was included within the regulated quarantine area which restricted the movement of true firs (see *Balsam Woolly Adelgid Regulation*), however, this regulation was repealed in 2019.

Douglas-fir beetle

Douglas-fir beetle is a native insect that attacks fresh wind throw or trees predisposed by other factors, such as drought, defoliation or root diseases. Instances of Douglas-fir beetle attacked root-diseased trees are common in 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 through to 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, three of which were near the Nahatlatch River and the rest in areas along Highway 3 between Sunshine Valley and the west gate of Manning Park. In 2004, populations increased along the Fraser Canyon corridor and Nahatlatch River with about 2590 ha infested, and in Manning Park where 155 ha were infested. Populations stayed low with 500-1500 ha reported annually from 2011-2014. A spike to 4271 ha in 2015 was primarily

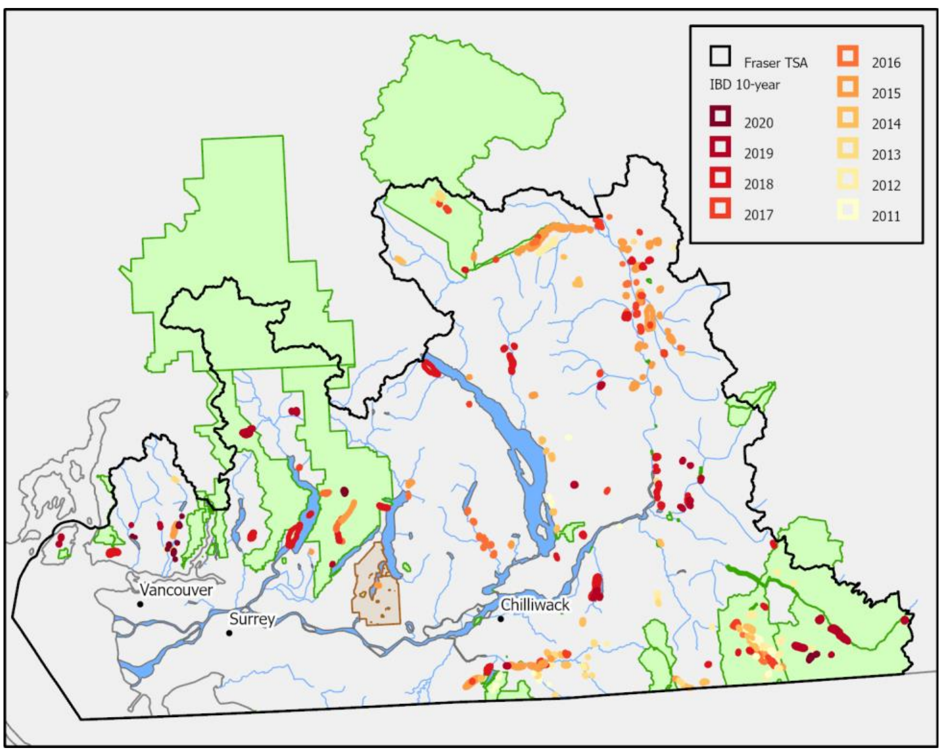


Figure 7. Annual occurrence of Douglas-fir beetle in the Fraser TSA over the past decade.

in the Fraser and Nahatlatch Valleys. Endemic level mortality around the Sunshine Valley area prompted calls from the locals. Recently, the beetle has been trending down with 3603 ha found in 2018 but only 288 ha in 2020.

Drought

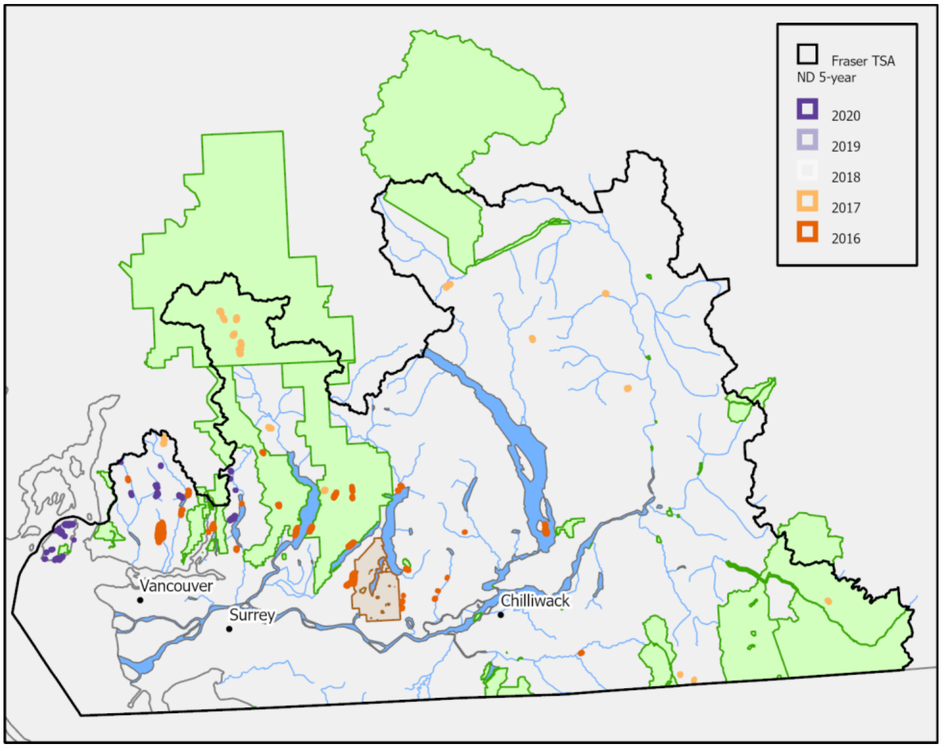


Figure 8. Annual occurrence of drought mortality in the Fraser TSA from 2016-2020.

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 enough 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 measurable precipitation, like the ones in 1998, 2004, 2017 and 2018 can lead to significant amounts of tree decline and mortality if conditions are severe enough. Local climate shifts suggest this may occur more often. Recent drought is especially noticeable in areas where dead and declining western redcedar are present.

Forest Tent Caterpillar

In 2014, this insect caused 2,205 ha of light to moderate defoliation mostly in the Cultus Lake area. While the defoliation can be unsightly due to 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. Defoliated trees typically reflush later in the growing season or normally the following spring.

Spongy 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 a partnership role with the Canadian Food Inspection Agency in monitoring for this pest and a lead role in conducting aerial and ground eradication treatments, 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, mostly in populated areas, however, 197 moths were trapped near Cloverdale in 2014 resulting in a spray treatment in 2015. There have been several ground and aerial spray treatments within the TSA since 1984. Over the last decade, areas have been sprayed near Agassiz, Burnaby, Chilliwack, Coquitlam, Delta, Harrison Hot Springs, Langley, Mission, Richmond, Delta, and Surrey. These are exclusively in urban or agricultural areas and not in managed forests. A history of areas treated with Btk for Spongy Moth can be found on the BC government website[37].

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, and in 1973 in the Nahatlatch River drainage. The infestation continued in both 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 about 9300 ha recorded in Manning Park and Skagit valley, and 3300 ha outside park boundaries along Highway 3, in 2004. This is an 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 pines in 2007. Population levels then steadily declined to about 4000 ha in 2013 mostly in the Manning Park and Nahatlatch areas. These areas showed light to moderate severity. Since then it has only been reported on a few dozen hectares annually, primarily in the Fraser Canyon and in the coast-interior transition zone.

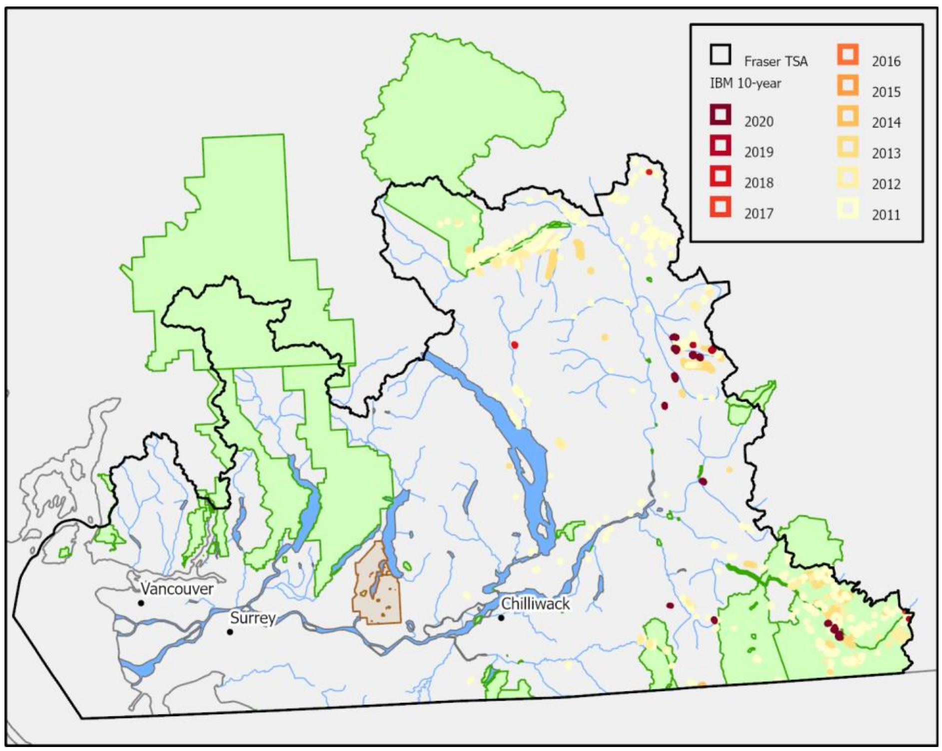


Figure 9. Annual occurrence of mountain pine beetle in the Fraser TSA over the past decade.

[37] https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/invasive-forest-pests/spongy-moth/treatment-history

Root Diseases

The TSA has both *Coniferiporia sulphurascens* (= *Phellinus weirii* Fd-type) and *Armillaria ostoyae* acting as mortality agents of immature and mature trees, primarily Douglas-fir, in drier subzones. Root disease losses have been not been accounted for in the 2016 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, east of Hope. It has also been confirmed in hybrid poplar plantations found on private lands in or near the Fraser River. A follow-up survey in 2020 sampled 231 black cottonwoods in the same area as the 2012 survey. Only three samples were positive for *S. musiva*, about the same incidence as the earlier survey. 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 of this disease currently is slow; however, the use of specific hybrid poplar strains should be avoided. Consult the Chief Forester's letter regarding "Guidance on the use of hybrid poplar clones for reforestation on Crown land[38]" (April 26, 2019) for more information.

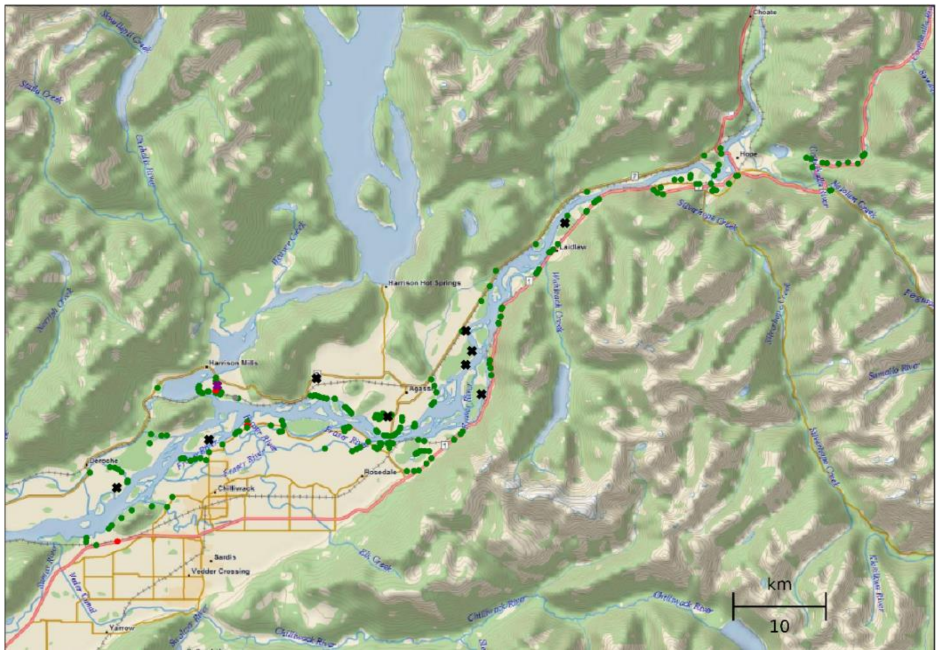


Figure 10. Distribution of sites in the Fraser Valley where Septoria canker was found (red spots) during a 2020 survey.

Spruce Beetle

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 about 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 about 55 ha of infested spruce were detected south of the Nahatlatch River. Between 2004 and 2016 areas attacked by spruce beetle increased

[38] https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/forest-health/forest-health-docs/septoria_guidance.pdf

modestly with 738 ha mapped in 2016 with the majority found in Manning Provincial Park. The area affected increased in the park between 2017 and 2019 with just under 4,000 ha detected.

Swiss Needle Cast

Swiss needle cast (*Nothophaeocryptopus gaeumannii*) and Douglas-fir needle cast (*Rhabdocline pseudotsugae*) have been found in young Douglas-fir plantations in the Fraser TSA. Douglas-fir needle cast has been found on Vedder Mountain and in the Lake Errock area and can cause severe defoliation in some years enough to affect growth. Swiss needle cast has been confirmed throughout the TSA except in the driest subzones and has had more consistent occurrence on trees since 2010. These foliar diseases thrive during warm winters followed by damp and mild spring conditions, so their occurrence is heightened when conditions are right. Changes in weather patterns favouring damp springs has led to severe occurrences of Swiss needle cast in TFL 26 and stands around Harrison Lake. The district also has 20 long-term impact monitoring plots in the CWHdm and vm subzones. Data from these plots should supply impact estimates for this disease in the coming years.

Western Balsam Bark Beetle

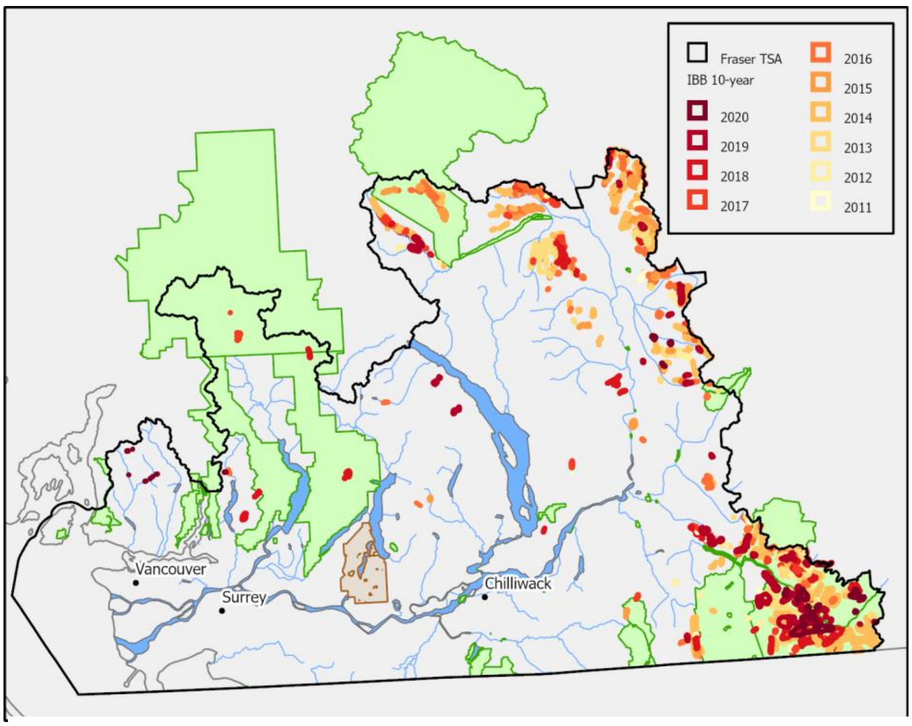


Figure 11. Annual occurrence of western balsam bark beetle in the Fraser TSA over the past decade.

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. A few thousand hectares have been reported annually since. It is impractical to manage this beetle on the coast.

Western Black-Headed Budworm

In 1941 light defoliation occurred from Vancouver to Surrey. In 1967, about 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 these defoliations have been light to moderate and have not had significant impacts. No detections have been recorded in recent years.

Western Hemlock Looper

Seven 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 about 2100 ha defoliated noted near Stave and Harrison Lakes. These populations collapsed in 2004 with only 18 ha defoliated near Stave Lake. In 2020, a new outbreak was recorded in the North Shore watersheds with 5978 ha affected. This increased to 10,297 ha in 2021 and then declined to 578 ha in 2022 and 229 ha in 2023.

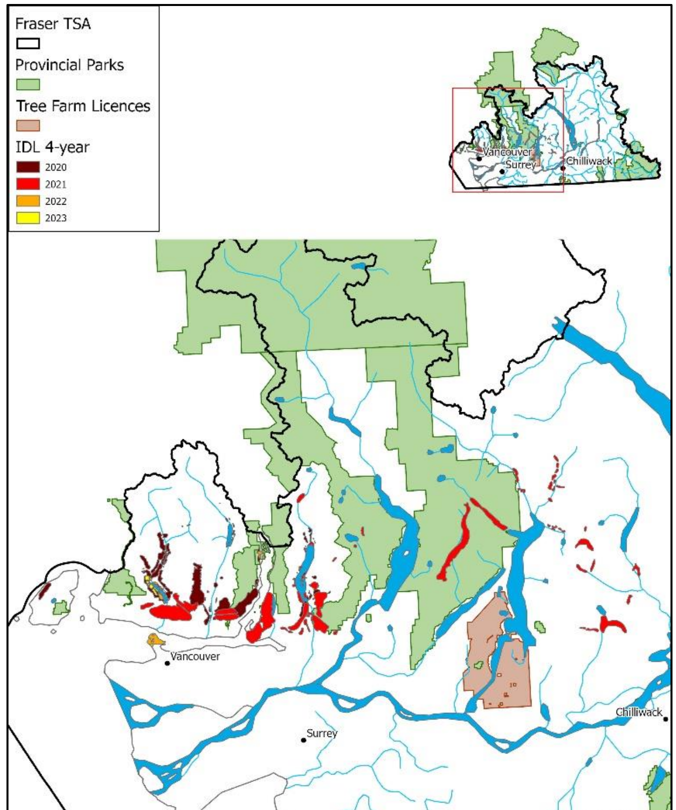


Figure 12. Annual occurrence of western hemlock looper in the Fraser TSA from 2020-2023

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 about 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. A new outbreak occurred along the Fraser Canyon in 2023 and affected 15,893 ha.

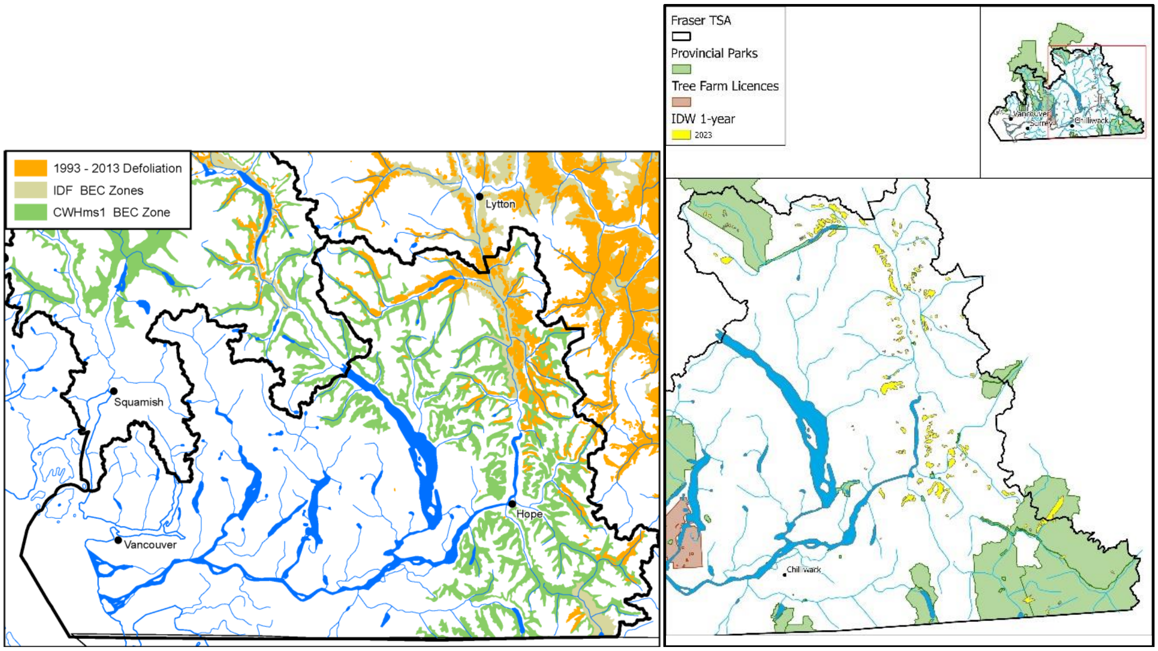


Figure 13. Areas defoliated by western spruce budworm from 1993-2013 (left) and 2023 (right) in the Fraser TSA.

Control treatments have been conducted in 2008 and 2009 specifically targeting young Douglas-fir stands in the Fraser Canyon and Coquihalla areas. The aim 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 found 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 8. Summary of western spruce budworm defoliation in the Fraser TSA between 1943-2020, by biogeoclimatic zone and total years of defoliation in hectares

	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 estimates, windthrow is estimated to account for a loss of 2340 m^3/year.

Great Bear Rainforest (GBR) North TSA

The GBR North TSA is created from the former North Coast and Mid Coast TSAs effective January 1, 2017. The TSA was created under the *Great Bear Rainforest (Forest Management) Act*. The allowable annual cut for the TSA is 803,000 m^3. This includes a partition of 468,600 cubic metres limited to Crown land within the North Island Central Coast district and not within the Owikeno Lake basin. Another partition for 113,200 m^3 is attributed to western redcedar and yellow-cedar within the Coast Mountain district.

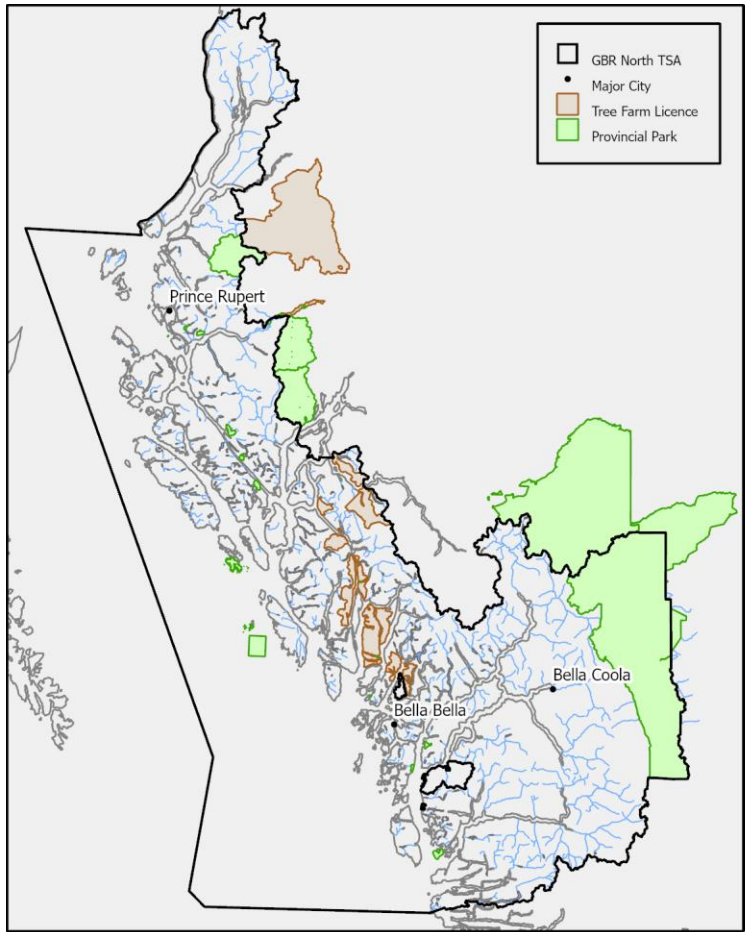


Figure 14. The Great Bear Rainforest North Timber Supply Area.

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 defoliation being quite severe. In 2018 the insect appeared again on 7104 ha in the very northeast part of the TSA and 4683 ha in 2020. Due to aspen being the most common species attacked, much of the damage is confined to Tweedsmuir Park and the far eastern part 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

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 was harvested. Spot infestations were noted in 1993 near Bella Coola, and once again in 1994 with about 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 2018, 1634 ha of mostly light attack was recorded west of Tanya Mountain.

Drought

Drought has become with 11,282 ha of foliar drought recorded in 2023, mostly on western red cedar.

Hemlock Dwarf Mistletoe

The incidence of dwarf mistletoe on all ages of hemlock is expected to rise 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 require leaving residual trees within cutblocks. Small clearcuts, helicopter logging, and dispersed retention are common practices in the GBR North 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 stem breakage and mortality, reduced lumber quality and value, and affects 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 about 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 about 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 about 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 mountain pine beetle has returned to endemic levels not considered problematic. Most recent occurrences have been in Tweedsmuir Provincial Park.

Table 9. Annual comparison of hectares attacked by mountain pine beetle and balsam bark beetle in the GBR North TSA

	Area Attacked (ha)						
	2017	2018	2019	2020	2021	2022	2023
Mountain Pine Beetle	1,317	1,961	8,581	11,606	4,442	479	1,834
Spruce Bark Beetle	344	1,402	465	508	455	351	251
Western Balsam Bark Beetle	47,419	84,082	71,717	53,852	46,914	25,019	36,997

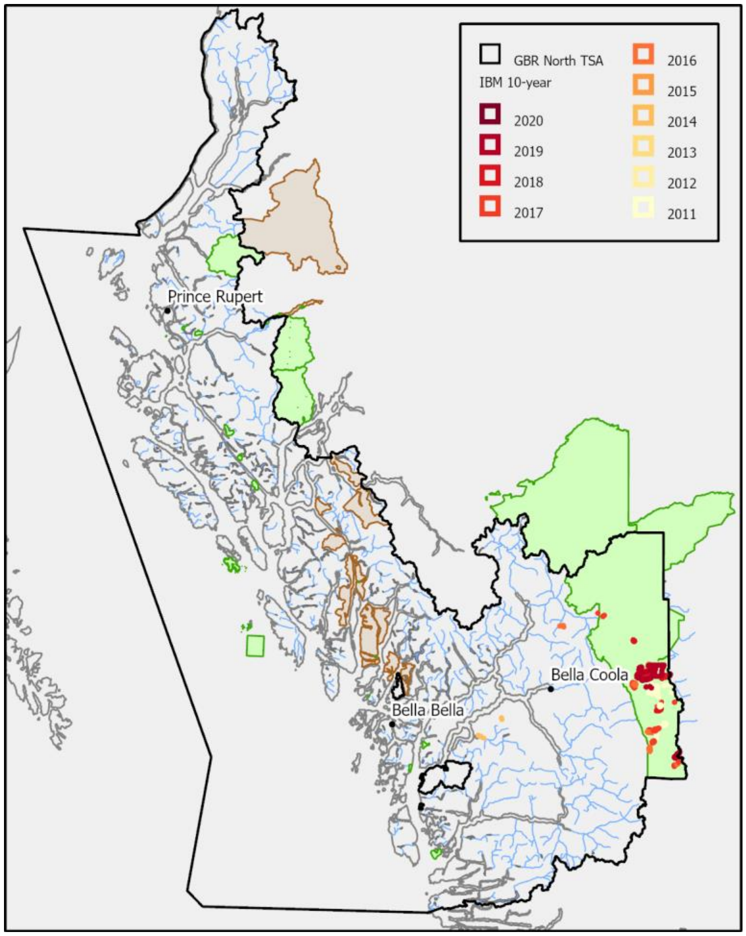


Figure 15. Annual occurrence of mountain pine beetle in the GBR North TSA over the past decade.

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. A small peak of 1402 ha occurred in 2018 but has dropped since.

Western Balsam Bark Beetle

Western balsam bark beetle infestations are ubiquitous in stands having 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. From 2012 incidence levels increased from around 4000 to over 12,000 ha of mostly trace levels of endemic damage. However, occurrence has exploded with tens of thousands of hectares mapped over the last eight years. Most of this loss is unsalvaged.

Western Black-Headed Budworm

Defoliation by blackheaded budworm was recorded from 1973-1974 when about 8400 ha were recorded near Ocean Falls, Fiordland and Kitlope River.

Western Spruce Budworm

About 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 100,000 ha of coastal BC since 2006. This decline is caused by changing climatic conditions, like 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 found as far south as Cypress Lake on Banks Island in the former North Coast Forest District. A follow-up aerial survey of the mainland part of the TSA in 2006 found yellow-cedar decline in the areas south of Burke Channel, including the Ambach Creek and Kilbella River areas. Further investigation has found a band of mortality running through the TSA occurring along the elevation boundary of the CWH vm1 and vm2 in the coastal maritime zone. Salvage opportunities of the dead and dying material is limited but could be undertaken where economically viable since yellow-cedar decays slowly and can stay upright and sound for decades.

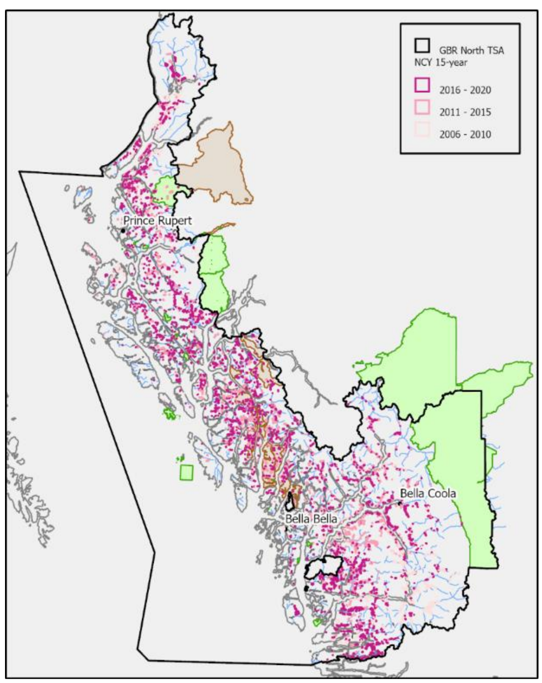


Figure 16. Occurrence of yellow-cedar decline in the GBR North TSA since 2006.

Great Bear Rainforest (GBR) South TSA

The GBR South TSA was created from the mainland portions of the former Kingcome and Strathcona TSAs effective January 1, 2017. The TSA was created under the *Great Bear Rainforest (Forest Management) Act*. The allowable annual cut for the TSA is 830,500 m^3.

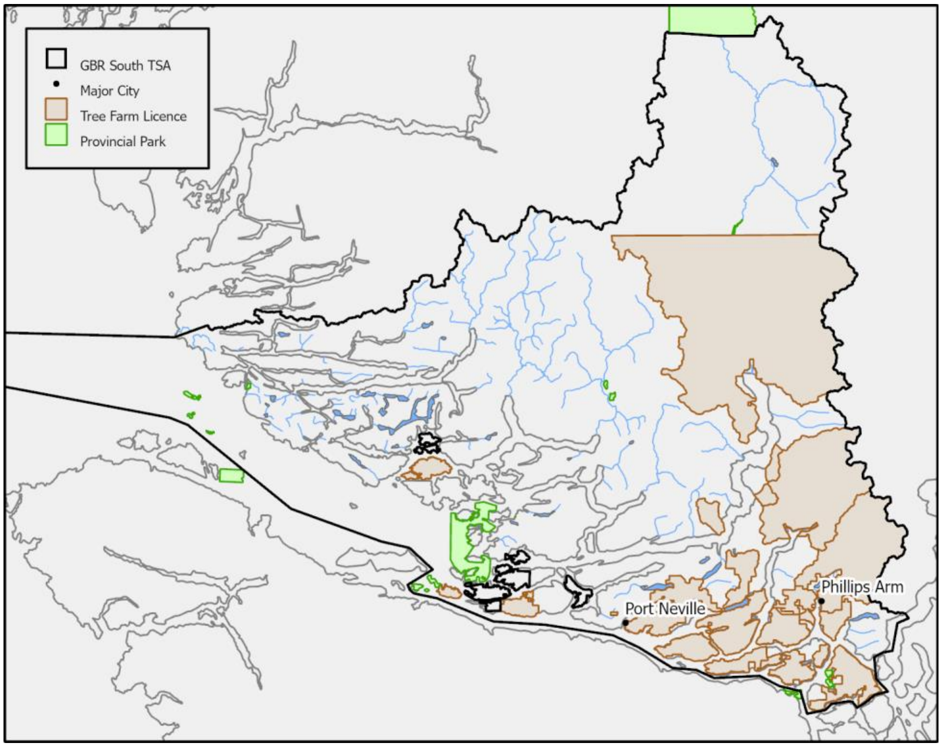


Figure 17. Great Bear Rainforest South Timber Supply Area.

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 needed.

Hemlock Dwarf Mistletoe

The incidence of dwarf mistletoe on all ages of hemlock is expected to rise as we move away from clear-cutting. Partial cutting systems now account for about half of all coastal harvesting, and Ecosystem Based Management involves leaving trees and groups of trees within cutblocks. Unavoidably, a percentage of residual 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 stem 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. Infestations have increased significantly with 8,581 ha and 11,606 ha mapped in 2019 and 2020, respectively.

Spruce Weevil

The impact of spruce 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 part 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.

Yellow-Cedar Decline

Yellow-cedar decline extends over 200,000 hectares in Alaska and the mortality has been mapped on over 100,000 ha of coastal BC. This decline is caused by changing climatic conditions, like 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 part 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 added 2227 ha of decline was mapped in the TSA. Since then the decline has been mapped every year with over 6000 ha reported in 2017 and 2019. As the affected areas are not often suitable candidates for harvest or salvage, non recoverable losses should include an allowance for this in the next TSR.

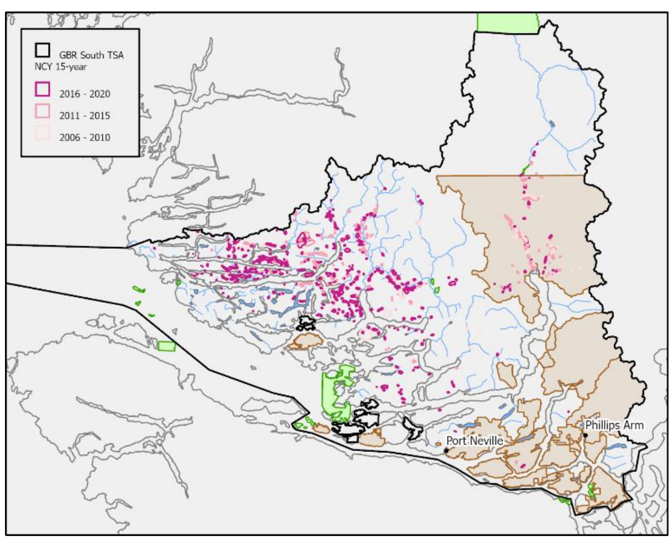


Figure 18. Occurrence of yellow-cedar decline in the Great Bear Rainforest South TSA since 2006.

Haida Gwaii Management Area

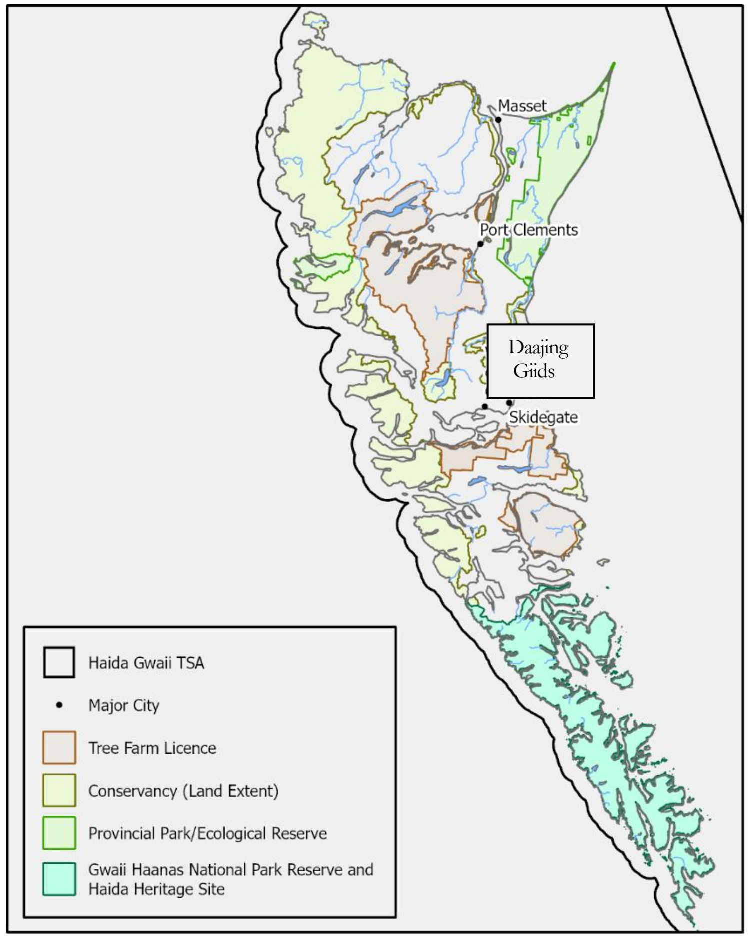


Figure 19. Haida Gwaii Timber Supply Area.

Xaadaa Gwaay, Xaaydağa Gway yaay, or Haida Gwaii ("Islands of the people") is an archipelago of more than 150 islands off the north coast of BC. The mainland north coast of BC lies 80 kilometres to the east across Hecate Strait, and the state of Alaska lies to the north across Dixon Entrance. Haida Gwaii's total landmass of just over a million hectares is situated mostly on two main islands: the larger, Graham Island, being to the north and Moresby Island to the south. The geography of the Islands is like the mainland coast of BC and the southern regions of Alaska, including mountainous terrain, deep fjords, temperate rainforests, sub-alpine forests and alpine tundra. Haida Gwaii's coastal temperate rainforests occur at lower elevations with western hemlock, western redcedar and Sitka spruce being the most dominant tree species along with lodgepole pine, mountain hemlock, yellow-cedar, western yew, and red alder. At yet higher altitudes, closed forests give way to open parkland forests and alpine meadows. About 80% of Haida Gwaii is forested.

Effective September 28, 2021, the Haida Gwaii Timber SupplyArea's new allowable annual cut (AAC) determination is 272,061 m^3.

Armillaria Root Disease

This root disease, caused by the pathogen *Armillaria ostoyae*, was thought to be discovered around Tlell, well outside of its previously identified range, by district staff in 1996. Genomic testing done in 2018 confirmed that the original identification was incorrect, and the disease was a related species, *A. sinapina*, a saprophyte. In the summer of 2023, genetic testing confirmed *A. ostoyae* on the north side of Skidegate Lake. In 2024, the area will be revisited to determine the geographic extent of *A. ostoyae*. Saprophytic species of *Armillaria*, often quite difficult to visually differentiate from the pathogenic variety, are commonly found on dead trees. All the juvenile dead trees sampled on Haida Gwaii during 2017 and 2018 with evidence of *Armillaria* were killed by *A. sinapina* so it does pose a risk to regenerating stands on the east side of Graham and Moresby Islands.

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. Most Douglas-fir on Crown land have been removed but there are still live trees on private property.

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 this 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 one of the most significant and costly forest damage agents on Haida Gwaii, primarily on western redcedar and yellow-cedar in the establishment phase. Recently, the lack of prompt removal of browse protectors on cedar saplings has also 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 browsing height (1.2 m).

Spruce Beetle

Despite widespread occurrence, spruce beetle outbreaks have only been reported occasionally in this TSA. No extensive damage has been recorded.

Spruce Aphid

In 1961 a severe and extensive outbreak of aphid was recorded in this TSA. Infestations decreased in intensity in 1962 but caused defoliation once again in 1963. Increases in populations have occurred periodically since throughout Haida Gwaii but tends to only be significant within a fringe along the coastline. The last outbreak was mapped at 578 ha mostly around the Village of Masset and the east side of Masset Inlet. 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 part 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. 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 patchy mortality and top-kill. About 12,000 ha were aerially sprayed with DDT in 1960. An experimental application of an early formulation of Btk was also successfully conducted in 1960. An outbreak started in 1996 with about 6300 ha defoliated in the southern part of the islands. In 2000, the outbreak covered over 31,100 ha and covered the mid-central to southern part of the islands. The population collapsed in 2001, with only 1500 ha mapped. It is interesting to note that juvenile stands, especially those that had been thinned, were heavily defoliated which resulted in patch mortality. another outbreak cycle ran from 2008 to 2012 peaking at 37,378 ha in 2011. The most recent outbreak started in 2022 with 19,103 ha mapped and increased to 22,155 ha in 2023.

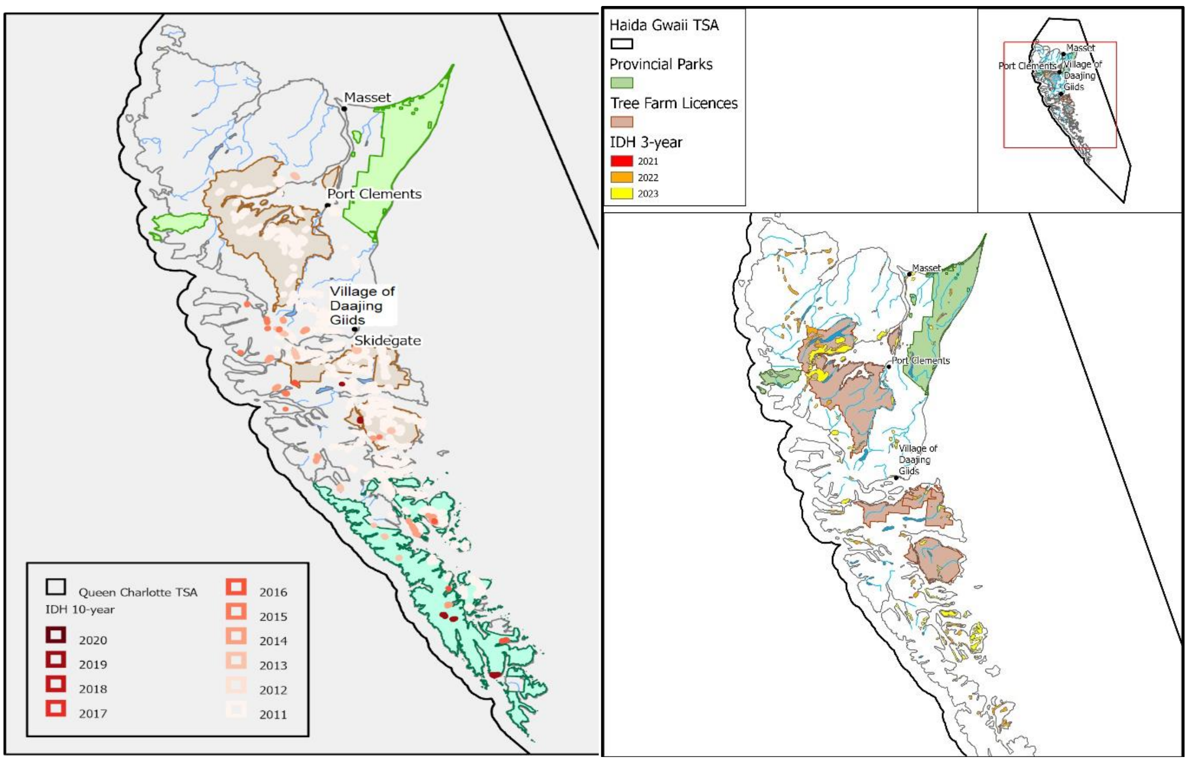


Figure 20. Occurrence of western blackheaded budworm in the Haida Gwaii TSA from 2011-2020 (left) and 2021-2023 (right).

Windthrow

Wind is a major disturbance agent in the TSA with an average of 1952 ha mapped each year from 2012-2014. However, a sizable 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.

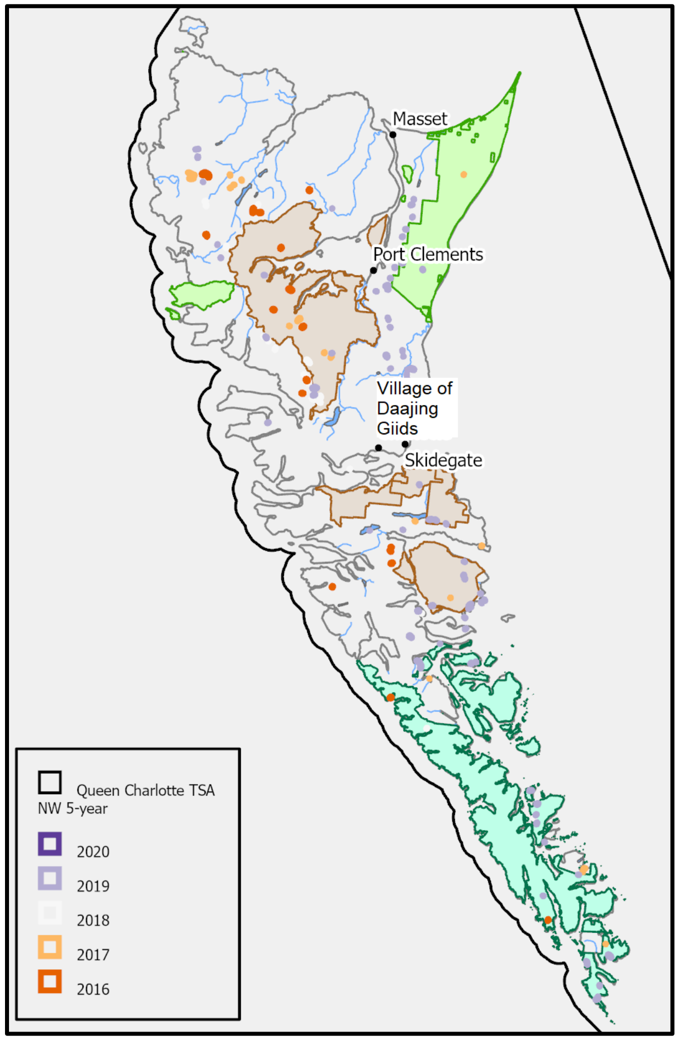


Figure 21. Occurrence of windthrow events in the Haida Gwaii TSA over the previous five years.

Yellow-Cedar Decline

Yellow-cedar decline extends over 200,000 hectares in Alaska and the mortality has been mapped on over 100,000 ha of coastal BC. This decline is caused by changing climatic conditions, like 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 found as far south as Cypress Lake on Banks Island in the North Coast Forest District. Until 2006, the decline was not mapped on Haida Gwaii, but the 2014 survey found over 14,000 ha of trace to severe decline, mostly on the west side of Graham Island. Since then, areas experiencing decline have varied widely in location and area but nearly every year yields newly mapped declining trees. Salvage opportunities of the dead and dying material is limited but could be undertaken where economically viable since yellow-cedar decays slowly and can stay upright and sound for decades. Extensive field studies of the decline have been conducted on Haida Gwaii over the last decade and results are presented in the Pest Profiles section under Abiotics.

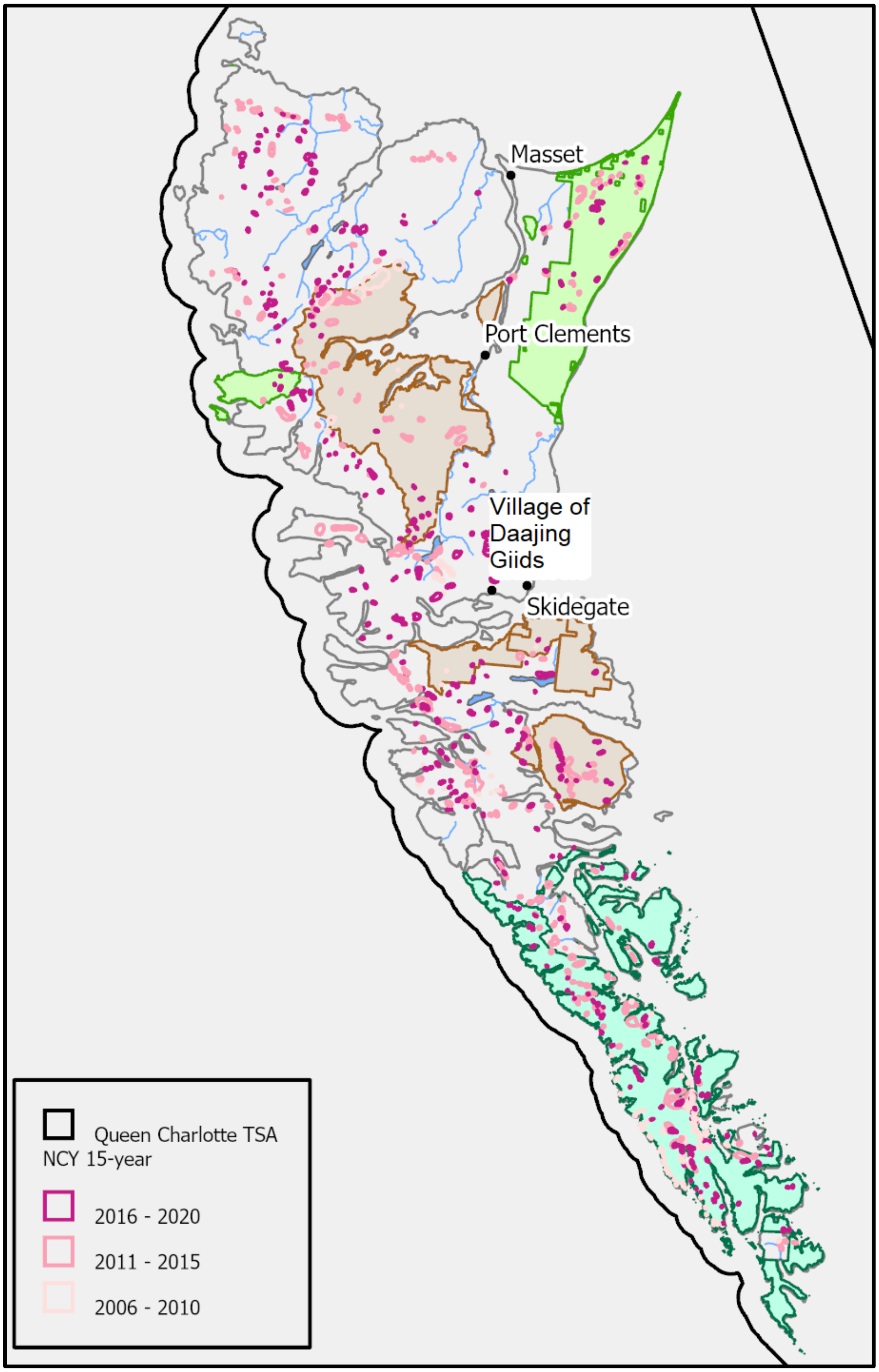


Figure 22. Occurrence of yellow-cedar decline on Haida Gwaii since first mapped in 2006.

North Island TSA

The North Island TSA, located on the northern half of Vancouver Island, was created in January 2017 when the *Great Bear Rainforest (Forest Management) Act* and regulations came into effect. Under the regulations, this new TSA was created from the Vancouver Island portions of the former Kingcome and Strathcona TSAs. Segments of the Pacific TSA are interspersed throughout the TSA, as well as TFLs 6, 19, 37, 39 and 47. The total TSA land base area is approximately 1 749 460 hectares and it is administered by the Campbell River Natural Resource District office in Campbell River, and the North Island Central Coast Natural Resource District office in Port McNeill.

The western and northern Vancouver Island areas are characterized with rugged marine coastlines, steep mountainous terrain, and deep river valleys and ocean inlets.. The eastern TSA and some interior northern areas have terrain ranging from rugged mountains to poorly drained lowlands. The TSA overlaps three biogeoclimatic zones: the CWH located between sea level and 1000 metres of elevation, and the higher elevation zones of MH and CMA. Dominant tree species are western hemlock (Hw) and amabilis fir (more often called balsam (Ba) – HwBa together referred to as "hembal"), western redcedar (Cw) and yellow cedar (Yc), mountain hemlock (Hm), Douglas fir (Fd) and small amounts of alder (Dr) and spruce (Ss).

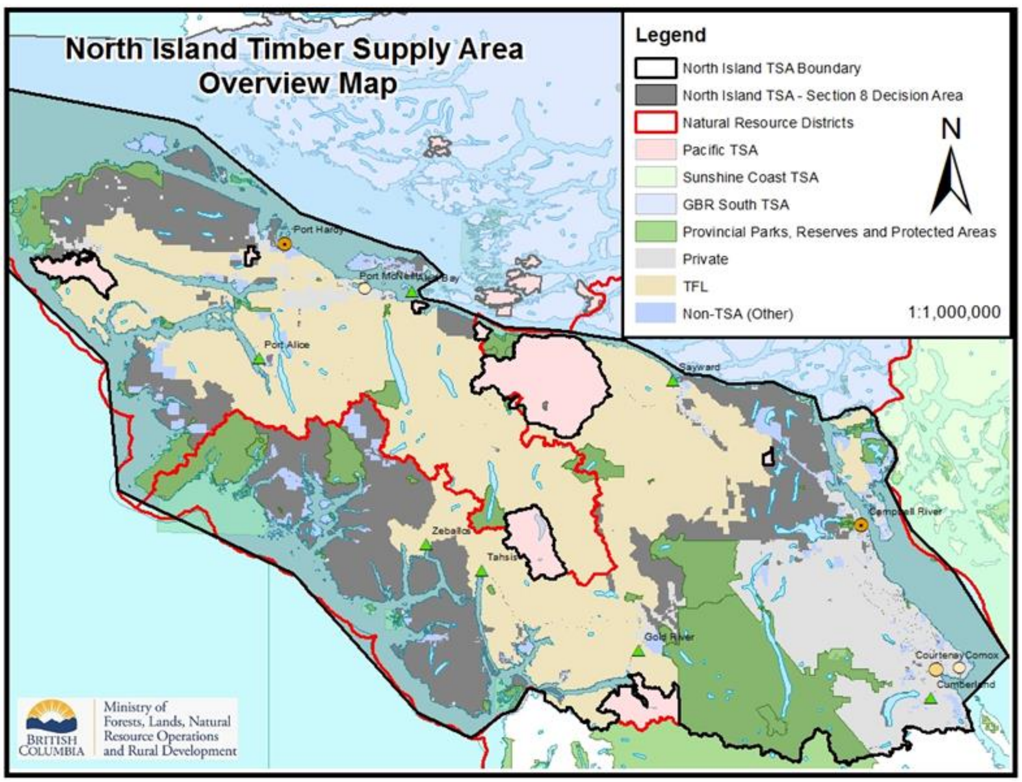


Figure 23. North Island Timber Supply Area.

Land use planning for the TSA area is guided by the Vancouver Island Land Use Plan approved in 2000. Twenty-five First Nations have Aboriginal Interests within the North Island TSA.

The initial AAC for the TSA was legislated and set effective on January 1, 2017 in the *Great Bear Rainforest (Forest Management) Regulation*. The current allowable annual cut is 1,248,100 m^3 but a new

AAC decision is imminent. The *Act* specifies that subsequent (non GBR) AAC determinations must be made by the chief forester. The new AAC for this TSA is expected to be determined in 2024.

Balsam Woolly Adelgid

This introduced pest has been reported occasionally in the North Island TSA. It can cause considerable damage, including mortality, to *Abies* species; yet within this TSA its impacts have not been found to be significant. However, over the last two years, hectares mapped have increased dramatically with 1351 ha reported in 2019 and 5072 ha in 2020. The TSA was included within the regulated quarantine area which restricted the movement of true firs (see *Balsam Woolly Adelgid Regulation*), however, this regulation was repealed in 2019.

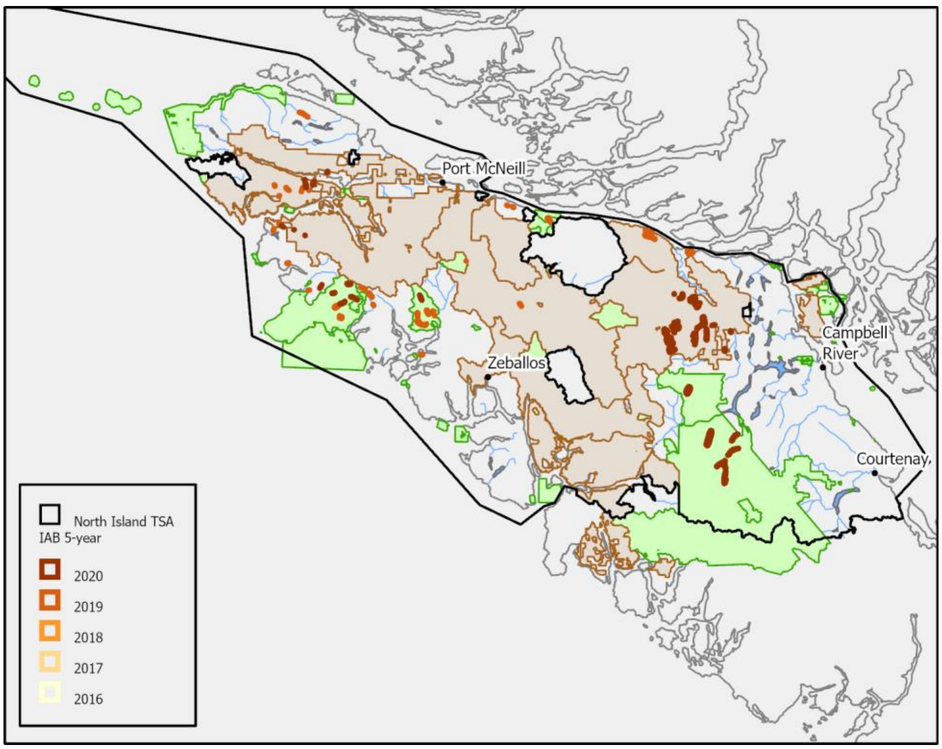


Figure 24. Occurrence of balsam woolly adelgid in the North Island TSA during the previous five years.

Conifer Sawflies

Populations of conifer sawfly (*Neodiprion* spp.) periodically reach outbreak levels within this TSA in the Adam, White and Memekay river areas and in 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 to 20% of amabilis fir can be killed. In 1952, spot activity was noted between Salmon River and Great Central Lake. The first major outbreak recorded in the TSA occurred in 1978 – 1980 with over 4,470 ha in the Sayward area. Significant salvage harvesting followed as *Pseudohylesinus* bark beetles attacked the stressed trees. The last recent outbreak occurred in 1995 – 1998 in the same general areas. At the peak of the outbreak in 1996, about 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. About 330 ha were salvage harvested. A new suspected outbreak (around 11,000 ha) in and around Horseshoe Creek and Strathcona Park was mapped in 2023 and will be ground checked during active sawfly feeding in 2024.

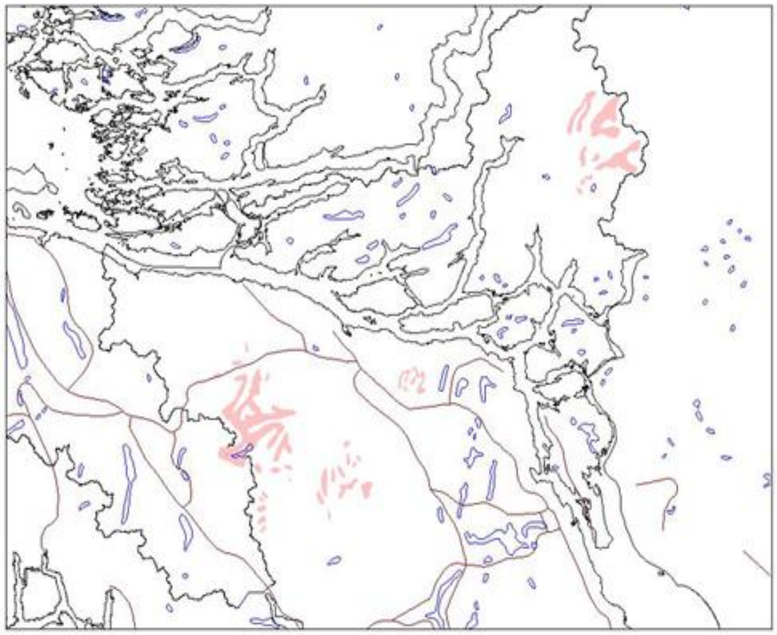


Figure 25. Area defoliated by conifer sawflies in 1996 near Schoen Lake Park and in the Phillips River drainage on the mainland.

Douglas-fir Beetle

Very few records of Douglas-fir beetle activity exist for the North Island 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 at an endemic level, and usually associated with trees affected with root disease. However, the beetle is commonly found in trees that die due to other causes. Recently, the beetle saw a brief uptick in 2018 with 1027 ha attacked and in 2019 with 3191 ha attacked mainly west of Campbell and Buttle Lakes and north of Atluck River. This recent mortality was likely triggered by the extensive summer droughts of 2017 and 2018. A new outbreak around Marble River Park was mapped at around 800ha (trace severity). This build of Douglas-fir beetle comes after recent blowdown events in the park.

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 found south of Sayward but no further mortality was reported.

Root Disease

Laminated root rot occurs throughout the drier regions of the North Island TSA, primarily in young Douglas-fir stands in the Sayward forest, Quadra Island and in the Gold River area.

Spruce Aphid

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 considered a forestry pest.

Western Blackheaded Budworm

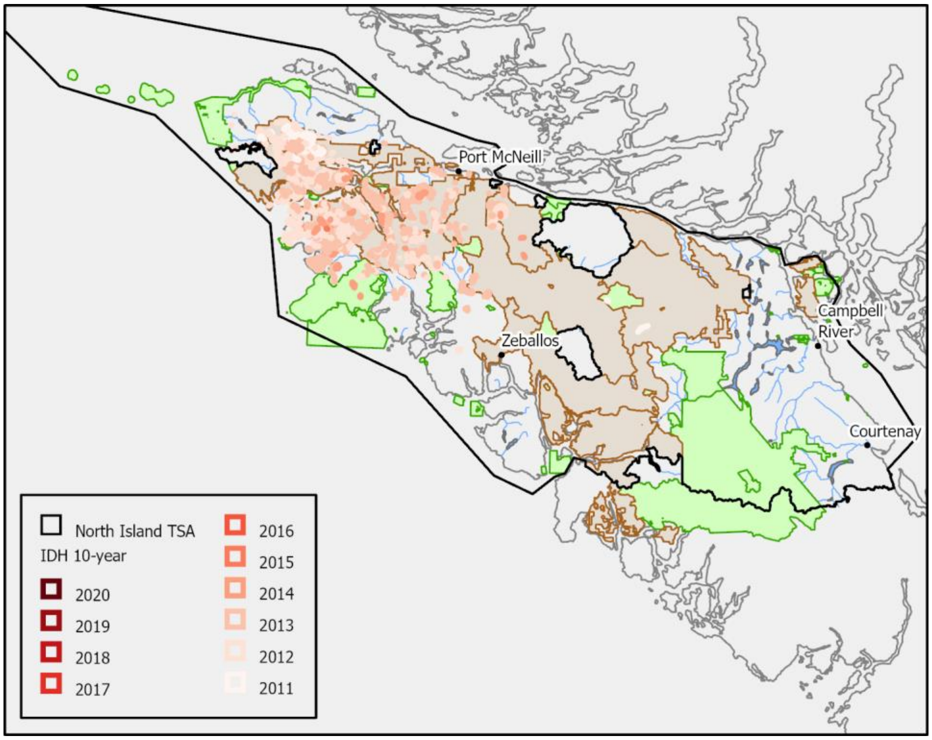


Figure 26. Area defoliated by western blackheaded budworm during the past decade on the northern Vancouver Island.

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 increasing dramatically to about 35,000 ha in 1972 and included areas west of Victoria Lake to Brooks Peninsula and north to Quatsino Sound. The population collapsed in 1973, and no further defoliation noted until 1988 when about 5000 ha were infested near Port Hardy. This outbreak persisted until 1990. From 1997 to 1999, about 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 old growth hemlock-balsam stands, but damage in younger regenerating hemlock 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 and stretching as far east as Bonanza Lake. This most recent outbreak collapsed in 2014.

Western Hemlock Looper

Between 1926 and 1927 about 1500 ha were defoliated at the mouth of Neroutsos Inlet. This is the only record of western hemlock looper activity in the former 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 see scattered damage throughout the range that the host trees grow. These are often recorded as spots or small scattered polygons. In 2010, 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 in the middle of Vancouver Island along the Nimpkish River north of Vernon Lake.

Windthrow

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

Pacific TSA

The Pacific TSA is made up of 38 blocks spread throughout the Coast (29 blocks) and Skeena Region (9blocks) that together make up a portion of the BC Timbers Sales (BCTS) operating area (Fig. 26). In the AOS roll up these blocks are included in the larger TSA's that surround them. Together the coast area blocks make up three BCTS business areas: Seaward/tlasta (10 blocks), Strait of Georgia (16 blocks), and Chinook (3 blocks). Table x lists the blocks that make up the Pacific TSA and the TSA's that these blocks are included in in the AOS summary report.

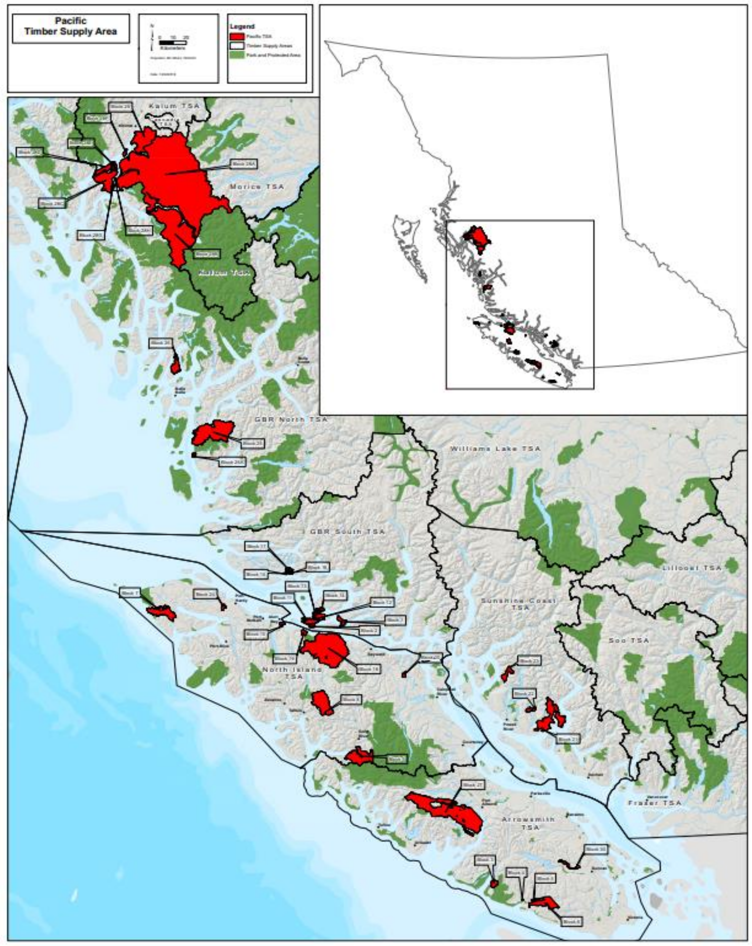


Fig 26. Map of Pacific TSA blocks.

Table 9. Pacific TSA blocks and the TSAs they are included with in the AOS roll-up.

Pacific TSA Blocks	# Blocks	TSA blocks are compiled with in the AOS
3-6, 27,30	6	Arrowsmith
7-10, 18-20, 24	8	North Island
21-23	3	Sunshine Coast
1, 2, 11-17	9	GBR South
25, 25A, 26, 28A-H, 29	12	GBR North
Total	**38**	

Soo TSA

The Soo 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 THLB, in order of abundance, are Douglas-fir, amabilis fir (balsam), western hemlock, western redcedar, and Engelmann spruce.

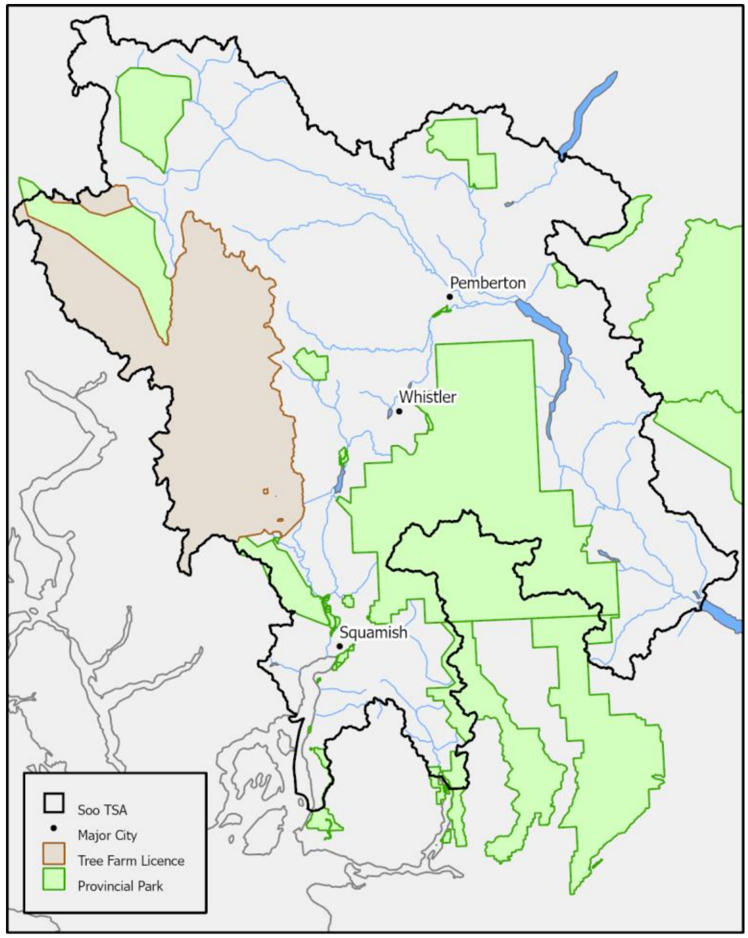


Figure 28. Soo Timber Supply Area.

The region has experienced one of the highest population growth rates in the province in recent years. One of the most significant changes in the 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 TSA.

Effective April 20, 2023 the AAC for the Soo TSA is 368 276 m^3.

Balsam Woolly Adelgid

An introduced pest, the balsam woolly adelgid has been recorded in the Whistler, Joffre and Hurley Pass areas. The TSA was included within the regulated quarantine area which restricted the movement of true firs (see *Balsam Woolly Adelgid Regulation*), however, this regulation was repealed in 2019.

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 with a few dozen to a few hundred hectares reported annually. A recent spike to 1068 ha in 2019 did not see similar numbers in 2020 (51 ha).

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 1970'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, about 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. Areas affected by mountain pine beetle peaked at a high of 16,848 ha in 2007 and have decreased since. Still, several hundred hectares are mapped

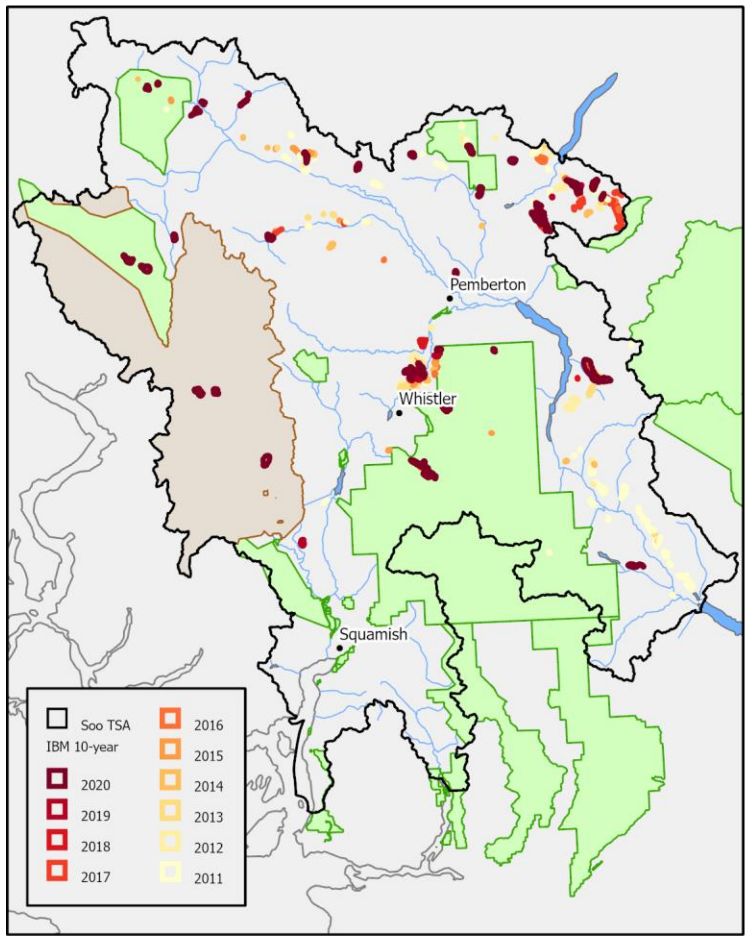


Figure 29. Annual occurrence of mountain pine beetle in the Soo TSA over the past decade.

annually with most occurring near Whistler and in the transition areas near the northern and eastern TSA boundaries. In 2020, 4832 ha were reported, an increase from the 502 ha in 2019.

Root Diseases

The TSA has areas with extensive amounts of root disease, primarily laminated root disease of Douglas-fir and Armillaria root disease on many conifers. Root disease losses have been partially accounted for in the current TSR. The impact of root disease within transition zone forests is unclear. Stands show 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, mortality has also occurred in the Haylmore and adjacent drainages. In 2004, about 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 drainages. 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. Since then, occurrence has trended upward with several thousand hectares reported annually hitting a peak of 27,637 ha mapped in 2019. Attack is usually scattered throughout forested areas and often is recorded as trace levels (<1% of the trees attacked) but severity has increased along with occurrence over the last few years. Control activities are not feasible for this insect.

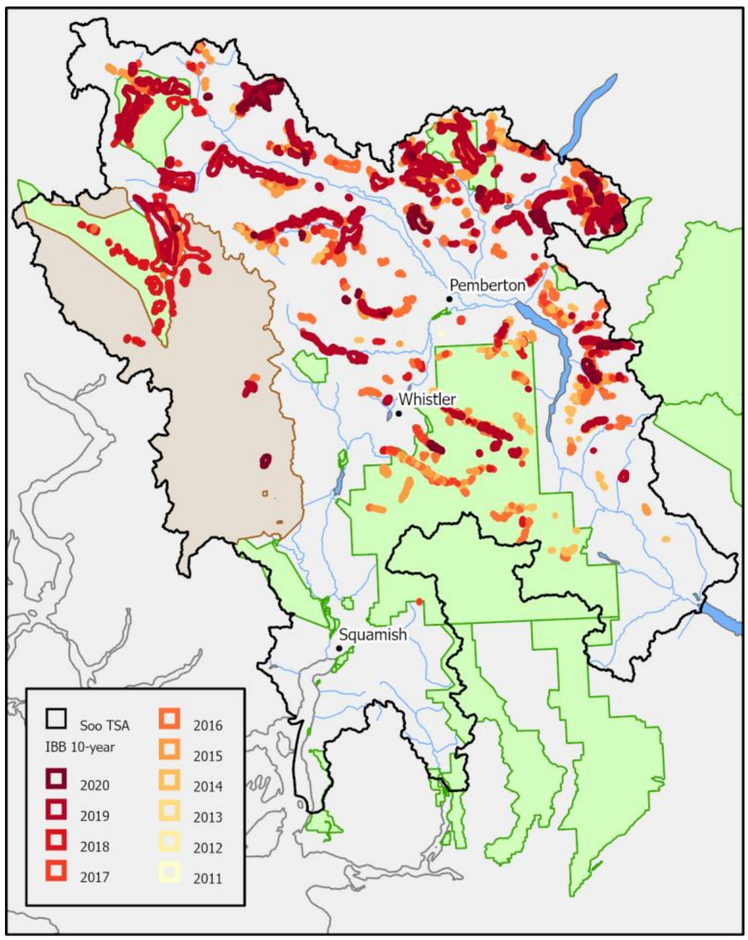


Figure 30. Annual occurrence of western balsam bark beetle in the Soo TSA over the past decade.

Western Spruce Budworm

Six outbreaks of western spruce budworm have been recorded in the Soo TSA in 1943-1944, 1953-1959, 1968-1979, 1986-1992, 2003-2008 and most recently occurring from 2022 to the present. 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 began 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 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. In 2022 there was a new outbreak centered around Birkenhead Provincial Park and Upper Lillooet River Park (4,409 ha). This expanded outward to 18,294 ha in 2023 and included some new areas to the west of Lillooet Lake. As noted earlier, the historic elevational band ranges may change over time because of climate change. The most recent outbreak appears to have started out along higher elevational bands. 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. More recent defoliation has occurred primarily in the CWHms1.

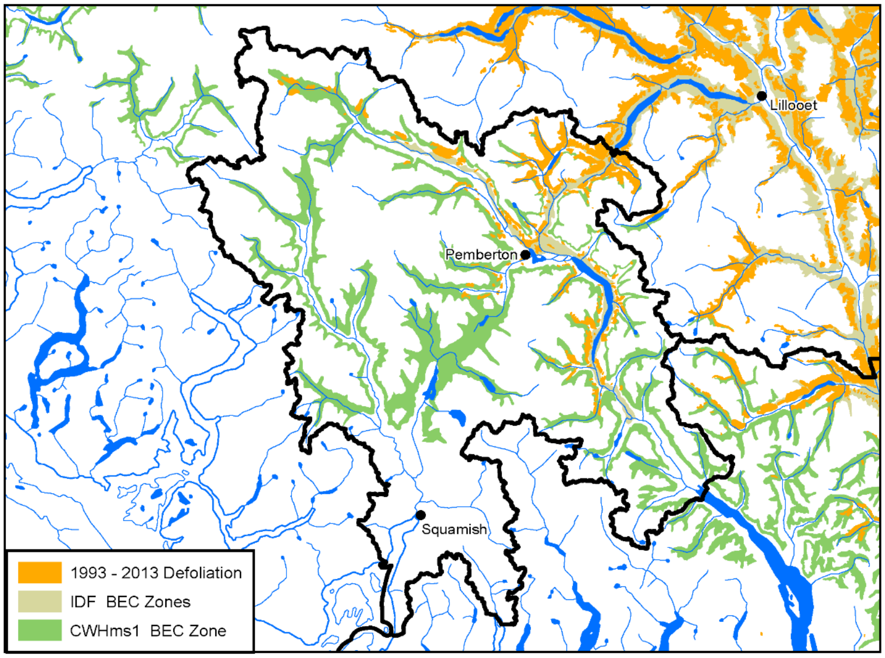


Figure 31. Area defoliated by western spruce budworm from 1993-2013 in the Soo TSA.

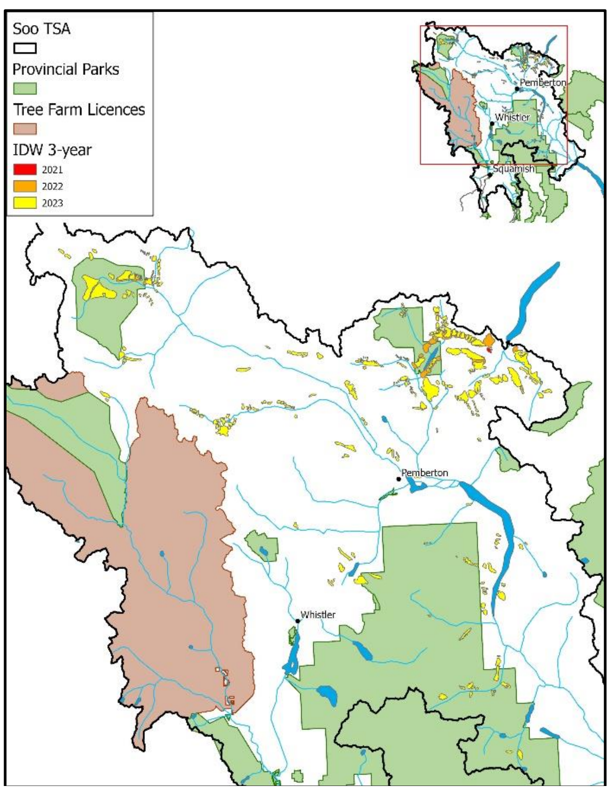


Figure 32. Area defoliated by western spruce budworm from 1993-2013 in the Soo TSA

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 GBR South TSA to the west and the Williams Lake TSA to the north. It is also next 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 productive forest land managed by the Province, of which just over half is 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 current AAC is now is set at 1,197,466 m^3 effective Dec 4, 2018 with a new determination expected soon.

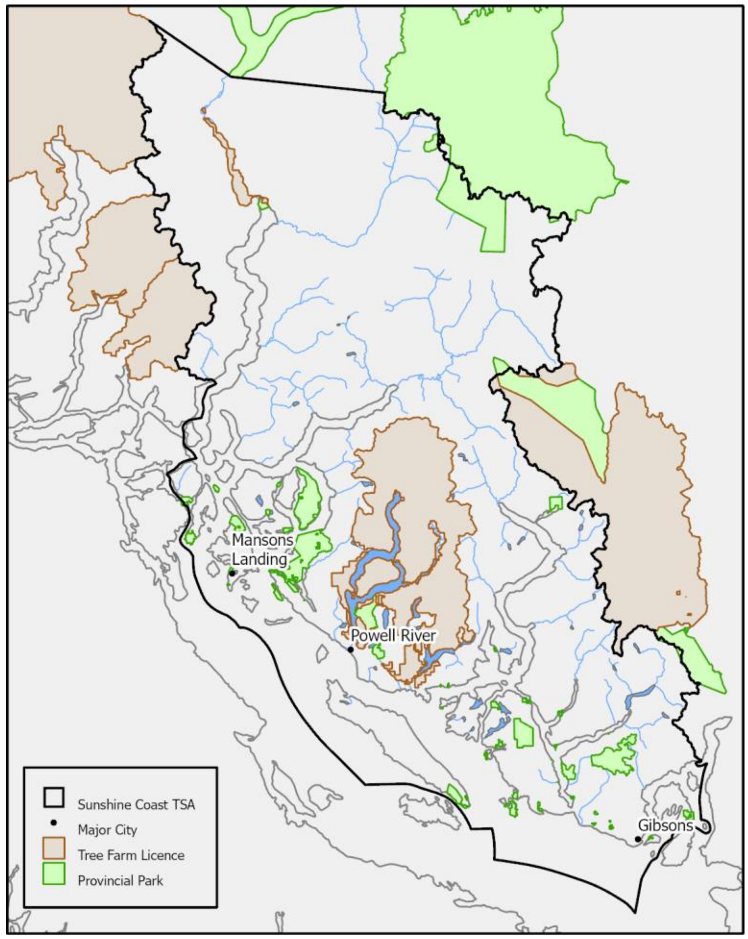


Figure 5. Sunshine Coast Timber Supply Area.

Balsam Woolly Adelgid

BWA has spread into the Sunshine Coast TSA and has been confirmed in four sites north of Jervis Inlet. The TSA was included within the regulated quarantine area which restricted the movement of true firs (see *Balsam Woolly Adelgid Regulation*), however, this regulation was repealed in 2019.

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 weakens the stem, with wind and snow resulting in breakage, killing the tree, and contributing to 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. From 2011 to 2014, 400 to 800 ha of damage were reported annually. Since 2011, trap tree baiting, and removal is used to reduce beetle populations near Powell River and on the Sechelt Peninsula, especially in areas having recently experienced wildfire. Still, trace and light recent attack is mapped every year across the TSA.

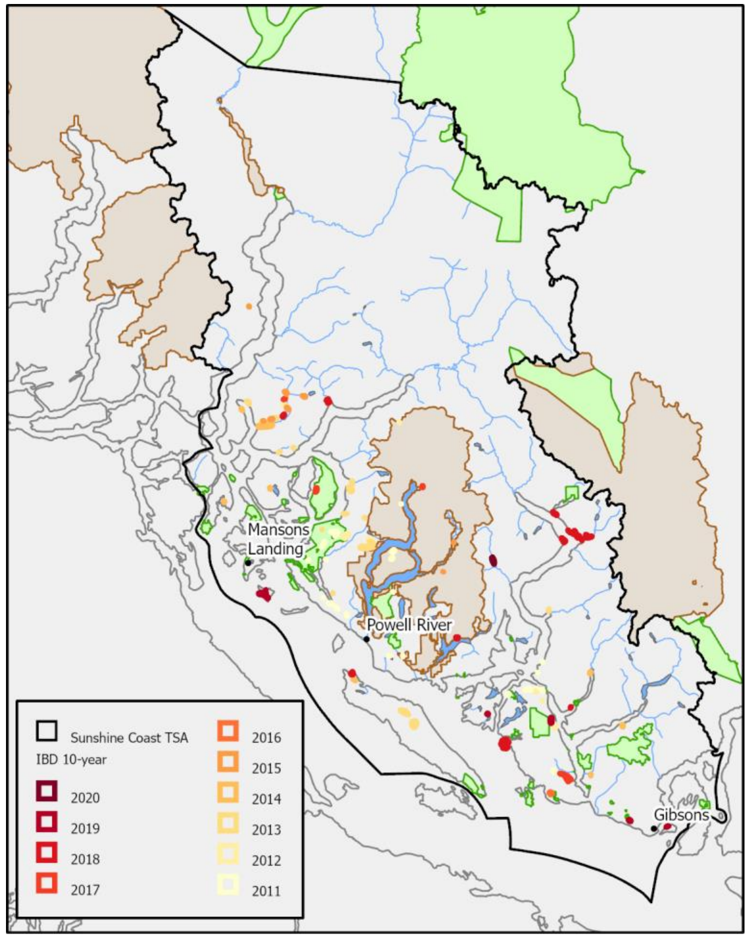


Figure 34. Occurrence of Douglas-fir beetle in the Sunshine Coast TSA over the past decade.

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. Over the last few years some beetle attack has been mapped with 380 ha reported in 2020 mainly in the northeast portion of the TSA.

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 m^3 of timber. Salvage operations were curtailed when Canadian Forest Products surrendered their 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 remained at endemic levels until 2020.

In 2019, BCTS discovered a looper infestation in the Brittain River prior to canopy symptoms becoming apparent. The following year, looper was mapped also in the Rainy River area and adults were easily spotted around Powell River, Sechelt and Gibsons. This coincided with the extensive appearance of looper in the Metro Vancouver watersheds that same year. Defoliation in the TSA increased from 2,145 ha (primarily light severity) in 2019 to 4,279 ha (primarily light severity) in 2020 and 10,428 ha in 2021. No new hemlock looper areas were mapped in 2022.

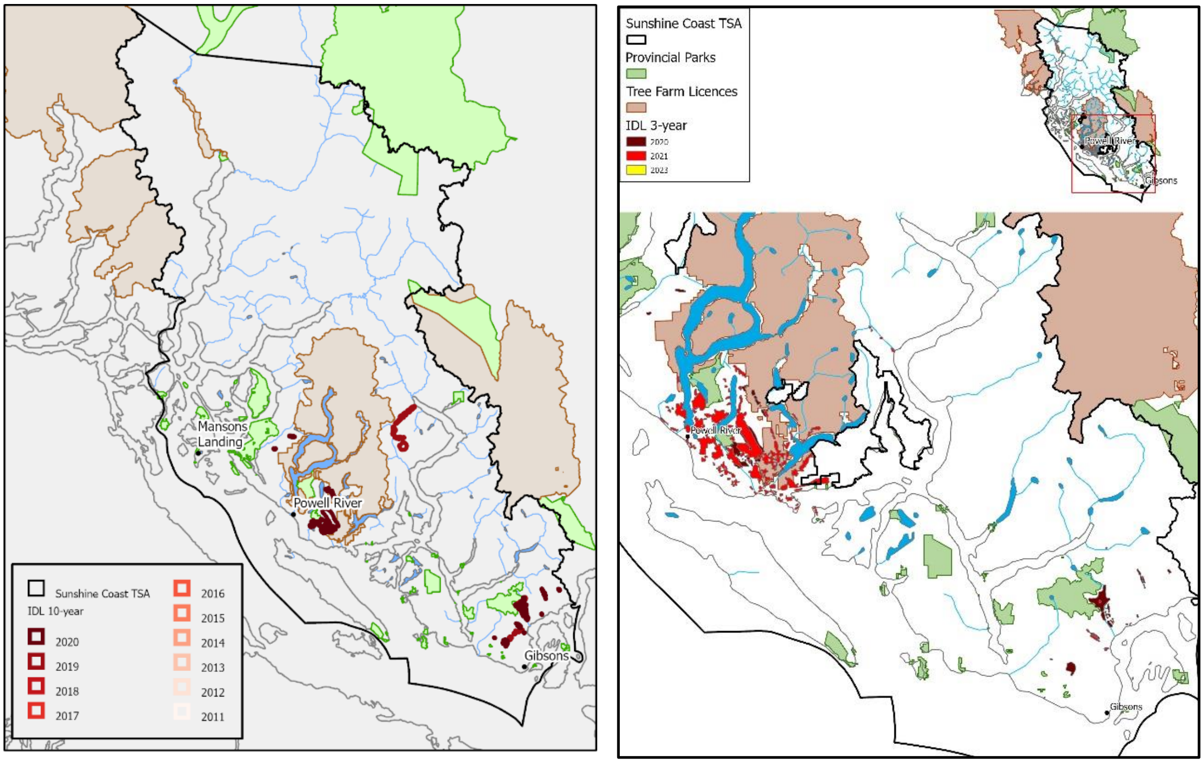


Figure 35. Occurrence of western hemlock looper in the Sunshine Coast TSA from 2011-2020 (left) and 2020-2023 (right).

Appendix B: YSM Summary for Coast

Table 10. Summary of YSM forest health factor incidence for the coast area by BEC variant.

BEC Unit			# Plots	Mean trees/plot	Sapsucker %	sapsucker circumf. girdled %	Hemlock Dwarf Mistletoe %	Mean Hawks. Rating	Armillaria %	Laminated Root Rot %	DSB %	Unidentified insect defoliator %	Mean insect defoliation affected plots %	black headed budworm %	mean budworm defoliation affected plots %	spruce weevil %	Wildfire Damage %	Frost Cracks %	Wind Scarring %	Snow or Ice damage %	Snow Press %	Mechanical damage %	Unknown (%)	Vegetation Press %	Tree competition %
CWH	dm		4	49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.6	0.0	0.0
CWH	ds	1	8	48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.2	0.2	1.4	4.5	0.0	0.0	12.6	1.7	0.0
CWH	mm	1	5	85	0.0	0.0	1.3	0.5	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	6.6	0.8	0.0	0.0	1.6	0.9	0.0
CWH	ms	1	16	60	0.1	1.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.8	1.4	1.1	3.9	6.2	0.0	0.0	8.1	2.2	0.0
CWH	ms	2	4	56	0.3	1.0	0.0	0.0	0.7	0.0	0.0	1.8	33.0	0.0	0.0	0.9	0.0	0.3	0.0	0.0	2.1	0.0	15.0	0.0	0.6
CWH	vh	1	7	59	0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.6	20.0	0.0	0.0	3.1	0.0	0.0	3.6	0.0	0.0	0.0	3.6	0.6	6.7
CWH	vh	2	2	58	0.0	0.0	4.8	1.5	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0
CWH	vh	3	9	63	2.1	2.2	0.0	0.0	9.8	0.0	0.0	0.0	0.0	2.1	35.0	0.3	0.0	0.6	4.0	0.0	0.0	0.0	4.1	0.6	0.0
CWH	vm	1	93	65	1.0	2.5	0.5	0.1	3.3	0.0	0.0	0.1	0.5	10.8	49.0	0.7	1.1	0.5	5.2	0.2	0.5	0.0	5.6	1.0	2.2
CWH	vm	2	24	61	0.3	46.6	0.0	0.0	1.5	0.0	0.0	0.5	1.1	13.5	0.0	0.0	0.0	1.1	3.7	5.2	1.7	0.0	6.2	0.7	0.6
CWH	wh	1	34	67	1.5	2.5	1.2	0.4	4.6	0.0	0.0	0.1	30.0	0.4	62.5	0.5	0.0	0.3	5.2	0.0	0.1	0.0	10.4	1.2	0.5
CWH	wh	2	3	71	1.0	1.3	0.0	0.0	10.5	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	1.3	0.0
CWH	ws	2	2	30	1.8	9.0	0.0	0.0	1.8	0.0	0.0	3.5	7.0	0.0	0.0	0.0	0.0	1.8	50.9	0.0	50.0	0.0	7.9	0.0	0.0
CWH	xm	1	3	35	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.8	0.6	0.0	5.5	14.9	0.6	0.0
CWH	xm	2	8	70	0.9	1.3	0.0	0.0	21.0	3.9	2.7	0.1	2.0	0.0	0.0	0.0	0.0	0.0	1.9	1.0	1.1	0.0	6.4	0.3	1.7
MH	mm	1	4	34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	3.0	41.4	0.0	0.0	13.4	0.0	0.0

Table 11. Summary of YSM forest health factor incidence for the coast area by BEC subzone.

BEC Unit		# Plots	Mean trees/plot	Sapsucker %	sapsucker circumf. girdled %	Hemlock Dwarf Mistletoe %	Mean Hawks. Rating	Armillaria %	Laminated Root Rot %	DSB %	Unidentified insect defoliator %	Mean insect defoliation affected plots %	black headed budworm %	mean budworm defoliation affected plots %	spruce weevil %	Wildfire Damage %	Frost Cracks %	Wind Scarring %	Snow or Ice damage %	Snow Press %	Mechanical damage %	Unknown (%)	Vegetation Press %	Tree competition %
CWH	ms	20	59	0.1	1.0	0.0	0.0	0.1	0.0	0.1	0.4	33.0	0.0	0.0	1.6	1.2	0.9	3.2	5.0	0.4	0.0	9.5	1.7	0.1
CWH	vh	18	61	1.0	2.2	0.5	0.2	5.8	0.0	0.0	0.2	20.0	1.0	30.0	1.4	0.0	0.3	3.4	0.0	0.0	0.0	3.9	0.5	2.6
CWH	vm	117	64	0.8	8.4	0.4	0.1	2.9	0.0	0.0	0.2	11.7	0.4	49.0	0.5	0.9	0.6	4.9	1.2	0.7	0.0	5.7	0.9	1.8
CWH	wh	37	67	1.4	2.4	1.1	0.3	5.1	0.0	0.0	0.1	30.0	0.3	62.5	1.1	0.0	0.3	5.0	0.0	0.1	0.0	9.5	1.2	0.5
CWH	xm	11	60	0.7	1.3	0.0	0.0	17.5	2.9	2.0	0.1	2.0	0.0	0.0	0.0	0.0	0.0	3.3	0.9	0.8	1.5	8.7	0.4	1.3