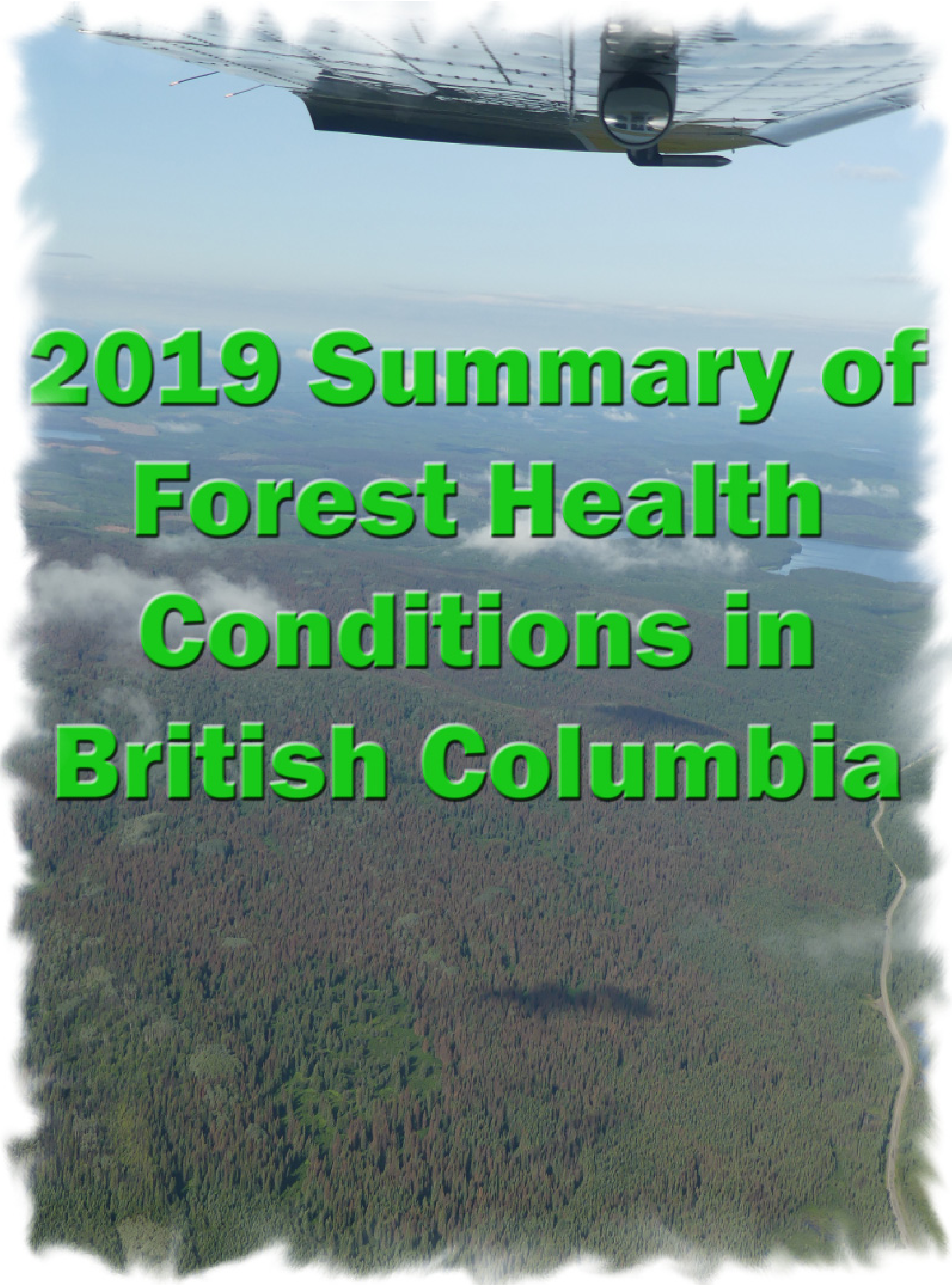
# 2019 Summary of Forest Health Conditions in British Columbia



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Front cover photo by Joan Westfall, two-year-cycle budworm in Prince George TSA

# 2019 Summary of Forest Health Conditions In British Columbia

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# Summary

The *2019 Summary of Forest Health Conditions in British Columbia* (BC) is primarily based on forest health damage data collected during the 2019 BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) aerial overview surveys (AOS). Some of this material is augmented by information from other FLNRORD sources such as detailed helicopter surveys, forest health ground surveys, pheromone trapping, lab examinations of ground check samples and ground observations made by trained personnel.

Approximately 79% of the province was surveyed between June 23rd to October 18th, 2019, by 24 surveyors using nine small aircraft companies. A total of 658 flight hours were logged over 129 days of flying. Damage caused by at least 46 agents was mapped affecting a wide variety of commercial tree species of all ages, resulting in 5.9 million hectares (ha) of damage (a mix of mortality and partial tree damage) across the province. This total only included damage that was visible at the time and height that the AOS was flown, which is known to under-estimate some damaging agents, especially forest pathogens.

Bark beetles continued to be the primary damaging agent in the province, with infestations totalling 4 million hectares recorded. Western balsam bark beetle disturbances at low intensity accounted for 3.2 million hectares, most of which was mapped in northern BC. Spruce beetle mortality increased to 515,447 ha, primarily located in Omineca Region. For the first time in a decade, mountain pine beetle attack increased, with 177,444 ha of damage mapped across BC. Douglas-fir beetle infestations declined slightly to 97,964 ha, chiefly observed in Williams Lake TSA of Cariboo Region.

Defoliation caused by insects was mapped on 1.6 million hectares in 2019. Aspen leaf miner damaged 1.3 million hectares provincially, with the majority detected in Omineca and Skeena Regions. Satin moth infestations declined to 77,532 ha, primarily observed in central BC. Budworm activity generally declined, with two-year cycle budworm damaging 120,205 ha (mainly in the northern interior), western spruce budworm affecting 24,102 ha in the southern interior, eastern spruce budworm observed on 3,885 ha in northeastern BC, and western blackheaded budworm defoliating 370 ha in Haida Gwaii TSA. Birch leaf miner infestations continued to increase to 10,242 ha in the interior, and pine needle sheathminer also increased to 7,079 ha in central BC. Western hemlock looper infestations were on the rise, with 3,276 ha mapped in southern BC. Douglas-fir tussock moth population were also increasing, with 2,708 ha mapped in the southern interior, most notably in Williams Lake TSA of Cariboo Region for the first time.

Abiotic damage decreased five-fold from last year to 329,535 ha, mainly due to a large reduction in wildfires. Cedar flagging damage accounted for a record 115,581 ha, mapped throughout western redcedar stands in the BC interior. Post-wildfire mortality rose to a record 106,873 ha of damage, mainly in young lodgepole pine stands in Cariboo and Kootenay/Boundary Regions. Yellow-cedar decline affected 23,449 ha along the BC coastline. Wildfire burnt only 22,053 ha, mainly in the far north. Drought caused mortality decreased to 19,978 ha, chiefly in Kootenay/Boundary, West/South Coasts and Skeena Regions. Flooding damage dropped to 11,778 ha, and windthrow disturbances increased to 11,635 ha, both of which were most prevalent in Northeast Region.

Observed disease damage decreased by almost half from 2018 to 26,716 ha. Venturia blight was the predominant disease damaging agent, with 13,729 ha mapped, chiefly in Skeena Region. White pine blister rust affected 5,478 ha at low intensity in coastal regions. A total of 4,136 ha of large-spored spruce-labrador tea rust damage was observed in northeastern BC, while 2,122 ha of larch needle blight damage was delineated in southeastern BC.

Visible animal damage across the province declined to 2,080 ha, with most (1,646 ha) attributed to black bear.

Localized damage due to other agents such as defoliators (leaf beetles, Bruce spanworm), western pine beetle, diseases (laminated root disease, Dothistroma needle blight, cottonwood leaf rust) and abiotics (slides, frost) were noted in small, scattered disturbances as well. All damage recorded during the AOS is discussed by host tree species in the body of this report. Abstracts of special projects, meetings, presentations and publications conducted by FLNRORD pathologists, entomologists and their associates are also included in the final sections of this report.

# 2019 Summary of Forest Health Conditions in British Columbia

## Introduction

The diverse ecosystems of British Columbia (BC) are rich in complex forests that vary in structure, age and tree species. These forests are often damaged by a variety of diseases, insects, animals and abiotic factors that can vary greatly in area, intensity and location from year to year. Hence, an aerial overview survey (AOS) is conducted annually across the forested lands of BC to capture current damage in a timely and cost-effective way. All visible damage to commercial tree species is recorded by host, damaging agent, extent and severity. For the past 23 years the provincial government has been responsible for the AOS, currently under the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD).

When the AOS is finished each year, the data is digitized, reviewed and collated. For this report, summaries are produced by Timber Supply Areas (TSAs, Figure 1). The exceptions are the Pacific and Cascadia TSAs that are small fragmented units within several larger TSAs, which are incorporated within the larger TSA units that surround them. TSAs are amalgamated into eight regions in BC: Skeena, Omineca and Northeast Regions cover northern BC; Cariboo, Kootenay/ Boundary and Thompson/Okanagan are in the southern interior; West Coast and South Coast account for the coast area (Figure 1). In 2016, four coastal TSAs were merged/changed to create Great Bear Rainforest (GBR) North and South TSAs. Since these TSAs are under special management constraints and the GBR North TSA straddles two regions, they are considered an entity separate from the regions for this report.

Results in this report are discussed by individual damaging agents and grouped by host tree species. Some damage is not well captured by the AOS due to the elevation the survey is flown, the time period of the survey or the lack of aerial visibility. This includes a variety of diseases, low-intensity insect defoliation, very scattered or partial tree damage, very young tree damage or understorey damage. Information about these disturbances may be collected by other methods, such as helicopter surveys or ground assessments. This supplemental information is discussed in this report but since data collection methods are fundamentally different, it is not usually added to the AOS database. An exception is sometimes made to fill significant gaps in the survey coverage. Insect population information (including pheromone-baited traps, larval/egg surveys, and tree branch beatings) and ground observations may also be included.

Information obtained from the annual aerial overview survey is used by many interest groups including government agencies, industry, academia and the public for a variety of purposes. This includes input into government strategic objectives, guidance for management efforts related to forest health, as a source for research projects, contributions to national indicators for sustainable forest management (see Canada's National Forest Database: http://nfdp.ccfm.org/en/index.php), input into timber supply analyses, input into the National Forest Pest Strategy *Pest Strategy Information System* (www.ccfm.org/pdf/PestStrat_infosys_2012_en.pdf) and analyses relating to


Figure 1. Map of British Columbia outlining Ministry of Forests, Lands and Natural Resource Operations and Rural Development Timber Supply Areas (TSAs) and Regional Boundaries.

climate change and carbon accounting (i.e., estimating the success in meeting greenhouse gas emission reduction targets).

Relevant forest health projects, presentations, workshops and publications conducted by FLNRORD pathologists, entomologists and their associates over the past year follow the damaging agent reporting section of this report. Not all forest health activities conducted by provincial staff or other agencies in the province are necessarily captured in this overview report. A more detailed annual report of forest health in the Southern Interior of BC and previous copies of this publication are also available at:
https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/aerial-overview-surveys/summary-reports.

# Methods

Aerial overview surveys are conducted in small (minimum four seats) high-wing configuration aircraft that are Ministry approved (Transport Canada licensed, approved maintenance schedule, appropriate insurance and experienced pilots). In addition to the pilot, two trained observers sit on opposite sides of the plane. The "primary surveyor" is usually seated in the front next to the pilot and is responsible for mapping out the right side of the aircraft, as well as general navigation and survey planning. The "second seat surveyor" sits in the back on the opposite side of the aircraft and is responsible for mapping out the left side of the aircraft. Total survey time is limited to 5-6 hours to ensure a quality product, though if necessary, ferry time can be added to this.

*A survey plane used in northwestern BC, where limited landing strips and plentiful lakes make float planes a practical choice*

An additional trainee may map from the seat behind the primary surveyor. To become a second seat surveyor, an initial training course followed by a minimum of 15 hours of trainee mapping in varied forest types is required. To be considered a primary surveyor, one season of flying second seat (minimum 50 hours) is required. A minimum of two observers and a pilot survey each FLNRORD Region.

Current forest damage that is visible during the AOS is hand sketched on customized 1:100,000 scale maps (colour Landsat 8 satellite images with additional digital features such as contours, feature names, water bodies, roads, and previous year's fires or large bark beetle polygons). On flight completion, the information recorded on the individual working maps is combined and transferred to base maps, which are then manually digitized to capture the data spatially. Clear polyester film is used for these final composite maps. Various digital methods for capturing the data during flight have been tested over the past few years, but technology and database compatibility issues, along with the complexity of the survey in BC, have not resulted in adoption of a digital recording method to date.


*Aerial overview surveyor*

Surveys are conducted when damage caused by the primary forest health factor(s) of concern for a given area are most visible, flight conditions permitting. Flight lines are recorded with recreational quality Global Positioning Satellite (GPS) receiver units. The resulting track files are collated and disseminated weekly to participants so coverage intensity and survey progress can be monitored. Depending on terrain and visibility, surveys are conducted between 700 to 1400 m above ground level. In relatively flat terrain, parallel lines are flown 7 to 14 km apart, depending on the intensity of mapping activity and visibility. For mountainous terrain, valley corridors are flown. Intensity of coverage in the mountains depends on visibility up side drainages, as stands are surveyed to the tree line. Aircraft speed ranges from 140 to 250 km/h, depending on mapping complexity and wind speed.

All forested areas on the flight lines are observed for visible current damage, regardless of land ownership or tenure. The goal is to survey all BC forested land each year, weather and funding permitting. This goal can be difficult to obtain within the survey window, which is dependent on timing for optimum damage visibility (e.g. damaged needles/leaves may fade or drop off at different times, or snow may cover damage). Therefore, high priority areas are targeted first, followed by major drainages in lower priority areas. Areas not covered in a given year are given a higher priority the next year.

Tree mortality (caused by bark beetles, animal feeding, root diseases, and some abiotic factors) is identified primarily by the colour of the foliage. Only trees killed within the past year are mapped. Small clumps of up to 50 dead or dying trees are mapped as points (referred to as spot infestations) with an estimated number of dead trees noted. When digitized, spots of 1 to 30 trees are given a size of 0.25 ha, and 31 to 50 trees 0.5 ha with an intensity rating of severe, to capture the approximate area affected. Larger, more continuous areas of mortality are delineated as polygons and are assigned one of five severity rating classes based on the proportion of recently killed trees within the delineated area (Table 1).

Trees with foliar damage (caused by insect feeding, foliage diseases and some abiotic factors) usually cover large areas and often all age classes of host trees are affected. Therefore, only polygons are used to map this type of damage. Severity rating classes are assigned based on the amount of foliage damaged during the past year on all host trees in the polygon. Three severity rating classes are used for foliar damage, with any cumulative damage that results in mortality recorded as grey once a damaging agent has run its course in a given area (Table 1).

Table 1. Severity rating classes used during aerial overview surveys for recording forest health damage that occurred over the past year.

| Disturbance | Intensity Class | Description |
|---|---|---|
| Mortality (bark beetle, some abiotic, yellow cedar decline and animal damage) | Trace | <1% of the trees in the polygon recently killed. |
| | Light | 1-10% of the trees in the polygon recently killed. |
| | Moderate | 11-29% of the trees in the polygon recently killed. |
| | Severe | 30-49% of the trees in the polygon recently killed. |
| | Very Severe | 50%+ of the trees in the polygon recently killed. |
| Foliage Damage (defoliating insect, foliar disease and some abiotic) | Light | Some branch tip and crown damage, barely visible from the air. |
| | Moderate | Noticeably damaged foliage, a third of many trees severely damaged. |
| | Severe | Most trees sustaining more than 50% total foliage damage. |
| | Grey | Cumulative foliage damage resulting in mortality, recorded at end of damage agent cycle. |
| Aspen and birch declines | Light | Characterized by thin crowns and no individuals without visible foliage. |
| | Moderate | Thin crowns are accompanied by individuals devoid of foliage. Greater than an estimated 50% of individuals have some foliage. |
| | Severe | Crowns are very thin and greater than 50% of standing stems are devoid of foliage. |

Some exceptions are made to the "polygon only" rule for foliar damage. Venturia blight damage sometimes affects only a small clump of trees (most likely a single clone) within a stand of undamaged suitable hosts and can be recorded as a spot infestation. Occasionally, needle diseases (particularly in Kootenay/Boundary Region) severely affect host trees that are a very low component of the stand composition. This damage is sometimes recorded as spot damage. Aspen leaf miner damage that is visible from the air tends to have an "all or nothing" signature that has very little discernible tree-to-tree variation in damage. Additionally, in many areas, aspen occurs in mixed rather than pure stands. To most accurately record damage intensity, a standard was adopted in 2012 to record these disturbances in a manner like mortality, with severity ratings based on the percentage of the stand affected, rather than the intensity of the defoliation to the trees, although the defoliator categories of light, moderate and severe are used.

Aspen and birch decline (caused by a variety of combined damaging agents) are mapped as light, moderate or severe based on thinning crowns and mortality (Table 1).

If surveyors are uncertain from the aerial signature as to what damaging agent is causing a disturbance, then the damage is mapped by location and severity, tree species affected and as much detail as is known about the agent (e.g. foliar disease, defoliator, etc.) and aerial photos are taken. Local experts are then consulted and, if necessary, ground checks (if damage is accessible) are conducted with photos, samples and site data collected to determine the cause. Ground check information for 2019 is available at: https://www.for.gov.bc.ca/ftp/HFP/external/!publish/Aerial_Overview/2019/, under directory "Ground checks".

There are known limitations with the data collected during the aerial overview survey. Not all damage is visible: for example, needle cast damage often fades dramatically in intensity or the needles fall off before the AOS is conducted. Also, many damage agents that cause significant growth loss and tree defects do not generally produce an aerial signature that can be recorded by the AOS. Thus, damage by agents like dwarf mistletoe infections and gall rust are rarely detected during the AOS.

*An atropellis canker on lodgepole pine, one of the diseases that can't be detected during the aerial overview survey*

Care must also be taken in interpretation of the data. Area recorded as damaged by a certain forest health factor during past surveys cannot be added cumulatively, as new damage may be recorded in all or a portion of the same area leading to double counting. Also, the relatively broad intensity classes and known errors of omission must be considered. For example, calculating accurate mortality volume is not possible since the actual number of trees killed (and consequently volume) is not precise. Spatial accuracy of the data can also be lower in areas without clearly visible geographic references and thus can be unreliable for directing site specific operational surveys and treatments.

Despite these survey limitations, FLNRORD Forest Analysis and Inventory Branch have used the overview survey data to estimate cumulative and projected volumes of pine killed by the mountain pine beetle, since the data is the most complete record of the outbreak's progress across the province. Similarly, the timber supply impacts of the current spruce and Douglas-fir beetle outbreaks will also be estimated. The annual survey data is also used by districts to estimate non-recoverable pest-caused losses for incorporation into timber supply reviews.

Recently revised Forest Health Aerial Overview Survey Standards for British Columbia is available at:
https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/forest-health/aerial-overview-surveys/methods

# Overview Results

Aerial overview surveys commenced on June 23rd and were completed on October 18th. In general, BC experienced an early, warm and dry spring, which prompted predictions of another record wildfire season. With this in mind surveys began as early as possible within the limitations of whether the damage from principal forest health factor(s) of concern for an area were visible. Thus, surveys began in the flattest, driest areas of the southern Cariboo Region, where damage from the important agents Douglas-fir beetle, pine needle diseases and aspen defoliators show early. This is the earliest recorded start of the survey. AOS commenced the next day in similar territory in Omineca Region. Shortly after surveys started, the weather turned dramatically to wet cool conditions interspersed with short warm dry spells throughout the flying season, with a slightly larger flying window developing near the end of August. The only exception to this pattern was the far northwest of Cassiar TSA and the southeast of BC, which remained relatively dry most of the summer. Rain and low cloud were often a challenge for the surveyors, resulting in a late end to the flying season for some regions. The last flight for Skeena Region was relatively early on September 1st, but only because another suitable survey window did not occur before snow set in. The weather issues resulted in a significant portion of the northwest not being surveyed: 79% of the province was flown, which is the lowest coverage in a decade and below the 10-year average of 86% (Figure 2). This is a gross annual estimate of the proportion of the province flown as it does not net out non-forested types such as lakes, grasslands, or alpine. Since it has been calculated the same way every year, results are comparable year-to-year.

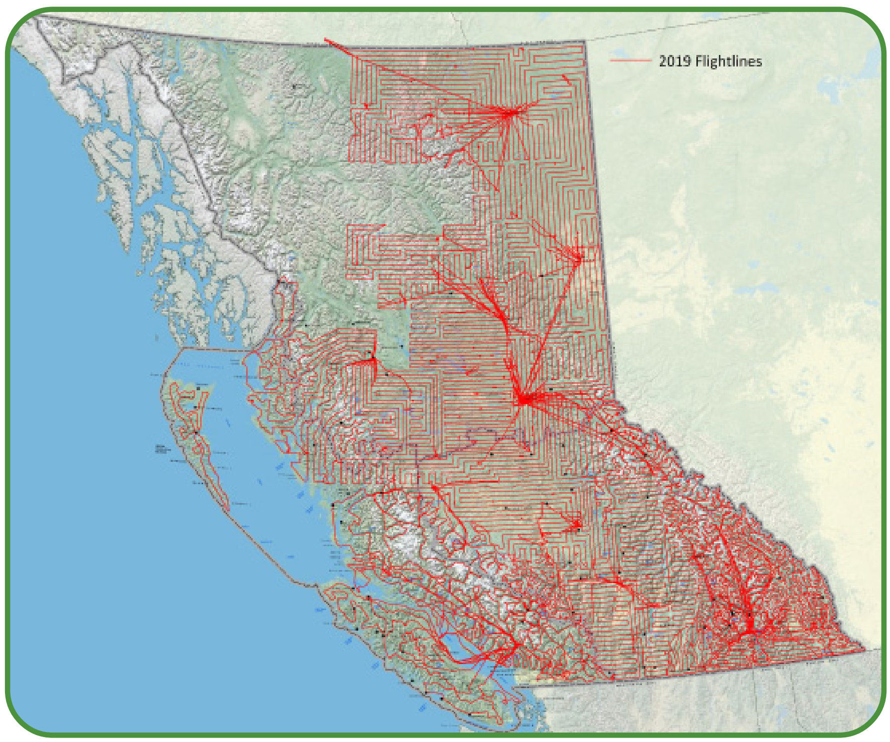



Figure 2. Flight paths flown while conducting the 2019 aerial overview survey. Approximately 79% of the province was surveyed this year.

Mentoring flights conducted with all new surveyors and quality assurance flights of at least 10% of each of the six survey contractors was completed during the first half of the survey season. Feedback was provided to improve the quality of the survey and ensure data integrity was maintained.

Total survey flight time was lower than last year, reflecting the lower coverage, with 658 hours logged over 129 days of flying, for an average of 5.1 hours flown per day (Table 2). This did not

Table 2. Flying hours and survey dates by region for the 2019 provincial aerial overview survey.

| Regions | Flight hours | Days flown | Survey Dates |
|---|---|---|---|
| Cariboo | 94.7 | 20 | Jun 23rd – Sep 5th |
| Thompson/Okanagan | 47.4 | 8 | July 15th – July 26th |
| Kootenay/Boundary | 107.5 | 19 | July 21st – Aug 29th |
| Omineca & Northeast | 265.3 | 56 | Jun 24th – Oct 19th |
| Skeena | 65.4 | 11 | July 12th – Sep 1st |
| West & South Coast | 77.8 | 15 | July 25th – Oct 2nd |
| **Total** | **658.1** | **129** | **Jun 23rd – Oct 18th** |

include quality assurance flight checks. A total of 24 surveyors and nine aircraft companies participated in the flying.

Composite maps were completed in a timely fashion and then were promptly scanned, geo-referenced and posted at: http://www.for.gov.bc.ca/ftp/HFP/external/!publish/Aerial_Overview/ for use by anyone needing quick access to the draft information. The final provincial summaries of the spatial and tabular data were available at the same site by January 28th, 2019.

Hectares of forest damage across BC was 5,988,109 ha, down a quarter since 2018 (Table 3). Bark beetles continued to cause the most damage by area, with 4,038,107 ha affected, down from 4,206,910 ha last year. Western balsam bark beetle infestations declined slightly to 3,247,135 ha, though almost all the mortality (99%) continued to be trace to low intensity. Damage was highest in Omineca and Skeena Regions, where 1,732,726 ha and 799,275 ha were affected, respectively. Spruce beetle disturbances rebounded to 2017 levels with 515,447 ha delineated. Omineca Region continued to be most affected, with one-year as well as two-year beetle life cycles still occurring. Colour change varied widely in 2019, making it difficult to distinguish old attack from new. Mountain pine beetle attack increased by a third since 2018 to 177,444 ha across BC, the first increase seen in a decade. The most active infestations continued to be in Robson Valley TSA of Omineca Region and in the western portion of Williams Lake TSA in Cariboo Region. Douglas-fir beetle infestations declined slightly with 97,964 ha mapped. Cariboo Region continued to be most affected, with almost three-quarters of the provincial damage, particularly in Williams Lake TSA. Populations are building in the large 2017 wildfires and are expected to move out of the fire perimeters in 2020.

Foliage damage due to insect feeding declined almost a quarter since 2018 to 1,591,671 ha. Most of the deciduous defoliation continued to be caused by aspen leaf miner with 1,326,903 ha affected. Almost three-quarters of the infestations were observed in Omineca and Skeena Regions, where 580,521 ha and 379,541 ha were mapped, respectively. After satin moth defoliation peaked in 2018 at 209,932 ha, observed damage dropped to 77,532 ha in 2019, with most of the disturbances continuing to be delineated in Prince George TSA of Omineca Region. Birch leaf miner infestations continued to grow to 10,242 ha, particularly in Fort Nelson TSA in Northeast Region. Alder leaf beetle was mapped for the first time during the AOS, with 1,064 ha damaged in both coast regions.

Conifer defoliation decreased substantially this year, primarily due to two-year-cycle budworm damage declining to 130,205 ha, after a record 414,319 ha delineated in 2018. Omineca Region sustained most of the defoliation (99,207 ha), mainly in Prince George TSA. Skeena Region had

Table 3. Summary of hectares affected by forest damaging agents as detected in 2019 aerial overview survey in British Columbia.

| Damaging Agent | Area Affected (ha) | Damaging Agent | Area Affected (ha) |
|---|---|---|---|
| *Bark Beetles:* | | *Diseases:** | |
| Western balsam bark beetle | 3,247,135 | Venturia blight | 13,729 |
| Spruce beetle | 515,447 | White pine blister rust | 5,458 |
| Mountain pine beetle | 177,444 | Large-spored spruce-labrador tea rust | 4,136 |
| Douglas-fir beetle | 97,964 | Larch needle blight | 2,122 |
| Western pine beetle | 62 | Laminated root disease | 693 |
| Unknown bark beetle | 54 | Dothistroma needle blight | 346 |
| *Total Bark Beetles:* | 4,038,107 | Cottonwood leaf rust | 139 |
| *Defoliators:* | | Armillaria root disease | 49 |
| Aspen leaf miner | 1,326,903 | Unknown disease | 32 |
| Two-year-cycle budworm | 130,205 | Comandra blister rust | 13 |
| Satin moth | 77,532 | *Total Diseases:* | 26,716 |
| Western spruce budworm | 24,102 | *Abiotics:* | |
| Birch leaf miner | 10,242 | Cedar flagging | 115,581 |
| Pine needle sheathminer | 7,079 | Post-wildfire mortality | 106,873 |
| Eastern spruce budworm | 3,885 | Yellow-cedar decline | 23,449 |
| Western hemlock looper | 3,276 | Wildfire | 22,053 |
| Douglas-fir tussock moth | 2,708 | Drought (mortality) | 19,978 |
| Balsam woolly adelgid | 1,796 | Aspen decline | 11,860 |
| Unknown defoliators | 1,573 | Flooding | 11,778 |
| Leaf beetles | 1,064 | Windthrow | 11,635 |
| Bruce spanworm | 751 | Slides | 3,348 |
| Western blackheaded budworm | 370 | Drought (foliage) | 2,881 |
| Lodgepole pine sawfly | 184 | Frost damage | 53 |
| *Total Defoliators:* | 1,591,671 | Treatment mechanical | 45 |
| *Animals:* | | *Total Abiotics:* | 329,535 |
| Bear | 1,646 | | |
| Unknown animal | 419 | | |
| Porcupine | 16 | | |
| *Total Animals:* | 2,080 | | |
| ***Provincial Total Damage:*** | **5,988,109** | | |

* Disease damage is greatly underestimated in aerial overview survey data

27,527 ha affected, chiefly in Lakes TSA. Western spruce budworm damage increased slightly to 24,102 ha, mainly located in Cariboo and Thompson/Okanagan Regions. A treatment program was conducted on 16,667 ha in Cariboo Region in 2019. Pine needle sheathminer damage increased to 7,079 ha with most of the attack delineated in Prince George TSA of Omineca Region. Eastern spruce budworm defoliation in Fort Nelson TSA of Northeast Region declined to 3,885 ha from a peak of 35,753 ha in 2018. Ground and air monitoring indicated that western hemlock looper infestations are increasing, with 3,276 ha mapped in 2019, up from only 17 ha last year. South

Coast and Kootenay/Boundary Regions sustained most of the attack, though a 741 ha severely defoliated stand in Cariboo Region (classified as unknown defoliation, inaccessible for confirmation) was suspected to be western hemlock looper caused as well. Douglas-fir tussock moth damage also increased substantially, from only 65 ha in 2018 to 2,708 ha. A large portion of this defoliation (1,662 ha) occurred for the first time in recorded history in Williams Lake TSA of Cariboo Region, with the remainder in Thompson/Okanagan Region. A record 1,796 ha of balsam woolly adelgid damage, primarily in West Coast Region, was recorded this year, though intensity of damage was rated very low.

Abiotic damage decreased five-fold from 2018 to 329,535 ha. Cedar flagging damage was mapped on a record 115,581 ha in 2019. This damage was more severe than normal cedar flagging, and experts concurred it was most likely caused by winter desiccation combined with previous drought stress. Damage was mapped throughout western redcedar stands in the interior of BC. Post-wildfire damage from the past two record years of wildfires accounted for a record 106,873 ha. Most of this damage was observed in Cariboo Region and young lodgepole pine were most affected. Wildfires have been the number one abiotic damaging agent reported from the AOS survey every year since 2003, when they were first included in the survey. With the inclement weather across most of BC in the summer of 2019, hectares burnt fell from a record of 1,351,837 ha in 2018 to 22,053 ha, primarily in the far north, moving wildfire damage into third place. Mortality caused by drought decreased substantially to 19,978 ha. Kootenay/Boundary Region sustained more than a third of the damage, followed by the Coast and Skeena Regions. Flooding damage declined to 11,778 ha, with 85% of the damage occurring in the Northeast Region. Windthrow damage increased to 11,635 ha, of which 82% was mapped in Fort Nelson TSA of Northeast Region. Slides affected 3,348 ha provincially, with 2,517 ha observed in West Coast Region. Drought caused excessive needle damage on 2,881 ha, primarily in Thompson/Okanagan Region.

Visible disease damage declined to almost half of what was observed during the AOS in 2018 to 26,716 ha. Disease damage is known to be underestimated in the AOS, but the data collected is consistent. Venturia blight damage almost tripled since last year to 13,729 ha. Most of the damage (11,305 ha) was mapped in Skeena Region. White pine blister rust damage declined to 5,478 ha of mostly trace intensity damage in coastal regions. In Fort Nelson TSA of the Northeast Region, 4,136 ha of large-spored spruce-labrador tea rust damage was recorded. A total of 2,122 ha of larch needle blight was mapped in Kootenay/Boundary Region, mainly in Cranbrook TSA. Foliage damage caused by disease is anticipated to be higher next year, due to ideal infection conditions across most of the province in 2019. Other observed disease damage was less than 700 ha per disease agent.

Visible animal damage, primarily mortality, declined to a third of what was mapped in 2018 to 2,080 ha, chiefly affecting young lodgepole pine. Black bear caused mortality continued to lead animal damage, with 1,646 ha recorded across the province. Kootenay/Boundary and Northeast Regions sustained most of the damage. Unknown animal damage affected 419 ha, mainly in Skeena Region, and the cause was most likely bear or hare. Porcupine damage was observed on 14 ha in Fort Nelson TSA.

Locations, extent and intensity of damage by forest health factors are detailed in the following sections and summarized by host tree species.

# Damaging Agents of Pines

### Mountain pine beetle, *Dendroctonus ponderosae*

For the first time in a decade, mountain pine beetle caused mortality increased from a low of 113,781 ha last year to 177,444 ha in 2019. Most disturbances continued to be scattered spots or trace intensity polygons, though substantial increases were observed in a few infestations (Figure 3). Severity of attack was classified as 81,265 ha (46%) trace, 73,703 ha (42%) light, 19,898 ha (11%) moderate, 2,376 ha (1%) severe and 202 ha (<1%) very severe. Some surveyors noted that although some infestations were in mature stands, others were initiating in older, intermediate aged stands that were too small to be susceptible to attack at the height of the last outbreak. The primary host continued to be lodgepole pine, which sustained over 80% of the mortality. Whitebark pine accounted for 18% of the attack, with very minor areas of ponderosa and western white pine affected.

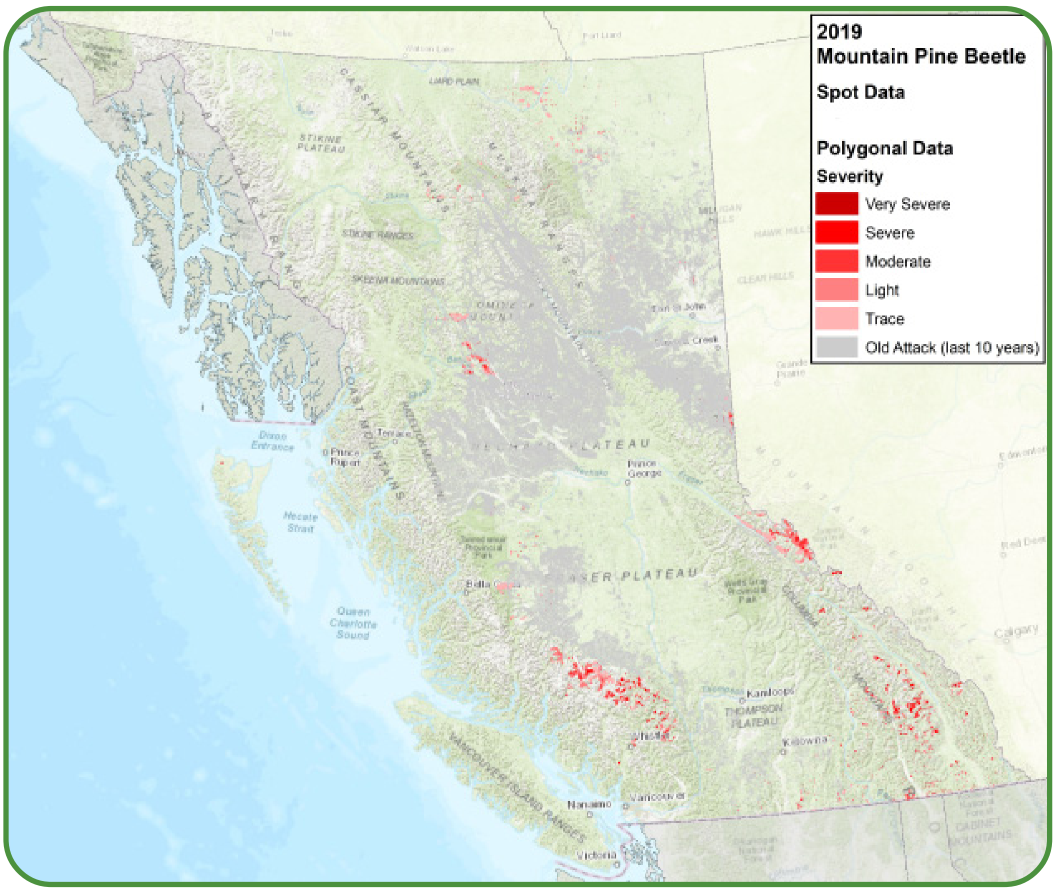



Figure 3. Current mountain pine beetle infestations recorded by severity in British Columbia in 2019 with old attack in grey.

For the fourth consecutive year attack was highest in Omineca Region with 86,657 ha mapped, up a third from 2018 (Figure 4). Most of the mortality continued to occur in Robson Valley TSA where 63,220 ha were attacked, up 39% from last year. Intensity of damaged declined however in the main infestation located from Moose Lake south to Reunion Peak (to primarily light with some small moderate patches) and most of the newly mapped disturbances from Valemount to McBride east of the Fraser River were observed at trace intensity. Mountain pine beetle mortality

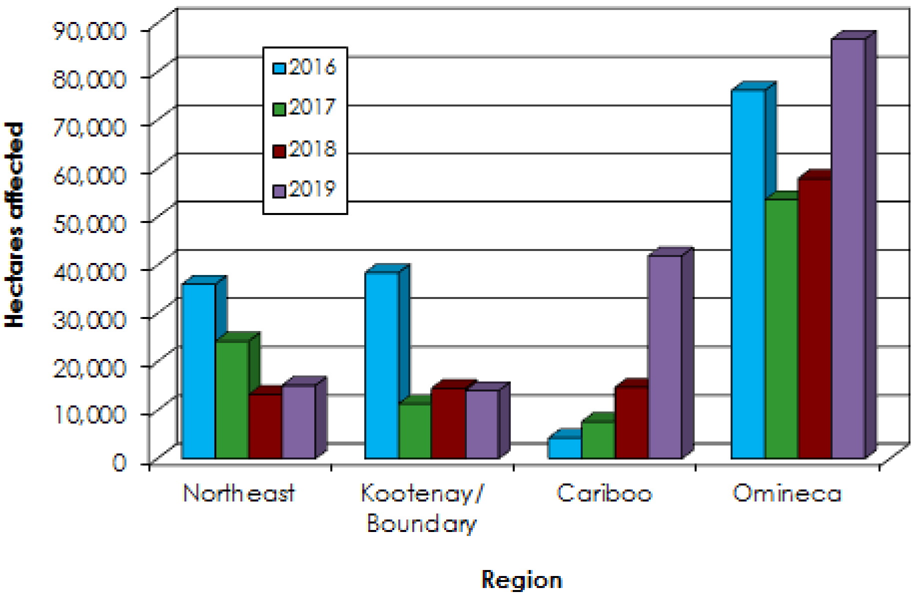



Figure 4. Area infested (all severity classes) by mountain pine beetle from 2016 – 2019 by regions with over 10,000 ha of attack per year.

in Prince George TSA rose to 21,561 ha, with the bulk of the attack continuing to occur in the north tip of Fort St. James District around Bear Lake and south to Takla Landing. Infestations in Mackenzie TSA continued to decline to only 1,877 ha located in the north tip in small scattered trace polygons and spots.

The largest increase in mountain pine beetle damage in BC occurred in Cariboo Region with area damaged almost tripling since 2018 to 41,964 ha (Figure 4). Almost all the mortality occurred in the western portion of Williams Lake TSA, with the largest concentration and some of the highest intensities continuing to occur around the Taseko Mountain to Chilko Lake area. Hectares affected grew substantially in the Homathko River area, though mortality intensity was low. A few small disturbances were observed around Anahim Lake area. Total area affected in Williams Lake TSA was 41,902 ha, with the remaining 62 ha in the western tip of Quesnel District near Eliguk Lake.

Northeast Region sustained a small increase to 15,173 ha of damage. Most attack continued to occur in Fort Nelson TSA where 13,534 ha were mapped in scattered trace intensity polygons or spots. The most northerly polygons were mapped northeast of the Liard and Toad River junction with a few (unconfirmed) spots north of Crow River near the Yukon border (Figure 3). Infestations continued to occur primarily near Redwillow River on the Alberta border in Dawson Creek TSA but at a reduced level, with 1,167 ha delineated. Very dispersed, low intensity mortality was observed in Fort St. John TSA, where the total rose to 472 ha of damage.

*Mountain pine beetle mortality near Chilko Lake*

Mountain pine beetle caused mortality in Kootenay/Boundary Region remained static at 14,093 ha. In general, infestations were small and widely scattered. The regional entomologist noted that mountain pine beetle is capitalizing on drought conditions with increasing levels of attack in smaller diameter stressed trees. Invermere TSA continued to sustain the most damage with 6,083 ha mapped. Of note are populations in the Palliser (in combination with both spruce beetle and western balsam bark beetle) and west of Columbia Lake in the Brewer/ Dutch, Toby and Jumbo drainages. A total of 3,586 ha were affected in Kootenay Lake TSA, especially on the east side of Kootenay Lake including Campbell Creek North of Riondel, Fry Creek, Hamill Creek and the east side of Duncan Lake up Glacier Creek. Cranbrook and Arrow TSAs damage increased to 1,364 ha and 1,072 ha of mortality, respectively. The remaining TSAs in this region had less than 1,000 ha of attack per TSA. Extensive detailed aerial surveys, associated with ground surveys and single tree directed treatments are being conducted in the Invermere, Cranbrook and Kootenay Lake TSAs.

Since 2018, Great Bear Rainforest North TSA sustained a four-fold increase to 8,581 ha of damage. It is important to note however that 97% of the mortality was rated as trace, with the remaining light or spot. All attack was mapped near Atnarko.

Mountain pine beetle damage in Thompson/Okanagan Region remained static at 6,852 ha. However, the regional entomologist noted building populations observed as scattered single mass attacked trees mainly in the south Okanagan were not picked up during the AOS. Most of the mapped damage (6,803 ha) continued to be observed in Lillooet TSA, mainly in the western half with concentrations near Downton Lake and Bridge River. Okanagan TSA had 47 ha of scattered damage in the south half, and Merritt TSA contained a few spots.

Infestations in Skeena Region increased slightly to 3,202 ha with mortality located primarily in the same areas as last year. Most of the mortality (1,979 ha) in Bulkley TSA was mapped in the north tip, though some of the south wasn't surveyed. Cassiar TSA damage rose to 1,221 ha, all in the Pitman River area. Remaining Skeena Region TSAs only had a few spots of damage mapped.

South Coast Region attack rose to 871 ha. Soo TSA had 502 ha mapped, primarily north of Whistler. Small polygons of mortality totalling 286 ha were noted in the northeast part of Sunshine Coast TSA. Two infestations north of the Coquihalla Summit in Fraser TSA accounted for the remaining 83 ha in the region.

West Coast Region had only 51 ha of mountain pine beetle attack in two polygons west of Old Massett in Haida Gwaii TSA. These were not ground checked in 2019, but mountain pine beetle has previously been confirmed in the area.

*Mountain pine beetle mortality in whitebark pine and western balsam bark beetle mortality, near Chilko Lake*

## Pine needle sheathminer, *Zelleria haimbachi*

After a two year decline in pine needle sheathminer damage, defoliation increased provincially to 7,079 ha. Intensity of attack increased as well, to 2,501 ha (35%) light, 2,806 ha (40%) moderate and 1,772 ha (25%) severe (Figure 5).

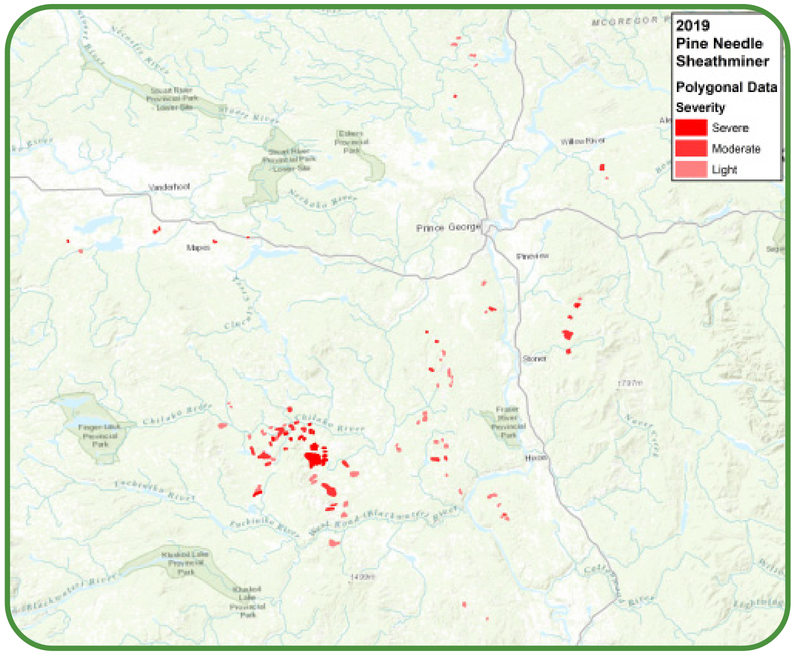



Figure 5. Pine needle sheathminer damage recorded by severity rating class in BC in 2019.

Much of the attack shifted northward since 2018, with 6,327 ha delineated in Prince George TSA of Omineca Region. Ground checks confirmed the damaging agent. A few small infestations were scattered near Vanderhoof and around Prince George, but most were noted around the Punchaw area, where most of the severe defoliation occurred. Most of the visible attack was in young stands, but attack in some intermediate aged stands was observed as well, which is unusual to detect from the AOS height. The damage continued south into Quesnel TSA of the Cariboo Region, where 751 ha were affected.

This marks the sixth consecutive year for substantial pine needle sheathminer damage in the central interior, which is quite unusual as pine needle sheathminer outbreaks have historically been short lived.

*Pine needle sheathminer damage on border of Prince George and Quesnel TSAs*

*Pine needle sheathminer defoliation*

## White pine blister rust, *Cronartium ribicola*

After a large increase to a record 12,561 ha of white pine blister rust damage in 2018, observed damage declined to 5,478 ha. White pine blister rust can be difficult to see from the height of the AOS unless tree mortality occurs, and most of the damage is always rated as trace. Hence, large changes in hectares of mapped damage are not necessarily indicative of large changes in infected trees. Damage was assessed as 5,384 ha (99%) trace, 62 ha (1%) moderate and 11 ha (<1% severe, all of which were spot infection centers) in 2019.

South Coast Region contained 4,033 ha of white pine blister rust damage. Almost all of this was observed in Sunshine Coast TSA (4,032 ha). Most of the disturbances were small and scattered, except for concentrations on the south end of Texada Island and east of Larsons Landing. Fraser and Soo TSAs only had a few spot disturbances.

West Coast Region sustained 739 ha of damage. North Island TSA had 377 ha mapped along the east edge of the TSA and north of Woss Lake. Arrowsmith TSA was similarly affected with 362 ha of damage noted northwest of Nanaimo Lakes.

Thompson/Okanagan Region had 633 ha of white pine blister rust damage. All but two spots (in Okanagan TSA) were observed in Kamloops TSA near Harbour Lake and Upper Adams River.

Damage in Great Bear Rainforest South TSA totalled 53 ha, all located south of Heydon Lake.

## Dothistroma needle blight, *Dothistroma septosporum*

Due to the dry conditions during the growing season in 2017 and 2018 (not conducive to needle disease infections), Dothistroma needle blight damage declined substantially last year to 22,944 ha and to 346 ha in 2019. This is the lowest level mapped since 2013, when a similar number of hectares were affected. Damage was assessed as 176 ha (51%) light and 170 ha (49%) moderate.

Thompson/Okanagan Region sustained 190 ha of damage, with 166 ha impacted in Okanagan TSA. Most of the disturbances were mapped along the eastern TSA boundary south of Sugar Lake, with two polygons located west of Mabel Lake. Kamloops TSA had one 24 ha polygon north of Tumtum Lake.

All 156 ha of Dothistroma needle blight damage in Kootenay/Boundary Region occurred in Arrow TSA. The mapped disturbances were all along Arrow Lake just north of Nakusp.

Very good infection conditions occurred in the 2019 growing season, with many warm, moist days over much of the province. Hence, visible damage is anticipated to be higher in 2020 as needles infected in a given year die the next year. Areas of historical damage will be closely monitored, and efforts will be made to fly those areas as early as possible in the season, when the damage signal is most visible.

## Neodiprion sawfly, *Neodiprion nanulus contortae*

Neodiprion sawfly continued to damage small shore pine in Haida Gwaii TSA of West Coast Region. After a three year decline to 86 ha in 2018, 184 ha of defoliation were mapped this year. Infestations were noted in the southern half of Moresby Island and one at the south tip of Kunghit Island. Intensity of attack was similar to last year, with 169 ha (92%) light and 15 ha (8%) moderate.

## Western pine beetle, *Dendroctonus brevicomis*

Western pine beetle caused mortality increased to 62 ha in 2019 from 29 ha last year. Intensity of attack was rated 51 ha (82%) moderate and 11 ha (18%) severe. Kootenay/Boundary Region sustained most of the damage with 60 ha attacked. The 43 ha identified in Arrow TSA were primarily located in two disturbances between Crescent Valley and Playmor Junction. Kootenay Lake TSA had 13 ha of mortality mapped (except for a few spot infestations) in one disturbance west of Nelson near Taghum. The remaining 4 ha were observed in dispersed spots in other TSAs in the region. Western pine beetle damage in Thompson/Okanagan Region totalled only 2 ha. The affected hectares were all spot infestations, widely scattered between Lillooet, Merritt and Okanagan TSAs.

## Unknown bark beetle

In Fort Nelson TSA of the Northeast Region, seven small disturbances totalling 54 ha were mapped and were most likely mountain pine beetle or lodgepole pine beetle, and possibly porcupine damage. The mortality was noted along the Petitot River in the northeast corner of the TSA, at trace intensity.

## Unknown pine foliage disease

Only 31 ha of foliage damage due to a disease that could not be identified was mapped in 2019, in an intermediate aged lodgepole pine stand. The damage was rated as light and it occurred in one polygon in Kootenay Lake TSA of the Kootenay/Boundary Forest Region south of Ainsworth Hot Springs on Kootenay Lake. No damage was detected in this area last year, but stands were affected there the two previous years. A ground check was conducted and samples submitted to the regional pathologist but the actual cause could not be confirmed. Judging by the very thin crowns caused by multiple years of infection, the most likely disease was Dothistroma needle blight. This area will be closely watched early next season.

## Comandra blister rust, *Cronatium comandrae*

Comandra blister rust damage is greatly underestimated during the AOS because the disturbances (primarily in very young trees) are only visible once substantial mortality occurs.

In 2018 no observed damage was attributable to this stem rust, and in 2019 only 13 ha of trace damage was delineated in Thompson/Okanagan Region. This damage all occurred in one disturbance in Okanagan TSA north of Big White Mountain.

# Damaging Agents of Douglas-fir

## Douglas-fir beetle, *Dendroctonus pseudotsugae*

Douglas-fir beetle damage declined slightly for the second consecutive year to 97,964 ha provincially (Figure 6). Since 2018, intensity of mortality declined substantially to 58,524 ha (60%) trace, 25,226 ha (26%) light, 10,287 ha (10%) moderate, 3,807 ha (4%) severe and 120 ha (<1%) very severe in 2019 (Figure 7).

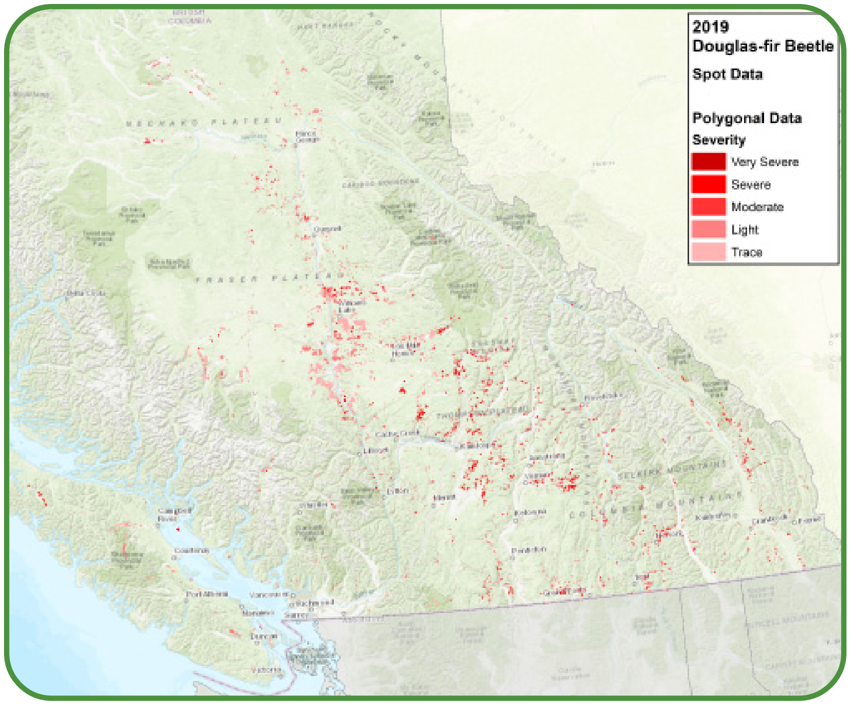



Figure 6. Douglas-fir beetle attack recorded in BC in 2019, by severity rating class.

Cariboo Region damage remained the highest in the province and was reasonably stable at 69,798 ha. The bulk of the larger disturbances continued to be concentrated on dry, steep slopes, particularly near the Fraser River. Populations are building in the remaining live mature Douglas-fir patches within the large 2017 wildfires, which are anticipated to fly out of the fire perimeters in 2020. Williams Lake TSA continued to be the most affected, with 54,733 ha of damage delineated. Sampling conducted in the Knife Creek area found that the beetles were highly parasitized. In addition to infestations along the Fraser River, 100 Mile House TSA had large polygons of attack noted in the Elephant Hill fire area and around Canim Lake (where trap trees are being employed). In total, 12,379 ha were mapped in 100 Mile House TSA. Attack in Quesnel TSA was observed to be 2,686 ha.

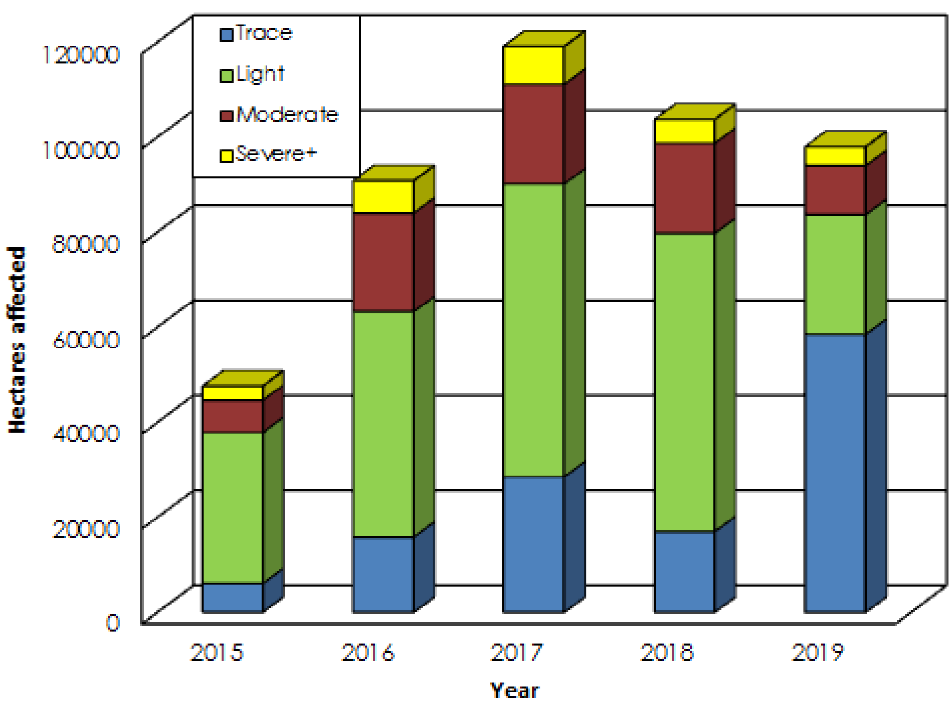



Figure 7. Area of Douglas-fir beetle damage recorded in BC by severity class from 2015 to 2019.

Douglas-fir beetle infestations rose slightly since last year in Kootenay/Boundary Region to 7,084 ha. All mapped disturbances were relatively small. Extensive funnel trapping was conducted to "mop up" growing beetle populations associated with recent wildfires. In Selkirk District (Golden, Revelstoke, Kootenay, Arrow and Boundary TSAs) ministry and licensee staff and contractors collected over four million beetles across 142 sites. The regional entomologist noted that the peak beetle flights occurred in May and June, with smaller flights into July and August. Mapped damage was highest in Arrow TSA at 2,395 ha in dispersed disturbances. Invermere TSA sustained 1,515 ha of attack, chiefly scattered to the east of Columbia River. Most of the 1,127 ha of mortality observed in Boundary TSA were in the dry zones along the southern border. Kootenay Lake TSA sustained 1,024 ha of attack, primarily along dry, steep, Kootenay Lake drainages. Less than 600 ha of Douglas-fir beetle mortality affected each of the remaining TSAs.

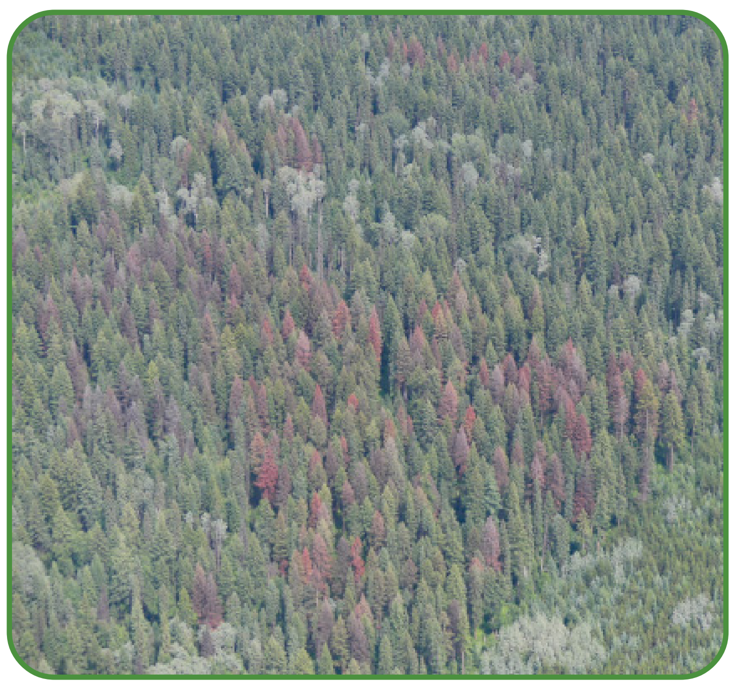
Infestations in Thompson/Okanagan Region increased slightly since 2018 to 6,619 ha. Kamloops TSA contained 3,339 ha of damage, chiefly from Clearwater south and north of Mahood Lake. Douglas-fir beetle attack totalling 2,526 ha was widely spread across Okanagan TSA, with concentrations from Vernon through Cherryville and southwest of Penticton. Merritt and Lillooet TSAs had minor attack, with 488 ha and 266 ha, respectively.

Attack in the West Coast Region more than doubled since 2018 to 5,714 ha. A total of 3,191 ha of damage was observed in North Island TSA, mainly west of Campbell and Buttle Lakes and north of Atluck. Most of the 2,523 ha recorded in Arrowsmith TSA occurred from Lake Cowichan to Fulford Harbour.

Douglas-fir beetle attack decreased more than half in Omineca Region to 5,334 ha. Prince George TSA had most of the damage, with 5,044 ha delineated. Infestations were scattered throughout Douglas-fir stands in the southern half of the TSA, particularly around Stuart Lake and Summit Lake areas. Robson Valley contained the remaining 290 ha in the region, chiefly south of Valemount.

South Coast Region damage declined by more than a third since 2018 to 2,967 ha. Fraser TSA continued to be most affected, with 1,569 ha of attack. The larger disturbances were noted in Manning Park, east of Hope and around Alvin. Soo TSA had 1,068 ha of attack, with concentrations west of Lillooet Lake, near Capricorn Creek, and west of Elaho Giant. Sunshine Coast TSA had scattered infestations in the southwest totalling 329 ha. District staff noted the major beetle flight occurred early to mid-May.

All remaining TSAs in the province had less than 430 ha of attack per TSA.



*Douglas-fir beetle infestation in Prince George TSA*

## Western spruce budworm, *Choristoneura occidentalis*

Western spruce budworm defoliation rose sharply in the southern interior of BC in 2018 to 22,634 ha, from only 704 ha the year before. Damage observed during the AOS in 2019 was similar to last year at 24,102 ha, though some of the locations changed (Figure 8). Severity of attack was assessed as 17,542 ha (73%) light, 1,978 ha (8%) moderate and 4,582 ha (19%) severe.

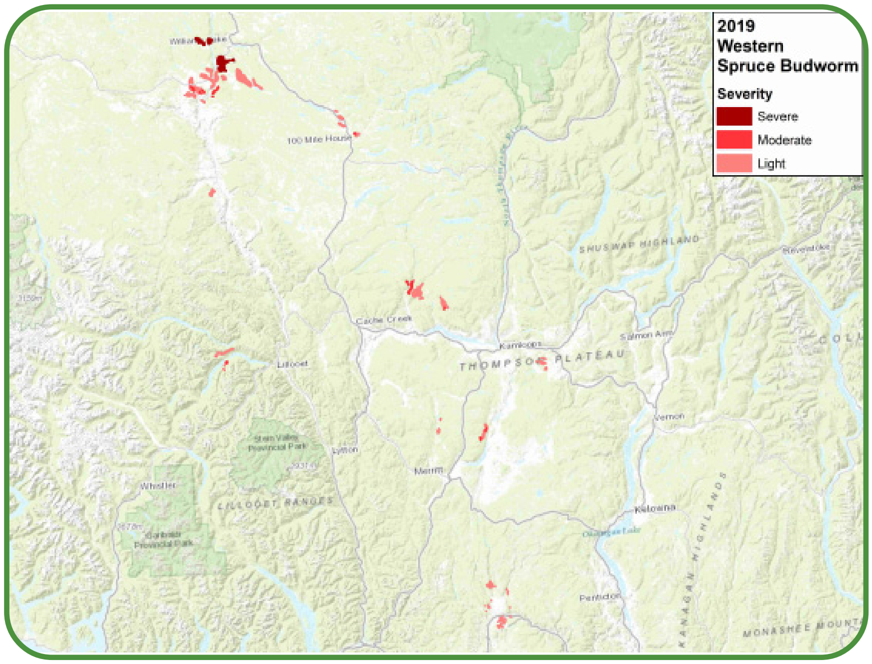



Figure 8. Western spruce budworm defoliation recorded in BC in 2019, by severity rating class.

Cariboo Region continued to be the most affected, with 15,944 ha of western spruce budworm defoliation. Most of this (14,885 ha) was observed in Williams Lake TSA, from Chimney Lake west to Riske Creek and north of Meldrum Creek. The remaining 1,059 ha of attack was mapped in 100 Mile House TSA around the 105 Mile House area. For the first time in recorded history, a low level of western spruce budworm feeding on Douglas-fir was observed in the valley around Horn Lake south of Tatla Lake (ground observation).

*Unhatched western spruce budworm egg mass*

Based on visible defoliation and egg mass survey results in the fall of 2018, a treatment program was conducted in the spring of 2019 in Cariboo Region. A total of seven blocks ranging from 444 ha to 7,900 ha were sprayed with the biological control agent *Bacillus thuringiensis* var. *kurstaki* (*Btk*), formulation Foray 48B® at a rate of 2.4 litres/ha in a single application. Six blocks were treated in Williams Lake TSA from Chimney Lake to Meldrum Creek and one block in 100 Mile House TSA in the Canoe Creek area. The spray was conducted with one Lama 315B and one Hiller UH12ET helicopter and the program ran from June 16$^{th}$ to 21$^{st}$ on a total of 16, 667 ha. Except for one small block, defoliation dropped within the treated areas from predicted moderate/severe to light or no visible defoliation mapped during the AOS.

Defoliation in Thompson/Okanagan Region almost doubled to 8,091 ha. Infestations were primarily in the same areas as last year, but many expanded. Kamloops TSA sustained 4,296 ha of damage, located north of Kamloops Lake and south of Monte Creek. Attack was more spread out in Merritt TSA, where 2,945 ha were mapped. Concentrations were noted around Princeton and between Stump and Nicola Lakes. Lillooet TSA had 850 ha of damage, all north and south of Seton Portage.

Visible western spruce budworm defoliation dropped dramatically in Kootenay/Boundary Region to only 67 ha in Boundary TSA, in two polygons west of Bridesville (ground confirmed). Defoliation too light to see from the air was noted on the ground in the Anarchist Mountain area.

*Larval sampling for western spruce budworm spray program*

Egg mass surveys were conducted again in the fall of 2019 in high value stands and in areas of historic defoliation in the southern interior. As in 2018, many of the stands had nil or light defoliation predicted, for which no control treatment is necessary. The number of sites where moderate defoliation was predicted dropped sharply from 49 last year to only eight in 2019, and no sites had a severe prediction (Table 4). The Cariboo entomologist hypothesized that egg mass laying may have been hampered by abundant wet weather. Six of the eight sites with moderate defoliation predicted next spring are in the Thompson/Okanagan Region. There is a treatment program proposed for this region in 2020, pending funding. Total area proposed for treatment is just over 8,000 ha in Kamloops (Criss Creek) and Merritt (northwest of Nicola Lake and east of Mamit Lake) TSAs. Two sites with moderate defoliation are predicted for Williams Lake TSA, where 10,000 ha of treatment is proposed.

Table 4. Summary of western spruce budworm defoliation predictions for 2020 based on 2019 egg mass survey results.

| **Region** | **TSA** | **Number of Sites by Defoliation Category** | | | | **Total Sites** |
|---|---|---|---|---|---|---|
| | | **Nil** | **Light** | **Moderate** | **Severe** | |
| Cariboo | 100 Mile House | 27 | 9 | 0 | 0 | 36 |
| | Williams Lake | 40 | 13 | 2 | 0 | 55 |
| Thompson/ Okanagan | Kamloops | 30 | 19 | 1 | 0 | 50 |
| | Merritt | 15 | 12 | 5 | 0 | 32 |
| | Lillooet | 27 | 2 | 0 | 0 | 29 |
| | Okanagan | 12 | 0 | 0 | 0 | 12 |
| Kootenay/ Boundary | Boundary | 11 | 7 | 0 | 0 | 18 |
| | **Total** | **162** | **62** | **8** | **0** | **232** |

## Douglas-fir tussock moth, *Orgyia pseudotsugata*

A total of 2,708 ha of Douglas-fir tussock moth damage was recorded in the BC interior in 2019, up from 65 ha last year. Intensity of defoliation was assessed as 211 ha (78%) light, 646 ha (24%) moderate and 1,851 ha (68%) severe.

For the first time, the AOS recorded 1,662 ha of Douglas-fir tussock moth attack in Williams Lake TSA of Cariboo Region. The infestation occurred along the Fraser River from Gang Ranch north to Alkali Lake (Figure 9). All damage was rated as severe.

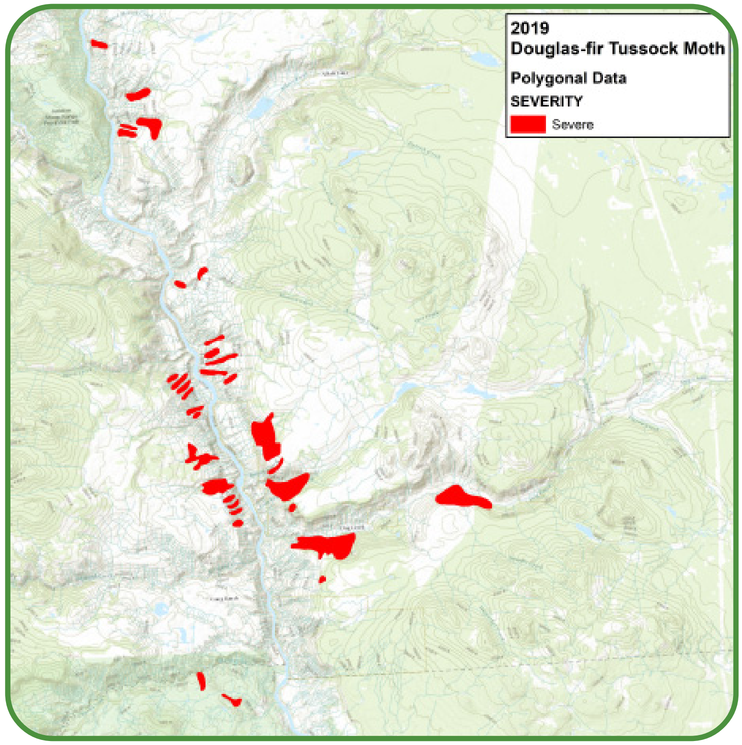


Figure 9. Douglas-fir tussock moth defoliation recorded in Williams Lake TSA in 2019.

Douglas-fir tussock moth defoliation was observed for the first time in five years during the 2017 AOS in Kamloops TSA of Thompson/Okanagan Region, with 15 ha mapped at Heffley Creek, which expanded to 65 ha in 2018. In 2019, observed defoliation expanded to 1,046 ha in the region. Almost all (1,028 ha) was in Okanagan TSA, primarily west of Vernon and southeast of Oliver. Merritt TSA had 14 ha of damage mapped in four small polygons just west of Hedley. The infestation at Heffley Creek in Kamloops TSA subsided to only 4 ha of current defoliation.


*Douglas-fir tussock moth larva*

Monitoring of Douglas-fir tussock moth populations is conducted in areas where outbreaks may occur with pheromone-baited traps. When a consistent upward trend is noted in a given stand for two years and the average catch reaches 8-10 moths per trap, an outbreak is likely two summers later. For the past four years, pheromone lures have been sourced from three different suppliers (Scotts, Chem Tica, Synergy) to compare efficacy among formulations. The average trap catches are summarized in Table 5. Trap result details are available in the *2019 Overview of Forest Health Conditions in Southern British Columbia* report. To determine lure efficacy or to recalibrate trap catch numbers with expected defoliation, traps will need to be deployed and evaluated through a complete outbreak cycle.

Table 5. Average number of male Douglas-fir tussock moths caught per trap from 2013 – 2019 in six trap clusters, by TSA and sub area, if applicable, with number of sites in brackets. More details on this lure comparison trial are available in the *2019 Overview of Forest Health Conditions in Southern British Columbia* Report.

| **TSA (Area,# of sites)** | **Average moth catch per site** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Scotts lures** | | | **Average of three lure producers** | | | |
| | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** |
| Kamloops (9) | 9.3 | 2.9 | 1.8 | 5.9 | 6.7 | 8.8 | 13.7 |
| Kamloops (West, 11) | 6.7 | 0.7 | 2.1 | 3.5 | 4.5 | 3.8 | 14.6 |
| Okanagan (8) | 0.3 | 0.2 | 0.1 | 4.8 | 7.1 | 14.4 | 8.6 |
| Merritt (9) | 0.3 | 0.6 | 1.3 | 9.5 | 8.8 | 26.0 | 18.2 |
| Boundary (8) | 0.6 | 0.2 | 0.2 | 0.6 | 1.3 | 2.3 | 5.0 |
| 100 Mile House (16) | 3.6 | 1.6 | 0.1 | 1.6 | 2.4 | 1.8 | 5.3 |

Average trap catches rose substantially in Kamloops TSA but declined in Okanagan and Merritt TSAs. Catches in Boundary and 100 Mile House TSAs increased but were still relatively low. In anticipation of climate change pushing populations further, the 100 Mile House TSA trap sites were set up nineteen years ago north of any historical outbreaks. The traps have usually caught some moths but at low levels, and visible defoliation has not occurred in Cariboo Region. In 2019 the Dog Creek outbreak occurred further north than any of the monitoring trap locations. The most relevant trap site was 40 km south near the Fraser River, where this year an average of 28 moths were caught. A genetic analysis of the Dog Creek Douglas-fir tussock moth population is planned to determine if they are resident, or if they migrated from the south.

*Douglas-fir tussock moth female with eggs*

An aerial treatment with the biological control agent *Bacillus thuringiensis* var. *kurstaki* (*Btk*), formulation Foray 48B® is planned to control the Williams Lake TSA outbreak. The treatment area is expected to be 12,000 ha to 27,000 ha, depending on ground survey results.

*Douglas-fir tussock moth infestation in Williams Lake TSA*

### Laminated root disease, *Coniferiporia sulphurascens* (= *Phellinus sulphurascens*)

Laminated root disease is common in southern BC but due to the difficulty of identifying it from the height of the AOS, it is under-represented in the data. Most of the mapped damage is due to local knowledge of the surveyors. In 2019, identified infection centers decreased by half from last year to 693 ha provincially. Intensity of damage increased to 136 ha (20%) trace, 393 ha (57%) light, 31 ha (4%) moderate and 132 ha (19%) severe.

Most of the damage was mapped in South Coast Region (476 ha). Sunshine Coast TSA had 333 ha in 3 polygons and 1 spot, around Desolation Sound and Sechelt Inlet. Damage in Fraser TSA totalled 112 ha in one polygon along Lynn Valley. Only one disturbance of 31 ha was observed in Soo TSA as well, located between Henrietta Lake and Woodfibre.

Laminated root disease damage is very rarely identified outside of coastal regions. However, in 2019, 126 ha were observed in Thompson/Okanagan Region. All mapped laminated root disease damage occurred in Okanagan TSA at the north end of Okanagan Lake.

West Coast Region sustained 86 ha of damage, of which one spot was noted in Arrowsmith TSA with the remainder in North Island TSA north of Campbell River.

All 4 ha in Great Bear Rainforest South were identified in one disturbance on West Thurlow Island.

## Damaging Agents of Spruce

### Spruce beetle, *Dendroctonus rufipennis*

After a decrease to 340,405 ha of spruce beetle mortality in 2018, damage rebounded to 2017 levels with 515,447 ha mapped across BC (Figure 10). Intensity of damage increased as well, to 259,475 ha (50%) trace, 175,121 ha (34%) light, 74,155 ha (15%) moderate, 5,914 ha (1%) severe and 782 ha (<1%) very severe. All regions sustained some attack. In many areas the AOS, surveyors observed that colour change varied widely this year, from the more traditional chlorotic to brownish tint, and to the more brilliant pinky-red that has been the norm during the present outbreak. Thus, it was difficult to discern old attack from new.

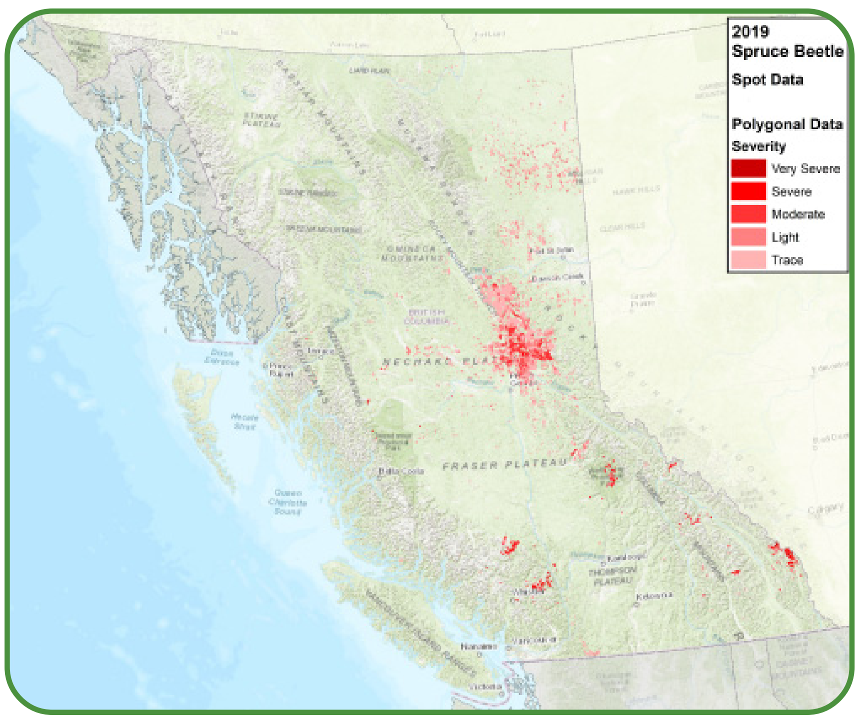



Figure 10. Spruce beetle infestations recorded in 2019 in BC, by severity rating class.

Omineca Region sustained two-thirds of the attack, with 354,851 ha infested with spruce beetle. The regional entomologist noted that one-year as well as two-year beetle life cycles are still being observed, though the cooler summer in 2019 may have led to more two-year (anecdotal). The beetle flight peaked during one week in May, and it was too rainy to have a concentrated flight after that. The current outbreak in this region began in 2014. The first year hectares of attack were high, but intensity of mortality was low. In 2015, hectares affected dropped, but intensity increased. Area and intensity increased in 2016, followed by a peak of hectares affected but lowered intensities in 2017. In 2018, both area and intensity declined but both rebounded this year (Figure 11).

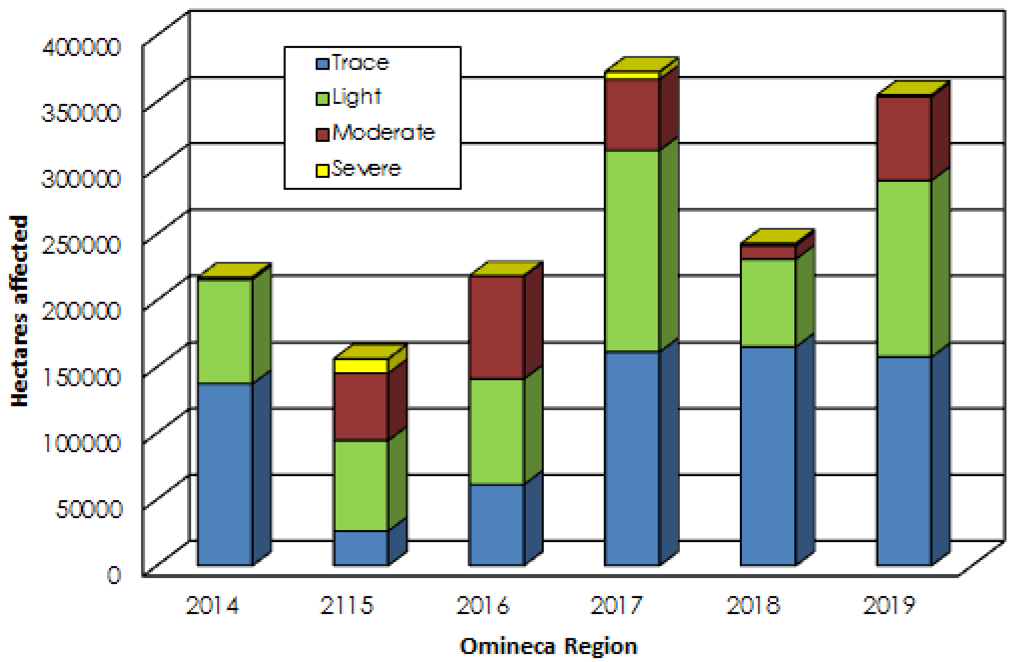



Figure 11. Spruce beetle infestations in Omineca Region from 2014 to 2019, by severity rating class.

Prince George TSA continued to be most affected, with 259,629 ha attacked, primarily northeast of Prince George. AOS surveyors noted that in this area, the spruce beetle has for the most part decimated all mature spruce stands. This infestation continued into the southeast tip of Mackenzie TSA, where most of the 94,215 ha of attack was delineated. Like Prince George TSA, the core of this area (south of the Peace Arm and east of Williston Lake) has been attacked for several consecutive years and very little mature spruce is left alive. Detailed 2019 helicopter surveys suggest infestations have moved north along both sides of Williston Lake, with many new points identified in the Chunamon, Ospika and Collins-Davis Beetle Management Units. Ground surveys are underway to determine the extent and severity of the new infestations. Damage in Robson Valley TSA declined substantially with only 1,007 ha observed, primarily in two polygons east of Mount Monashee.

Spruce beetle attack in Northeast Region totalled 118,367 ha. Infestations tripled in Dawson Creek TSA to 84,561 ha, as the beetle moved in from the Mackenzie and Prince George TSAs along the western border. Damage in Fort St. John TSA increased five-fold to 23,769 ha, dispersed throughout the TSA. Disturbances in Fort Nelson TSA grew slightly, to 10,037 ha located primarily along the southern border and north of the Liard River.

Infestations in Kootenay/Boundary Region increased from 8,237 ha in 2018 to 11,555 ha. The regional entomologist noted that attack was associated with a flood event that occurred in 2013, drought conditions in 2017 and 2018, and the added stress of defoliation by the two-year-cycle budworm. Attack was most prevalent in Invermere TSA, where 4,061 ha were mapped, primarily around Mount King George. Cranbrook TSA had 3,952 ha of spruce beetle mortality, of which almost all was observed in the northern tip from Elkford to Elks Lake Provincial Park. A total of 1,824 ha affected in Golden TSA was primarily observed in Glacier National Park area. Most of the 1,110 ha mapped in Kootenay Lake TSA was west of Slate Mountain. Arrow and Revelstoke TSAs had minor attack with 429 ha and 179 ha affected, respectively.

Cariboo Region sustained 10,620 ha of spruce beetle attack in 2019, up from 3,300 ha last year. Most of this (10,620 ha) was mapped in Williams Lake TSA, primarily around Quesnel Lake in the east and north of Elbow Mountain in the west. Most of the 2,139 ha observed in Quesnel TSA occurred south of Ghost Lake and west of Mount Tinsdale.

*Spruce bark beetle mortality in Prince George TSA*

Spruce beetle attack declined by a third since 2018 in Thompson/Okanagan Region, to 8,256 ha. Kamloops TSA was the most affected, with 5,016 ha recorded mainly west of Murtle Lake. Lillooet TSA sustained 3,126 ha of damage scattered from Duffy Lake to Stein Mountain and north of Gun Lake. Okanagan TSA infestations were low with 114 ha affected.

Skeena Region spruce beetle disturbances declined more than four-fold since 2018 to 6,086 ha, in part due to a smaller percentage of the region being surveyed. Lakes TSA had 3,022 ha of attack identified, mostly in the north tip along Babine Lake. Morice TSA had scattered infestations totalling 2,033 ha mapped. All other TSAs in this region had less than 600 ha of damage per TSA recorded.

Infestations in South Coast Region remained stable with 4,878 ha attacked. Most of the damage continued to occur in Fraser TSA, primarily in Manning Park. Soo TSA had 844 ha of spruce beetle attack in a few, dispersed polygons. Only 47 ha of damage was observed in Sunshine Coast TSA this year.

All other TSAs combined had less than 500 ha of spruce beetle attack.

## Eastern spruce budworm, *Choristoneura fumiferana*

An eastern spruce budworm outbreak began in 2018 in Fort Nelson TSA of Northeast Region, with 35,753 ha of defoliation mapped. Most of the damage occurred along the Liard River, and the damaging agent was confirmed. In 2019, eastern spruce budworm attack declined substantially, with 3,885 ha observed. Damage continued to be most prevalent along Liard River, but disturbance sizes shrank. On the Cassiar/Fort Nelson TSA border, 12 ha were mapped in Cassiar TSA on Liard River. The bulk of the damage continued to occur in Fort Nelson TSA.

Intensity of defoliation was similar to last year, with 1,219 ha (31%) light and 2,666 ha (69%) moderate. Damage was noted to be affecting subalpine fir as well as spruce.

*Eastern spruce budworm defoliation in Fort Nelson TSA*

Minor tree defoliation of spruce trees by eastern spruce budworm on Dawson Creek private property was also reported in Dawson Creek TSA.

## Large-spored spruce-labrador tea rust, *Chrysomyxa ledicola*

*Tree infected with large-spored spruce-labrador tea rust*

Large-spored spruce-labrador tea rust was mapped during the AOS for the first time in 2011, with a record 12,153 ha of damage, all in Fort Nelson TSA of Northeast Region. In 2012 damage declined to 4,103 ha, and it wasn't visible during the AOS survey again except for 130 ha in 2017 in Mackenzie TSA of Omineca Region.

In 2019 4,136 ha of damage were delineated, all in Fort Nelson TSA. Intensity of the damage was rated as 2,526 ha (61%) light, 1,610 ha (39%) moderate. Most of the disturbances were located north of Liard hot springs, with a smaller area of damage west of Long Mountain Lake.

# Damaging Agents of True Fir

## Western balsam bark beetle, *Dryocoetes confusus*

Western balsam bark beetle mortality declined slightly since 2018 to 3,247,135 ha provincially (Figure 12). Intensity of damage increased slightly to 2,800,679 ha (86%) trace, 430,599 ha (13%) light, 14,084 ha (<1%) moderate and 1,773 ha (<1%) severe. Mortality continued to be widespread throughout subalpine fir stands in BC. It was noted by a regional entomologist that drought (which was prevalent the last two summers) plays a major role in predisposing subalpine fir to western balsam bark beetle attack.

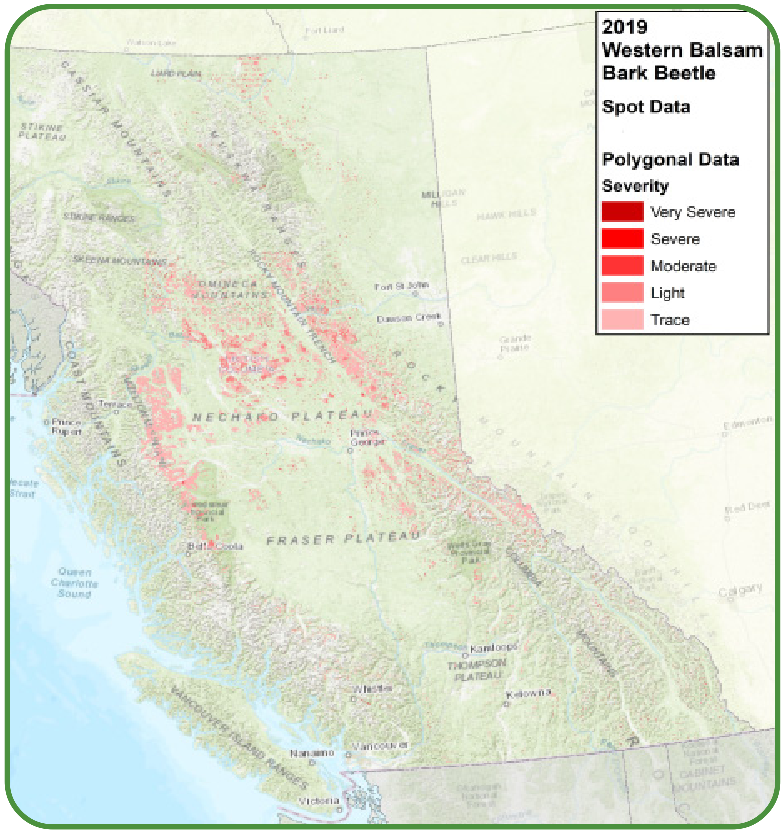



Figure 12. Western balsam bark beetle damage mapped in 2019, by severity rating class.

Omineca Region continued to sustain the highest level of attack in the province, with 1,732,726 ha mapped (which was very similar to 2018). The majority of stand mortality above trace level also occurred in this region, mainly in the south half of Mackenzie TSA and the north half of Prince George TSA. Area affected in Prince George TSA was 934,810 ha, chiefly north of Trembleur Lake and east of Summit Lake. Most of the 564,823 ha mapped in Mackenzie TSA was in the southern half, particularly east of Williston Lake. Robson Valley TSA had 233,932 ha of attack scattered throughout the TSA.

Western balsam bark beetle infestations observed in Skeena Region declined by a third since 2018, but this was primarily an artificial decline due to less aerial coverage of some areas that contained large polygons of damage last year. Even with this issue, Skeena Region was still the 2nd most affected in BC with 799,275 ha delineated. Morice TSA continued to sustain the most damage, with 321,230 ha mapped, primarily in the southern half of the TSA. Bulkley TSA had 211,576 ha detected, mainly in the western half and north tip of the TSA. A total of 166,611 ha of attack was noted in Lakes TSA, mainly around Taltapin Lake and west of Fenton Lake. Kispiox TSA sustained 85,142 ha of damage south of Hazelton and north of Shedin Peak. Infestations in Kalum TSA (10,788 ha) was located chiefly around Howson Peak and Rosswood. Cassiar TSA was largely not surveyed, with 2,410 ha delineated on the eastern edge near Pitman River. This was also the case in Nass TSA where 1,518 ha were mapped west of Slamgeesh Range.

Northeast Region attack was similar to 2018, with 294,160 ha of western bark beetle mortality mapped. Dawson TSA contained 194,372 ha, almost entirely along the western boundary of the TSA. Most of the 89,310 ha mapped in Fort Nelson TSA ran in a band mid TSA. Disturbances were small and scattered in Fort St. John TSA, where 10,478 ha were affected.

Damage in Cariboo Region remained stable, with 130,101 ha of damage delineated. Williams Lake TSA had 71,108 ha of western balsam bark beetle infestations mapped, mainly in the Taseko/Tatlayoko Lakes area in the west and east of Likely in the east. The bulk of the damage in Quesnel TSA occurred east of Coldspring House, with a total of 54,988 ha for the TSA. A total of 4,005 ha of attack was observed in 100 Mile House TSA, primarily in the northeast tip.

Western balsam bark beetle attack in Thompson/Okanagan Region declined slightly to 123,046 ha. Disturbances totalling 57,429 ha were widely scattered throughout Kamloops TSA, with concentrations around Dunn Peak and south of Murtle Lake. Okanagan TSA sustained 42,362 ha of dispersed attack. Infestations in Lillooet TSA were small and scattered for a total of 15,697 ha. Merritt TSA had 7,558 ha mapped, primarily along the western edge, and east of Princeton.

All the Great Bear Rainforest western balsam bark beetle damage was observed in the GBR North TSA this year, where 71,717 ha were mapped. All disturbances were in the southeast tip.

Western balsam bark beetle damage increased for the second consecutive year in Kootenay/Boundary Region, where 58,283 ha were delineated. Most of the disturbances were small and very dispersed. Invermere and Golden TSAs had the most damage, with 15,522 ha and 11,059 ha recorded, respectively. Attack levels in Cranbrook and Kootenay Lake TSAs were very similar, with 8,937 ha and 8,540 ha mapped, respectively. Arrow TSA had 7,183 ha of damage delineated, with Revelstoke TSA reporting 5,359 ha. The remaining 1,683 ha were noted in Boundary TSA.

*Western balsam bark beetle attack in Kootenay Lake TSA*

Infestations increased by a quarter since 2018 in South Coast Region, with 37,532 ha of damage mapped. Most of the mortality was reported in Soo TSA where 27,638 ha were delineated, primarily along the northern boundary with Lillooet TSA. Almost all of the 5,861 ha marked in Fraser TSA were along the eastern boundary. All the attack in Sunshine Coast TSA occurred in the northern half with 4,033 ha mapped, mainly from Bute Inlet to Bishop River.

Western balsam bark beetle attack dropped more than six-fold since 2018 in West Coast Region to 294 ha. Most of this damage was mapped north of Oshinow Lake, with 149 ha in Arrowsmith TSA and 145 ha in North Island TSA.

## Two-year-cycle budworm, *Choristoneura biennis*

After a record 414,319 ha defoliated provincially in 2018, two-year-cycle budworm damage declined to 130,205 ha. Defoliation intensity was similar, with 89,212 ha (69%) light, 31,461 ha (24%) moderate and 9,532 ha (7%) severe. Subalpine fir continued to be most affected, but spruce was also defoliated to a lesser extent in stands with both species. South of Prince George, where this budworm was in the first year of its two-year life cycle, almost all the damage was light and occurred in elevational bands. Conversely north of Prince George where the second year in the cycle was prevalent, substantial moderate to severe damage was mapped over a larger elevation range (Figure 13).

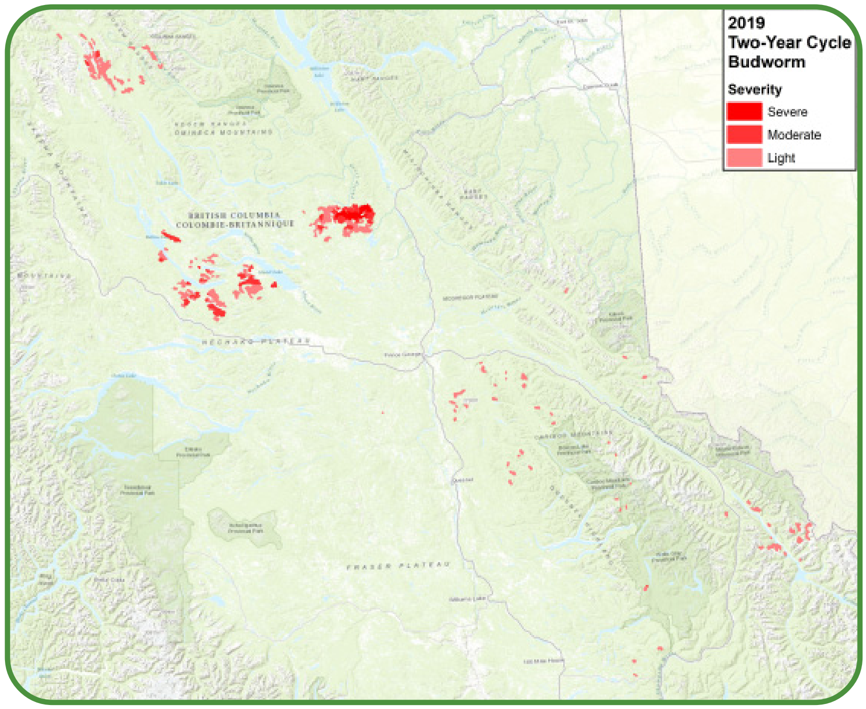



Figure 13. Two-year-cycle budworm defoliation mapped in 2019, by severity rating.

Omineca Region was most affected, with 99,207 ha of two-year-cycle budworm defoliation mapped. The majority was observed in Prince George TSA, where 73,171 ha were delineated. Three concentrated, large disturbances were noted west of Stuart Lake, around Bear Lake and north of Carp Lake. Southeast of Prince George small scattered polygons were mapped. The Carp Lake infestation continued into Mackenzie TSA, where 16,065 ha were affected. Various ground sources also reported defoliation north of Omineca Park, though this damage was not visible from the height of the AOS. Small infestations in Robson Valley TSA, primarily at the south end, totalled 9,971 ha.

Skeena Region contained 27,527 ha of two-year-cycle budworm defoliation. Most of this damage (22,981 ha) occurred in the north end of Lakes TSA around the Taltapin Lake area. The disturbances continued into Morice TSA southeast of Topley Landing where 4,540 ha were affected. A small piece of the Bear Lake infestation in Prince George TSA was mapped on the border of Bulkley TSA (6 ha).

Disturbances were small and dispersed in the eastern portion of Cariboo Region, totalling 2,549 ha. Infestations east of Beaver Pass House accounted for 1,897 ha of damage in Quesnel TSA. Five small polygons south of Mitchell Lake in Williams Lake TSA totalled 402 ha. In 100 Mile House TSA, 3 small polygons resulted in 250 ha of damage on the eastern border east of Wavey Lake.

In Thompson/Okanagan Region 922 ha were defoliated, all of which was observed in Kamloops TSA west of Clearwater.

Two-year-cycle budworm pheromone traps were installed and monitored throughout July and August in Elks Lake Provincial Park in Cranbrook TSA of the Kootenay/Boundary Region. In this area, odd years are expected to be the first year of the life cycle with lower populations. True to this assumption, trap catches were half of what they were the previous year. Low to moderate defoliation was noted on spruce trees here. Noticeable damage was also observed south of Riondel on the east side of Kootenay Lake in Kootenay Lake TSA. None of this damage was visible during the AOS.

*Two-year-cycle budworm in Prince George TSA*

## Balsam Woolly Adelgid, *Adelges piceae*

Balsam woolly adelgid damage reached a record 1,796 ha in 2019, up from only 35 ha last year. However, the intensity of the damage was generally very low, with 1,543 ha (86%) trace, 215 ha (12%) light, 21 ha (1%) moderate and 17 ha (1%) severe.

Most of the infestations occurred in West Coast Region, where 1,351 ha were mapped. Except for one spot disturbance in Arrowsmith TSA, all damage was observed in North Island TSA, with concentrations around Silburn Lake, Power Lake and west of Colony Lake. GBR South TSA damage totalled 247 ha in small scattered disturbances near Phillips Arm, Heydon Lake, West Thurlow Island and Sonora Island. Almost all of the 131 ha in South Coast Region occurred in Sunshine Coast TSA (121 ha) north of Mount Denman. The remaining disturbances in this region were minor, with 10 ha in Fraser TSA and one spot in Soo TSA.

For the first time, balsam woolly adelgid damage was recorded by the AOS in Thompson/Okanagan Region, with 66 ha affected. Two disturbances totalling 61 ha were observed in Merritt TSA, west of Kingsvale and west of Tulameen. The remaining 5 ha in the region were noted in two small polygons north of Paul Lake in Kamloops TSA.

Recent ground surveys have identified that balsam woolly adelgid has spread substantially beyond what is normally mapped but it is difficult to identify from the height of the AOS, and is underestimated (see Forest Health Projects).

# Damaging Agents of Hemlock

### Western hemlock looper, *Lambdina fiscellaria lugubrosa*

Western hemlock looper outbreaks are generally cyclical and monitored in the southern interior and coast regions. The last western hemlock looper outbreak peaked in 2012, with 8,103 ha of defoliation in the southern interior. Then, after 2013, no looper damage was recorded during the AOS until 2018 when 17 ha of moderate suspected western hemlock looper defoliation was mapped near Revelstoke. This year 3,276 ha of damage was mapped in BC. Intensity of defoliation was rated as 2,744 ha (84%) light, 366 ha (11%) moderate and 166 ha (5%) severe. Hemlock was the most affected host, but Douglas-fir and Amabilis fir were also defoliated.

*Western hemlock looper larva*

South Coast Region sustained 2,184 ha of the damage. Ground checks confirmed the causal agent. Sunshine Coast TSA had 2,145 ha of defoliation mapped (primarily light) in the Rainy River and Brittain River drainages. These population increases could precede a more extensive outbreak in the South Coast Region. Populations are continuing to be monitored in Sunshine Coast TSA. An additional 39 ha of damage were observed east of Stave Lake in Fraser TSA. The ground check on this infestation confirmed defoliation but was too late to positively identify the defoliator. Since it was confirmed elsewhere on the Lower Mainland and budworm is not active there at present, the decision was made to call it western hemlock looper. Defoliation of western hemlock was also noted in Metro Vancouver's three watersheds (Capilano, Seymour and Coquitlam). Due to weather, the watersheds were not aerially surveyed. Other areas of the lower mainland also observed increases in looper activity with reports of increased moth populations. It was also noted that phantom hemlock looper was observed in greater numbers than normal and could also be trending to outbreak levels throughout the Metro Vancouver region.

*Phantom hemlock looper moth*

Western hemlock looper damage was also ground confirmed in Kootenay/Boundary Region in several locations. A total of 1,074 ha were mapped. Arrow TSA had 548 ha of attack, with infestations located at Valhalla Provincial Park, Sandon, and north of Wilson Lake. Kootenay Lake TSA had 298 ha of defoliation detected, north of Taghum, Retalick, and four scattered locations north of Duncan Lake. Damage in Revelstoke TSA totaled 220 ha in six polygons dispersed around the Canyon Hot Springs area. One small disturbance of 8 ha was in Invermere TSA west of Spillimacheen.

One small infestation of 18 ha was observed in North Island TSA of the West Coast Region, west of Victoria Lake.

Table 6. Average number of western hemlock looper male moths caught per trap at various FLNRORD monitoring sites (6-trap clusters per site), 2011 - 2019. Number of sites in brackets.

| Year | TSA (# sites) | | |
|---|---|---|---|
| | Kamloops | Okanagan | Revelstoke |
| 2011 | 698 (6) | 853 (10) | 725 (11) |
| 2012 | 130 (6) | 565 (10) | 484 (11) |
| 2013 | 6 (6) | 75 (10) | 80 (11) |
| 2014 | 4 (6) | 35 (10) | 14 (11) |
| 2015 | 22 (6) | 62 (10) | 6 (11) |
| 2016 | 1 (6) | 10 (10) | 2 (11) |
| 2017 | 50 (6) | 27 (10) | 9 (11) |
| 2018 | 120 (6) | 184 (10) | 68 (11) |
| 2019 | 140 (9) | 250 (11) | 269 (11) |

The number of moths caught in pheromone traps at monitoring sites continues to rise, though numbers are still well below that of the last outbreak (Table 6). This may indicate that infestations will continue to grow next year. Although no western hemlock looper defoliation was mapped in Thompson/Okanagan Region in 2019, areas with high trap counts included the Greenbush Lake and Shuswap River areas of Okanagan TSA and near Murtle Lake in Kamloops TSA.

The number of western hemlock looper larvae caught at three tree beating sites also grew substantially in 2019. Western hemlock looper larvae were observed defoliating drier predominantly Douglas-fir stands in the southern interioras well.

*Western hemlock looper defoliation in Kootenay Lake TSA*

## Western blackheaded budworm, *Acleris gloverana*

Western blackheaded budworm outbreaks are typically cyclical. The peak of the last outbreak was 87,497 ha of defoliation on Haida Gwaii in 2010. This outbreak followed the historical pattern of moving south, where North Island TSA sustained 28,000 to 35,000 hectares of damage for three years. After that only minor damage was mapped, with no defoliation at all detected the last two years.

In 2019, 370 ha of light defoliation by western blackheaded budworm was delineated in Haida Gwaii TSA. The damage was mapped in five small polygons all located on Moresby Island, at the north end and south tip. It is suspected that infestations will grow in Haida Gwaii TSA in 2020.

# Damaging Agents of Larch

### Larch needle blight, *Hypodermella laricis*

*Larch needle blight damage in Cranbrook TSA*

Historically in BC, the majority of larch needle blight damage occurs in Kootenay/Boundary Region, with minor amounts recorded in Thompson/Okanagan Region. Usually, western larch is the affected tree species. This trend continued in 2019, with 2,122 ha damaged, all in Kootenay/Boundary Region. Intensity of damage was rated higher than last year, with 23 ha (1%) trace, 1,308 ha (62%) light, 754 ha (35%) moderate, and 36 ha (2%) severe. Ground checks were conducted and the casual agent was confirmed. Most of what was mapped was in young stands as it is most visible aerially, however it was noted that much more was visible on the ground, including damage in mature trees. The amount of larch needle blight damage has been relatively low since 2011 and 2012, when over 30,000 ha were mapped each of those years.

Cranbrook TSA sustained the majority of the damage, with 1,790 ha mapped. Disturbances were concentrated west of St. Mary's Lake and west of Sparwood. Damage in Kootenay TSA totalled 189 ha in several small polygons around Duncan Lake. Arrow TSA contained a few small, widely scattered areas of damage totalling 93 ha. Boundary and Golden TSAs had minor larch needle blight damage, with 25 ha and 24 ha recorded, respectively.

# Damaging Agents of Cedar

### Cedar Flagging Damage

Cedar flagging damage was mapped on a record 115,581 ha in the BC interior in 2019 (Figure 14). Severity was assessed as 178 ha (>1%) trace, 59,355 ha (51%) light, 50,327 ha (44%) moderate and 5,721 ha (5%) severe. The host was western redcedar. A substantial occurrence of cedar foliage damage was last recorded in 2014, when 32,870 ha of damage that was attributed to unusual weather, most likely winter desiccation, occurred.

Late summer/early fall AOS flights in Omineca and Cariboo Region in 2018 noted a distinct chlorotic cast to western redcedar stands, most likely from drought. It was not recorded however as early summer flights had already covered a significant portion of the regions with no such observations, then a substantial break in surveys occurred due to wildfires, hence the two survey periods were not comparable for this forest health issue. Damage expanded and intensified this spring with a distinct reddish cast developing in the stands, though by mid-summer new foliage was beginning to obscure the damage signature. Several experts did ground excursions to Robson Valley and Kamloops TSAs to look at the damage. The consensus was it was caused by winter desiccation combined with previous drought stress. Although the damage was more severe than normal cedar flagging, it was decided this code best fit the disturbance.

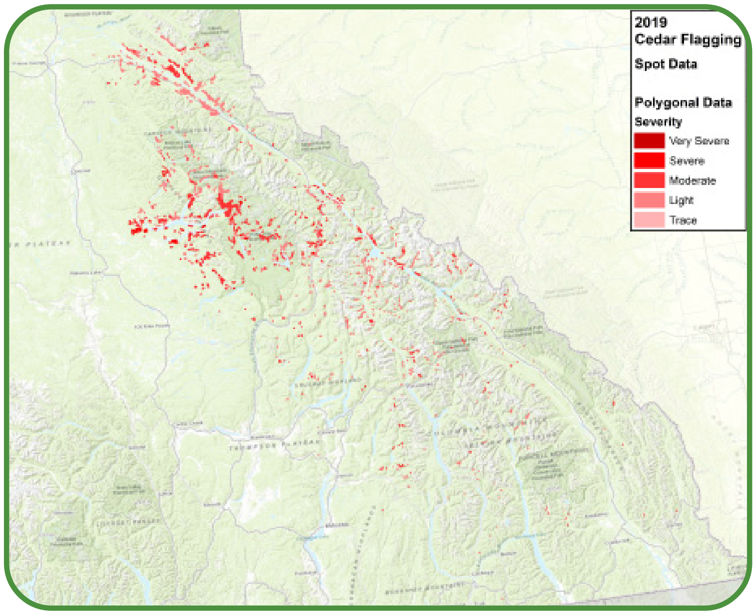



Figure 14. Cedar flagging damage by severity mapped in BC in 2019.

Cariboo Region sustained 43,096 ha of cedar foliage damage. All 35,430 ha mapped in Williams Lake TSA was east of Big Lake. This TSA also had most of the severe intensity damage mapped in the province. Quesnel TSA had 4,804 ha of damage observed, all east of Mount Tinsdale. Disturbances in 100 Mile House TSA were all north of Canim Lake and totalled 2,971 ha.

Omineca Region reported 37,537 ha of cedar foliage damage. Prince George TSA contained 20,821 ha of disturbances, located from Purden Lake along Fraser and McGregor Rivers. Robson Valley TSA had 16,716 ha of damage mapped, primarily along the Fraser River and Kinbasket Lake.

Damage in Thompson/Okanagan Region totalled 21,605 ha. The majority (19,233 ha) was observed in Kamloops TSA, chiefly north of Blue River. Small scattered disturbances affected Okanagan TSA, where 2,372 ha were mapped, mainly north of Creighton Valley.

*Cedar flagging damage in Prince George TSA*

Kootenay/Boundary Region had 13,342 ha of cedar foliage damage recorded. Revelstoke TSA contained 6,228 ha, scattered mainly north of Revelstoke. A total of 4,701 ha were affected in Golden TSA, with concentrations around the Kinbasket Lake area. Kootenay Lake TSA disturbances totalled 1,220 ha, chiefly around the Duncan Lake area. Small, scattered areas of damage were noted in Arrow, Invermere and Cranbrook TSAs at 568 ha, 338 ha and 287 ha, respectively.

## Yellow-cedar decline

Observed yellow-cedar decline damage in 2019 was similar to last year with 23,449 ha mapped along the BC coast (Figure 15). Rated disturbance intensity was similar with 14,420 ha (61%) trace, 5,878 ha (25%) light, 1,605 ha (7%) moderate and 1,546 ha (7%) severe. Decline damage tended to be dispersed throughout the stands.

Damage continued to be highest in GBR North TSA, where 11,860 ha were affected. GBR South TSA sustained 6,609 ha of yellow-cedar decline, particularly around Seymour Inlet.

Haida Gwaii TSA of West Coast Region contained 4,626 ha of yellow-cedar decline damage, up slightly from last year.

Damage observed in Kalum TSA of Skeena Region dropped substantially to 354 ha, primarily located south of Kitimat, on Hawkesbury Island, and north of Nitrogen Peak.

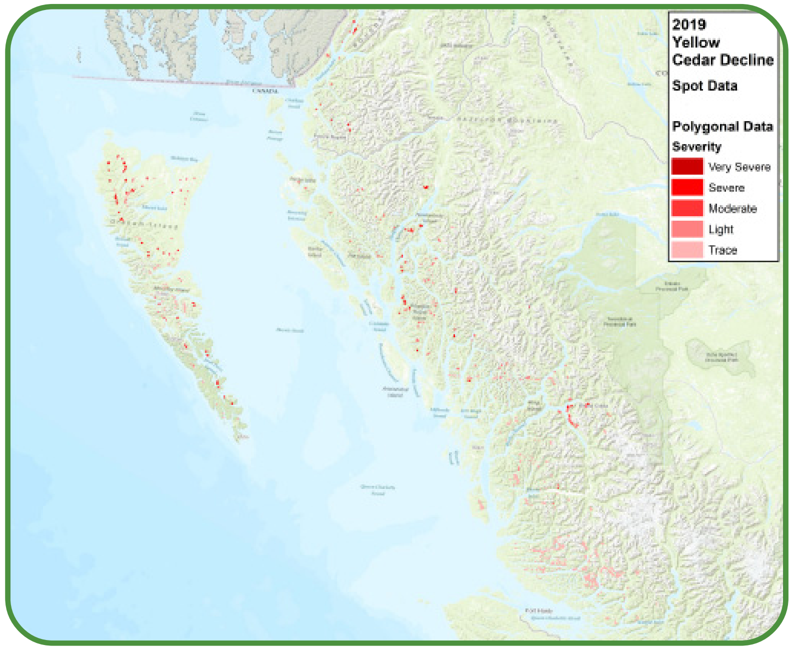


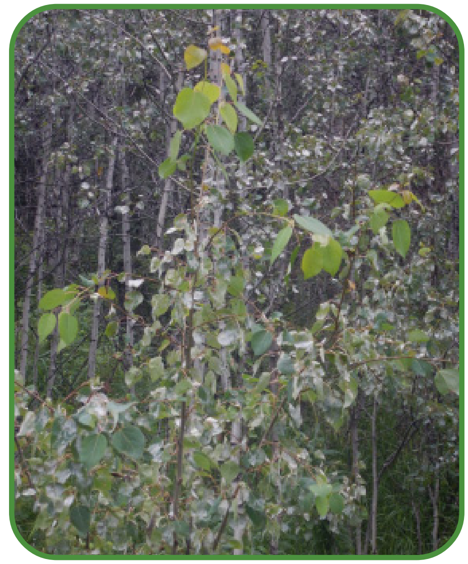

Figure 15. Yellow-cedar decline damage mapped in 2019, by severity rating class.

*Yellow-cedar decline damage in Kalum TSA*

# Damaging Agents of Deciduous Trees

## General deciduous defoliation observations

With the generally wet growing season across the province, there were several ground reports of tree refoliation after spring damage from various defoliators. This primarily occurred in the summer with a small component of very large leaves sprouting at the top of trees, which tended to mask some of the aerial signature of defoliator damage.



*Tree refoliating at top after aspen leaf miner attack*

## Aspen (serpentine) leaf miner, *Phyllocnistis populiella*

Damage by aspen leaf miner rose slightly in 2019 to 1,326,903 ha with the majority of the disturbances identified in central BC (Figure 16). Intensity of damage, which is rated by percentage of trees affected, was 444,293 ha (34%) light, 615,174 ha (46%) moderate and 267,436 ha (20%) severe. Trembling aspen continued to be the most affected though cottonwood was sometimes damaged as well, chiefly in Robson Valley and Prince George TSAs.

Multiple years of aspen leaf miner defoliation, combined with damage from other defoliators, diseases, drought, and flooding, continued to result in aspen decline, particularly in the Northeast Region.

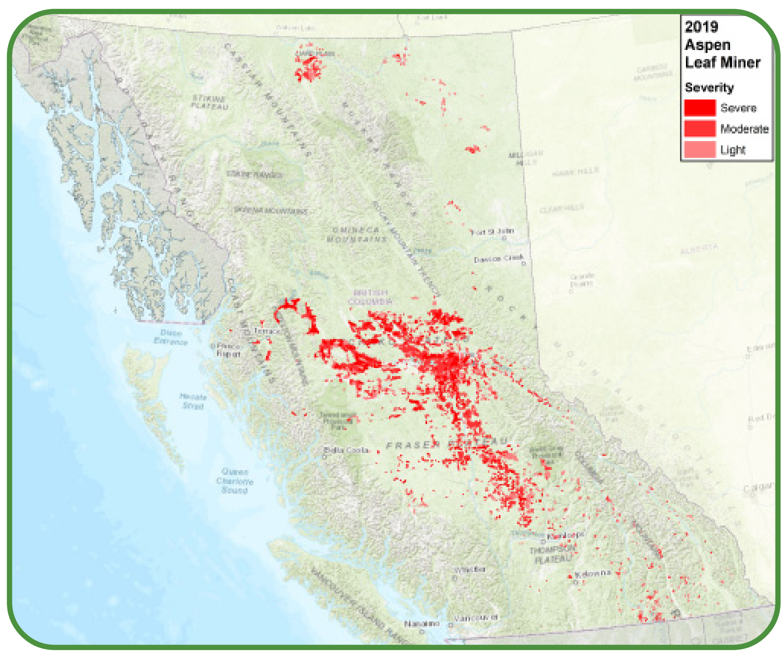



Figure 16. Aspen leaf miner defoliation mapped in 2019, by severity rating class.

Aspen leaf miner damage increased more than a third in Omineca Region since last year to 580,521 ha. Prince George TSA sustained the majority of the defoliation with 562,234 ha affected in the southern half of the TSA, particularly around Prince George. Mackenzie TSA infestations increased to 12,142 ha, all located in a few large disturbances in the southern tip of the TSA. All 6,143 ha noted in Robson Valley TSA were in the Fraser River valley.

*Aspen leaf miner damage in Prince George TSA*

Infestations observed in Skeena Region declined by more than 40% since 2018 to 379,541 ha. This was primarily an artificial decline due to a reduction in area surveyed in 2019 that contained substantial damage last year. The regional entomologist noted that the large decline in 2017 was due to a very cold winter with little snow for protection. However, last year conditions were good for development and indications are the populations are up again, with big clouds of aspen leaf miner adults observed in flight. Most of the damage continued to be in Lakes TSA with 212,172 ha mapped extensively in all the major valleys in the north half of the TSA. Infestations in Morice TSA fell slightly to 81,654 ha, most of which occurred mid TSA around Houston, BC. Bulkley TSA disturbances declined to 44,220 ha, all in large polygons north and south of Smithers. Kispiox TSA saw the largest reductions to 30,010 ha, all mapped south of Hazelton. All infestations observed in 2018 in Kalum TSA were flown this year, so the decline to less than a third of that mapped last year to 11,244 ha was actual. The remaining 240 ha in the region delineated in Cassiar TSA were small infestations noted in the far northeast tip.

Aspen leaf miner damage observed in Cariboo Region increased by a third over 2018 to 259,843 ha. Quesnel and Williams Lake TSAs were similarly affected, with 89,687 ha and 89,157 ha mapped, respectively. Infestations continued to be most prevalent east and west of the Fraser River, with some scattered small disturbances out west. Defoliation was more scattered throughout 100 Mile House TSA with 80,999 ha delineated.

Infestations declined by almost half in Northeast Region where 45,536 ha were observed in 2019. Almost all the decrease occurred in Fort Nelson TSA, where 40,474 ha were recorded. Damage was concentrated from Liard River southwest to Birches Lake, north of Nelson Forks, and around Fort Nelson. Defoliation in Fort St. John TSA increased substantially to 4,572 ha, primarily along the northeast edge and some small scattered disturbances south of Pink Mountain. Three polygons totalling 490 ha were observed in Dawson Creek TSA, west of Chetwynd and Brule Mines.

Aspen leaf miner defoliation increased by half in Thompson/Okanagan Region since 2018 to 34,250 ha. Infestations were primarily small and scattered. Kamloops TSA contained 29,399 ha of damage with concentrations east of Mahood Lake, around Chris Creek and Monte Creek. Okanagan TSA sustained 4,833 ha of attack, while only 18 ha were observed in Merritt TSA.

Infestation levels in Kootenay/Boundary Region remained stable, with 25,936 ha affected in 2019. Arrow TSA continued to be most affected, particularly west of Fauquier and south of Castlegar. Kootenay Lake TSA sustained 6,050 ha of attack, chiefly around Nelson and north of Argenta. A total of 2,849 ha were mapped in Revelstoke TSA, primarily south of Revelstoke and north of Carnes Creek. All remaining TSAs in the region had less than 1,600 ha of damage per TSA.

Great Bear Rainforest North TSA had a six-fold decrease in damage from 2018 to 1,275 ha. Most of this attack was observed south of Natuza Lake.

## Satin moth, Leucoma salicis

After a record high of 209,932 ha last year, satin moth defoliation dropped provincially to 77,532 ha in 2019 (Figure 17). Intensity of recorded damage increased however, with 16,810 ha (22%) light, 47,462 ha (61%) moderate and 13,259 ha (17%) severe.

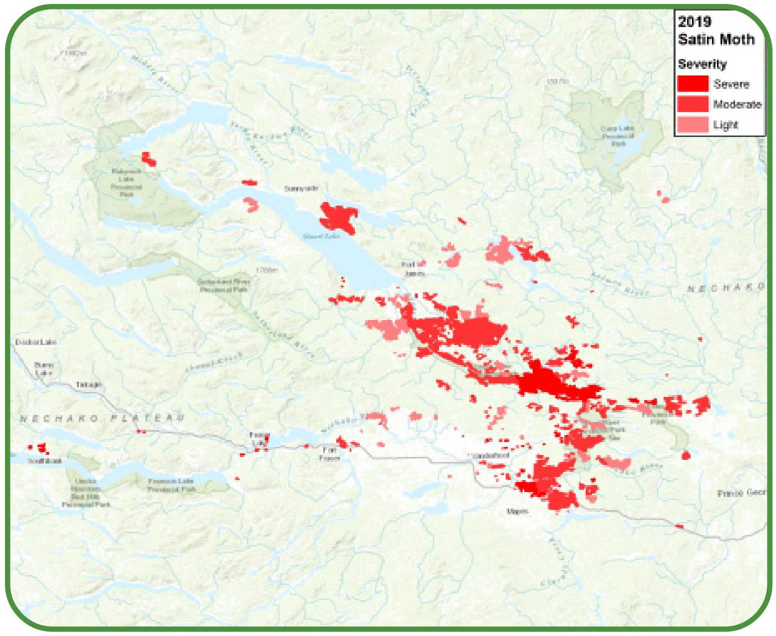



Figure 17. Satin moth defoliation mapped in northern BC in 2019, by severity rating.

Most of the disturbances continued to be mapped in Prince George TSA of Omineca Region where 77,008 ha were defoliated. Damage was concentrated from Nukko Lake northwest to Stuart Lake. Ground observations in Prince George TSA confirmed the damaging agent and it appears to be declining; however, around Vanderhoof there appears to be some associated mortality from multiple years of defoliation.

A small infestation of 324 ha on the shore of Francois Lake accounted for all the defoliation observed in Lakes TSA in Skeena Region. This area was ground checked and defoliation was confirmed, though positive identification of the insect was not made as it was late in the season and the affected foliage was too high to inspect. This is a logical assumption considering satin moth has been the most recent aspen defoliator of this type in the region, and infestations are nearby around Fraser Lake in Omineca Region.

Scattered small infestations (none over 24 ha) totalled 200 ha in Thompson/Okanagan Region. Merritt and Okanagan TSAs contained 74 ha and 70 ha respectively, with other TSAs sustaining less than 50 ha of damage.

*Satin moth larva*

*Satin moth defoliation in Prince George TSA*

## Venturia blights, *Venturia* spp.

Venturia blight damage almost tripled since 2018 to 13,729 ha provincially (Figure 18). Intensity of damage was similar, with 203 ha (2%) light, 1,251 ha (9%) moderate and 12,275 ha (89%) severe. Trembling aspen was the only host observed to be affected this year.

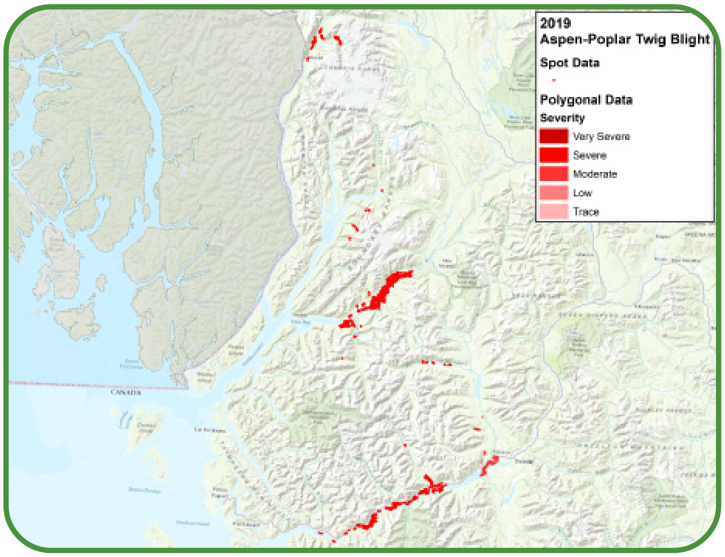



Figure 18. Venturia blight damage in TSAs with over 2,000 ha of damage observed in 2019.

*Venturia blight infection center in an aspen leafminer infestation*

For the fifth consecutive year, the majority of Venturia blight damage was in Skeena Region with 11,305 ha mapped. The regional pathologist noted that serpentine leaf miner was masking some of the damage, hence the true amount of damage most likely was higher as conditions were ideal this year. Kalum TSA contained 10,339 ha of Venturia blight disturbances, primarily in Nass Valley and along the Skeena River. All of the 966 ha mapped in Nass TSA was around and north of Stewart.

Venturia blight damage in Great Bear Rainforest North TSA totalled 2,307 ha. Damage was scattered north and south of Alice Arm, and on islands in the Skeena River.

Damage continued to be low in Northeast Region, where 117 ha were affected. The aerial surveyors noted however that small clonal areas of damage were increasing by the end of the summer. All 80 ha mapped in Fort Nelson TSA occurred in one polygon on Tuchodi Lakes. Dawson and Fort St. John TSAs had minor damage with 29 ha and 8 ha observed, respectively.

*Venturia blight infection on young aspen leader*

## Gypsy moth, *Lymantria dispar*

Gypsy moth is a non-native, invasive species that can defoliate and kill a broad range of host trees. The European strain of gypsy moth is not native to BC but it is established in eastern Canada and the eastern United States. It is frequently introduced into BC through the movement of vehicles and household goods from gypsy moth infested areas. These periodic introductions are detected by the Canadian Food Inspection Agency (CFIA). The CFIA carry out an annual pheromone-trapping program in high-risk areas, notably on Vancouver Island, the Gulf Islands and the Lower Mainland/Fraser Valley. The remainder of the province is surveyed at a lower intensity and monitoring is annually supplemented by FLNRORD with traps placed at BC Parks and recreation sites.

Gypsy moth is a threat in BC as it has more than 300 known hosts which include native shade trees, the rare and endangered Garry Oak, and valuable ornamental trees. Additionally, gypsy moth threatens BC fruit producers as it will eat the leaves of fruit and hazelnut trees, and blueberry plants.

Eradication programs are essential to maintain the gypsy moth free status of the province, for both socio-economic and environmental reasons. When a breeding population of gypsy moth is discovered, an interagency Gypsy Moth Technical Advisory Committee provides treatment recommendations that range from increased trapping densities to ground or aerial spray treatments with the biological insecticide Foray 48B (Btk). Up until 1999, eradication programs were the responsibility of the CFIA. Since 1999, under the Long-Term North American Gypsy Moth Management Plan for BC, eradication programs for the North American strain of the gypsy moth are the responsibility of FLNRORD.

Following monitoring in 2018, FLNRORD planned and implemented a 62.2 ha aerial spray program in the Fraser Heights neighbourhood of Surrey, BC. This same area was ground sprayed in 2017 and 2018, however due to limited site access the establishing gypsy moth population was not eradicated.

In 2019, over 4,300 traps were set-up by CFIA as part of the provincial annual monitoring program and included delimitation trapping in areas of concern. Overall, 57 male European gypsy moths (North American strain) were trapped across the province (Table 7). One Asian gypsy moth was intercepted by CFIA on Annacis Island.

Table 7. Numbers of male gypsy moths caught in pheromone traps in BC in 2019 by location and management recommendations.

| **Location** | **Male Gypsy Moths Caught** | **Management Recommendations** |
|---|---|---|
| Lake Cowichan | 21 | 231 ha Aerial Spray |
| Surrey | 14 | 241 ha Aerial Spray |
| Raspberry (Castlegar) | 13 | 167 ha Aerial Spray |
| South Island | 3 | Delimitation Trapping (16/mile$^2$) |
| Maple Ridge | 3 | Delimitation Trapping (16/mile$^2$) |
| Saanich | 1 | Delimitation Trapping (32/mile$^2$) |
| Hope | 1 | Delimitation Trapping (16/mile$^2$) |
| Revelstoke | 1 | Delimitation Trapping (16/mile$^2$) |

The 2019 trapping data identified three areas that will require aerial spray treatments in the spring of 2020 (Surrey, Lake Cowichan, Raspberry/Castlegar) and five areas require delimitation trapping (Table 7). The planned 2020 spray program in Surrey includes the area that was aerially treated in spring 2019. The 2019 aerial program failed to eradicate the establishing gypsy moth population due to limited trapping data, however the population was significantly reduced.

Detailed maps showing trap and treatment locations are available on the FLNRORD gypsy moth web site: www.gov.bc.ca/gypsymoth.

## Aspen decline

Aspen decline damage was observed for the ninth consecutive year in BC. Disturbances declined however from the peak of 66,191 ha in 2018 to 11,185 ha in 2019. Intensity of damage increased though to 7,929 ha (67%) light, 3,756 ha (32%) moderate and 175 ha (<1%) severe. Many factors can contribute to aspen decline, including cankers, insect defoliation and drought.

Most aspen decline disturbances continued to occur in Northeast Region, where 11,185 ha were mapped. Most of the 9,083 ha of damage noted in Fort Nelson TSA occurred north of Nelson Forks along the Liard River. A total of 1,495 ha were delineated in Fort St. John TSA, mainly in small polygons scattered around Cecil Lake. Primarily light damage totalling 607 ha was observed around Dawson Creek in Dawson Creek TSA.

Damage in Thompson/Okanagan Region increased to 421 ha, with most (347 ha) mapped in Merritt TSA primarily around Kingsvale. Four disturbances totalling 74 ha were observed in Kamloops TSA, west of Cache Creek and south of Logan Lake.

*Aspen decline damage in Williams Lake TSA*

A total of 226 ha of aspen decline damage was noted in small, very scattered disturbances in Cariboo Region. This region sustained most of the severe intensity damage in the province. Williams Lake TSA contained 226 ha of damage, while one disturbance of 21 ha was mapped west of Hathaway Lake in 100 Mile House TSA.

Remaining aspen decline damage in the province was minimal, with 21 ha mapped in Cranbrook TSA in Kootenay/Boundary Region, and 6 ha in Prince George TSA of Omineca Region.

## Birch leaf miner, *Lyonetia prunifoliella*

Birch leafminer larva

Area defoliated by birch leaf miner continued to increase to a peak of 10,242 ha, the highest level recorded since the peak of 22,507 ha in 2003. Damage was ground checked in various areas (Robson, Kamloops, Okanagan, Merritt and Arrow TSAs). Larval collections were made in mid-June through to the beginning of July in these areas, and genomic DNA sequencing confirmed the pest species to be *Lyonetia prunifoliella* (See Forest Health Projects).

Intensity of damage dropped substantially since last year however, although surveyors in the southern interior noted that it generally was much heavier in the spring prior to the AOS, before refoliation masked the damage. Defoliation was assessed provincially as 8,704 ha (85%) light, 1,408 ha (14%) moderate and 129 ha (1%) severe.

Birch leaf miner damage increased dramatically in Northeast Region to 7,272 ha. Most of this (6,408 ha) were scattered across the eastern half of Fort Nelson TSA. Almost all of the 864 ha recorded in Fort St. John TSA were just north of Gutah Creek.

Observed infestations grew to 1,636 ha in Kootenay/Boundary Region. Disturbances were relatively small and scattered. Kootenay Lakes and Arrow TSAs were most affected, with 788 ha and 701 ha of defoliation delineated, respectively. Other TSAs had less than 100 ha of damage noted per TSA.

Thompson/Okanagan Region defoliation decreased to almost a third of what was detected last year at 1,325 ha. Almost all disturbances (1,267 ha) were in Kamloops TSA, with the largest concentration around Clearwater to Vavenby. In Okanagan TSA 58 ha of defoliation were noted south of Turtle Valley and east of Vidler Peak.

Birch leafminer damage in Kootenay Lakes TSA

Robson Valley TSA in Omineca Region had the most birch leaf miner damage last year (4,388) but only 8 ha were mapped this year. This is most likely due to this TSA being flown later in the year in 2019, when damage was masked by new growth.

## Alder flea beetle, *Macrohaltica ambiens*

An outbreak of alder flea beetle was observed in the coast regions in 2019. Extensive damage on red alder was noted stretching along eastern Vancouver Island, the Gulf Islands and along the Sunshine Coast in late spring and early summer by ground crews. This beetle skelotonizes the leaves of its host and impacted trees typically recover under normal conditions. Trees impacted in back-to-back years and/or under drought stress are more susceptible to mortality.

*Alder flea beetle damage*

Alder flea beetle was recorded during the AOS for the first time in 2019. A total of 1,064 ha were mapped in the coast regions. Ground crews noted that damage was much more extensive than could be seen from the air (timing of surveys is critical, and the aerial signature can be difficult to detect). Intensity of defoliation was assessed as 234 ha (22%) light, 367 ha (35%) moderate and 463 ha (43%) severe.

*Alder flea beetle larvae*

Sunshine TSA of South Coast Region sustained 900 ha of damage scattered along inlets and on Read, Cortes, Hernando and Texada Islands. A total of 165 ha of alder leaf beetle defoliation was noted in West Coast Region. Four polygons totalling 93 ha were in Campbell River and Union Bay in North Island TSA. Arrowsmith TSA contained one 72 ha disturbance west of Cowichan Lake.

## Bruce spanworm, *Operophtera bruceata*

After a peak of 8,491 ha last year, Bruce spanworm defoliation decreased to 751 ha in 2019, all located in Northeast Region. Intensity of damage decreased as well, to 535 ha (71%) light, 205 ha (27%) moderate and 11 ha (2%) severe. Infestations were also smaller and more widely scattered. Fort St. John TSA sustained 533 ha of damage, with the largest concentration northwest of Farrell Creek. Dawson Creek TSA had 218 ha of defoliation mapped.

## Cottonwood leaf rust, *Melampsora occidentalis*

Cottonwood leaf rust has historically intermittently affected a small number of low-lying stands in the Thompson/Okanagan Region. Damage in 2018 was only 10 ha observed in Kamloops TSA. In 2019, 138 ha of cottonwood leaf rust damage was delineated in four polygons at the south tip of Mabel Lake in Okanagan TSA. All damage was rated as moderate.

# Damaging Agents of Multiple Host Species

## Abiotic injury and associated forest health factors

*Post-wildfire damage to young lodgepole pine*

**Post-wildfire damage** affected a record 106,873 ha across BC, following -two record years of wildfires. This damage is due to a complex of factors associated with prior wildfire damage and has historically occurred one to five years after a fire. Intensity of mortality was assessed as 78 ha (<1%) trace, 26,350 ha (25%) light, 26,612 ha (25%) moderate, 41,751 ha (39%) severe and 12,081 ha (11%) very severe. Tree species most affected were lodgepole pine leading stands throughout the province and accounted for 73,214 ha of damage. Of this, 55,196 ha were identified as young managed stands, which historically have been most vulnerable. Douglas-fir leading stands had 22,158 ha of post-wildfire damage, mainly in Cariboo Region, and Douglas-fir beetle likely also contributed to tree mortality in these stands. Other conifers were also impacted. Post-wildfire damage was also observed across 581 ha of aspen, primarily in the northern half of the province.

Most post-wildfire damage (66,661 ha) was observed in Cariboo Region (Figure 19), which sustained record wildfires in 2018. Williams Lake TSA had 37,233 ha mapped, particularly north of Williams Lake and northwest of Gang Ranch to the TSA boundary. In Quesnel TSA 16,228 ha were affected, almost all of which were located west of Tzenzaicut Lake. 100 Mile House TSA sustained 13,200 ha of damage in the southern half. A total of 15,246 ha of post-wildfire damage was mapped in Skeena Region, primarily in Lakes TSA (12,586 ha) on the TSA's eastern edge. Small disturbances totalling 2,221 ha were noted in Morice TSA east of Nadina Lake. Almost all the 10,232 ha of damage in Omineca Region occurred in Prince George TSA (9,825 ha). Most of this was mapped south of Francois Lake and north of Tatin Lake. Kootenay/Boundary Region sustained 5,661 ha of damage with 2,418 ha in Invermere TSA, chiefly south of Franklin Peaks. Small scattered disturbances accounted for 1,694 ha in Cranbrook TSA. A total of 766 ha were mapped in Kootenay National Park in Golden TSA. All of the 5,323 ha affected in GBR North TSA were observed in the northeast corner. Almost all of the 1,926 ha mapped in Northeast Region occurred in Fort Nelson TSA (1,685 ha), south of Scoop and Hare Lakes. The 1,467 ha of post-wildfire damage recorded in Thompson/Okanagan Region was primarily in Kamloops TSA, where 1,048 ha were mapped mainly north of Cache Creek. All remaining damage in the province was less than 320 ha per TSA.

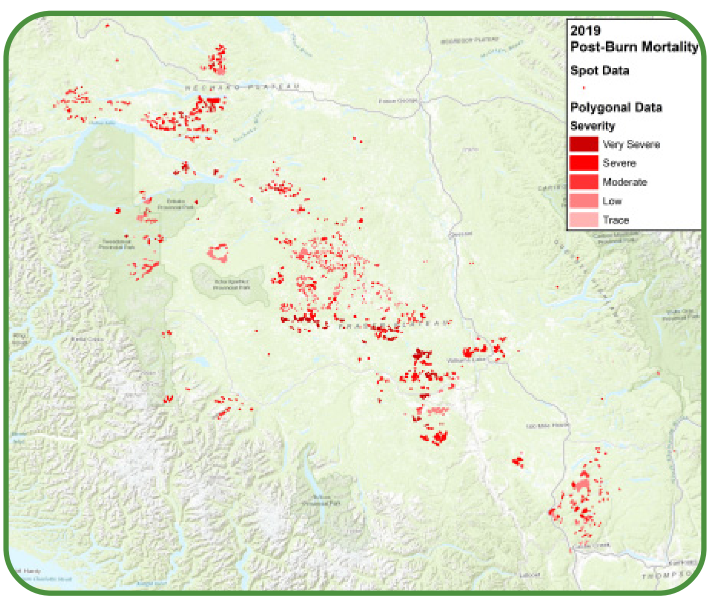



Figure 19. Post wildfire damage mapped in Cariboo Region in 2019, by damage intensity.

**Wildfire damage** in 2018 was the worst in recorded history in BC with 1,351,837 ha burnt. With milder temperatures and intermittent rain across most of the province during the summer of 2019, hectares burnt fell to only 22,053 ha. Almost all the damage was rated as severe.

Skeena Region was most impacted by wildfire with 9,441 ha damaged. Most (9,361 ha) occurred in Cassiar TSA where three fires (near Telegraph Creek, south of Fantail Lake and east of Vincent Lake) accounted for 92% of the damage. Less than 50 ha were burnt in each of the remaining TSAs. Northeast Region had 7,295 ha burnt by wildfire. Fort Nelson TSA sustained 6,262 ha of damage with one 5,584 ha fire north of Nelson Forks accounting for most of it. Fort St. John TSA had 1,023 ha affected and Dawson Creek TSA only 10 ha. Wildfire damage in Thompson/Okanagan Region totalled 4,131 ha with most (3,564 ha) occurring in Okanagan TSA. Most of this damage occurred in three fires south of Vaseux Lake. Wildfire disturbances in all other TSAs were small and scattered, totalling less than 400 ha per TSA.

**Drought damage leading to mortality (Drought Mortality)** decreased ten-fold since 2018 to 19,978 ha across BC. Intensity of mortality was rated as 5,450 ha (27%) trace, 7,707 ha (38%) light, 5,751 ha (29%) moderate, 923 ha (5%) severe and 147 ha (1%) very severe. Lodgepole pine followed by Douglas-fir were most affected in the interior, whereas western red cedar was the primary species followed by Douglas-fir in coastal areas. Although observed drought mortality decreased, sub-lethal effects of drought were noted in several areas including branch flagging, top kill and increases in secondary insect damage. Drought mortality mapped in young stands also decreased greatly to 746 ha, but drought damage to young trees is difficult to see from the height of the AOS, particularly if they are understory trees. Generally, sites most affected by drought mortality were south facing slopes or ridges/knolls, edges of open areas, and on rocky/thin soils.

Kootenay/Boundary Region sustained the highest level of drought mortality in 2019, with 6,952 ha mapped. The majority (4,874 ha) of damage was in the western half of Boundary TSA. Scattered disturbances in Invermere TSA totalled 875 ha, with concentrations southwest of Canal Flats and west of Spillimacheen. Cranbrook TSA disturbances were small and widely scattered with 680 ha mapped. Kootenay Lake and Arrow TSAs sustained similar levels of damage with 296 ha and 205 ha affected, respectively. Only 22 ha of mortality was observed in Golden TSA.


*Young lodgepole pine drought mortality*

Drought caused mortality in West Coast Region remained similar to last year with 3,856 ha recorded. Almost all the 1,756 ha in North Island TSA and 1,634 ha in Arrowsmith TSA were delineated on the east coast. Ground observations in Arrowsmith TSA (from Port Alberni to the east coast along the spine of the coast range and south of Nanaimo) identified significant western red cedar mortality over the last two years. If the cedar was located anywhere but the edge of a lake or stream it was adversely affected. In Haida Gwaii TSA, 466 ha of mortality was observed scattered throughout the islands but with a concentration west of Skidegate. In some traditionally very wet, low-lying stands in Haida Gwaii, particularly for western red cedar, it was noted that a slight change in ground moisture was resulting in drought damage because the trees are so shallow rooted. Non-commercial species (not mapped) were also observed to be drought damaged in West Coast Region, including salal, cypress and willow.

Skeena Region sustained 3,442 ha of drought caused mortality in 2019. Lakes TSA had 2,807 ha of damage, primarily northeast of Knapp Lake, north of Glatheli Lake and west of Burns Lake. All drought mortality noted in Kispiox TSA (366 ha) was along Highway 16 west of Kitwanga. A total of 252 ha were mapped in Morice TSA east of Morice Lake. Only 17 ha were observed in Kalum TSA. Throughout this region, ground observations noted far more damage than observed during the AOS, though the primarily wet summer of 2019 has led to some recovery. There were many reports of tree mortality in Kalum TSA, in and around the city of Terrace and along Highway 37. Most affected were western redcedar, young amabilis fir and hemlock. In Bulkley TSA, in the area around Smithers, mature spruce were experiencing top dieback, and in many areas along rivers dieback to cottonwood was observed. The regional pathologist noted there is not a history of moisture deficit in many areas of the region, hence the trees are very sensitive to drought conditions.

*Western red cedar drought mortality*

A total of 2,937 ha were affected in South Coast Region. Sunshine Coast TSA contained most of the damage (2,642 ha), scattered along the east side of the TSA. District staff noted western red cedar was dying throughout the TSA, though damage wasn't as bad as 2018, with most of the damage occurring in understory and juvenile trees.

Cariboo Region contained 1,109 ha of mortality caused by drought. Williams Lake TSA had a total of 932 ha mapped throughout the TSA, with concentrations south of Alkali Lake and south of Elbow Lake. 100 Mile House TSA sustained 177 ha of damage, chiefly west of 105 Mile House.

Thompson/Okanagan Region had the largest decline in drought mortality in BC since 2018, from 56,018 ha to only 822 ha this year. Most of the damage (790 ha) was mapped in Okanagan TSA, mainly from Chute Lake south to Skaha Lake. Merritt and Kamloops TSAs sustained 24 ha and 8 ha of damage, respectively.

Except for 1 ha, all of the 618 ha of drought mortality recorded in Omineca Region occurred in Prince George TSA in disturbances scattered south of Fraser Lake.

Great Bear Rainforest TSAs had a total of 218 ha of drought mortality observed, with 179 ha in the south and 39 ha in the north. Multiple ground reports identified drought damage to western redcedar near Prince Rupert in Great Bear Rainforest North TSA, particularly along powerlines and along highway 16. Many of the trees sustained topkill with lower crowns surviving. This is consistent with most western redcedar leading stands on the coast which have old dead tops dispersed throughout them, most likely from previous drought cycles.

The remaining 23 ha of drought caused mortality in the province was observed in Fort Nelson TSA of Northeast Region.

**Drought damage leading to excessive needle loss** increased to 2,881 ha in 2019. Intensity increased as well, with 949 ha (33%) light, 1,669 ha (58%) moderate and 263 ha (9%) severe. As in 2018, most of the damage (2,831 ha) was observed in Thompson/Okanagan Region. Kamloops TSA sustained 2,666 ha of drought needle damage, chiefly north of Blue River. Most of the 165 ha of damage in Okanagan TSA was observed north of Craigellachie. Two disturbances totalling 39 ha were mapped in Fort Nelson TSA of Northeast Region. One polygon of 11 ha accounted for the damage in Robson Valley TSA of Omineca Region.

**Flooding damage** declined provincially for the second consecutive year to 11,778 ha. Intensity levels remained similar to last year with 471 ha (4%) trace, 5,062 ha (43%) light, 3,816 ha (32%) moderate, 2,300 ha (20%) severe and 129 ha (1%) very severe. Most of the disturbances remained small and widely scattered. Aspen and spruce were most affected (primarily in the northeast) followed by minor damage to other conifer species.

*Flooding damage*

Northeast Region continued to sustain the majority of the flooding mortality with 10,075 ha affected. Fort Nelson TSA continued to be most affected in the region with 6,189 ha of damage mapped. A concentration of relatively large disturbances were observed south of Kotcho Lake. Some aspen disturbances were ground checked as it looked like severe defoliation from the air, but the damage was caused by flooding. This damage continued into Fort St. John TSA where 3,271 ha were delineated primarily south of Ekwan Lake. Small disturbances primarily along the Alberta border accounted for 615 ha of damage in Dawson Creek TSA.

Cariboo Region contained 843 ha of flooding mortality, with most (707 ha) located in Williams Lake TSA. All other TSAs in the province had less than 200 ha each of flooding damage.

**Windthrow damage** increased to a peak of 11,635 ha, the highest recorded since 2005. Severity of damage was assessed as 551 ha (5%) light, 6,491 ha (56%) moderate, 4,420 ha (38%) severe and 173 ha (1%) very severe.

Northeast Region sustained 9,665 ha of windthrow damage, of which 9,516 ha were in Fort Nelson TSA. The disturbances were larger than most, scattered from Prophet River northwest to Ewe Mountain. A total of 3,271 ha were mapped in Fort St. John TSA, and only 1 h in Dawson Creek TSA. Aspen in the Northeast Region were most affected, followed by a wide variety of conifers. Disturbances were mostly small and scattered. Trees downed by snow or ice are included in this category and for the first time caused the majority (82%) of the damage. Determining what causes windthrow, unless a large storm is witnessed, normally doesn't occur. In this case most of the

Northeast Region damage could be attributed to an unseasonal heavy snow mid-August, just before the survey of that area was conducted.

West Coast Region had 1,506 ha of windthrow damage identified, with most (1,315 ha) occurring in Haida Gwaii TSA. North Island TSA sustained 191 ha of damage. Remaining windthrow damage observed throughout the province was less than 250 ha per region. However, not all the damage was captured. A major storm event occurred on December 20, 2018 in West Coast Region that caused substantial damage in Arrowsmith TSA. It was too late to be observed last year, and the surveyors didn't recognize it as a "new" event in 2019. Additionally, it was noted from ground observations that a significant blowdown event occurred near Lac La Hache in 100 Mile House TSA (Cariboo Region) at the end of July. Since this area was flown in late June, it wasn't included in the 2019 data.

**Slide damage** increased by half over 2018 to 3,348 ha. Intensity of the damage was assessed to be 30 ha (1%) light, 723 ha (22%) moderate, 987 ha (29%) severe and 1,607 ha (48%) very severe. Slide damage due to snow avalanches remained very low with only 7 ha attributed to this causal agent. Spruce was the most affected tree species, with various other coniferous tree species and some aspen also damaged. Disturbances were small and widely dispersed.

*Slide damage*

Most of the slide damage continued to be observed in West Coast Region where 2,517 ha were affected. Haida Gwaii TSA sustained 1,822 ha of scattered damage and 695 ha were mapped at the north tip of North Island TSA. Slide damage decreased in Great Bear Rainforest TSAs with 138 ha in the south and 107 ha in the north. Northeast Region had 210 ha of damage mapped with 98 ha in Fort St. John TSA, 85 ha in Fort Nelson TSA, and 26 ha in Dawson Creek TSA. All other regions had less than 200 ha of damage per region.

**Frost damage** was observed on 53 ha in 2019; all disturbances were assessed at moderate intensity. One 45 ha polygon of frost damage was mapped in Fort Nelson TSA of Northeast Region (south of Mount Prudence) in lodgepole pine. A total of 8 ha of damage was noted in Thompson/Okanagan Region in two small polygons around Stump Lake (4 ha in each of Kamloops and Okanagan TSAs). This damage was to mature ponderosa pine only and limited to terminal ends of upper and outer crowns which is typical of frost damage sustained during late winter (ground checked).

**Mechanical treatment damage** severely affected 45 ha south of Lakelse Lake in Kalum TSA of Skeena Region. This damage was first observed in 2018 when 83 ha of mortality was mapped in 2 polygons and a ground check found mechanical girdling of trees in research plots was the cause. In 2019, the new damage was less but was spread over 7 small polygons. Spruce and subalpine fir were the girdled species.

## Animal damage

Animal damage is known to be underestimated in the AOS data as it tends to be scattered and often occurs in younger trees, which are difficult to see from the height of the AOS. Only substantial feeding that causes top kill or mortality is detectable.

As noted in data comments, the causal animal isn't always obvious: in older trees porcupine vs. black bear is difficult to determine and sometimes in younger stands black bear vs. hare is hard to tell, without ground checks or at least stand history (black bears tend to feed for multiple years in the same young stands).

**Black bear** (*Ursus americanus*) damage decreased by half since 2018 to 1,646 ha provincially. Intensity of mortality was assessed as 50 ha (3%) trace, 1,354 ha (82%) light, 116 ha (7%) moderate and 127 ha (8%) severe. Lodgepole pine continued to be the preferred tree species and most of the disturbances were small and widely scattered. Kootenay/Boundary Region sustained 832 ha of attack where 325 ha were mapped primarily east of Christian Valley in Boundary TSA. A total of 211 ha were observed in Arrow TSA east of Upper Arrow Lake and the remaining TSAs had less than 200 ha of attack each. Northeast Region had 581 ha of black bear attack with almost all (570 ha) observed in Fort Nelson TSA, chiefly west of Prophet River. Remaining damage in BC was under 150 ha per region.

*Mortality caused by black bear feeding*

**Unknown animal damage** was recorded on 419 ha in 2019. Intensity of mortality was assessed as 351 ha (84%) light, 41 ha (10%) moderate and 27 ha (6%) severe. All affected trees were young and primarily lodgepole pine. Most (321 ha) occurred in Skeena Region with 244 ha in Lakes TSA and 77 ha in Morice TSA, from Topley to Francois Lake. It is suspected this damage was caused by either bear or hare. The remainder of the unknown animal damage was mapped on 98 ha in Prince George TSA of Omineca Region.

**Porcupine** (*Erethizon dorsatum*) damage decreased to only one 14 ha polygon in Fort Nelson TSA of Northeast Region in 2019. The disturbance was rated at trace intensity and lodgepole pine was the affected tree species. The polygon was located near Gilliland Lakes.

## Armillaria root disease, *Armillaria ostoyae*

Damage caused by Armillaria root disease is known to be underestimated during the AOS due to the height flown and the subtle aerial signature of disturbances. Observed damage in 2019 decreased from 197 ha last year to 49 ha. Intensity of mortality was assessed as 26 ha (53%) trace, 23 ha (47%) light and one spot disturbance (severe). Damage historically has been mapped in young Douglas-fir stands and that was the case again this year.

South Coast Region sustained 26 ha of Armillaria root disease damage; primarily in one polygon on the edge of Roberts Creek Provincial Park and one spot near Sechelt (Sunshine Coast TSA). One 23 ha polygon was mapped in Arrowsmith TSA of West Coast Region north of Cameron Lake.

### Black army cutworm (*Actebia fennica*)

Figure 20. Characteristic shot-hole feeding signs of black army cutworm on a preferred host.

Black army cutworm (BAC) has historically been a periodic pest of herbaceous agricultural crops and was a common forestry pest in the 1980's when prescribed burning was regularly used for site preparation. With the observed increase in wildfire activity (and increase in average hectares per fire) since 2014, select areas have experienced BAC feeding impacts on recently planted seedlings. Typically, BAC will feed on preferred herbaceous hosts (Figure 20) when populations are low but as populations increase or preferred hosts are not available the larvae will feed on conifer seedlings. Feeding damage can vary from minor defoliation to complete defoliation and consumption of the terminal buds (Figure 21). Site conditions, weather and extent of defoliation influence survival rates. Generally, seedlings that experience more than 60% BAC defoliation and/or experience prolonged drought following BAC feeding have a lower likelihood of surviving or experience reduced growth.

Figure 21. Black army cutworm defoliated spruce seedling on a severely burned site in Quesnel.

Following the 2017 wildfire season most areas that were recently planted or where planting was planned for the next season were monitored with pheromone baited traps to assess the BAC risk and to minimize seedling losses.

Quesnel TSA in Cariboo Region has experienced the greatest BAC impact in the province. Minor BAC damage has also been noted in the western half of Williams Lake TSA in Cariboo Region, Kootenay/Boundary Region and Skeena Region. Many of the areas that experienced BAC impacts were severely burned, planted either one or two years following a fire and had little to no herbaceous cover at the time of planting. Impacted seedlings were planted under the Forest Carbon Initiative (FCI) and Forests For Tomorrow (FFT) reforestation program or by British Columbia Timber Sales (BCTS).

In the Quesnel TSA, FFT estimated that 180,000 seedlings over 100 hectares experienced severe defoliation in 2019 and 40 ha were impacted in 2018. The 2019 growing season was cool and wet, and could enhance survival as it reduces further drought stress on the defoliated seedlings. A full survival survey of the 2018 and 2019 BAC impacted areas will be completed by FFT at the end of the 2020 growing season to assess mortality and determine where replanting or fill-planting is required. The BCTS Quesnel Field Team reported no impacts for 2018 however they estimated that approximately 1.2M seedlings were impacted. Like the District FFT program, survival surveys to quantify mortality and determine replanting requirements will be completed at the end of the 2020 growing season.

During the 2019 AOS, two areas of burnt cut blocks in Quesnel TSA (near China Bluff and northwest of Nazko) were observed to be very red in colour, with no discernable young trees at the height of the survey. Surrounding blocks with visible young trees were green and it was too early in the season to be attributed to drought or fall shrub colour change. This couldn't be ground confirmed as BAC damage to foliage and/or seedlings (although it was suspected), so the blocks were not included in the data.

The Cariboo Chilcotin monitored areas identified for planting in 2019 and 2020. The BCTS Williams Lake Field Team observed BAC impacts west of Williams Lake and east of Alexis Creek (Aneko Creek). Five blocks were monitored and approximately 277 out of 5,500 surveyed seedlings had been impacted by BAC feeding. Follow-up survival surveys will be completed at the end of the 2020 growing season to determine if fill-planting is required. Monitoring completed by the DCC confirmed no threat to areas planned for 2020 planting and no significant impacts to 2019 plantations were observed.

In Cranbrook TSA of Kootenay/Boundary Region, three wildfires were monitored with a total of 16 traps in 2019. One trap at the Meachan wildfire site exceeded the 350 moth threshold for defoliation at 406 moths, but the rest were all under.

In Nadina District (Morice and Lakes TSAs) of Skeena Region, FLNRORD and industry worked together to establish 49 monitoring traps in wildfires. Six traps had unreliable data, mainly due to downed traps. Eighteen traps were assessed as low risk, with an average 150 moths per trap. Twenty-one traps were rated as moderate risk, with an average 622 moths per trap. Four traps at Dayeecha, Co-op Road, Helene and Bomberger were considered high risk, with an average 712 moths per trap.

## Unknown defoliator damage

Defoliation caused by unknown insects rose to 1,573 ha in 2019 across BC. Intensity of damage was assessed as 560 ha (36%) light, 187 ha (12%) moderate and 826 ha (52%) severe. Identification of the forest health factor(s) could not be confirmed due to inaccessibility of the affected stands.

Cariboo Region had one severe disturbance of 741 ha observed in Williams Lake TSA at the junction of Homathko River and Nude Creek, west of Tatlayoko Lake (Figure 22). The tree species affected was Douglas-fir. It is unlikely to be two-year cycle budworm as the preferred host subalpine fir just upslope was unaffected. Western spruce budworm has never been recorded in this area previously, and neither budworm is likely to cause such significant defoliation in this

Figure 22. Suspected western hemlock looper damage on Douglas-fir west of Tatlayoko Lake

concentrated of an infestation. Since hemlock looper damage is on the rise in the province and the insect has been found in 2019 in various interior Douglas-fir stands, it is the suspected causal agent.

Northeast Region sustained 364 ha of damage to scattered aspen stands primarily along the Alberta border. A total of 351 ha were mapped in Fort Nelson TSA and one disturbance of 13 ha in Fort St. John TSA. Historically, large aspen tortrix is the primary aspen defoliator in this part of the province and is most likely the cause. The surveyors noted the aerial signature of the damage was an odd whitish-green colour with light thinning. There was also a significant amount of flooding in the area this season, so it may have been a combination of factors.

Disturbances in West Coast Region totalled 313 ha, and all were concentrated around Leader Lake in Arrowsmith TSA. Conifers were affected, including amabilis fir. The remaining unknown defoliation in the province was minor, with less than 100 ha per region.

## Miscellaneous Damaging Agents

**Willow borer** (*Cryptorhynchus lapathi*) damage was noted to be increasing in Vanderhoof District of Prince George TSA. Mortality was occurring even in mature willow.

**Willow leaf blotch miner** (*Micurapteryx salicifoliella*) defoliation, which was not noticeable last year, was prevalent again in Dawson Creek and Fort St. John TSAs in 2019.

**Ugly nest caterpillar**, (*Archips cerasivorana*) activity was observed during ground reconnaissance to be scattered along the east site of Arrowsmith TSA and around Campbell River in North Island TSA of West Coast Region.

**Douglas-fir pole beetle** (*Pseudohylesinus nebulosus*) mortality was noted to be increasing in grand fir in association with drought conditions in Arrow and Kootenay Lake TSAs in the south.

*Ugly nest caterpillar larvae*

# Forest Health Projects

## Balsam woolly adelgid

*Babita Bains, Provincial Forest Entomologist*
*Don Heppner, Pacific Ecological Services*

The balsam woolly adelgid (BWA; *Adelges piceae* (Ratz.)) was introduced into North America from Europe and was first discovered in 1910 in southern Nova Scotia and much later in BC. In 1992 a quarantine zone was established by the Ministry of Agriculture to restrict the spread of BWA throughout the province. The quarantine zone was amended in 2014 and included Vancouver Island, and extended from the coast to northeast of Bella Coola and southeast to Lillooet, Merritt and Princeton.

Reports of BWA outside of the quarantine zone were confirmed in 2014 (Rossland) and 2015 (Okanagan). FLNRORD conducted surveys in 2016, 2017 and 2018 in subalpine fir (*Abies lasiocarpa*) stands to determine the current range of this invasive insect. Surveying confirmed that BWA had spread into the interior of the province (east of the Columbia River and south of Quesnel). Considering BWA had spread and established beyond the quarantine zone, the province deregulated and removed the quarantine zone as of March 31, 2019, allowing nursery and Christmas tree growers to move true firs (*Abies* spp.) throughout the province without any restrictions.

There were records of seedlings being moved from within the quarantine zone and planted in the Smithers area while the regulation was in place. To confirm if BWA was accidentally introduced into the Smithers area nine plantations (ages ranged from 4 – 24 years old) were inspected for BWA in 2019. No signs or symptoms of BWA were observed.

FLNRORD will only conduct future BWA surveys if there are observations or concerns of BWA moving north, and it is recommended that nurseries limit the movement of potentially infested stock into uninfested areas.

## Brown birch issue in the Robson Valley 2019 update – DNA analysis confirms insect defoliator ID

*Jeanne Robert, Forest Entomologist, Omineca and Northeast Regions*

Fewer birch trees along Highway 16 near McBride and Dunster, BC turned brown during the spring and summer of 2019 than were observed in 2018. Morphological species identification of the defoliator in 2018 was thought to be either the birch leaf skeletonizer, likely *Bucculatrix* sp., or possibly *Lyonetia* sp. DNA analysis in 2019 positively identified the samples as *Lyonetia prunifoliella*, commonly known as a leafminer causing damage in apple

*Brown birch photographed near McBride BC along highway 16 on June 19, 2019* trees (Schmitt et al. 1996). There is little available information on these insects in natural birch stands, but these insects are native to North America. Historically, these insects have not caused widespread mortality in birch.

The Ministry of Forests, Lands, Resource Operations, and Rural Development will continue to carefully monitor the size of the infestation area.

Reference:
Schmitt JJ, Brown MW, and Davis DR. 1996. Taxonomy, Morphology, and Biology of *Lyonetia prunifoliella* (Lepidoptera: Lyonetiidae), a Leafminer of Apple. Ann. Entomol. Soc. Am. 89(3): 334-345.

## Dwarf mistletoe sanitation trial update

*David Rusch, Forest Pathologist, Cariboo and Thompson Okanagan Regions*

In 2014 a dwarf mistletoe sanitation site was set up at Gaspard Creek in the Cariboo IDFdk4 biogeoclimatic zone to compare the effects of different sanitation heights on dwarf mistletoe levels (0.3m, 1m, 2m, and no treatment). The sanitation treatments were randomly assigned. Height, dbh, location and dwarf mistletoe severity were recorded on trees over the sanitation height in 0.1ha circular plots. There were 3 plots per treatment. Following sanitation and planting in 2015, the trees in a 0.05 ha subplot were tagged, stem mapped and assessed. Only dwarf mistletoe trees were assessed in the larger 0.1ha plot. In addition to dwarf mistletoe severity, % scarring, and elytroderma needle cast were also recorded. Elytroderma severity was measured using the Hawksworth dwarf mistletoe rating system where elytroderma infected branches were assessed in place of dwarf mistletoe infected branches.

In 2017 a fire went through the Gaspard Creek site and burned all the trees. In 2018, an additional site was added at Skyranch Road south of Fletcher Lake (SBPSxc biogeoclimatic zone). This site was assessed prior to sanitation for dwarf mistletoe severity, eytroderma severity, and percent circumference scarred. This site was planted and reassessed in 2019 and a third site was assessed prior to sanitation near Little Gaspard Creek (IDFdk4 biogeoclimatic zone). The Little Gaspard Creek site will be reassessed following planting in 2020 bringing the total number of sites with post sanitation measurements to three. All three sites are BCTS Forest For Tomorrow blocks.

Tables 8 and 9 show the stocking of affected trees pre and post sanitation and the percent reduction in dwarf mistletoe, elytroderma, and scarring as a result of the sanitation treatments. A high percentage of affected trees in the 0.3m treatment at both sites were trees that should have been removed during the sanitation treatment. This points out the difficulty in cutting down to a 0.3m sanitation height and emphasizes the importance of careful monitoring of sanitation crews when using a sanitation height of 0.3m to get the maximum possible benefit from the treatment.

Table 8: Estimated Reductions in dwarf mistletoe and elytroderma from sanitation.

| Site | Treatment | Dwarf Mistletoe Sanitized 0.01 ha plot (stems/ha) A | Dwarf Mistletoe Post-sanitation 0.01 ha plot (stems/ha) B | Estimated Dwarf mistletoe reduction (%) A/(A+B)x 100% | Elytroderma Sanitized (stems/ha) 0.05 ha plot C | Elytroderma Post-sanitation (stems/ha) 0.05 ha plot D | Estimated Elytroderma reduction (%) C/(C+D)x100% |
|---|---|---|---|---|---|---|---|
| Gaspard Creek | 0.3 m | 370 | 60 | 86 | No data | 80 | No data |
| | 1 m | 193 | 134 | 59 | No data | 260 | No data |
| | 2 m | 83 | 323 | 20 | No data | 180 | No data |
| | Control | 0 | 403 | 0 | 0 | 593 | 0 |
| Sky Ranch | 0.3 m | 1247 | 64 | 95 | 700 | 27 | 96 |
| | 1 m | 813 | 303 | 73 | 480 | 100 | 83 |
| | 2 m | 537 | 790 | 40 | 307 | 273 | 53 |
| | Control | 0 | 870 | 0 | 0 | 420 | 0 |

Table 9. Estimated reductions in scarred trees from sanitation.

| Site | Treatment | Scarred trees sanitized 0.05 ha plot (stems/ha) A | Scarred trees Post sanitation 0.05 ha plot (stems/ha) B | Estimated Scarred tree reduction % A/(A+B) x100% |
|---|---|---|---|---|
| Gaspard Creek | 0.3 m | No data | 40 | No data |
| | 1 m | No data | 120 | No data |
| | 2 m | No data | 67 | No data |
| | Control | 0 | 167 | 0 |
| Sky Ranch | 0.3 m | 213 | 33 | 80 |
| | 1 m | 173 | 80 | 67 |
| | 2 m | 147 | 400 | 25 |
| | Control | 0 | 667 | 0 |

## For endangered five-needle pines - seed orchards are the future

*Michael Murray, Forest Pathologist, Kootenay/Boundary Region*

The introduction of the fungal pathogen, *Cronartium ribicola*, also known as white pine blister rust, has decimated stands of five-needle pine species. While disease-resistant western white pines are widely available for replanting, the promotion of resistant whitebark and limber pines is emerging from infancy. Thanks to rust screening efforts, initiated in 2011, we are beginning to produce whitebark pine seedlings that can survive disease pressure (see past summaries of *Forest Health Conditions in BC* 2011, 2013, 2014).

The demand for whitebark pine seedlings is higher than the supply. Timber and mining companies, BCTS, First Nations, and Provincial and National Parks are all in line to plant this tree – for significant cultural and ecological values. To meet this demand, seed orchards can supply a reliable long-term supply of disease resistant material.

Seed orchards currently don't exist. Once established, they will provide disease resistant stock. Currently, we are collecting scion (cone producing branch tips) from mature healthy trees that have produced seedlings that are being assessed in our disease screening program. The scion is grafted to existing sturdy whitebark seedlings (rootstock) at Kalamalka Research Centre (FLNRORD, Vernon). To date, we have produced 1,517 grafted seedlings.

In November, a planning workshop was held in Revelstoke. Participants included Parks Canada (the host), FLNRORD, Alberta Ag & Forestry, Vernon Seed Orchard Company, Whitebark Pine Ecosystem Foundation, and the Calgary Zoo. Three results emerged from this workshop. The first, a short-list of potential seed orchard sites - as proposed by participants. Second, a target strategy for acquiring adequate numbers of disease-resistant material for a designated minimum number of orchards (Table 10). And third, designation of seed collection areas (two in the east plus two in the western portion of whitebark pine's natural range – while limber pine has only two zones total.)

Table 10. Targets determined at the Whitebark/Limber Seed Orchard Workshop, Revelstoke 2019.

| Target | Goal |
|---|---|
| Resistant Parent Trees | 60 trees per seed zone per species |
| Whitebark pine Orchards | Four orchards and two clone banks |
| Limber pine Orchards | Two orchards and two clone banks |

*Whitebark pine cones*

## Limber pine health

*Michael Murray, Forest Pathologist, Kootenay/Boundary Region*

Limber pine (*Pinus flexilus*) is one of British Columbia's rarest native trees. In 2014, the federal committee on the status of endangered wildlife in Canada declared "This tree species is imminently and severely threatened throughout its Canadian range by white pine blister rust, mountain pine beetle, and climate change" (COSEWIC 2014). The range of limber pine in Canada is restricted to extreme southeast BC and southwestern Alberta. In BC, it can be found sporadically on the east side of the Rocky Mountain Trench from the US Border north to the Kicking Horse Canyon – Fields area. It is poorly mapped, thus comprehensive knowledge of population occurrences is very lacking.

*Limber pine forest health survey*

Limber pine is not commercially harvested in BC, however it is impacted by mining operations and occasional other developments. Limber pine is like whitebark pine (*P. albicaulis*) because its large seeds are a valuable food source for bears, small mammals and birds.

In 2012, the first Provincial survey of limber pine forest health occurred near Columbia Lake (Canal Flats, BC). A transect assessment of 100 trees indicated 0% infection by blister rust or mountain pine beetles. Only a single tree was dead. Returning to the site in 2014, trees were tagged in order to establish a permanent monitoring transect. No trees were found to be infected until 2019, when a single canker was detected. Thus, this population is doing very well health-wise. Our results contrast with the findings from Alberta where 43% of trees surveyed (85 plots) were infected with blister rust (Smith and others 2013).

To better understand the health status of limber pine in BC, the establishment of permanent monitoring transects at numerous sites is necessary.

Reference:

COSEWIC. 2014. COSEWIC assessment and status report on the Limber Pine (*Pinus flexilus*) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 49 pp.

Smith, C.M.; Langor, D.W.; Myrholm, C.; Weber, J.; Gillies, C. Stuart-Smith, J. 2013. Changes in white pine blister rust infection and mortality in limber pine over time. 2013. Canadian Journal of Forest Research 43:919-928

## Pest incidence in young pine:
## A retrospective analysis and survey of young stands

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

**Background:**
Changing climate, pest activity and fire are affecting forest health, value and productivity across a wide range of forested landscapes. Lodgepole pine, *Pinus contorta* ssp. *latifolia*, is the dominant species in most dry, cold forests of western North America forming pure successional stands or co-dominant mixtures (Klinka et al. 2000). The forests of British Columbia (B.C.) cover an area of just over 60 million hectares (https://www.for.gov.bc.ca/hfd/pubs/docs/mr/mr113/forests.htm) and lodgepole pine is ubiquitous, growing throughout the interior of the province. Numerous pests affect lodgepole pine throughout its rotation, with the key natural disturbance agent of mature lodgepole pine being the mountain pine beetle, *Dendroctonus ponderosae* Hopk. (Coleoptera: Scolytidae) (Safranyik and Carroll 2006; Westfall and Ebata 2017) and fire (Kurz et al. 2008). Mountain pine beetle (MPB) populations periodically erupt killing thousands of hectares of mature, or nearly mature pine trees (Safranyik and Carroll 2006; Maclauchlan et al. 2015). At least four large-scale outbreaks of mountain pine beetle have occurred in western Canada in the past 120 years, as documented in forest survey records or detected as growth releases in tree rings (Alfaro et al. 2004; Taylor et al. 2006; Westfall and Ebata 2017). Alfaro et al. (2004) identified three large outbreaks through tree ring analysis: 1890's, 1940's and the 1980's with many smaller, more localized outbreaks occurring between these major events. The most recent MPB outbreak in B.C. began in the late 1990's, peaking in 2007 at 10 million hectares affected (Westfall and Ebata 2017). By 2008, the beetle had affected almost 14 million hectares of pine forests, an area 10 times larger than any previously recorded outbreak (Safranyik et al. 2010). Since that time, the area affected has declined

rapidly to pre-outbreak levels with only 119,089 hectares affected in 2017 (Westfall and Ebata 2018). In addition to extensive timber losses, MPB epidemics may increase fuel loading, which can lead to more severe wildfires, alter successional trajectories and a myriad of other resource values. Gray (2013) found that as the dead overstory of unsalvaged, MPB-impacted stands decayed and fell, both the hazard and risk to wildfire were high. Many of the stands, which burned in the 2017 wildfires, were killed by MPB more than a decade ago. These stands are now falling down and creating massive amounts of ground fuel.

Accelerated harvesting and reforestation efforts increase dramatically in the wake of each MPB outbreak. In addition to many new plantations resulting from MPB harvest, BC is now challenged with reforesting extensive areas that were burned in the 2017 wildfires (Fletcher 2018). The result is a vast landscape of young forests, many of which are composed of pure lodgepole pine or mixtures of lodgepole pine and other species. Insight into the challenges these new plantations face as they develop may assist in future reforestation and stand tending decisions.

There are always notable differences in stand development across ecosystems and geographic regions due to natural factors, harvest techniques and regeneration methods. However, stands regenerated after the last MPB outbreak appear more vulnerable to damaging agents, both in terms of variety and abundance of pests. A retrospective investigation was conducted in 2019 to compare and quantify temporal and spatial differences, if any, of current *versus* past stand health of young lodgepole pine stands. In the late 1990's, many young lodgepole pine stands in the southern interior of BC were surveyed to assess pest incidence and impact in the aftermath of the 1980-1990's MPB outbreak. In 2019, young lodgepole pine stands resulting from the harvest and regeneration of stands killed by the recent MPB outbreak (1995-2002), were surveyed to assess present day pest incidence and impact. The objective of this project is to identify the suite of pests impacting this cohort of young stands and determine if pest incidence and impact has changed over time in stands that are otherwise comparable in age, geographic location and biogeoclimatic zone.

**Objectives:**
Young lodgepole pine stands may be more vulnerable to pests due to climate change. Using a standard Survey for Pest Incidence (SPI) data, and other data collected from plots and other research trials conducted in the Thompson Okanagan Region (old Kamloops Region) in the 1990's as a baseline, we identified stands of comparable age (±20 years) in the same geographic areas and ecosystems. Stands surveyed in the 1990's were matched with candidate stands to be surveyed in 2019. Stands were assessed using a SPI noting: age, stand density, species composition, relative growth (diameter at breast height and height) and pest diversity, occurrence and impact. All data collected from the 1990's and 2019 surveys were matched by ecosystem, age and geographic area as closely as possible and analyzed for any differences or similarities.

This project hopes to identify changes in tree-pest dynamics under erratic climate regimes and provide options for mitigation by comparing pest incidence and impact in stands initiated in the 1970-1980's to those harvested and regenerated post-MPB (2000-2012).

**Methods:**
All stand data from the 1996-2000 surveys have been collated into a standardized database. The 2019 surveys were conducted in three TSAs (Okanagan, Kamloops, and Merritt) and two TFLs (Tree Farm Licenses) (TFL 49 located in the North Okanagan; and TFL 59 located in the South

Okanagan). The VRI (Vegetation Resource Inventory) data were used to identify candidate stands for survey in 2019. A SPI was conducted in 2019 to collect stand, tree and pest information and to ensure the data could then be compared to the various surveys and installations done from 1996-2000. The SPI is a continuous series of 50 to 100 meter long plots. Plots can vary in width from 1 meter to 5 meters depending on age, size and density of the stand (tree size, species mix, layers). Plot widths were selected so that approximately 50 trees were assessed in each 50-meter strip plot. Every tree greater than 1 meter in height within the plot boundary was examined and tallied, by species, for pest occurrence and severity. If there was a significant number of trees less than 1 meter high (ingress) in a stand, these trees were counted and assessed in a sub-plot (plot width x 10 meters). All SPI plots were located a minimum of 25 meters from the stand edge, roads and unnatural openings.

Information from each SPI plot included:

- Location (GPS; BEC; road system or geographic description);
- site and soil characteristics;
- aspect;
- species composition (e.g. lodgepole pine; mixed species; shrubby);
- stand age, height, tree diameter at breast height; and,
- damaging agents and severity

All trees in a plot were assessed and categorized by silviculture layer (layer 1-4), species, live (no pests), live (with one or more pests) or dead. Pests (damaging agents) were identified and the severity of damage recorded. Ten live trees in each plot were randomly selected and height, dbh and age were recorded.

Data were summarized and compared by TSA, BEC and year of survey.

**Preliminary Results:**
70 SPI surveys were conducted in 2019 in three TSAs and two TFLs within four BECs and were compared to 248 surveys conducted between 1996 and 2000 (Table 11). In 1996-2000 there were often multiple surveys done per opening (stand), particularly in the two TFLs, whereas in 2019 only one SPI was done per opening.

Overall, the average stand density did not vary significantly between the first and second survey periods, at 2,982 stems per hectare (sph) and 2,706 sph, respectively. Density varied by BEC and location, with densities generally decreasing in the ESSF, ICH and MS (Figure 20). On average, stand density in the IDF increased from 2,500 sph to 2,775 sph in 1996-2000 and 2019, respectively. Average stem density ranged from below 1,000 sph to over 6,000 sph (Figure 20).

Table 11. Number of plots, by TSA and biogeoclimatic zone (BEC), assessed in 2019 and 1996-2000.

| TSA | BEC | No. plots in 2019 | No. plots in 1996-2000 |
|---|---|---|---|
| Okanagan | ESSF | 2 | 2 |
| | ICH | 11 | 25 |
| | IDF | 1 | 3 |
| | MS | 20 | 32 |
| Merritt | ESSF | 1 | 14 |
| | IDF | 3 | 13 |
| | MS | 6 | 26 |
| Kamloops | ICH | 10 | 11 |
| | IDF | 2 | 2 |
| TFL 49 | ESSF | 2 | 27 |
| | IDF | 1 | 8 |
| | MS | 3 | 18 |
| TFL 59 | ESSF | 2 | 6 |
| | IDF | 1 | 25 |
| | MS | 5 | 36 |
| Total plots | | 70 | 248 |

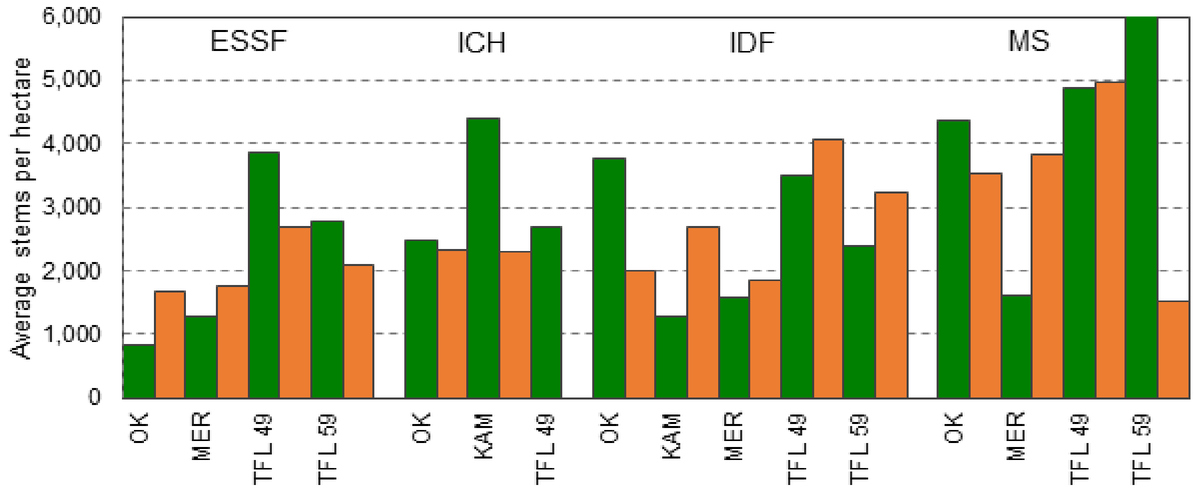



Figure 20. Average density (stems per hectare, including dead trees) by BEC in surveys conducted in 1996-2000 (green bars) and 2019 (orange bars), by TSA and TFL.

The average percent clear stems (free of any damaging agent) was lower in 2019 than in 1996-2000 across all BECs (Figure 21). The most notable declines were observed in the ESSF and MS (Figure 21). All ecosystems surveyed in TFL 59 saw drastic increases in damaging agents in 2019. In the ESSF, the average percent stems affected increased from 25% to 91%, and in the MS from 30% to 91% (Figure 21) in 1996-2000 and 2019, respectively. Stand density declined to 2,100 sph in the ESSF and to just over 1,500 sph in the MS. By contrast, stand density in Merritt ESSF stands surveyed was low, below 2,000 sph at both sampling times although the sample size in 2019 was low, and had comparable pest levels, with over 70% of stems affected.

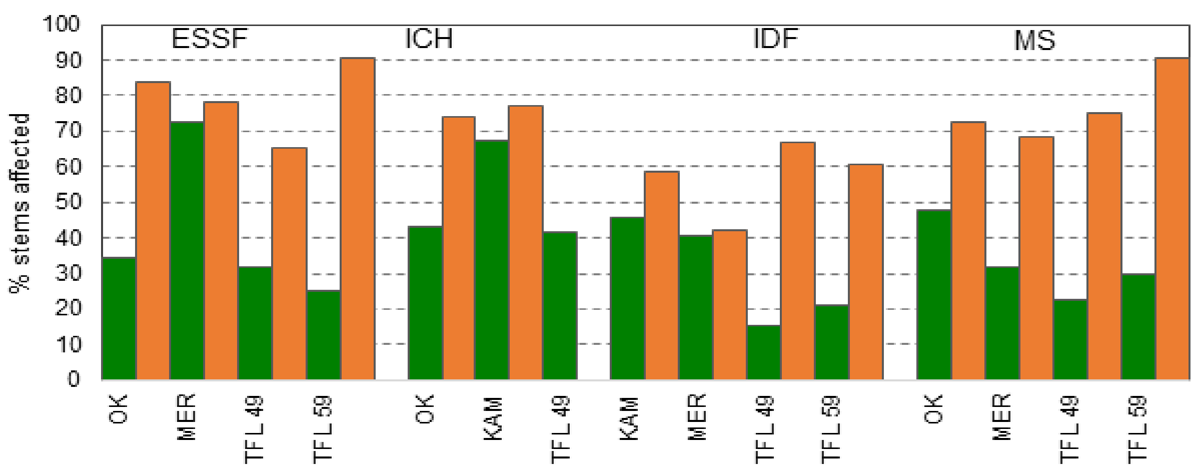



Figure 21. Percent stems affected (lower graph) in surveys conducted in 1996-2000 (green bars) and 2019 (orange bars), by TSA and TFL.

In the Kamloops TSA, average stem density in the IDF was higher in 2019, increasing from 1,270 to 2,700 sph (Figure 20), and pest incidence increased from 46 to 59 percent stems affected in 1996-2000 and 2019, respectively (Figure 21). IDF stands in TFL 49 had very similar stem densities at both sampling periods, at 4,877 and 4,982 sph respectively (Figure 20). However, the incidence of damaging agents was significantly higher in 2019, going from 23% to 75%. Density seems to play a role but is most likely dependent upon the biology and dynamics of each pest organism and ecosystem.

Some of the most common damaging agents found in these surveys (Table 12) are compared between the two sampling times in Figure 22. The thirteen most common damaging agents are listed in Table 12 and Figure 22. Of these, only three declined in stands from 1996-2000 to 2019: lodgepole pine dwarf mistletoe, pitch nodule moth and Warren's root collar weevil. There are now guidelines for harvesting stands with dwarf mistletoe so our result shows these eradication efforts have been successful. The other two pests are very site specific. All other pests increased in incidence between these two survey times. Western gall rust and lodgepole pine terminal weevil had the most notable increases in stems affected from 1996-2000 to 2019 (Figure 22). Comandra blister rust had moderate levels of infection in 2019, at nine percent stems infected compared to only 1.5% stems infected in the first survey time.

The average percent lodgepole pine infected by western gall rust, lodgepole pine terminal weevil and comandra blister rust were compared among the three TSAs and two TFLs at each survey time (Figure 23). In 1996-2000 surveys, western gall rust levels were below five percent stems infected on both TFLs, whereas in 2019, levels were over 35 percent stems infected (Figure 23). In the first survey, comandra blister rust was found at very low infection levels in Merritt, TFL 49 and TFL 59 (less than one percent), but by 2019 trees of the same age and in the same location and BEC had noticeably higher rates of infection (3-20 percent). The Kamloops and Okanagan TSAs had moderate levels of comandra infection at both survey times,

Table 12. Pest codes for common damaging agents found in young lodgepole pine surveys.

| Pest Code | Damaging agent |
|---|---|
| AC | Cattle |
| AS | Squirrel |
| DFL | Pine Needle Cast (*Lophodermella concolor*) |
| DMP | Lodgepole Pine Dwarf Mistletoe (*Arceuthobium americanum*) |
| DSA | Atropellis Canker (*Atropellis piniphila*) |
| DSC | Comandra Blister Rust (*Cronartium comandrae*) |
| DSG | Western Gall Rust (*Endocronartium harknessii*) |
| DSS | Stalactiform Blister Rust (*Cronartium coleosporioides*) |
| ISP | Pitch Nodule Moths (*Petrova species*) |
| ISQ | Sequoia Pitch Moth (*Synanthedon sequoiae*) |
| IWP | Lodgepole Pine Terminal Weevil (*Pissodes terminalis*) |
| IWW | Warrens Root Collar Weevil (*Hylobius warreni*) |
| ND | Drought |

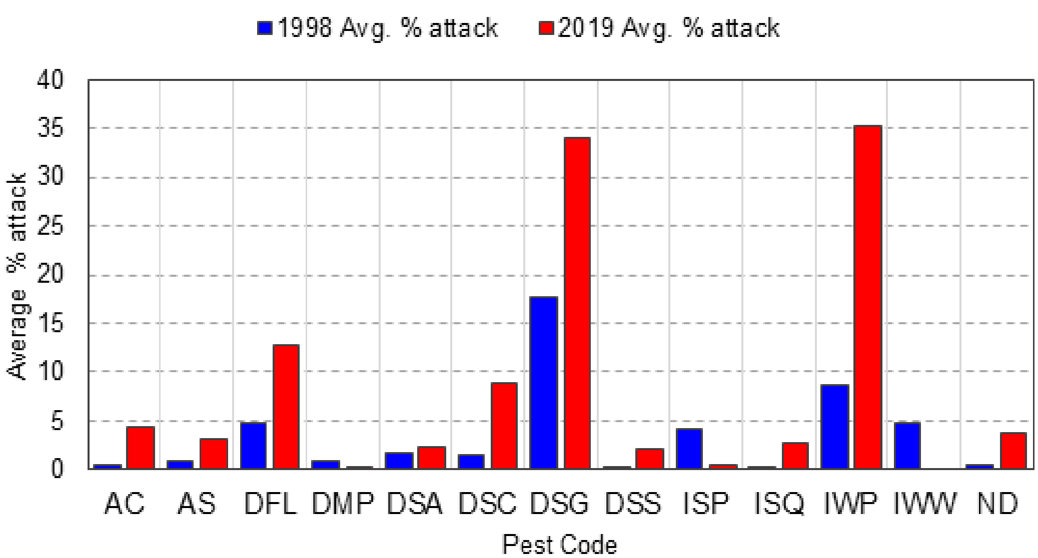



Figure 22. Average attack levels of major pests found in the 1996-2000 and 2019 surveys.

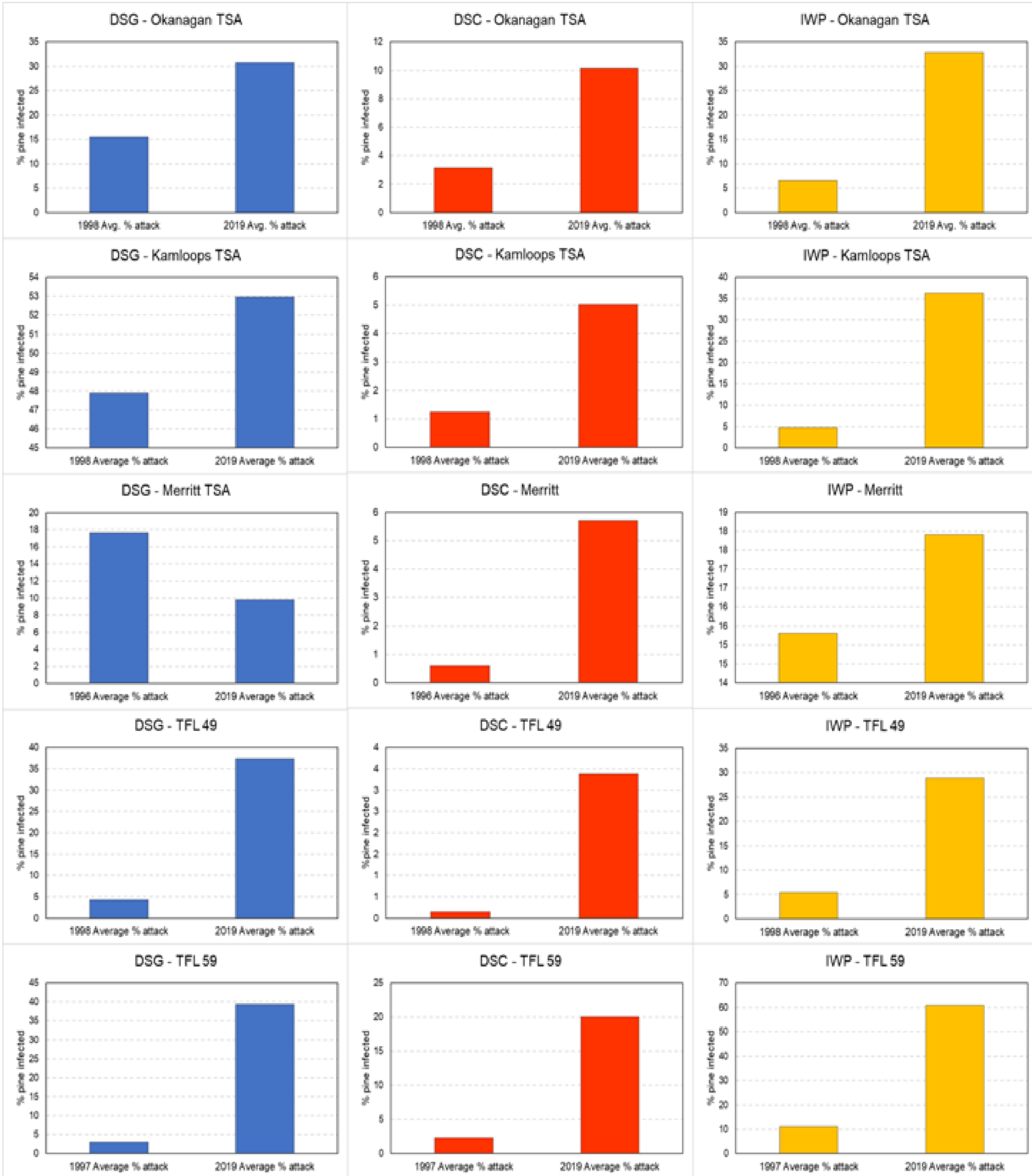



Figure 23. The average percent lodgepole pine infected by western gall rust, lodgepole pine terminal weevil and comandra blister rust were compared among the three TSAs and two TFLs at each survey time.

although it was higher in 2019. There were up to seven-fold increases in the incidence of terminal weevil attack between the two survey times. Other studies show that lodgepole pine growing in more open scenarios have higher levels of weevil attack and more severe stem defects due to attacks (Maclauchlan and Borden 1996; Buxton and Maclauchlan 2015).

In summary, there is wide variability in the type and severity of damage to young pine stands in the southern interior. Preliminary results highlight the increase in pest damage throughout the range of lodgepole pine in the south. With all other parameters being equal, except for the year of regeneration and possibly stocking levels, conditions in the past decade seem to be promoting increased pest occurrence. Further stand density and pest interactions will have to be examined. A more detailed analysis of this project and a full report will be available in late 2020.

## Re-assessment of western balsam bark beetle permanent sample plots

Lorraine Maclauchlan, *Forest Entomologist, Thompson/Okanagan Region*

**Background:**
The western balsam bark beetle (*Dryocoetes confusus* Swaine, Coleoptera: Scolytinae) (IBB) is the major cause of subalpine fir mortality in BC. IBB selectively kills small groups of subalpine fir at relatively low, but constant, levels every year in infested stands. Over time, the cumulative mortality can be significant and IBB is considered the primary successional force in these high elevation forests. We have described a continuous yet increasing rate of mortality in subalpine fir-dominated ecosystems over the past two decades, with IBB as the primary driver. Other insects, pathogens and drought are pushing the speed of succession in these forest types. Long-term installations were established to monitor IBB attack and stand succession in subalpine fir forests throughout the Thompson/Okanagan Region.

Ten permanent sample plots, each one hectare in size, were established from 1998-2002, with a final plot established in 2012. Plots are located in the ESSF biogeoclimatic zone within the ESSFwc (6 plots), ESSFmw (2 plots), and ESSFxc (3 plots) subzones (Figure 24, Table 13).

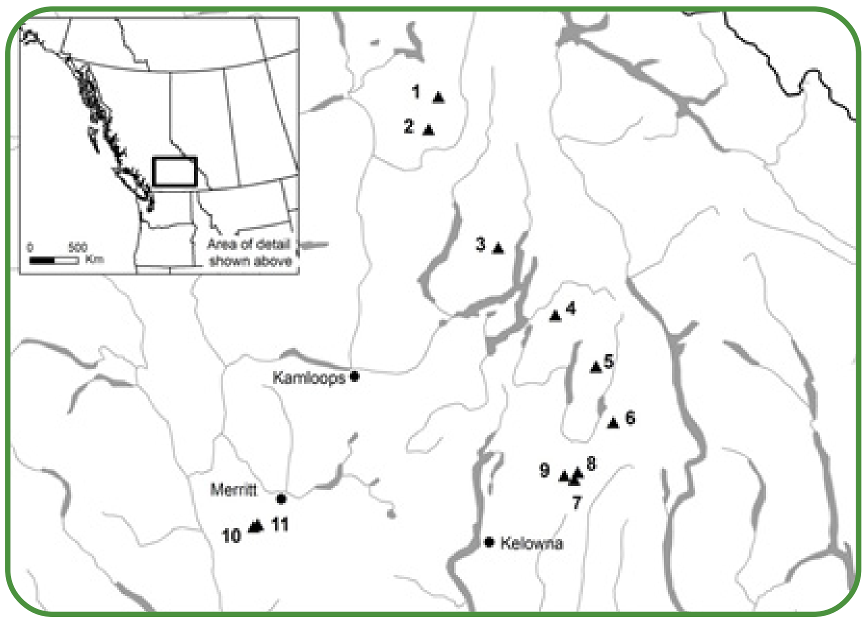


Figure 24. Location of eleven western balsam bark beetle monitoring plots in the Thompson Okanagan Region.

At establishment, all trees within the plot equal to or greater than12.5 cm diameter at breast height (dbh) were tagged, stem mapped, measured, and assessed for forest health agents and damage. Data collected included: dbh of all trees; a sub-sample of heights and ages (increment core taken); tree status (live/dead/down); pest incidence; and, detailed information on IBB attack. At the time of plot establishment, only standing live or dead trees were tagged and assessed. All tagged trees were stem mapped. In subsequent assessments, all windthrow (of tagged trees) was recorded for an estimate of tree fall over time. Initially, plots were assessed annually to gather detailed information on IBB attack dynamics, development and tree decline. Later, assessments were done periodically at ±5 year intervals. In each assessment year, all trees were assessed for any new IBB attack, fall down, other pests and damage. Trees previously attacked by IBB were evaluated for foliage colour change, bark sloughing and checking (last assessment 2013). Height and dbh were measured periodically (last measurement in 2008). In 2019, six plots were assessed and the remaining five plots will be assessed in 2020.

Table 13. List of eleven western balsam bark beetle permanent sample plots noting: biogeoclimatic classification (BEC); year of plot establishment; number of subalpine fir (Bl) at establishment (dead and alive), number of live Bl, and the number of all species at establishment.

| | | Year of plot establishment and number of trees (live and dead) | | | |
|---|---|---|---|---|---|
| **Location** | **BEC** | **Year** | **Live Bl** | **Total Bl** | **All species** |
| 1. Raft River | ESSFwc2 | 2012 | 428 | 570 | 876 |
| 2. Martin Creek | ESSFwc2 | 2000 | 1,113 | 1,161 | 1,417 |
| 3. Scotch Creek | ESSFwc2 | 2002 | 328 | 664 | 722 |
| 4. Sicamous Creek | ESSFwc2 | 1998 | 365 | 732 | 930 |
| 5. Torrent Creek | ESSFwc | 1998 | 356 | 514 | 597 |
| 6. Cherry Creek | ESSFwc4 | 1998 | 177 | 430 | 496 |
| 7. Home Lake-1 | ESSFxc | 1999 | 605 | 995 | 1,202 |
| 8. Home Lake-2 | ESSFxc | 1999 | 642 | 1,149 | 1,313 |
| 9. Buck Mountain | ESSFxc | 1999 | 748 | 1,215 | 1,317 |
| 10. Spius Creek-1 | ESSFmw | 2002 | 494 | 785 | 844 |
| 11. Spius Creek-2 | ESSFmw | 2002 | 560 | 674 | 1,317 |

**Methods:**

In the 2019 assessment, each tree that was still standing at the last assessment time (live and dead) was located and evaluated. The following information was recorded or verified:

- tree status (live, dead, down)
- IBB attack status, crown colour and condition (see Tree Codes, Table 14)
- dbh (cm) of all live trees and Tree Code 1 and 2 trees (Table 14)
- height of a subsample of live trees in each plot (±40 trees)
- other pest incidence or damage evident on trees

Table 14. Description of tree codes used to describe plot tree status (live or dead), the stage of decline (foliar fade), and standing or down. Codes 1-6 and 10 are all dead due to IBB. Codes 7 and 11 are unknown or affected by other pests.

| Tree Code | Description |
|---|---|
| 0 | healthy |
| 1 | green/current attack |
| 2 | brick red |
| 3 | faded/dull red |
| 4 | grey with fines, maybe a few red needles |
| 5 | grey without fines, just larger branches |
| 6 | snag - losing bark |
| 7 | dead - other or unknown cause |
| 10 | blowdown-previously attacked by IBB |
| 11 | blowdown-no IBB |

IBB often attacks in the upper bole of subalpine fir so that during ground assessments their diagnostic galleries cannot be found. These trees are often coded as “dead unknown” even though it is likely that IBB has been the cause of death. When these trees fall, the galleries can be located higher in the tree, and the cause of death more easily identified.

The data collected in the 2019 assessment will be added to master data sets that contain records of each assessment since plot establishment.

**Preliminary results:**
Six of the eleven plots were assessed in 2019 (Table 15). The remaining five plots will be completed in 2020. The percent mortality of subalpine fir in 2019 ranged from 26.6% at Spius Creek-2 to 58% and 61% at the Sicamous and Martin Creek plots, respectively. The Sicamous Creek plot has been monitored for twenty-one years (Table 15; Figure 25), going from 365 live subalpine fir per hectare to 152 live subalpine fir per hectare in this time. Mortality from IBB peaked around 2013 and many of the IBB-killed trees have since fallen. In the Sicamous plot, there are now fewer live trees than standing dead and down (Figure 25).

Table 15. Comparison of total number of live subalpine fir at plot establishment and at the last assessment. The Martin plot was partially logged (165 trees logged) so the mortality was adjusted to reflect this.

| | | | | Live Bl | | % Bl mortality |
|---|---|---|---|---|---|---|
| **Location** | **BEC** | **Year established** | **Last assessment** | **At establishment** | **At last assessment** | **between assessments** |
| Raft River | ESSFwc | 2012 | 2019 | 428 | 228 | 46.7 |
| Martin Creek | ESSFwc | 2000 | 2019 | 1,113 | 296 | 61.0 |
| Scotch Creek | ESSFwc | 2002 | 2011 | 328 | 250 | 23.8 |
| Sicamous Creek | ESSFwc | 1998 | 2019 | 365 | 152 | 58.4 |
| Torrent Creek | ESSFwc | 1998 | 2019 | 356 | 277 | 22.2 |
| Cherry Creek | ESSFwc | 1998 | 2013 | 177 | 137 | 22.6 |
| Home Lake-1 | ESSFxc | 1999 | 2013 | 605 | 206 | 66.0 |
| Home Lake-2 | ESSFxc | 1999 | 2013 | 642 | 245 | 61.8 |
| Buck Mountain | ESSFxc | 1999 | 2013 | 748 | 279 | 62.7 |
| Spius Creek-1 | ESSFmw | 2002 | 2019 | 494 | 325 | 34.2 |
| Spius Creek-2 | ESSFmw | 2002 | 2019 | 560 | 411 | 26.6 |

Mortality has increased in all plots and across all BECs since plots were established, at varying rates. Plots in the ESSFxc were last assessed in 2013 and had significant rates of mortality (Figure 26). Plots in the ESSFwc and ESSFmw generally had intermediate rates of mortality. However, the ESSFwc, there was geographic variation and

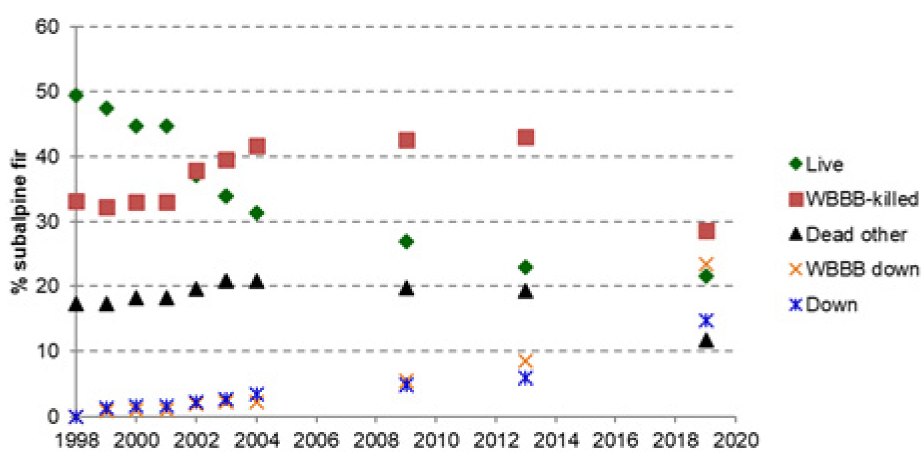



Figure 25. Mortality and fall down over time in the Sicamous Plot, 1998-2019.

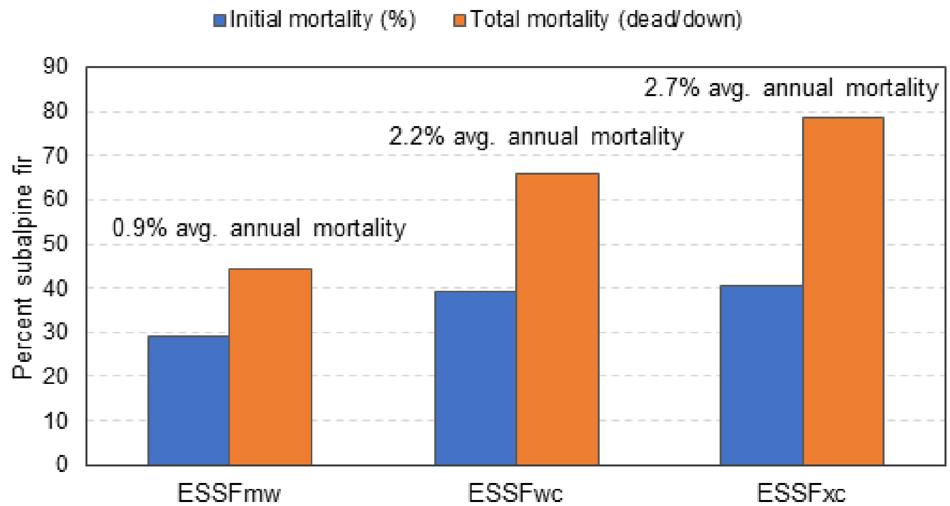



Figure 26. Percent dead subalpine fir (standing dead and down), by BEC, at establishment and at the most recent assessment. Six plots were assessed in 2019 and the other five plots were last assessed in 2011 or 2013.

some plots had very high mortality. The ESSFwc is the most predominant ESSF subzone in the Thompson/Okanagan Region.

The basal area (square meters) per hectare of subalpine fir in the plots has declined in two of the BECs (ESSFmw and ESSFwc) and has increased very slightly in the very dry, cold ESSFxc the past twenty-one years. In the Sicamous plot, the decline in live subalpine fir basal area is drastic (Figure 27); since establishment in 1998, there has been a 10.3 $m^2$ per hectare decrease in subalpine fir basal area. As of 2019, most of the original subalpine fir basal area of this plot is dead or down, with IBB being the dominant damaging agent.

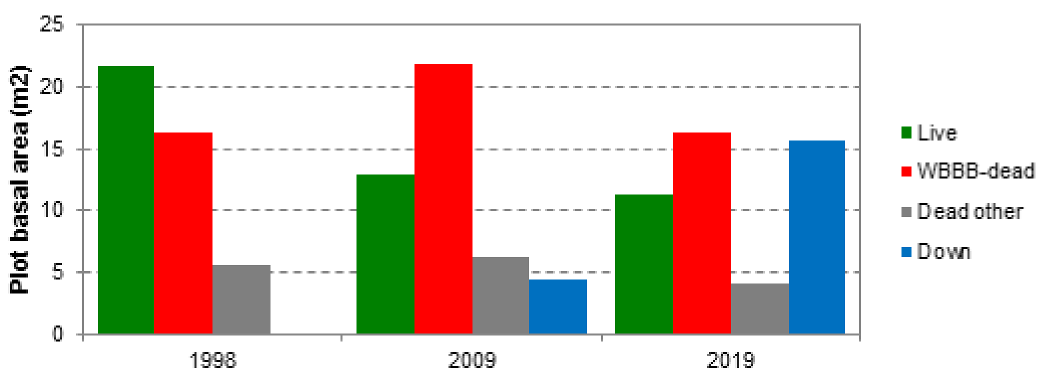



Figure 27. Basal area in the Sicamous Creek plot (square meters) of live, dead and down subalpine fir

Other damaging agents were also observed including root disease, animal damage, top breakage and balsam bark weevil, *Pissodes striatulus*. The balsam bark weevil was recorded in all plots assessed in 2013 and 2019, both in combination with IBB and as the sole mortality agent.

A full report will be prepared in 2020 when the remaining plots have been assessed.

# Soil disturbance and juvenile Douglas-fir growth following stump removal on the south coast

*Stefan Zeglen, Forest Pathologist, Coast Regions*
*Paul Courtin, Research Soil Scientist, Coast Regions (retired)*

One of the most contentious options for treating root disease infested areas is inoculum reduction in which machinery is used to remove tree stumps after felling (commonly referred to as stumping or destumping) or trees are felled by pushing or pulling them over with the root system still attached (push falling or whole tree harvesting). Due to the mechanization required, inoculum reduction is often viewed as being detrimental to the site due to the soil disturbance involved and the potential for soil degradation to occur even though reviews of studies have shown that these methods can offer effective control of root disease. The root diseases of most concern to us for this study are *Armillaria ostoyae* and *Coniferiporia sulphurascens*, both common on the south coast.

The degree of soil disturbance specific to stump removal can vary depending on the equipment used and the procedures involved. For example, employing bulldozers versus excavators, inverting stumps into the hole or windrowing, root raking, or blade scarification during stump removal will vary disturbance type and amounts. Soil physical properties play an important role. Soils prone to compaction or with high moisture contents will result in greater disturbance levels. In contrast, coarse-textured soils may not show any disturbance difference regarding tree growth between treated and untreated areas. Previous reviews evaluating tree growth following stump removal have shown variable results.

If a harvested area is infected with root disease, soil disturbance limits are circumvented by the necessity to remove infected stumps; however, the objective of soil conservation to limit soil disturbance should be attempted, regardless of the necessity to meet a forest health or stand productivity objective. To accomplish this, monitoring amounts and types of disturbance on stumped sites needs to be initiated, and current soil disturbance surveys should be expanded to differentiate disturbance from treatments such as stump removal from that caused by logging practices. This will reveal what background levels of disturbance are to be expected. In combination, contrasting tree growth assessments with treatment disturbance will help determine long-term effects on stand productivity.
The approach taken in our study is to compare areas treated with stump removal versus adjacent untreated areas across various locations in coastal BC. The objectives for this study were (*i*) to test the current soil conservation survey classification methodology to determine if it adequately captures the types of soil disturbances created by stump removal activities, and (*ii*) to test if these types of soil disturbances resulted in differences in young tree growth response in the 10 years following planting.

Our trial consisted of five sites with a treatment and control plot at each site. Four sites are located on eastern Vancouver Island and one site is on the BC mainland. These sites were selected due to their similarities in stand origin (previously logged), composition (primarily Douglas-fir), soil type, availability following recent harvest within one year, and presence of root disease in sufficient quantity to have required part of the harvested area to be treated by stump removal. Keeping the sites all within the same biogeoclimatic subzone helped reduce complications from large differences in environmental attributes such as annual precipitation or temperature. All sites are within the very dry maritime Coastal Western Hemlock subzone (CWHxm) in the eastern or western variants (CHWxm1 or CWHxm2).

The sites were logged in either 2006 or 2007 using feller–bunchers. The trees were either hoe-forwarded or grapple-skidded to the roadside. Each site contained areas where a stump removal treatment was performed using an excavator because of high root disease incidence determined by a pre-harvest survey. Two types of surveys were carried out to assess disturbance on each harvested area. A soil disturbance survey was used to tally various disturbance categories to assess compliance with soil conservation guidelines. Total disturbance included any disturbance that the surveyor can see on the ground, including counted disturbance plus disturbance that either does not meet the criteria of counted disturbance or is not counted because the hazard rating is too low. Counted disturbance differs from total disturbance and includes those categories always counted (i.e., regardless of soil sensitivity hazard rating): corduroyed trails, excavated bladed trails, deep gouges, long gouges, wide gouges, very wide scalps, deep ruts, and some disturbance types that may or may not be counted depending on the hazards. To better assess effects on tree growth, planting microsite surveys were also done for each tree used in the study. At each site, paired 25 × 25 m measurement plots were placed within treated and adjacent untreated areas. Tree growth measurements (height, diameter, seedling condition) were recorded for each tree at establishment and in the autumn of each year for the first 3 years and then on the 5th, 7th, and 10th years following planting.

From our results, total soil disturbance was 20%–46% greater, whereas counted disturbance was 8%–11% greater for treated versus untreated areas. There were 37%–63% (mean = 51%) more intact forest floor planting microsites in untreated areas. The majority of mineral soil microsites which Douglas-fir, as a pioneer species, prefers occurred in the treated plots. Deposits of mineral soil over intact forest floor was exclusively found on treated sites. Over 90% of these deposits occurred around the rim of the stump hole as soil was displaced during the stump extraction process in addition to soil falling away from the roots as they were lifted. Significant differences exist in the soil disturbance experienced between treated and untreated areas of the stands but did this difference affect seedling survival or growth?

Most planted trees survived to the 10-year mark with a combined mortality rate of 3.1% in the treated plots (10 of 324 trees died) and 8.8% in the untreated plots (24 of 274 trees died). Mortality due to root rot, primarily *Armillaria*, accounted for 17 of the 24 dead trees in the untreated plots and 10 more succumbed to drought across both treated and untreated plots. Mean 10-year tree growth parameters (i. e., height and dbh) were higher for treated plots, but none significantly (Figure 28). The percentage height advantage of trees growing on treated versus untreated plots was 10%, 16%, 21%, and 19% at years 3, 5, 7, and 10, respectively. These differences were significant at ages 3, 5, and 7 years after planting.

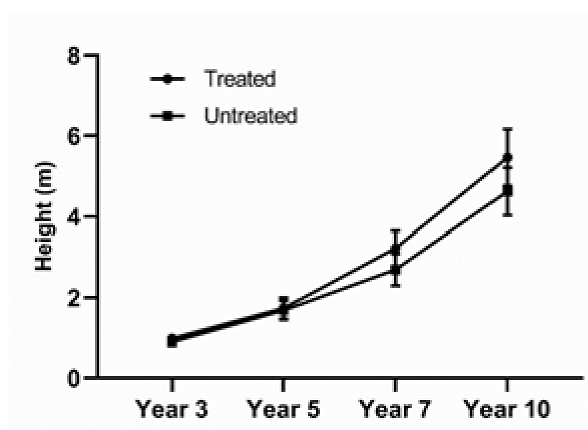


Figure 28. Mean height (with standard errors) for treated and untreated plots at 3, 5, 7, and 10 years after planting across all sites.

The sites chosen for the study were typical of those areas most affected by root rot in second- and third-growth coastal Douglas-fir stands. Although numerous other studies convey conflicting results as to whether stump removal has a positive, negative, or neutral effect on planted trees, our results indicate that, in the first decade at least, treatment by stump removal had a neutral to positive effect on coastal Douglas-fir. The inclusion of survey codes unique to the process of extracting stumps helps better categorize the amount and cause of soil disturbance. Being able to specifically identify holes, berms, or deposits created by extracting stumps as opposed to trying to fit those disturbances into categories related to logging more accurately conveys disturbance related to disease treatment and site preparation rather than timber extraction. It can also help define permissible limits of disturbance as opposed to that which is avoidable and undesirable.

More detail on this study can be found in the Canadian Journal of Forest Research article cited on page 81.

## Spruce beetle update – view from the ground

*<u>Jeanne Robert</u>, Forest Entomologist, Omineca and Northeast Regions*

A spruce beetle outbreak was declared for the Omineca Natural Resource Region in fall of 2015. By the fall of 2017, the provincial forest health survey identified a combined area of approximately 500,000 hectares of which just over 370,000 hectares were found in the Omineca Region. The Ministry of Forests, Lands and Natural Resource Operations and Rural Development (FLNRORD) appointed an Omineca spruce beetle operations coordinator and committed approximately 1 million dollars a year to the issue in 2016, 2017, 2018, and 2019. Forest industry representatives and government developed an annual joint action plan and significant management efforts have taken place principally in the Mackenzie and Prince George Natural Resource Districts.

This year, the spruce beetle outbreak continues in the area North of Prince George and around Mackenzie BC, with increasing populations also occurring in the Northeast Region. In locations within the main outbreak area, pockets of populations remain very high. In these areas, attack of unusually small diameter trees is occurring. Although many of these attacks on small diameter trees are unsuccessful, live beetles were found in some in November 2018 (Figure 29). In many of these areas, the larger dominant spruce are already dead.

Figure 29. Photos of small diameter trees attacked near Bear Lake BC (at the southern edge of the outbreak area). Left panel – a tree as small as 14 cm diameter showing signs of unsuccessful attack. Middle panel – frass collecting from a successful attack on a 16.4 cm tree in the same location. Right panel – immature adults of a one-year-life cycle beetle alive and well in a 17cm diameter tree.

## Swiss needle cast monitoring plots

*Stefan Zeglen, Forest Pathologist, Coast Regions*

With concern rising over the possible impacts of Swiss needle cast (SNC; causal agent *Nothophaeocryptopus gaeumannii*) on coastal Douglas-fir, in 2019 we have completed the monitoring network for this disease. There are now forty-three 0.08 ha plots spread across three subzones on Vancouver Island and the Lower Mainland. This network will help us track defoliation of Douglas-fir by the disease and capture tree response over the next decade.

Over the last three years of plot installation, foliar retention was measured on plot trees along with their physical attributes. Samples were taken to conduct genomic analysis of the pathogen and this has already led to the discovery of two distinct lineages of the fungus on the coast (from BC to Oregon) versus one lineage found in the interior. Our UBC collaborators Nicolas Feau and Sheryl Yin are conducting more detailed genetic analysis of our samples to determine variation within single tree crowns. We have also collected foliage and soil samples to determine if nutrient availability or uptake play a role in tolerance or expression of the disease.

A graduate student, Naomie Herpin-Saunier, has started work at the Laurentian Forest Centre in St Foy, QB using some of our data to develop a predictive model for SNC. She hopes to describe variations in disease severity between sites and create statistical models to associate disease response to tree, site and meteorological variables. Fourteen of our monitoring plots have weather stations that collect microsite data on air temperature, relative humidity, solar irradiance and leaf wetness. Using these and other site variables we hope to determine what factors are important in predicting the risk of SNC for certain site types. Now that plot installation is complete, the five-year re-measurements are scheduled to begin in late 2021.

## UNBC honours student compares mule deer and wildlife use of root rot centres and adjacent non-root rot affected Douglas-fir forests in Mule Deer Winter Range in the Cariboo

*David Rusch, Forest Pathologist, Cariboo and Thompson Okanagan Regions*
*Brendan Carswell, UNBC undergraduate student*

UNBC undergraduate student Brendan Carswell, working under the direction of Professor Roy Rea, compared mule deer and other wildlife usage of Armillaria and laminated root rot centres and adjacent non-root rot affected mature Douglas-fir stands. The study was conducted at three separate sites in the transition snow pack zone in mule deer winter range in the SBSdw1 biogeoclimatic zone (northeast of Williams Lake). Two of the sites were located in the Alex Fraser Research Forest and the other was in the Williams Lake Community Forest.

Mule deer winter range (MDWR) in this area is often located on lower elevation south facing slopes dominated by mature Douglas-fir. These stands tend to be warmer and have lower snow packs then surrounding forest types, reducing mule deer winter energy requirements. In addition, mature Douglas-fir needle litter and needles and lichens from broken off branches are an important food source for mule deer during periods of deep snow. Because this is close to the northern limit of Armillaria and laminated root disease, south facing Douglas-fir forests are also where Armillaria and laminated root disease most commonly occur in the area.

A number of methods were used to compare vegetation, coarse woody debris, winter snowpack depth, and wildlife usage in the root rot and adjacent non-root rot areas. Wildlife cameras were one of the main methods used to compare wildlife usage. Root disease centres were highly variable in terms of vegetation and crown closure, but root disease had some major overall effects on tree species composition and stand structure. The root rot areas had significantly more shrubs and deciduous trees, and significantly less crown closure and Douglas-fir basal area over 12.5cm diameter at breast height. These differences in tree species and stand structure significantly affected snow depth during the winter months. There was no difference in the amount of coarse woody debris, but root rot centres had significantly more tree cavities and animal dens. During the snow free and deep snow period (snow depth over 40 cm) mule deer used the root rot centres significantly less than the adjacent healthy mature Douglas-fir stands suggesting that snow depth is a factor limiting the use of root rot centres by mule deer during the winter. Despite the reduced use by mule deer during the deep snow period, evidence from this study suggests that root disease centers are an important source of structural and plant species biodiversity and provide important habitat for primary and secondary cavity nesters and possibly other species of wildlife.

The findings have important implications for mule deer winter range and root disease management, particularly on small area-based tenures. Opening size in transition snow pack MDWR is limited to openings less than 0.7ha in size and openings must be managed for 80% Douglas-fir species composition. This type of management is not conducive to root disease management for timber production and is unlikely to result in the desired stand level objectives for mule deer winter range where MDWR overlaps with root disease centres. In order to effectively manage for root disease, licensees must currently apply for an exemption to government action regulations that govern harvesting in MDWR and be able to demonstrate a net benefit to mule deer in order for the exemption to be approved.


*Images of wolves chasing a cow moose and calf were captured by a motion activated camera at one site.*

# Forest Health Meetings/Workshops/Presentations

## Bark beetle training courses throughout the Kootenay/Boundary Region

*Marnie Duthie-Holt, Regional Entomologist, Kootenay/Boundary Region*

Numerous bark beetle ground survey and management courses were held throughout the Kootenay/Boundary Region including locations in Cranbrook, Castlegar, Golden, Revelstoke, and Rock Creek. Courses ranged in length from a ½ day to 2 days, with over 200 participants in attendance from BC MFLNOROD, First Nations, Parks Canada, BC Parks, Major Forest Licences, Community Forest Groups, Woodlot Licensees, Forestry Consultants, and the general public. Participants gained skills in bark beetle (mountain pine, Douglas-fir, and spruce beetle) biology and identification, and various survey and management techniques both in the classroom and field. Additional courses are planned for 2020.

*Bark beetle training course*

## Biology, history and management of the Douglas-fir tussock, *Orgyia pseudotsugata*

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

**Venue:**
Anarchist Mountain Community, BC, September 26th, 2019

**Abstract:**
Anarchist Mountain is experiencing an outbreak of Douglas-fir tussock and this presentation focused on describing the history of tussock moth outbreaks in BC, the biology and life history, the human health issues and options for management, both for government and private landowners. There was approximately 40 people in attendance.

## Blister rust infection trends and distribution in southern British Columbia's endangered whitebark pine

*Michael Murray, Forest Pathologist, Kootenay/Boundary Region*
*Randy Moody, Director, Whitebark Pine Ecosystem Foundation Canada*

**Venue:** Genetics of Five-needle Pines & Rusts of Forest Trees, International Union of Forest Research Organizations (IUFRO), Invermere, BC, July 22-26, 2019.

**Abstract:**
In 2020, long-term forest health monitoring of endangered whitebark pine enters its twenty-first year in British Columbia. The Province of BC maintains 18 long-term forest health monitoring plots. Results indicate a continuous decline in healthy trees in Southeast BC primarily due to blister rust and mountain pine beetle. Along with this Provincial network, there are dozens of ancillary surveys and monitoring transects that have been conducted at additional sites. Combined data indicate that both blister rust infection and mortality rates differ across the pine's range in southern BC. In the southeastern corner, most live trees are infected, whereas the West Chilcotin area supports very low levels of incidence. Overall mortality rates due to all forest health agents appear to be highest in southeastern BC where greater than 80% of standing trees are dead at many sites. Highly impacted stands in southeast BC may provide the best opportunities for selecting rust resistant parents for recovery efforts.

## Cariboo and Thompson/Okanagan Regions Root Disease Training

*David Rusch, Forest Pathologist, Cariboo and Thompson Okanagan Regions*

Six root rot training workshops were put on this year and are listed below along with the location and approximate number of participants (in brackets). Attendees learned about root disease management and got hands on experience identifying Armillaria and laminated root disease in the field. The Merritt workshop had the best turnout. Training occurred on the first snowfall of the year in early October so participants had the opportunity of identifying root disease under 30cm of snow. If you are interested in pathology training in the Cariboo or Thompson/Okanagan Regions for the upcoming year, book now!

1. Root rot Training for Kamloops VRI/YSM contract managers – Barriere (4)
2. BCTS layout contractors and contract managers– Quesnel Lake (8)
3. Root rot training for Thompson Rivers Resource District – Kamloops (8)
4. Root Rot Training for Cascades Resource District – Merritt (25)
5. Root Rot Training for Cariboo Chilcotin Woodlot Owners - Big Lake (5)
6. Root rot training for Likely Community Forest – Likely (6)

## British Columbia's forest landscape: managing in a different ecological state. Insect outbreaks & everything else.

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

**Venue:**
Western Forest Insect Work Conference, Anchorage, Alaska, April 22 – 25th, 2019

**Abstract (Plenary Speaker):**
At the peak of the BC mountain pine beetle outbreak in 2007 over 10 million hectares were under attack. In total the outbreak impacted over 14 million hectares and killed roughly one-half of the mature pine in BC. The forest area disturbed by mountain pine beetle greatly exceeds the area disturbed by harvest, fire, and all other factors totaled over many years. How many times in the past two decades have we heard the phrases – the largest outbreak ever; the most severe; unprecedented? The answer is - far too many times and experts predict these dire statements will continue if more urgent action is not taken.

BC is home to many insect pest species and innumerable interactions of abiotic and biotic factors – no different than what is being experienced throughout the Pacific Northwest. Insects represent the dominant natural disturbance factor in Canada's forests. Management and research have largely been focused on outbreaks and not the stressors that *propel* insects from "background noise" to tree, stand, landscape-level killing episodes.

This talk focussed on some of the changing ecology observed in BC, moving from high elevation through to mid- and low-elevation sites. Insect impacts are most noticeable in high elevation forests (spruce, subalpine fir, white bark pine) but our mid- to low-elevation forests are struggling with multiple damaging agents, both biotic and abiotic. I highlighted some issues and some basic premises for moving forward and mitigating losses.

## Drought impacts and mitigation - coast

*Stefan Zeglen, Forest Pathologist, Coast Regions*

**Venue:**
Provincial Stewardship Meeting, Richmond, BC, October 30, 2019

**Abstract:**
The 2018 provincial overview survey reported over 19,000 ha of drought damaged forests on the coast, an amount over eight times the five-year average. Is this the new normal? Since 1998 the frequency of years experiencing periods of extended summer drought has increased resulting in localized die offs of some

*Drought-affected western redcedar on the shores of Hannah Lake, Chilliwack District.*

species like western redcedar. Weather data from expressive drought years like 1998, 2017 and 2018 was compared to the 1971-2000 normals. Each of those years had a period of extended summer drought combined with higher than average maximum daily temperatures. Somewhat surprisingly, for each of those drought years the amount of annual precipitation was from 1 – 9% greater than the average. This reinforces that it's not just the amount of precipitation but the timing that is critical to determining drought impact. Western redcedar, due to its physiology and growth habit, is particularly susceptible to extended drought, especially on coarse-textured, well drained soils with low moisture holding capacity and infrequent refresh. If the trend to prolonged summer drought continues, it is not recommended to plant western redcedar on sites drier than moist or fresh on the coast since growth loss (or mortality) during drought years may not be compensated for in drought-free years.

## Drought – it can't happen here

*Stefan Zeglen, Forest Pathologist, Coast Regions*

**Venue:**
Coastal Silviculture Committee Summer Workshop, Pemberton, BC, June 2019

**Abstract:**
At a field stop a brief presentation was given on the current trend toward droughty summers on the coast. Weather data was presented to describe the increasing frequency of warmer than average and drier than average spring, summer and fall months since 1998. The tendency has been toward prolonged periods of low or no precipitation during July, August and September in particular. Consecutive dry years of 2017 and 2018 have led to the abundant dieback of western redcedar apparent throughout the region.

## Forest Health: insects affecting our forests and implications of climate change

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

**Venue:**
Kamloops Adult Learners group (approximately 50 attendees), Kamloops, BC, October 28th, 2019

**Abstract:**
BC has many native insects that periodically reach outbreak levels and damage or kill small or vast areas of forest. Over the past few decades, we have been experiencing more frequent and more severe insect outbreaks, most notably the mountain pine beetle. The recent drought event of 2017 has even further exacerbated the health of our forests.

I introduced them to many forest insects and their response to climate and forest management. I linked the cumulative influences that are affecting our forests and some options we may have to manage those negative impacts.

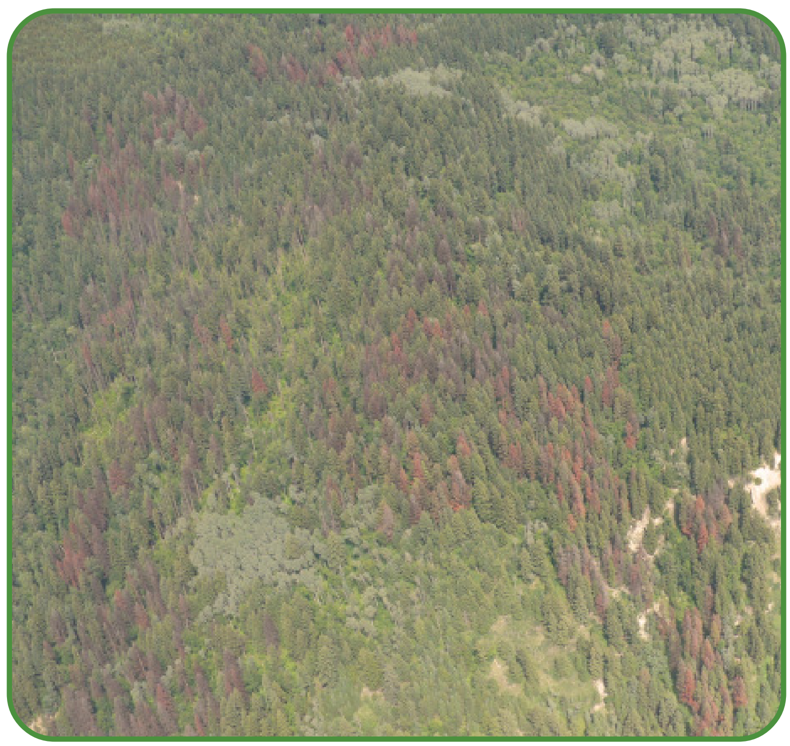
## Forest health resilience in an era of mega-disturbance

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

**Venue:**
ABCFP annual meeting, Kamloops, BC, February 6th, 2019

**Abstract:**
The inventory of mature forests is declining in part due to planned harvesting and regeneration, and in part due to natural (expected) mortality. In the past two decades we have experienced accelerated rates of mature forest mortality due to effects of climate change influencing insect and pathogen outbreaks, drought and wildfire. The forest and pest dynamic have never been stable, yet it has taken mere decades to disrupt this delicate system far beyond known historic associations. Climate change has caused stress to forests, wildlife and even insects. In the short term many insects take advantage of the changed, warmer conditions and stressed hosts. However, it is well documented that the diversity and abundance of some insect fauna is decreasing globally at an alarming rate. Although disturbances such as fire and native insects can contribute to natural dynamics of forest health, exceptional droughts, directly and in combination with other disturbance factors, are pushing some temperate forests beyond thresholds of sustainability. Insects and diseases adapt quickly and could respond to climate change faster than their long-lived hosts. Pest species are expected to expand, contract and shift their ranges; the number and variety of forest pests is expected to increase, and pest outbreaks are expected to be more common.

BC's mature forest inventory is aging and becoming increasingly susceptible to insect and pathogen outbreaks (e.g. bark beetles, *Dothistroma*). Plus, the area of mature forests is decreasing so it is more imperative to slow the mortality caused by insect outbreaks in mature forests. But more troubling is the increase in both incidence and impact severity of pests in our regenerating forests. We must be more diligent, thoughtful and targeted in addressing forest health going forward.



*Douglas-fir beetle mortality and aspen leaf miner defoliation*

## Forest health: the pulse of BC's forests

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

**Venue:**
Science to Policy Forum, Pacific Forestry Centre, Victoria, BC, November 19th – 20th, 2019

**Abstract:**
The Province and Canada strive to have healthy, resilient forests of all ages across the landscape. However, there are numerous native and non-native insects and diseases and climate-driven events that continue to damage trees and forests. Disease and insect defoliators, weevils, parasitic plants, stems cankers, bark beetles and many others affect both conifer and deciduous species in BC. Some affect form, height or incremental growth, predispose hosts to attack by other insects or pathogens, cause top-kill or kill trees. The health of forests has repercussions to all other functions.

BC has experienced numerous outbreaks over the past 100 years, and the frequency, amplitude and impact of future outbreaks is only expected to increase with changed climatic conditions, more pressure put on our forest resource, and stress to forested ecosystems. Each successive bark beetle, defoliator or disease outbreak is larger and behaves differently from past outbreaks. Forests are becoming more constrained and fragmented, creating barriers to proactive or pre-emptive management efforts. The Province excels at detection, but management still is in the reactive phase. We need new and innovative tools to better address emergent issues and the only way to adequately to accomplish this goal going forward is to re-invigorate the valuable partnerships of Provincial and Federal agencies and support collaborative research.

## Forest health training and presentations - Thompson/Okanagan Region

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

**Venue:**
Various locations, Thompson/Okanagan Region, 2019

**Abstract:**
Numerous forest health training sessions and presentations were given in 2019. The training was focused on bark beetles (Douglas-fir beetle, western balsam bark beetle), defoliators (Douglas-fir tussock moth, western spruce budworm) and pests of young stands. The training was mainly field oriented with a few classroom sessions and were typically one day in duration. Training sessions were given to FLNRORD and BC Timber Sales staff, First Nations, Woodlot Licensees, consultants, BC Institute of Technology, Vancouver Island University, other university groups and the general public.

Over a dozen talks were presented at a variety of venues during 2019 to management groups, scientific forums and special interest groups.

## Fourth Annual Bark Beetle Summit

*Jeanne Robert, Forest Entomologist, Omineca and Northeast Regions*

**Venue:**
Prince George Courtyard by Marriott Hotel, BC, November 13 – 14th, 2019

**Abstract:**
An integral part of the BC government's approach to the upswing in spruce beetle populations is the role of disseminating accurate and appropriate information to the public, to First Nations people, to forest professionals in industry, and internally within the public service. These groups are the target audience for our 4th annual Bark Beetle Summit. The Summit was designed to keep current research and new ideas for managing spruce beetle at the forefront of FLNRORD operations and outreach.

This 4$^{th}$ annual two-day summit continued to explore the top issues faced by government, industry, communities, and by First Nations concerned about bark beetle outbreaks. In 2019, a range of experts were invited to share knowledge on the four major bark beetles affecting British Columbia: Mountain pine beetle, spruce beetle, Douglas-fir beetle, and western balsam bark beetle. One of the highlights of this year's summit included a panel of local mayors presenting on the top bark beetle issues for their communities. Scientists, industry, and non-government organization representatives presented information and updates on each of the four major bark beetles.

## Intensive silviculture and forest insects. Which came first?

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

**Venue:**
SISCO (Southern Interior Silviculture Conference), Kamloops, BC, January 21$^{st}$, 2019.

**Abstract:**
BC forests are experiencing more frequent, and often more severe, episodes of biotic and abiotic stressors. Recent wildfire and drought events are just two examples of climate change that are likely to increase in frequency and severity. Both stressors can increase tree attractiveness to insects by altering cues used to identify potential hosts. The performance and impact of insects during and following drought and fire differ depending upon food substrate (phloem, foliage), feeding guild (bark beetles, defoliators, sucking insects), duration and severity of stress, and host defenses, among other factors. Climate induced events are expected to affect herbivorous insects through direct impacts to their development and survival, and/or indirect impacts mediated through host response. Some direct and indirect impacts that we need to anticipate, and address include: change to insect reproduction cycles; range expansion or contraction; reduced pest mortality from natural enemies; novel host-plant insect associations; behavioral changes (increased levels of migration); and establishment of non-native insects.

My presentation focussed on current and imminent insect issues; their population trends; and how we must change our approach to pest management by initiating more adaptive measures and quicker reaction times to these episodic events. Increased monitoring at the insect, host and forest landscape are key to improving future management regimes. Research into the biology and adaptive mechanisms of insects to changing climate, improved disturbance management and an open flow of policy advice and information is paramount to more adaptive, responsive and resilient management approaches to managing our forested ecosystems.

## Presentations at the National Pest Forum and Forest Pest Technology Workshop

*Tim Ebata, Forest Health Officer, Resource Practices Branch*

**Venue:**
Downtown Marriott Hotel, Ottawa, Ontario, Dec. 2-5th, 2019

**Abstract:**
At this annual meeting of provincial, territorial and federal forest health specialists, I gave three presentations entitled: 1) Young Stand Forest Health: Incidence vs Impact; 2) gypsy moth eradication in BC – how long can we keep this going? ; and 3) the 2019 BC Forest Health Conditions Report. The first talk described the general process in which forest health damage is recorded and assessed in BC and it was an opportunity to learn about impact assessment methods used in other jurisdictions (short answer: not many do). The second presentation followed the workshop's theme of declining capacity in forest health operations nation-wide and I described the status of BC's gypsy moth eradication program's limited resources. The final presentation was the annual forest health conditions report based on the earliest draft of the 2019 aerial overview survey results and provincial forest health program updates of interest to a national audience.

## Provincial Forest Health Meeting

The Forest Health Program organized a face-to-face workshop with branch, regional and district forest health specialists. Forty-eight ministry staff attended the two-day workshop with the intent to share knowledge among branch, regions and districts, and for regional specialists to provide leadership on forest disease and insect management at the district level. The main objectives of the meeting were to:

1. Outline district forest health priorities, activities and deliverables.
   - Each region had at least one district representative in attendance.
   - Representatives from one district in each region summarized their district forest health program and outlined what is working in their district and what needs improvements.
   - District programs varied among regions and within regions.

2. Identify district forest health challenges and work towards solutions.
   - Most districts requested more direction from regional specialists to support their forest health programs, and highlighted the importance of the support and training they receive from regional specialists.
3. Foster open lines of communications for district staff with regional and branch forest health staff.
   - The roles of forest health specialists at the branch and regional levels were reiterated.
   - Specific issues around information sharing/communication issues were addressed. Additionally, the budgeting process was outlined to ensure district staff understood how budget allocations were made.
   - An update on the latest proposals to amend the *Forest and Range Practices Act* and Forest Planning and Practices Regulation was presented along with a timeline and milestones.
4. Cover a wide-range of forest health topics in the field.
   - Lorraine MacLauchlan and David Rusch organized a one-day field tour to discuss climate change, fire-pest interactions, drought, bark beetles and declines.
   - The field tour focused on identifying specific abiotic/biotic forest health agents, the impacts and management options.

## Subalpine fir decline, bark beetles and climate change

*Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan Region*

**Venue:**
Bark Beetle Summit, Prince George, BC, November 13th – 14th, 2019

**Abstract:**
The western balsam bark beetle (WBBB) is considered the most destructive insect pest of subalpine fir. WBBB attack occurs in scattered, aggregated pulses year to year over susceptible landscapes. Cumulative mortality can be very high. Aggregations of mortality could be dependent on the occurrence pattern of susceptible trees in stands and susceptibility is changing due to rapidly rising temperatures and more frequent drought years.

WBBB and disease play key roles in the succession process by creating gaps that can be re-occupied by regeneration. The continual production and filling-in of these small gaps is a slow process which is fundamental in self-perpetuating climax old-growth forests where the general overstory canopy remains in place but may swing between spruce and subalpine fir. Changing climate over the past 20 years has changed the attack dynamics, canopy matrix and successional process in these forests.

Subalpine fir forests are aging, and mortality is expected. However, mortality rates over the past decades have increased, tree resilience has declined, and new mortality agents observed. This trend is being mirrored in other ecosystems. Climate is causing more widespread, eruptive and severe outbreaks over large areas. There are increasingly more dead trees on the landscape which has negative effects on carbon sequestration and future conditions.

## Spruce beetle survey courses

*Jeanne Robert, Forest Entomologist, Omineca and Northeast Regions*

**Venue:**
Prince George, BC, Fall 2019

**Abstract:**
During the fall of 2019, FLNRORD offered an additional spruce beetle surveying course in Prince George, BC. The two-day course included classroom information on spruce beetle biology, on management tools and approaches, on signs and symptoms of attack, and on the standardised survey techniques and reporting as well as a field survey training day.

In 2020, I plan to train at least two additional certified FLNRORD survey instructors located in the more remote communities of the Omineca and Northeast Regions, so that additional, local courses can be efficiently provided as needed.

## Swiss needle cast, Douglas-fir and you

*Stefan Zeglen, Forest Pathologist, Coast Regions*
*Lucy Stad, Stewardship Forester, Chilliwack District*

**Venue:**
Provincial District Managers Meeting, Chilliwack, BC, September 25, 2019

**Abstract:**
An overview of Swiss Needle Cast (SNC; *Nothophaeocryptopus gaeumannii*) was presented including interesting factoids about the disease and its impact on tree growth and implications for management of Douglas-fir. A review of the ongoing situation in Oregon was provided including a summary of the research conducted there over the last 20 years into disease impact and management strategies to mitigate damage. The coastal SNC monitoring plot network was explained and summary of findings from monitoring lines placed in the Chilliwack District in 2014 and 2015 was given. Overall, the dry spring weather in 2017 and 2018 appears to have provided a slight to notable boost to foliar retention (0.5 – 1.0 years additional retention) in some areas of the district. Given the infection cycle of SNC this was an expected but welcome confirmation of disease behaviour. Future data from the monitoring plots should help build a better understanding of how the disease acts in our geographically diverse south coastal forests.

# Forest Health Publications


Boone, C.K., N. Berkvens, J. Sweeney, F. Stephen, **L. Maclauchlan**, B. Bentz, A. Drumont, B. Zhao, H. Casteels and J. Grégoire. 2018. Traps and lures developed in Europe are effective in detecting *Monochamus* vectors of the *Bursaphelenchus xylophilis* exotic to Belgium. Journal of Pest Science. https ://doi.org/10.1007/s1034 0-018-0954-4.

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

**Woods, A.J**. and Watts, M. 2019. The extent to which an unforeseen biotic disturbance can challenge timber expectations. Forest Ecology and Management 453 117558.

**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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| | |
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Aaron Benterud (Red-cedar drought tree)
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