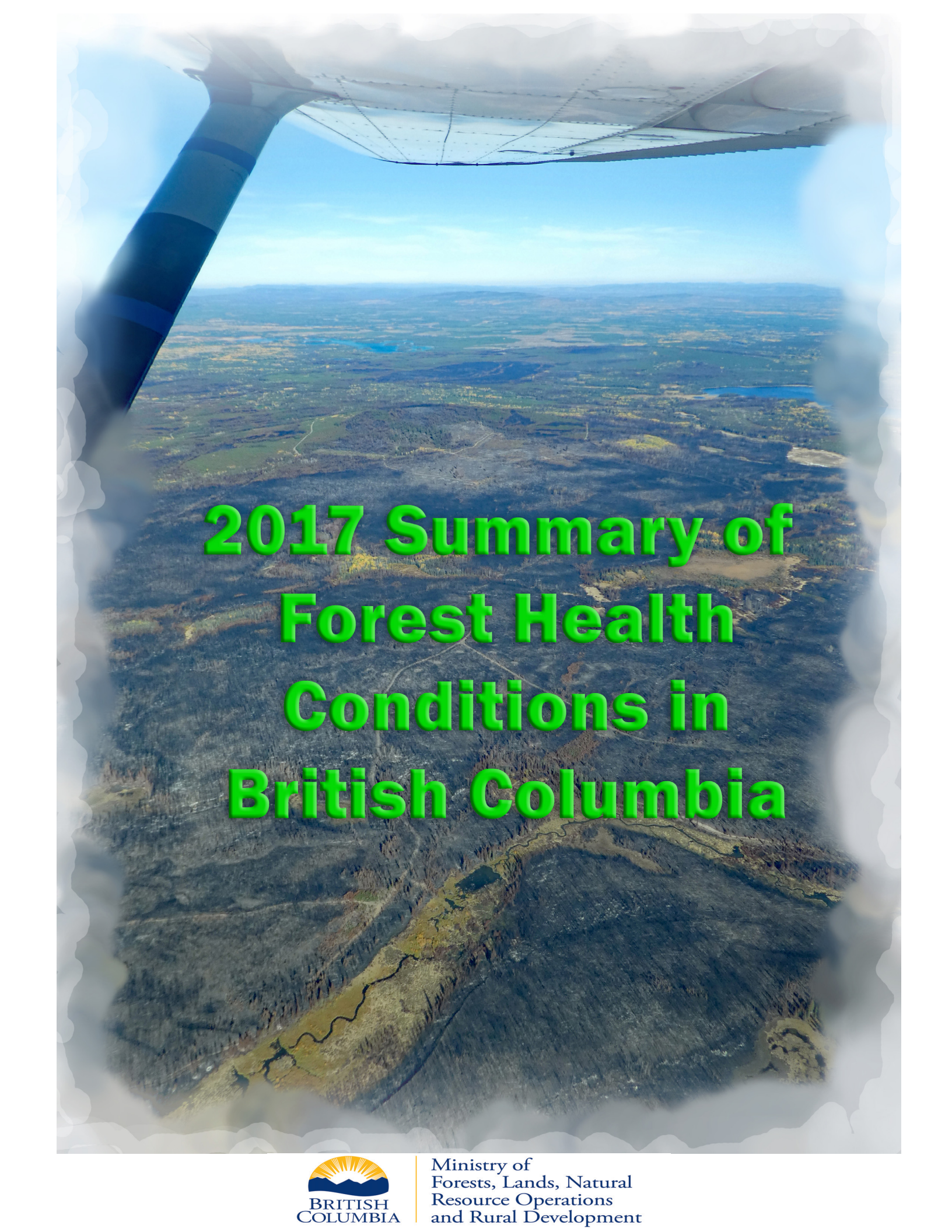




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Front cover photo by Joan Westfall: Wildfire damage south of Williams Lake

2017 SUMMARY OF FOREST HEALTH CONDITIONS IN BRITISH COLUMBIA

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SUMMARY

The *2017 Summary of Forest Health Conditions in British Columbia* (BC) is a compilation of forest health data obtained from the 2017 provincial aerial overview survey (AOS) and other BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD) sources. The AOS data was the primary source for reporting on damaging agents, but this material may have been augmented by detailed helicopter surveys, forest health ground surveys, laboratory examinations of damage samples and ground observations by trained personnel. Special projects, meetings, presentations and publications conducted by FLNRORD entomologists, pathologists and their associates are also included in the final sections of this report.

Approximately 84% of the province was flown between July 4th and October 14th 2017 by 25 surveyors using ten aircraft companies. Total flight time was 701 hours. A total of seven million hectares (ha) of damage caused by at least 45 damaging agents was mapped on many different commercial tree species of various ages. This only included damage visible at the time and from the height that the AOS is flown, which is known to under-represent some damaging agents, particularly some diseases.

Bark beetles continued to damage the most area, with 4.4 million hectares of mortality detected. Mainly trace to light intensity western balsam bark beetle infestations affected 3.7 million hectares, with the largest disturbances located in northern BC. Spruce beetle damage rose to half a million hectares, with the majority of the attack continuing to occur in Omineca Region. Douglas-fir beetle damage rose to 119,096 ha, with the most of the mortality occurring in central BC. For the eighth consecutive year, mountain pine beetle attack declined, now to a low of 119,089 ha, which was primarily located in localized infestations at higher elevations.

Abiotic damage increased more than five-fold since 2016 to 1.4 million hectares. A record wildfire year was responsible for this increase with 1.2 million hectares burned, mainly in the southern interior. Post-wildfire damage diminished to 26,183 ha, primarily located in northern BC. Yellow-cedar decline damage remained stable with 56,563 ha delineated along coastal BC. Flooding damage, chiefly in Northeast Region, increased to 42,075 ha. Drought damage that resulted in mortality affected mainly western redcedar on 4,045 ha, though excessive needle shedding suspected to be a result of drought affected 3,571 ha of lodgepole pine and 3,800 ha of western redcedar.

Defoliation damage decreased provincially to just under one million hectares of damage. Deciduous trees (in particular trembling aspen) continued to be the most affected. Aspen leaf miner damage declined but still impacted 428,986 ha, primarily in the northern BC interior. Satin moth defoliated a record 160,085 ha, also mainly in the northern BC interior. Bruce spanworm infestations affected 4,456 ha in Dawson Creek TSA of Northeast Region. Two-year-cycle budworm was the most significant conifer defoliator with 376,100 ha attacked in the BC interior. Pine needle sheathminer damage decreased to 2,944 ha, all located in Cariboo Region.

Damage caused by diseases that were visible during the AOS continued to increase to 191,230 ha. Young lodgepole pine stands were most affected with 90,232 ha of *Lophodermella* needle cast and 69,243 ha of *Dothistroma* needle blight, with an additional 4,015 ha of damage most likely caused by one of those two agents. *Venturia* blight damage declined to 12,067 ha, observed primarily in Skeena Region. *Septoria* leaf spot damage in Great Bear Rainforest North TSA rose to 9,197 ha. Low intensity white pine blister rust damaged a record 3,752 ha and larch needle blight affected 2,169 ha.

Localized damage due to agents such as bear, slides, birch leaf miner and root disease were observed in small, scattered disturbances across the province as well.



Lophodermella needle cast damage in Kamloops TSA

2017 SUMMARY OF FOREST HEALTH CONDITIONS IN BRITISH COLUMBIA

INTRODUCTION

A wide variety of commercial tree species grow in British Columbia's (BC) diverse ecosystems. Forest management practices and natural disturbances also contribute to the province's forest complexity by influencing stand compositions, structures and tree ages. 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. Therefore, the aerial overview survey (AOS) is conducted annually across BC forests to record current damage in a timely and cost effective manner. All visible damage on commercial tree species is recorded by host, damaging agent, extent and severity during this survey. For the past 21 years AOS have been the responsibility of the provincial government, currently under the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNRORD).

When the AOS is complete, the data is digitized, reviewed and collated. 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. This damage is 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 cover the southern interior; and West Coast and South Coast account for the south coast of BC (Figure 1). In 2016 four coastal TSAs were merged/changed to create Great Bear Rainforest North and South TSAs. Since these TSAs are under special management constraints and the north TSA straddles two regions, they are considered an entity separate from the regions for this report. AOS summarization by the new TSAs began this year.



Collecting budworm larvae

Results are presented in this report by individual damaging agents, organized by host tree species. Some types of damage are not captured well by the AOS because they are either not visible at the elevation the survey is flown or because of the time period during which the survey is conducted. This includes many diseases, low-intensity insect defoliation, very scattered damage or understory damage. In these cases information 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 added to the AOS database unless necessary to fill significant gaps in the survey coverage. Insect population information (including pheromone-baited traps, larval and egg surveys, and tree branch beatings) and ground observations may also be discussed.

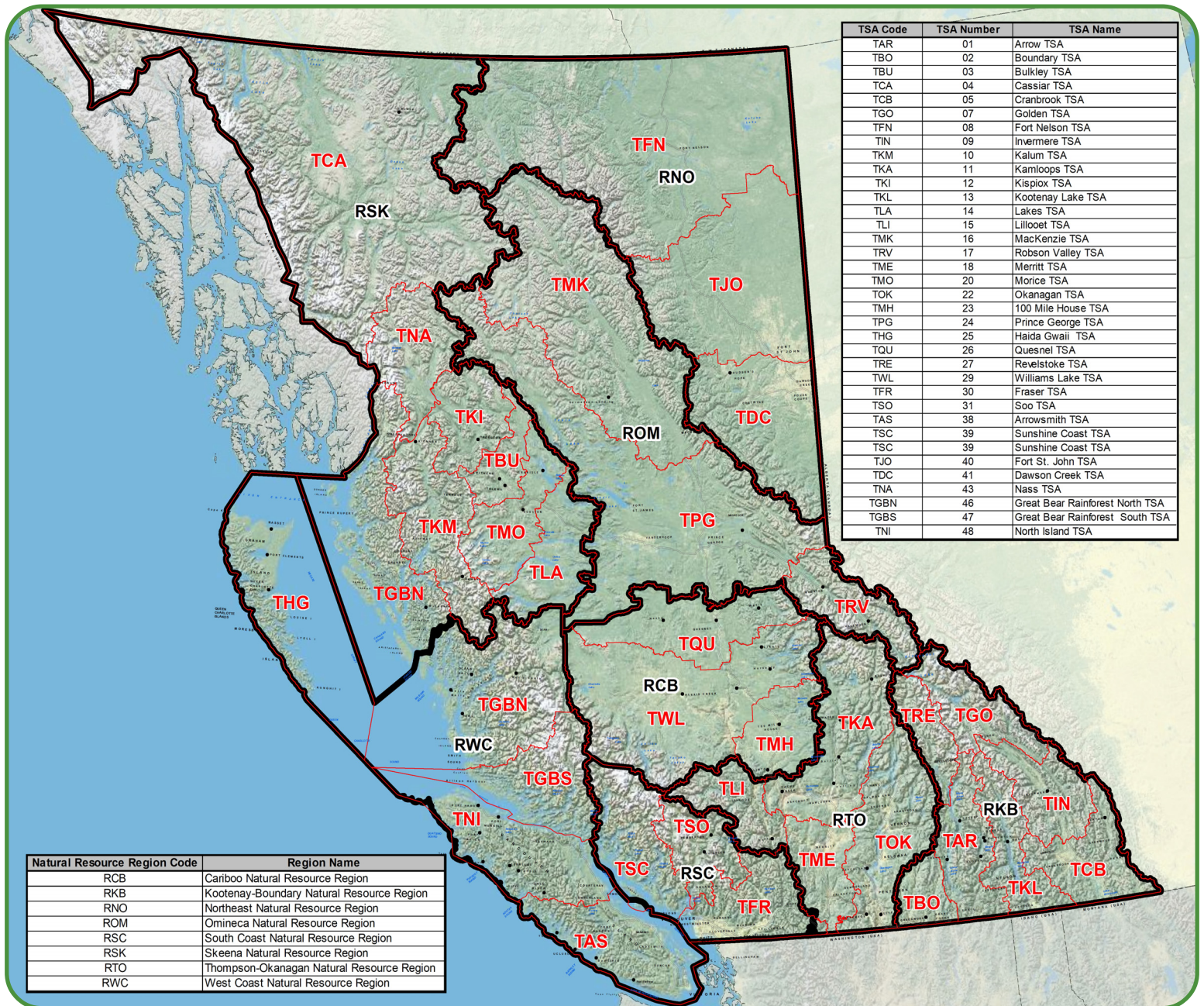


Figure 1. Map of British Columbia outlining Ministry of Forests, Lands, Natural Resource Operations & Rural Development Timber Supply Areas (TSAs) and Regional Boundaries.

Information obtained from the annual aerial overview survey is used by many interest groups including government agencies, industry, academia and the public. These uses include input into government strategic objectives, guidance for management and control efforts related to forest health, as a source for research projects, contributions to national indicators for sustainable forest management, input into timber supply analyses and input into the National Forest Pest Strategy *Pest Strategy Information System* (www.ccfm.org/pdf/PestStrat_infosys_2012_en.pdf). AOS data has also recently been included in discussions and analyses relating to 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 last year are documented after the damaging agent reporting section. Not all forest health activities conducted by FLNRORD staff or other agencies are necessarily captured. A more detailed annual report of forest health in the Southern Interior of BC and previous copies of this publication are also available at: <http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys/summary-reports>.

METHODS

Aerial overview surveys are conducted in small fixed-wing aircraft that are Ministry approved (Transport Canada licensed, approved maintenance schedule, appropriate insurance and experienced pilots). Two trained observers sit on opposite sides of the plane and map all visible damage. 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 for 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. 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.

Visible current forest damage 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 and roads). Upon flight completion, the



Aerial observer recording forest health damage

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, due to its superior dimensional stability. Various digital methods of 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 this recording method to date. Survey methodology and digitizing standards are available at: <http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys/methods>.

Surveys are conducted when damage from 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. This data is collated and disseminated weekly so coverage intensity and survey progress can be monitored. Surveys are conducted between 700 to 1400 m (2,300 – 4,600 ft) above ground level, depending on terrain and visibility. 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 from main drainages to the tree line. Aircraft speed ranges from 130 to 260 km/h (70 – 140 knots), depending on mapping complexity and wind speed.

All forested areas on the flight lines are surveyed 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 is difficult to obtain within the survey window, which is dependent on timing for damage visibility (e.g. damaged needles may drop off 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 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 denoted as points (referred to as spot infestations) with an estimated number of dead trees. 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, foliar diseases and some abiotic factors) usually cover relatively large areas. 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).

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.

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

Disturbance	Severity Class	Description
Mortality (bark beetle, abiotic, 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 and foliar disease)	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 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 similar to 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 ranges of light, moderate and severe are used.

If surveyors are uncertain what damaging agent is causing a

disturbance from the aerial signature, then the disturbance is mapped by location and severity of damage, tree species and as much detail as is known about the agent (e.g. foliar disease, defoliator, etc.). Local experts are then consulted and, if necessary, ground checks (if accessible) are conducted with photos, samples and site data collected to determine the cause. Ground check information for 2017 is available at: https://www.for.gov.bc.ca/ftp/HFP/external/!publish/Aerial_Overview/2017/, under directory “Ground checks”.

There are known limitations with the data collected during the aerial overview survey. Not all damage is visible due to a number of reasons including: altitude at which the survey is flown, the timing of the survey, because damage levels are very low, or damage is hidden in the understorey of a stand. For example, spruce beetle mortality can be under-reported because foliage changes on dying trees can happen very rapidly or occur outside the survey period. In addition, many diseases cause significant growth loss and tree defects which aren’t visible from the AOS, such as mistletoe infections and gall rust.



Aspen leaf miner damage in a mixed species stand, in Kootenay/Boundary Region

Care must also be taken in the interpretation of the data. Area recorded as affected 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 be lower in areas without clearly visible geographic references and thus can be unreliable for directing operational surveys and treatments.

Despite the 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.

OVERVIEW RESULTS

Surveys for 2017 commenced on July 4th and were finished by October 14th (Table 2). Weather played a large role in survey limitations. The province experienced a record breaking, unusually cold, wet spring until mid-June. This resulted in some survey delays due to late tree and accompanying damaging agent developments. Then, unusually hot and dry weather predominated, particularly in the southern interior, where century old maximum temperature records were broken. By the second week of July multiple large wildfires ignited (especially in the Cariboo Region) which resulted in reduced aircraft availability, flight zone restrictions and very limited visibility across many portions of BC until mid-September. It is likely that many foliage damaging agents were not well captured, particularly in the Cariboo Region as most of the survey was conducted after mid-September. Conditions were best in Skeena Region, where fires were

Table 2. Flying hours and survey dates by region for the 2017 provincial aerial overview survey.

Regions	Flight hours	Days flown	Survey Dates
Cariboo	109.6	23	Aug 1 st – Sep 29 th
Thompson/Okanagan	46.6	11	July 19 th – Sep 15 th
Kootenay/Boundary	94.3	15	July 22 nd – Oct 5 th
Omineca & Northeast	259.7	43	July 4 th – Oct 13 th
Skeena	109.0	18	July 10 th – Oct 5 th
West & South Coast	81.5	17	July 11 th – Sep 28 th
Total	700.7	127	July 4th – Oct 13th



Typical poor visibility due to wildfires across much of BC in the summer of 2017

minimal and prevailing winds primarily kept the wildfire smoke at bay, so all priority areas were surveyed. As the Omineca and Northeast Regions represented the largest survey area in the province, AOS began there on July 4th in mainly deciduous stands (where forest health agents primarily develop early) and ended the latest on October 13th. Despite the long survey window, not all of the Northeast Region could be completed due to weather and smoke limitations. Thompson/Okanagan Region was completely surveyed, though a large timing gap was necessary mid survey due to smoke. Visibility was also a significant issue for the Coast and Kootenay/Boundary Regions, where small portions were not covered. In total, 84% of the province was flown (Figure 2). This is the same as 2016 but slightly lower than in the previous few years. This estimate does not factor in whether areas contained non-forested types such as lakes, grasslands, or alpine, but it is a comparable statistic year-to-year.

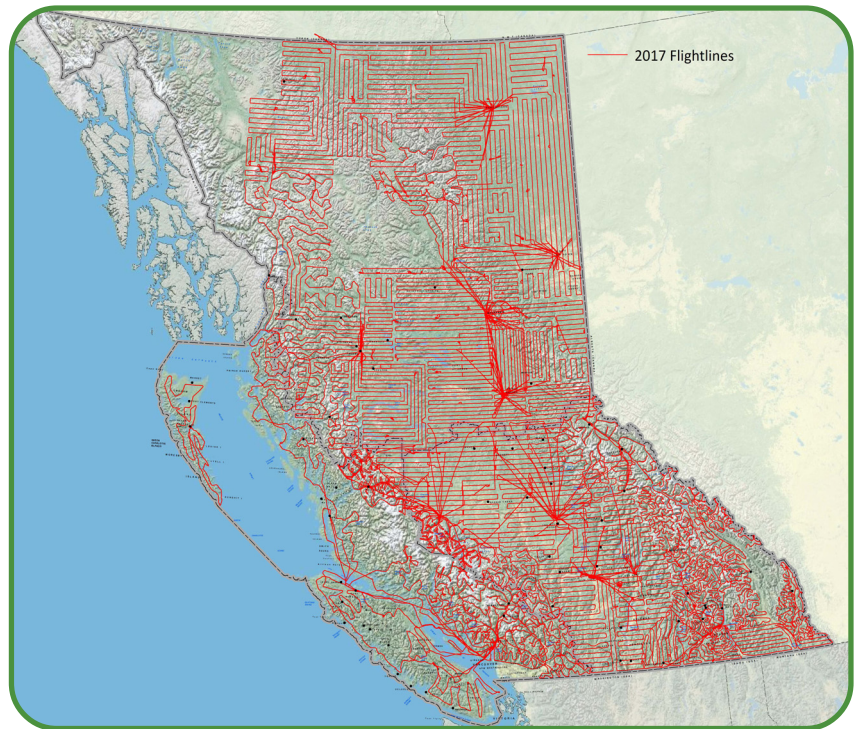


Figure 2. Flight paths flown while conducting the 2017 aerial overview survey. Approximately 84% of the province was surveyed this year.

Total AOS flight time was five percent higher than last year with 700.7 hours logged over 127 days of flying, despite coverage being the same. This was a result of seven more days of flying with some shorter than average days (hence more ferry time), primarily because surveys were cut short due worsening visibility from wildfire smoke as the day progressed. Flight time did not include quality checks. A total of 25 surveyors and ten aircraft companies participated in the surveys.

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 immediate access to the draft information. The final provincial summaries of the spatial and tabular data were available by January 3rd, 2018 at the same site.

Total area of forest damage recorded from the 2017 AOS was 16% higher than 2016, at 6,997,864 ha (Table 3). Bark beetles and defoliators usually account for most of the observed damage, but this year abiotic causes took second place due to record wildfire damage. Diseases affect many forests across BC, but much of the damage is either not visible at the AOS height flown, or damage visibility is outside the time window in which the survey is conducted.

Table 3. Summary of hectares affected by forest damaging agents detected during the 2017 aerial overview survey in British Columbia.

Damaging Agent	Area Affected (ha)	Damaging Agent	Area Affected (ha)
<i>Bark Beetles:</i>		<i>Diseases:</i>	
Western balsam bark beetle	3,701,556	Lophodermella needle cast	90,232
Spruce beetle	501,873	Dothistroma needle blight	69,243
Douglas-fir beetle	119,096	Venturia blight	12,067
Mountain pine beetle	119,089	Septoria leaf spot	9,197
Lodgepole pine beetle	1,015	Unknown Disease**	4,015
Misc. beetles	6	White pine blister rust***	3,752
<i>Total Bark Beetles:</i>	<i>4,442,636</i>	Larch needle blight	2,169
<i>Defoliators:</i>		Root diseases***	235
Aspen leaf miner	428,986	Large-spored Spruce-labrador Tea Rust	131
Two-year-cycle budworm	376,100	Lophodermium needle cast	98
Satin moth	160,085	Comandra blister rust***	64
Bruce spanworm	4,456	Larch needle cast	26
Pine needle sheathminer	4,246	<i>Total Diseases:</i>	<i>191,230</i>
Birch leaf miner	2,003	<i>Abiotics:</i>	
Large aspen tortrix	1,521	Wildfire	1,210,171
Unknown defoliators**	1,343	Yellow-cedar decline	56,563
Eastern spruce budworm	756	Flooding	42,075
Western spruce budworm	704	Post-wildfire mortality	26,183
Conifer sawflies	294	Aspen decline	25,892
Lodgepole pine sawfly	233	Drought	4,045
Balsam woolly adelgid	164	Cedar flagging	3,800
Douglas-fir tussock moth	15	Windthrow	4,533
<i>Total Defoliators:</i>	<i>980,906</i>	Unknown****	3,571
<i>Animals:</i>		Slides	2,637
Bear	3,168	<i>Total Abiotics:</i>	<i>1,379,472</i>
Hare	390		
Porcupine	62		
<i>Total Animals:</i>	<i>3,621</i>		
Provincial Total Damage:		6,997,864	

- * Refers to hemlock defoliation that could not be confirmed with ground checks
 ** Refers to young pine foliage disease, most likely Dothistroma needle blight or pine needle cast
 *** Root disease and rust damage is greatly underestimated from aerial overview survey
 **** Most likely drought damage that did not result in mortality

Bark beetles continued to be the cause of the majority of disturbances, with western balsam bark beetle impacting 3,701,556 ha (up slightly since 2016). Although the hectares affected are large, intensity of mortality due to western balsam bark beetle is low: 99% of the attack in 2017 was trace to light. Infestations were highest in northern BC, with 1,610,438 ha in Omineca Region and 1,531,656 ha in Skeena Region. For the third consecutive year, spruce beetle attack rose sharply to 501,873 ha. Omineca Region continued to sustain the bulk of the damage (372,483 ha), particularly in the northern half of Prince George District. Douglas-fir beetle mortality increased for the fourth consecutive year with 119,096 ha affected. Infestations decreased slightly in Cariboo Region to 65,446 ha, but continued to rise in Omineca Region to 36,249 ha. Mountain pine beetle mortality declined for the eighth consecutive year provincially to 119,089 ha. Omineca Region contained half the attack with the most active infestations still located in Robson Valley TSA. Northeast Region sustained 24,290 ha of mountain pine beetle damage and infestations in Skeena Region increased slightly to 12,492 ha.



Tree mortality caused by western balsam bark beetle

Area affected by abiotic factors increased dramatically to 1,379,472 ha. Most of the damage was attributable to wildfire, with a record 1,210,171 ha burned, primarily in the southern interior. This caused a record number of evacuations and major transportation route closures. Damaged timber is expected to feed the already substantial Douglas-fir beetle populations, especially in the Cariboo Region where 979,852 ha burned. Post-wildfire damage declined to 26,183 ha, though this damage is expected to expand over the next several years as influenced by the 2017 wildfires. Yellow-cedar decline disturbances in coastal BC were similar in size and intensity to 2016, with 56,563 ha affected. Aspen decline damage grew to 25,892 ha, with most of the disturbances delineated in Northeast Region. Flooding damage more than doubled since last year to 42,075 ha though intensity of disturbances was rated lower. Northeast Region had the majority of the damage with 38,289 ha delineated. Drought damage that caused mortality declined to 4,045 ha, with western redcedar the common host in coastal regions. Substantial young tree mortality due to drought was also noted from the ground and low elevation flights in the southern interior, but was not captured during the AOS. Excessive older needle death in 20 to 40 year old lodgepole pine stands was mapped in the southern interior on 3,571 ha, with drought the suspected primary cause. Similarly, 3,800 ha of cedar flagging were observed in the southern interior.

Deciduous insect defoliation continued to be led by aspen leaf miner with 429,280 ha affected, though this is far lower than the record peak of 3.6 million hectares in 2014. Ground observations generally confirmed that populations are on the decline, with lighter intensity of attack and lower moth abundance. Stands damaged by aspen leaf miner were highest in Skeena Region with 245,889 ha of attack, followed by Omineca Region at 116,382 ha. Satin moth infestations damaged a record 160,085 ha in 2017, with increased intensity of defoliation as well. Omineca Region sustained 107,002 ha of attack, Skeena Region 47,596 ha, and the remaining 5,474 ha were noted in Cariboo

Region. Bruce spanworm infestations grew to 4,456 ha in Dawson Creek TSA of Northeast Region. Minor birch leaf miner, large aspen tortrix and western winter moth infestations also affected deciduous trees in 2017.

Conifer defoliation was led again by two-year-cycle budworm with 376,100 ha attacked. This is the highest defoliation recorded by this insect in BC since a peak of 392,316 in 2009. This budworm is in the second year of its life cycle in northern BC, where damage was greatest in 2017. Omineca Region infestations totalled 179,294 ha and 138,547 ha in Skeena Region. Disturbances were still substantial in Thompson/Okanagan and Cariboo Regions with 32,405 ha and 25,855 ha mapped, respectively. After a peak of 10,202 ha in 2016, pine needle sheathminer damage declined to 2,944 ha, all of which were observed in Cariboo Region. All other conifer defoliators affected less than 1,500 ha each across the province.

Disease damage that is visible during the AOS increased more than half from 2016 to 191,230 ha. Unlike last year, conifers were the most affected. Young lodgepole pine sustained the majority of the damage. Pine needle cast infections increased dramatically to 90,232 ha, with almost all disturbances located in Thompson/Okanagan and Kootenay/Boundary Regions. A record 69,243 ha of *Dothistroma* needle blight damage was recorded in 2017. Cariboo Region sustained 40,279 ha, Omineca Region 18,773 ha and Thompson/Okanagan Region 9,031 ha. A further 4,015 ha of young lodgepole pine foliage disease was mapped in the southern interior and though the primary pathogen could not be determined, it was most likely *Dothistroma* needle blight or pine needle cast. White pine blister rust damage reached a record 3,752 ha, though the majority of the disturbances (98%) were trace intensity, so mortality was not high. Larch needle blight damage was observed on 2,169 ha, primarily in Kootenay/Boundary Region. Other conifer disease damage was observed on less than 250 ha per disease in BC this year.

Disease damage in deciduous trees was led by *Venturia* blight, which declined almost five-fold since 2016 to 12,067 ha affected in northern BC. Most of this damage (10,104 ha) was mapped in Skeena Region. *Septoria* leaf spot damage, first detected during the AOS in 2016, rose to 9,197 ha in Great Bear Rainforest North TSA.

Animal damage decreased by almost half of what was mapped in 2016 to 3,621 ha. Black bear continued to be the main cause of animal damage, with 3,168 ha affected. Disturbances were observed on 1,584 ha in Cariboo Region, 716 ha in Kootenay/Boundary Region and 453 ha in South Coast Region.



Larch needle blight damage

Localized damage due to other forest health agents were noted throughout the province. 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*

The mountain pine beetle has been in decline since 2007 but is still active in parts of BC (Figure 3). Damage mapped in 2017 decreased to 119,089 ha from 177,706 ha in 2016. Severity also decreased, with 59,589 ha (50%) trace, 29,772 ha (25%) light, 25,708 ha (22%) moderate, 3,961 ha (3%) severe and 59 ha (<1%) very severe (Figure 4).

Mature lodgepole pine continued to be the primary host for the mountain pine beetle. Mortality in whitebark pine leading stands was observed on 6,142 ha (5% of total area damaged). For the first time since recording mountain pine beetle attack in young pine stands began in 2007, no young damage was noted in 2017.

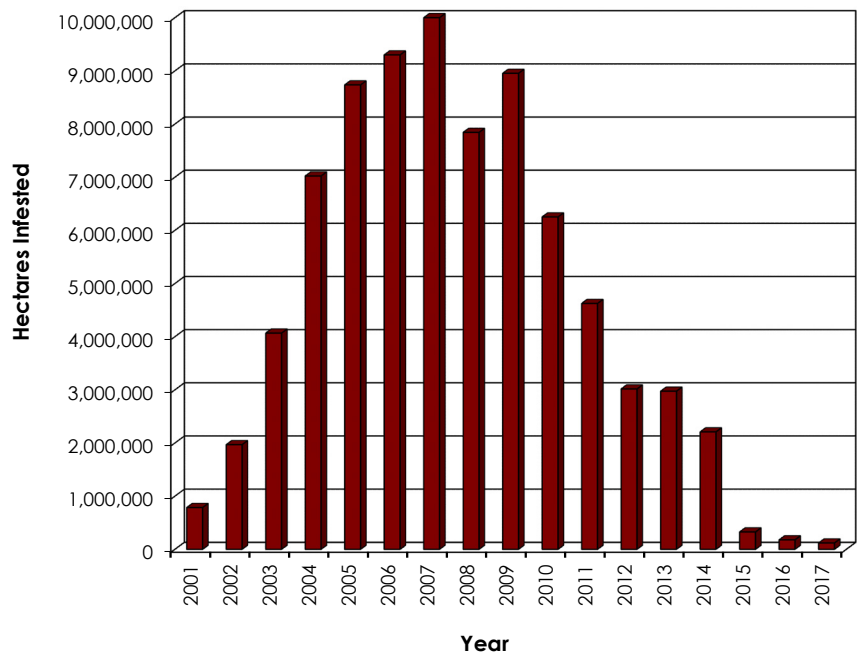


Figure 3. Area infested (all severity classes) by mountain pine beetle from 2001 – 2017 in British Columbia.

For the second consecutive year mountain pine beetle attack was highest in Omineca Region at 53,511 ha, down from 76,176 ha in 2016 (Figure 5). Robson Valley TSA continued to be the most affected with 34,396 ha of damage and the majority of moderate to severe infestations in the region. Most of the attack occurred from Moose Lake south to Ptarmigan Creek, in high elevation stands of lodgepole and whitebark pine. Mackenzie TSA sustained 11,116 ha of mortality, primarily in trace intensity polygons from Spinel Lake south to Bower Creek. For the third consecutive year however a large portion of Mackenzie TSA could not be surveyed, so attack levels could be higher. Prince George TSA contained 7,999 ha of chiefly light intensity infestations, with the majority of the attack occurring in Fort St. James TSA near Driftwood River.

Northeast Region infestations declined to 24,290 ha in 2017 from 36,088 ha last year (Figure 5). Fort Nelson TSA sustained 10,651 ha of damage, mainly mid TSA. In Dawson Creek TSA, most of the 9,335 ha mapped continued to occur along the Alberta border near South Redwillow River. Intensity of mortality was highest in this area as well, with light to moderate polygons delineated. All other attack in the region was rated as trace or spot. The 4,304 ha of damage mapped in Fort St. John TSA was widely scattered.

Mountain pine beetle attack in Skeena Region slightly increased since 2016, from 8,217 ha to 12,492 ha (Figure 5). The majority of the damage continued to be noted in Bulkley TSA with 9,739 ha affected. Most of the disturbances were of trace or spot intensity, with concentrations south of Mount Horetsky, around Tarkelsen Lake and around Hudson Bay Mountain. Infestations in

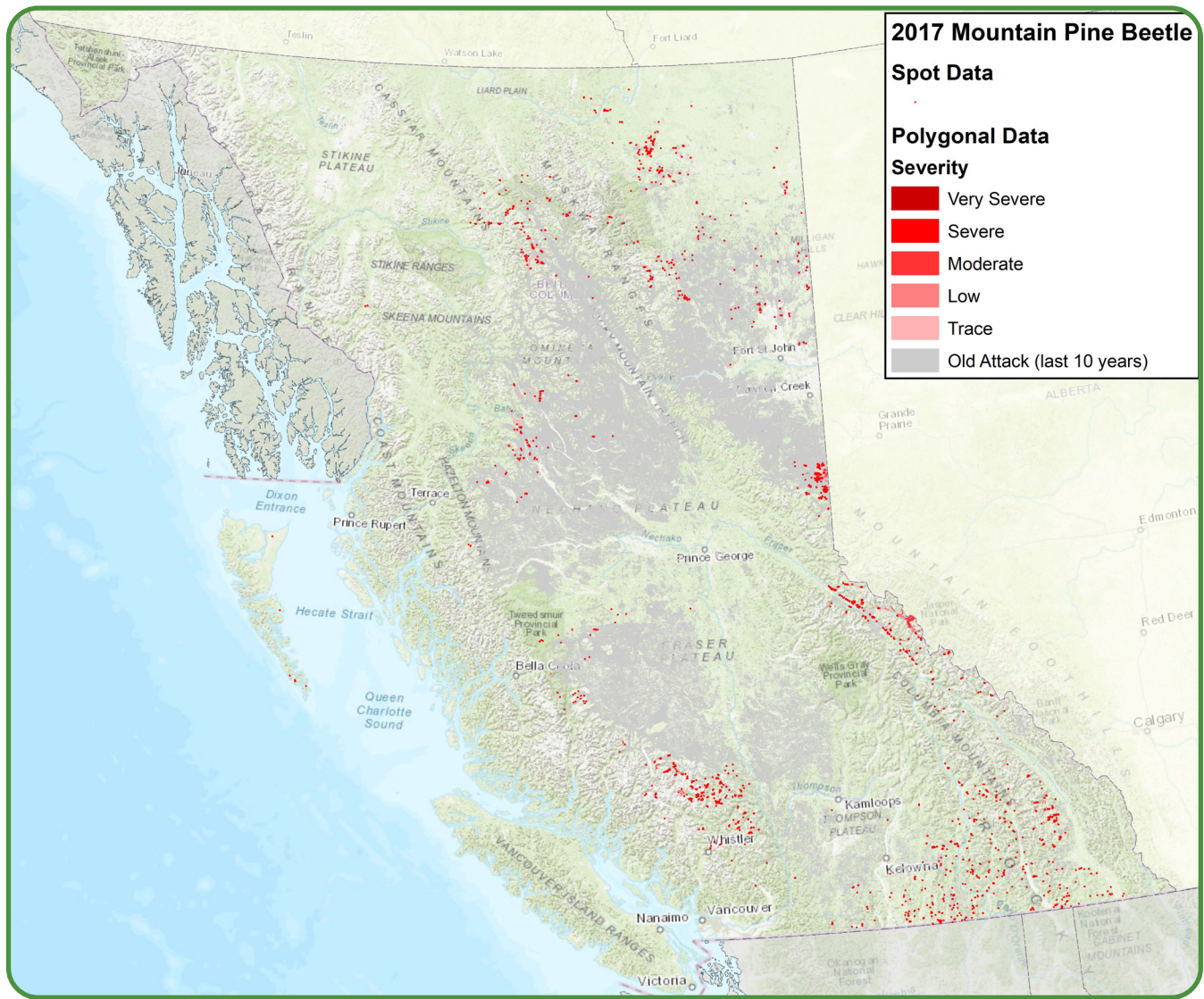


Figure 4. Current mountain pine beetle infestations recorded by severity in British Columbia in 2017 with old attack in grey.

Cassiar TSA accounted for 1,942 ha and were located around Bob Quinn Lake and Pitman River. Most of the 618 ha of attack in Morice TSA were mapped in the northern tip. Minor infestations were noted in Kispiox, Lakes and Kalum TSAs with 155 ha, 25 ha and 13 ha affected, respectively.

Mortality in Kootenay/ Boundary Region dropped to a third of that observed in 2016 with 11,371 ha affected (Figure 5). Invermere TSA mortality declined to 4,924 ha, but may be an artificial decrease as the eastern half of the TSA could not be surveyed. Infestations in Kootenay Lake TSA were small and widely scattered, accounting for 2,934 ha. Mountain pine beetle disturbances declined sharply in Boundary TSA to 1,277 ha, though infestations were still widely scattered. A total of 922 ha were damaged in Golden TSA, with small concentrations on Valenciennes River, Bachelor Creek and Columbia Reach of Kinbasket Lake. The 622 ha recorded in Arrow TSA were primarily in two areas near Trout and Summit Lakes. In Revelstoke TSA, infestations totalling 472 ha were mainly east of Revelstoke, north of Goldstream Mountain, and on Bigmouth Creek. The remaining 220 ha of damage in the region was noted in the western half of Cranbrook TSA.

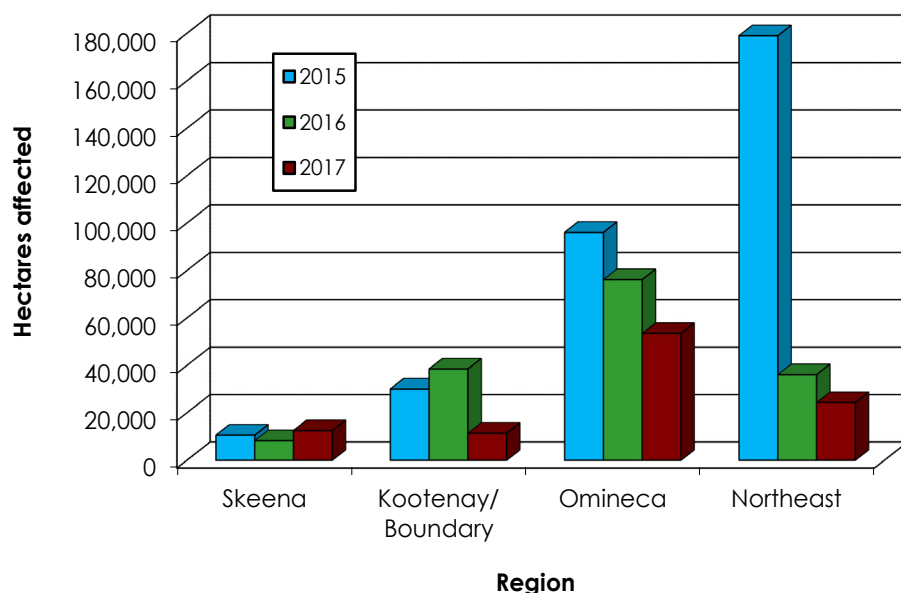


Figure 5. Area infested (all severity classes) by mountain pine beetle from 2015 – 2017 by regions with over 10,000 ha of attack per year.

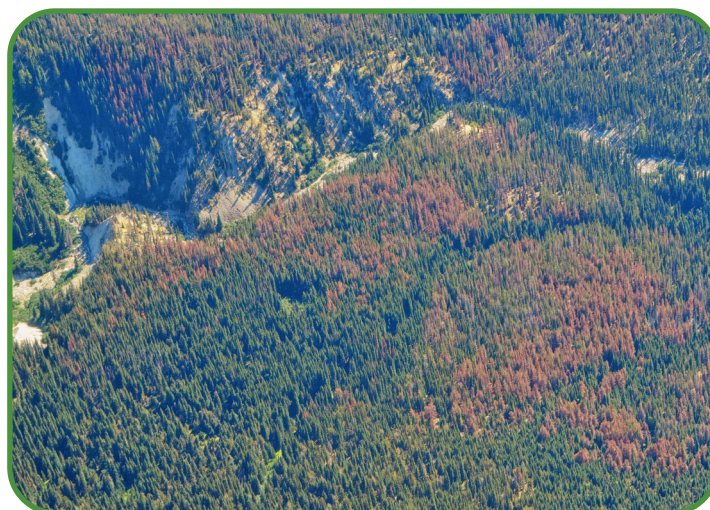
Mountain pine beetle infestations continued to increase in Cariboo Region, with a rise from 4,298 ha in 2016 to 7,718 ha. Almost all of the attack continued to occur in Williams Lake TSA, where 7,688 ha were affected. The largest, most active area continued to be from Taseko River west to Dorothy Lake. Two smaller infestations were mapped south of Razorback Mountain and around Whitton Creek. Along the northwestern boundary of Quesnel TSA, four small trace polygons and a few spot infestations accounted for 30 ha of damage.

After a slight increase in 2016, mountain pine beetle attack in Thompson/Okanagan Region declined by almost half to 6,903 ha. The majority of the damage continued to occur in the western half of Lillooet TSA, where 6,597 ha were affected. The most active area with the highest intensity of attack continued to be west of Downton Lake. It was noted that host pine supply is becoming depleted in this area, but mortality still is widespread. Attack in Okanagan TSA accounted for 213 ha of mortality, primarily north of Winnifred Creek. Damage in Merritt TSA declined to 93 ha, mainly observed north of Stemwinder Mountain. Only one spot infestation was mapped in Kamloops TSA.

Mountain pine beetle mortality remained stable in South Coast Region at 1,391 ha. Soo TSA was the most affected, with 1,005 ha of attack delineated, mainly south of Mount Currie. Almost all the infestations in Sunshine TSA continued to occur south of Bishop River with a total of 1,005 ha mapped. The remaining six ha in the region were scattered in Fraser TSA.

The 1,317 ha mapped in Great Bear Rainforest North continued to be found along the eastern edge of the TSA, where small 2016 infestations expanded six-fold. Most of the mortality occurred at high elevations on the east slope of the Coast Range.

In the West Coast Region, all 96 ha of mountain pine beetle attack were recorded in Haida Gwaii TSA, primarily on the south tip of Moresby Island.



Mountain pine beetle attack in Lillooet TSA

Pine needle cast, *Lophodermella concolor*

Provincially, pine needle cast damage has been relatively low for over a decade. However, in 2017 recorded disturbances increased dramatically to 90,232 ha (Figure 6). Intensity of damage was rated as 78,938 ha (88%) light, 10,325 ha (11%) moderate and 969 ha (1%) severe. The responsible pathogen was confirmed with ground checks in Thompson/Okanagan and Omineca Regions.

This level of pine needle cast damage is the second highest ever recorded, with the record peak occurring in 2002 when 268,314 ha were infected, primarily in Cariboo Region. It is suspected that the foliage damage that appeared in 2017 (a result of infections the spring of 2016) was even higher than mapped. In most of the Cariboo and Kootenay/Boundary Regions lodgepole pine in susceptible ecosystems couldn't be surveyed until fall due to wildfires. By fall the pine needle cast aerial signature is very light to nil, as damaged needle colour fades and needles drop.

The Thompson/Okanagan Region sustained a record 78,985 ha of damage. Okanagan TSA was the most impacted, with 46,354 ha mapped. The heaviest concentrations occurred on the east side of Okanagan Lake to the TSA border. Kamloops TSA contained 25,026 ha of pine needle cast disturbances, primarily north of Kamloops Lake/South Thompson River to Clearwater. Merritt TSA infection centers totalled 7,100 ha, almost all of which were in the southeastern portion of the TSA. The remaining 505 ha in the region were noted in Lillooet TSA, where disturbances were scattered along the southern border. Even with the large increase in this region, AOS surveyors noted pine needle cast damage in low elevation, hot ecosystems that was mapped during a flight in the spring was no longer visible later in the season when the AOS was conducted.

All 7,618 ha of pine needle cast damage in Kootenay/Boundary Region occurred in Boundary TSA along the western edge. In Omineca Region, all 2,210 ha of damage were recorded in small scattered disturbances in the southern half of Prince George TSA. A total of 1,275 ha were mapped in Cariboo Region along the eastern edge of 100 Mile House TSA. In South Coast Region, Fraser TSA had a few small polygons on the northeast tip that totalled 144 ha.

An early-season AOS pilot project was undertaken in the spring, to determine if conducting the survey earlier better captured damage due to foliar diseases of conifers such as pine needle cast (see Forest Health Projects, Project 1). The overall high levels detected are a reflection of this enhanced survey effort.

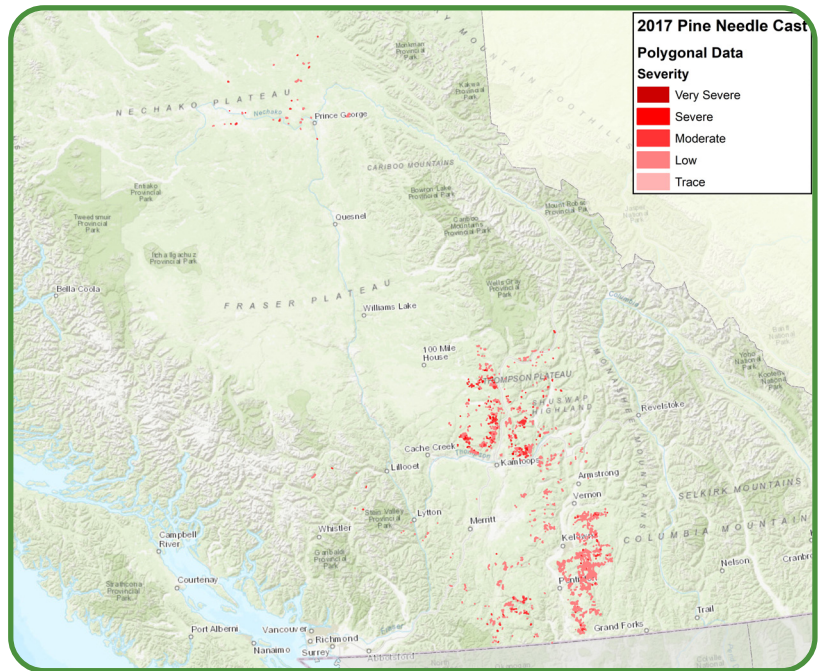


Figure 6. Pine needle cast damage in BC in 2017.



Pine needle cast damage

Dothistroma needle blight, *Dothistroma septospora*

Dothistroma needle blight damage (also known as redband needle blight) is often underestimated during the AOS, as damage is most visible in the spring or early summer, usually before the survey is conducted. At that time, new growth has not yet masked the previous year's damaged needles. Also, stands that have been infected for several years have less remaining foliage and smaller needles, making damage harder to detect. Although Dothistroma can infect mature trees, infections are most visible and damaging in young pine stands (all damage recorded to date during the AOS was in young stands).

A record 69,243 ha of Dothistroma needle blight damage was recorded provincially in 2017 (Figure 7), with only 17,709 ha of damage observed last year. Intensity of damage increased as well, with 25,719 ha (37%) light, 33,335 ha (48%) moderate and 10,189 ha (15%) severe. Disturbances were more visible this year at least in part due to the higher intensity. Damage increased due to intermittent damp weather conditions during the growing season last year, which was ideal for needle infections in many areas. Several stands in Omineca, Cariboo and Thompson/Okanagan Regions were ground checked to confirm the causal

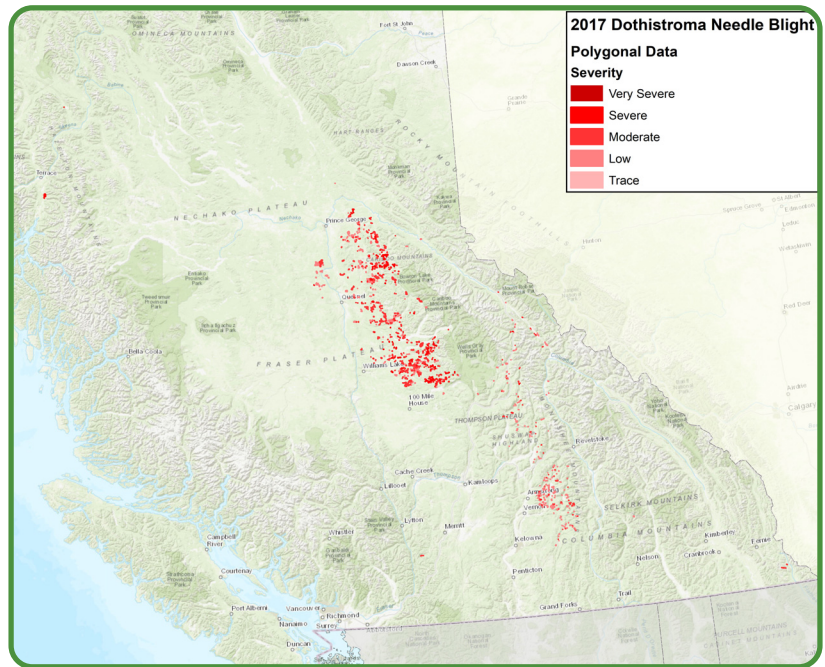


Figure 7. Dothistroma needle blight damage recorded in BC in 2017, by severity rating class.



Dothistroma needle blight damage

pathogen. Another 4,015 ha of damage due to foliage disease was mapped in young lodgepole, but the causal agent could not be confirmed (see *Unknown Foliage Disease* section).

Dothistroma needle blight damage in Cariboo Region was far higher than ever previously recorded, at 40,279 ha. Williams Lake TSA had 19,115 ha mapped in the eastern tip, particularly south of Horsefly Lake. Quesnel TSA sustained 12,705 ha of damage east of Fraser River. Damage in the northeast tip of 100 Mile House TSA totalled 8,460 ha, from Sprout Lake eastward.

Disturbances in Omineca Region rose to 18,773 ha. Most of the damage (18,042 ha) was mapped from Eaglet Lake

south to Stony Lake in Prince George TSA. In Robson Valley TSA, 731 ha were delineated along Kinbasket Lake.

Dothistroma needle blight damage in Thompson/Okanagan Region increased to 9,031 ha. Okanagan TSA sustained 7,234 ha of damage, with concentrations around Mabel Lake/Sugar Lake area. A total of 1,797 ha were damaged in the northeastern portion of Kamloops TSA.

Kootenay/Boundary Region had a slight increase in Dothistroma needle blight damage, with 561 ha affected. Cranbrook TSA sustained 261 ha of moderate damage south of Tombstone Mountain. Arrow TSA had one light disturbance of 125 ha south of Marten Mountain. Light damage in Revelstoke TSA affected 109 ha along Bigmouth and Old Camp Creeks. Boundary TSA had 66 ha of light damage southwest of Lightning Peak.

Unlike other regions with Dothistroma needle blight damage, observed disturbances fell from 6,258 ha in 2016 to only 475 ha in Skeena Region. Almost all (462 ha) of the damage was mapped in Kalum TSA just south of Lakelse Lake, mainly at moderate to severe intensity. One severe polygon of 13 ha was noted beside Kitwancool Lake in Kispiox TSA. Dothistroma needle blight damage has been damaging stands in this region for many years, first becoming visible enough to map from the AOS height in 2005. Hence, many stands have thinning crowns and the aerial signature is often too subtle to see during the AOS. The regional pathologist noted that Dothistroma needle blight continues to seriously impact lodgepole pine growth and survival along Highway 37, particularly in the Nass River area.



Dothistroma needle blight stand damage in Kamloops TSA

Dothistroma needle blight damage was observed for the first time during the AOS on 124 ha in South Coast Region. The damage was assessed as moderate and was located along Uztlius Creek in Fraser TSA.

Pine needle sheathminer, *Zelleria haimbachi*

The current pine needle sheathminer outbreak peaked at 10,202 ha in 2016, and declined to 4,246 ha in 2017. Intensity of attack also declined to 2,944 ha (69%) light and 1,302 ha (31%) moderate. All of the 2017 infestations were located in Cariboo Region (Figure 8). The outbreak began in 2012, with small areas of defoliation occurring in Thompson/Okanagan and Cariboo Regions (Figure 9). In 2014, minor infestations expanded into Omineca and Kootenay/ Boundary Regions. Defoliation has been dominant in Cariboo Region since 2015.

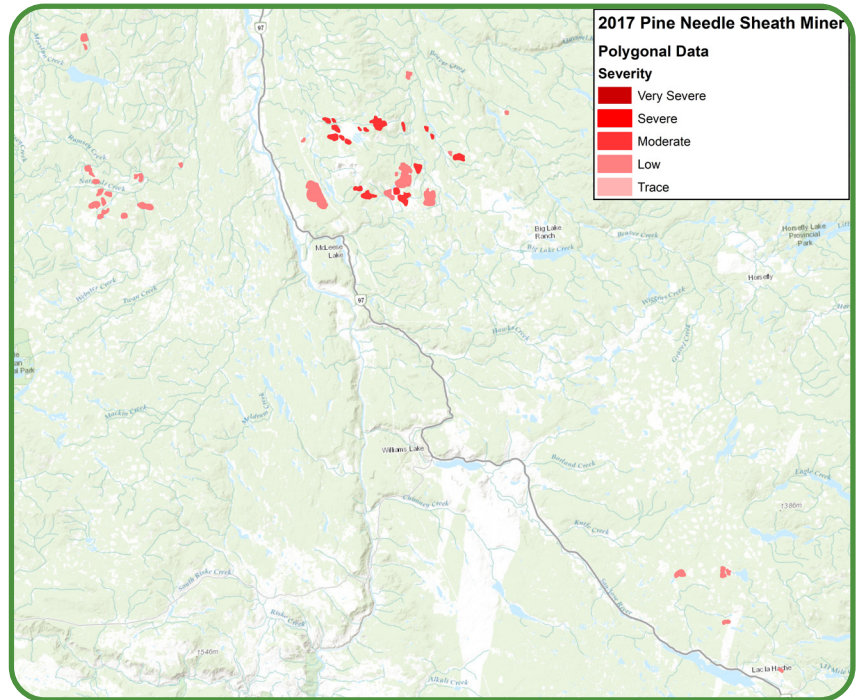


Figure 8. Pine needle sheathminer damage recorded by severity rating class in BC in 2017.

In 2017, pine needle sheathminer damage contracted to mid TSA along the southern boundary of Quesnel TSA and the northern boundary of Cariboo TSA, with a few additional stands mapped in the northwest corner of 100 Mile House TSA. With confounding aerial signatures from drought and needle diseases, several stands were checked on the ground to confirm pine needle sheathminer damage. During these checks it was observed that intensity of damage was definitely declining, and it is anticipated very little or no activity will be seen in 2018. Quesnel TSA continued to be the most affected, with 2,106 ha of defoliation. Disturbances in Williams Lake TSA totalled 1,839 ha. Five small polygons in 100 Mile House TSA accounted for 301 ha.

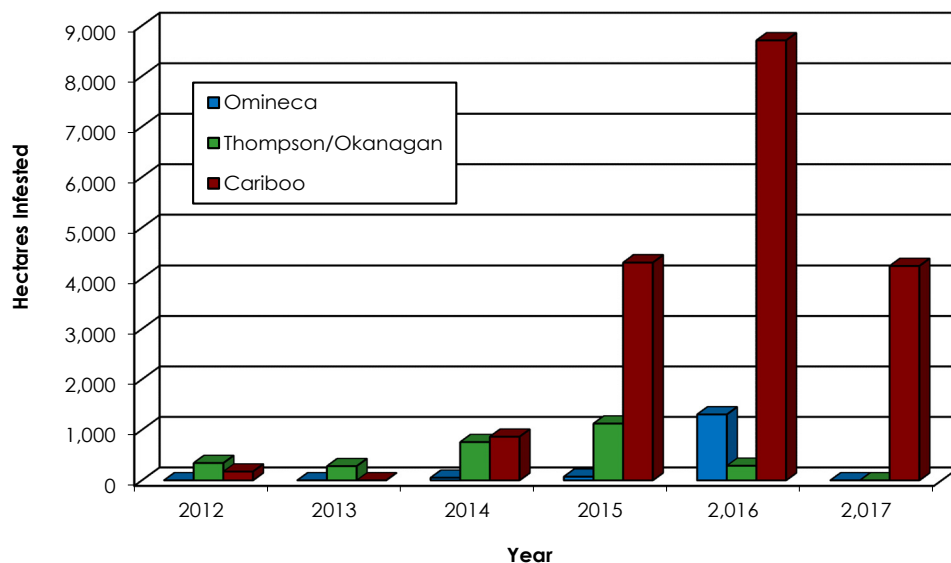


Figure 9. Pine needle sheathminer damage from 2012 to 2017, by regions with more than 50 ha of attack.

White pine blister rust, *Cronartium ribicola*

Branch infections and stem infections that haven't encircled the host are very difficult to detect during the AOS, hence damage by this disease is under-represented in the survey and, if noted, consists almost exclusively of tree mortality. Damage observed provincially this year was a record 3,752 ha. Intensity of damage was rated as 3,683 ha (98%) trace, 10 ha (<1%) light and 60 ha (2%, all spot disturbances) severe. Hectares affected appear to show a large increase from the 1,214 ha delineated in 2016, but it should be noted that almost all of the disturbances were of trace intensity, hence overall damage by host trees has not changed dramatically.

West Coast Region was most affected with 2,245 ha of damage. Arrowsmith TSA sustained 1,443 ha of white pine blister rust damage, primarily from Nanoose Bay south to Shawnigan Lake. North Island TSA had 802 ha, with scattered spots and trace intensity polygons delineated north of Mount Washington.

Thompson/Okanagan Region sustained 810 ha of damage. Most of the disturbances (792 ha) were mapped in Kamloops TSA as trace intensity polygons northwest of Celista Mountain. The remaining 18 ha in the region were observed in Okanagan TSA as one trace intensity disturbance north of Sicamous.

Damage in South Coast Region remained relatively stable with 697 ha affected. Sunshine Coast TSA was most affected with 693 ha. Most were scattered spots, with polygons chiefly mapped on Texada Island. Spot infection centers covered 3 ha in So0 TSA and 1 ha in Fraser TSA. Only one spot was observed in Great Bear Rainforest South TSA.

Lodgepole pine beetle, *Dendroctonus murrayanae*

Lodgepole pine beetle mortality was mapped historically as primarily trace intensity polygons or spot infestations in northern BC. Due to the very scattered mortality signature, this damage agent, in a similar fashion to porcupine damage, tends to be underestimated. The last time lodgepole pine beetle was observed was 2014, when a record 73,258 ha of damage was delineated in the north, almost all at trace intensity.

In 2017 1,015 ha were mapped, all in Cassiar TSA of Skeena Region (with the exception of 5 spot infestations in Fort Nelson TSA of Northeast Region). Spot infestations were widely scattered, with a concentration of polygons at the confluence of Pitman and Stikine Rivers. Intensity of mortality was noted as 952 ha (94%) trace, 36 ha (3%) light and 27 ha (3%) severe. The majority of Cassiar TSA has not been flown since 2014, which may partially account for the abrupt drop then rise in observed lodgepole pine beetle disturbances in northern BC. The infestations were not ground checked this year but the general areas where damage was noted had been checked in previous years.

Neodiprion sawfly, *Neodiprion nanulus contortae*

Neodiprion sawfly continued to defoliate small shore pine on the southern tip of Moresby Island in Haida Gwaii TSA of West Coast Region. Damage was a third of that recorded in 2016, with 233 ha of moderate intensity damage mapped across six small polygons. The damaging agent was confirmed with ground checks in 2015, when defoliation peaked at 5,005 ha. Small pockets of *Neodiprion* sawfly were observed in the North Thompson River area of Kamloops TSA, but damage was not severe enough to discern during the AOS.



Neodiprion sawfly feeding

Hard pine stem rusts



Stalactiform blister rust (left) and Comandra blister rust (right) infections

Comandra blister rust (*Cronatium comandrae*), stalactiform blister rust (*C. coleosporiodes*), and western gall rust (*Endocronartium harknesii*), are hard pine stem rusts that commonly cause damage in BC. This damage is greatly underestimated during the AOS because the disturbances are only visible once substantial mortality occurs. When rust damage is mapped during the AOS it is usually attributed to comandra blister rust as it is the most likely of the three to cause tree mortality. All observed damage has been in young lodgepole pine stands.

For the second consecutive year comandra blister rust damage was mapped in Okanagan TSA of Thompson/Okanagan Region east of Skaha Lake. Last year three light intensity polygons totalling 124 ha were observed, of which two were ground checked. In 2017 two polygons were noted just east of one of the 2016 ground checked polygons, with 64 ha affected at trace intensity.

Lophodermium needle cast, *Lophodermium pinastri*

Lophodermium needle cast damage was observed during the AOS in Merritt TSA of Thompson/Okanagan Region. Three lightly damaged disturbances totalling 98 ha were delineated during the AOS near Podunk Creek. All stands were young lodgepole pine. A definitive call on the pathogen causing the damage could not be made from the air, so a ground check was conducted to determine the causal agent. Forest pathologists in other regions also observed this needle cast from the ground in various stands.

Western pine beetle, *Dendroctonus brevicomis*

For more than a decade, western pine beetle attack was very difficult to separate from mountain pine beetle attack, as both were often present in a stand or even within a tree. Now that the mountain pine beetle outbreak has subsided in ponderosa pine ecosystems, western pine beetle is considered the primary mortality agent (other insects such as *Dendroctonus valens* may also contribute to ponderosa pine mortality).

Trace intensity polygons combined with spot infestations accounted for 343 ha of western pine beetle damage in southern BC in 2016. Most of the mortality occurred in Kootenay/Boundary Region as polygons. In 2017, only 11 spot infestations (3 ha) were delineated in BC in the southern portion of Okanagan TSA of Thompson/Okanagan Region. The trace intensity of damage in Kootenay/Boundary Region last year indicated that mortality was very scattered. It is possible that individual trees were difficult to detect with the wildfire smoke issues this summer. Additionally, some portions of Kootenay/Boundary Region where mortality was mapped last year could not be surveyed in 2017.

DAMAGING AGENTS OF DOUGLAS-FIR

Douglas-fir beetle, *Dendroctonus pseudotsugae*

Douglas-fir beetle caused mortality on 119,096 ha provincially in 2017, up from 90,826 ha last year (Figure 10). Intensity of attack remained at similar levels with 28,544 ha (24%) trace, 61,623 ha (52%) light, 20,973 ha (18%) moderate, 7,561 ha (6%) severe and 395 ha (<1%) very severe.

Attack observed in Cariboo Region decreased slightly to 65,446 ha, though this region continued to sustain the highest level of damage in BC. The small decrease is most likely an artefact, as Douglas-fir beetle damage was not discernable from wildfire damage in many areas of Cariboo Region in 2017. In areas that were not affected by wildfire, many small patch infestations grew to large polygons. It was observed that most stands of mature Douglas-fir were attacked to some degree. Most of the mapped mortality in Cariboo Region continued to be in Williams Lake TSA, with 46,231 ha delineated. The majority of the infestations continued to be observed on both sides of the Fraser River in the center of the TSA, though significant mortality also occurred from Big Creek and Taseko River north to Kleena Kleene River. Some of the largest increases were noted in West Branch, Tatlayoko and Eagle Lake areas. 100 Mile House TSA sustained 8,895 ha of damage with the majority located along the Fraser River. Attack in the northeastern portion of the TSA grew in size but was primarily assessed at low intensity levels, as the mortality occurred in mixed species stands. Quesnel TSA had a substantial increase in Douglas-fir beetle damage, with 10,320 ha delineated. Disturbances were smaller and more scattered than in the other TSAs, but were generally near the Fraser River and south of Mount Tinsdale. It is anticipated that Douglas-fir beetle populations in this region will remain high and will likely increase due to the proliferation of very susceptible (burnt) host material.

Douglas-fir beetle mortality continued to rise dramatically in Omineca Region, with a four-fold increase since last year to 36,249 ha. Almost all the damage (35,367 ha) was mapped in Prince George TSA. Most of these disturbances were delineated in Prince George District, from McLeod Lake south to Summit Lake, at trace to light intensity. Robson Valley TSA sustained 876 ha of light attack, chiefly along Foster and Dawson Creeks in the south. One small portion of a Prince

George TSA disturbance north of MacLeod Lake accounted for six ha of damage in Mackenzie TSA.

Thompson/Okanagan Region sustained 9,490 ha of Douglas-fir beetle damage, up almost a third since 2016. Infestations remained primarily small and widely scattered. Mortality increased in Kamloops TSA to 3,425 ha, particularly in proximity to previous wildfires. A total of 2,901 ha of attack were observed in Okanagan TSA. In the southern areas of this TSA, it was noted that in general infestations in low elevation stands seemed to be declining, but in higher/slightly wetter stands, populations were very active. Infestations in Merritt TSA seemed relatively stable, with 1,672 ha of damage mapped. Douglas-fir beetle attack in Lillooet TSA declined slightly since 2016 to 1,492 ha.

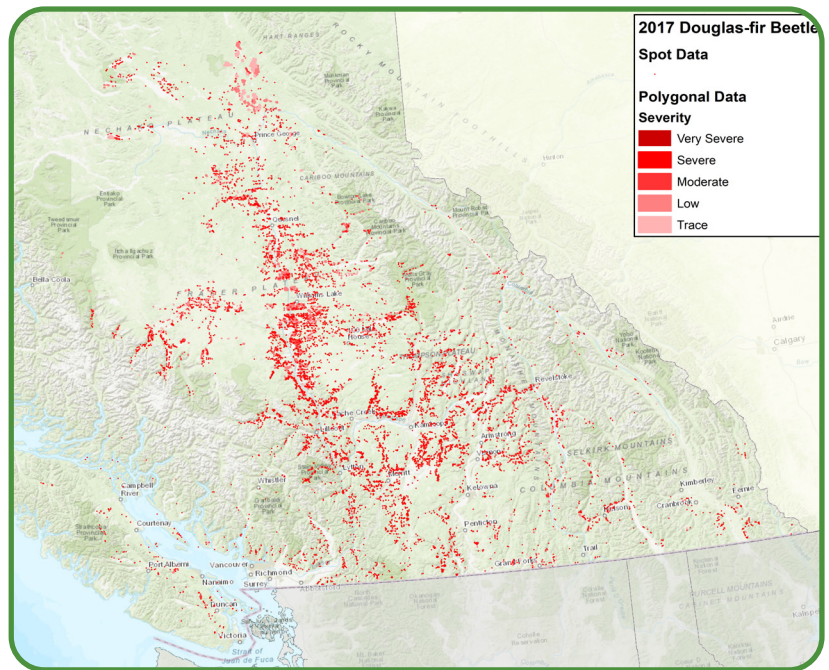
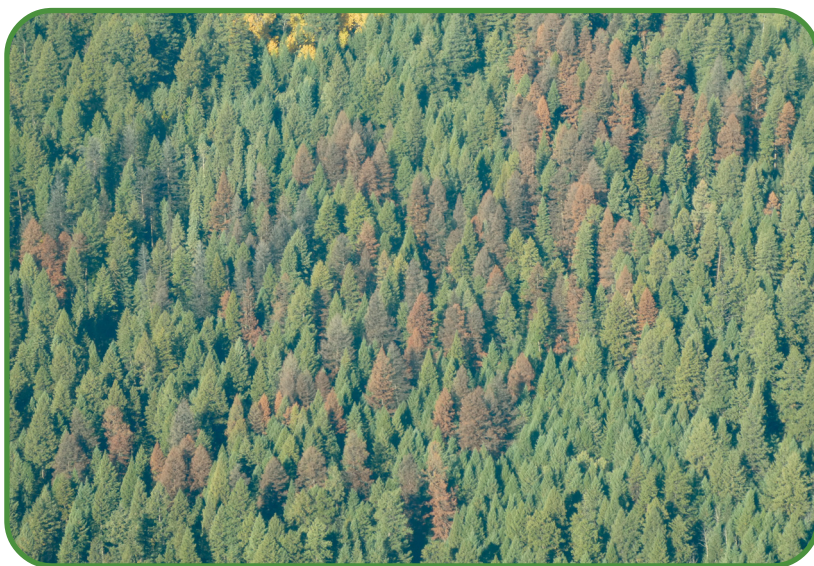


Figure 10. Douglas-fir beetle attack recorded in BC in 2017, by severity rating class.

Douglas-fir beetle mortality in Kootenay/Boundary Region appeared to remain relatively stable at 4,489 ha; however, damage may be higher than recorded considering most of Invermere TSA, where infestations were prevalent last year, could not be surveyed in 2017. Arrow and Boundary TSAs sustained the most damage with 1,552 ha and 995 ha affected, respectively, in small scattered disturbances. District staff noted that infestations in these TSAs were more active this year, primarily near previous wildfires. Active funnel trapping continued to be employed at 85 sites (2

or 3 traps per site) in the southern portions of Boundary, Arrow and Kootenay Lake TSAs. Total estimated number of beetles captured was 1,139,000. Douglas-fir beetle damage increased in Revelstoke TSA to 891 ha, primarily from Revelstoke south along Upper Arrow Lake. Infestations in Cranbrook TSA totalled 381 ha, mainly located around the Elko area. Disturbances were small and scattered in Kootenay Lake and Golden TSAs, with 373 ha and 245 ha affected, respectively. Two polygons and scattered spots totalled 52 ha of attack in the western portion of Invermere TSA that was flown.



Douglas-fir beetle mortality in Williams Lake TSA

South Coast Region Douglas-fir beetle damage increased slightly to 1,445 ha. The majority of the attack (1,122 ha) continued to occur in Fraser TSA, primarily along Fraser and Skagit Rivers. Sunshine Coast TSA sustained 279 ha of damage, chiefly northwest of Sechelt, on East Redonda and Texada Islands, and Quatam River. A total of 44 ha of attack were mapped in Soo TSA, in two trace polygons near Lillooet Lake and scattered spots. Funnel trapping continued at four wildfire areas burned in 2015 within the region and resulted in catches of about 200,000 beetles this year.

All of the 1,116 ha of Douglas-fir beetle attack in Skeena Region occurred in Lakes TSA. The majority continued to be found along the eastern boundary on Francois Lake, though one new infestation was mapped south of Cunningham Lake.

Douglas-fir beetle infestations in West Coast Region rose to 642 ha. Most of the damage (598 ha) was observed in Arrowsmith TSA, particularly west of Ladysmith and along the Englishman River. North Island TSA contained 44 ha of attack, primarily near Klaklakama Lakes.

The remaining Douglas-fir beetle attack mapped in the province was 218 ha in Great Bear Rainforest. Almost all the infestations (217 ha) occurred in Great Bear Rainforest North TSA, mainly along the southeast border. In Great Bear Rainforest South TSA, five scattered spots were delineated.

Western spruce budworm, *Choristoneura occidentalis*

Western spruce budworm defoliation declined for the sixth consecutive year in BC to 704 ha of light defoliation, all located in Thompson/Okanagan Region. Defoliation that was too light to be observed during the AOS flights continued to be noted in other locations in the southern interior.

Merritt TSA sustained 549 ha of western spruce budworm defoliation northwest of Agate Mountain and damage in Lillooet TSA totalled 155 ha at Seton Portage.

Western spruce budworm egg mass surveys were conducted in the fall of 2017 at 319 sites in southern BC, to predict populations and defoliation levels for 2018 (Table 4). Results continue to indicate declining populations. Nil defoliation predictions increased to 219 sites (67%) while light predictions on 98 sites (30%) correspondingly fell. Very few sites had moderate or severe defoliation predicted (12 sites, 3%) in 2018, but this was an increase from the 8 sites (2%) of moderate defoliation predicted in 2016.



Western spruce budworm egg mass

In Cariboo Region, three general areas are predicted to have moderate defoliation in 2018: Williams Lake TSA from lower Meldrum Creek to Moon Road, 100 Mile House/Williams Lake TSA north of Canoe Creek IR, and Spruce Hills Resort in 100 Mile House TSA. These areas are relatively small and primarily occur on private land. The same areas were predicted to be active in 2017 and defoliation was quite noticeable on the ground, but the AOS flights in these areas were delayed

Table 4. Summary of western spruce budworm defoliation predictions for 2018 based on 2017 egg mass survey results.

Region	TSA	Number of Sites by Defoliation Category				Total Sites
		Nil	Light	Moderate	Severe	
Cariboo	100 Mile House	17	24	2	0	43
	Williams Lake	11	41	4	0	56
Thompson/ Okanagan	Kamloops	81	3	0	0	84
	Merritt	41	13	1	0	55
	Okanagan	39	4	0	0	43
	Lillooet	1	0	0	0	1
South Coast	Fraser	9	7	0	0	16
Kootenay/ Boundary	Boundary	7	6	3	2	18
	Cranbrook	13	0	0	0	13
	Total	219	98	10	2	329

due to wildfires until the defoliation detection window had passed. Sampling was planned at 16 additional sites in Cariboo Region, but the stands were destroyed by wildfire.

All the sites with moderate to severe defoliation predicted in Kootenay/ Boundary Region occurred in Boundary TSA in the Rock Creek/Bridgesville area, all within 10 km of each other. One site in Thompson/Okanagan Region is predicted to have moderate defoliation. This site is in Merritt TSA near Copper Mountain Road south of Princeton.

Three tree beatings were also conducted to document defoliator richness and abundance at permanent sample sites with a history of western spruce budworm. The number of budworm larvae found was consistently low again in 2017. No control programs are warranted for 2018.

Laminated root disease, *Phellinidium (Phellinus) sulphurascens*

Laminated root disease is a common damaging agent in southern BC but it is difficult to identify from the height of the AOS, so the damage is not accurately reflected in the data. Observed damage in 2017 continued to be low, with 84 ha identified. Most of the disturbances were scattered spots, represented by 14 ha (16%) of damage. The remaining 70 ha (84%) were assessed as light mortality.

West Coast Region was most affected, with 77 ha of laminated root disease damage mapped. Arrowsmith TSA contained the majority (76 ha) of the damage, with most of it located in one polygon along Englishman River. Three additional spot disturbances were found in North Island TSA. South Coast Region contained the remaining 7 ha of damage in spots.

Douglas-fir tussock moth, *Orgyia pseudotsugata*

There has been no observed defoliation by Douglas-fir tussock moth in Thompson/Okanagan Region since the decline of the last outbreak in 2011. In 2017, one small infestation was mapped on 15 ha in Kamloops TSA of Thompson/Okanagan Region. The majority of the mapped defoliation was severe, which is typical of tussock moth in year one of potential outbreaks. The disturbance was located on private land in Heffley Creek. A ground check was conducted and numerous egg masses were found throughout the affected site.

Douglas-fir tussock moth outbreaks build to outbreak levels very rapidly. An early warning system is used to monitor and anticipate impending outbreaks throughout the southern interior. The monitoring system employs pheromone-baited traps (six traps per site) and three-tree beatings at permanent monitoring sites in areas of historic defoliation. The number of moths caught at these sites indicate building or declining populations. When a consistent upward trend is found in a given stand for two years and the average catch reaches 8-10 moths per trap, an outbreak will probably be two summers hence. Sites are located in the Kamloops, Lillooet, Merritt, Okanagan, Boundary and 100 Mile House TSAs.



Douglas-fir tussock moth larva

Since the last outbreak, average trap catches using Con Tech lures steadily declined in most areas through 2015 (Table 5). Lures have been sourced from three different suppliers (Con Tech (now Scotts), Chem Tica and Synergy) since 2016. The Cariboo and Thompson/Okanagan Regions have deployed all three lure types at monitoring sites for the past two years, to compare efficacy among formulations. Trap result details are available in the 2017 *Overview of Forest Health Conditions in Southern British Columbia* report.

Table 5. Average number of male Douglas-fir tussock moths caught per trap by TSA, 2010 – 2017 at six trap cluster sites; number of sites in brackets.

Year	Supplier	TSA					
		100 Mile House	Boundary	Kamloops	Lillooet	Merritt	Okanagan
2010	Con Tech	1.7 (30)	1.7 (9)	18.5 (19)	7.8 (1)	29.6 (2)	9.6 (12)
2011	Con Tech	1.6 (30)	72.7 (9)	33.2 (19)	82.5 (1)	7.8 (11)	8.5 (12)
2012	Con Tech	1.4 (31)	1.0 (9)	12.8 (19)	3.2 (1)	5.5 (11)	9.1 (11)
2013	Con Tech	3.6 (30)	0.2 (9)	8.5 (19)	0.7 (1)	0.7 (10)	0.2 (10)
2014	Con Tech	1.6 (19)	0.1 (14)	1.6 (19)	0.2 (1)	0.5 (10)	0.3 (10)
2015	Con Tech	0.1 (16)	0.2 (8)	2.3 (19)	0.2 (2)	0.8 (9)	0.6 (11)
2016	Scotts	0.3 (16)		0.4 (19)	0.2 (1)	0.2 (10)	0.5 (10)
	Chem Tica	0.4 (16)	0.6 (9)	2.9 (19)	0.3 (1)	0.3 (10)	4.7 (10)
	Synergy	4.0 (16)		10.7 (19)	4.2 (1)	4.2 (10)	14.5 (10)
	Average	1.6 (16)	0.6 (9)	4.7 (19)	1.6 (1)	1.6 (10)	6.5 (10)
2017	Scotts	2.6 (11)		1.0 (12)	0.2 (1)	8.4 (9)	2.9 (10)
	Chem Tica	1.1 (11)	1.1 (9)	7.9 (12)	11.0 (1)	1.5 (9)	10.5 (10)
	Synergy	3.4 (11)		14.8 (12)	17.2 (1)	19.7 (9)	20.5 (10)
	Average	2.4 (11)	1.1 (9)	7.9 (12)	9.5 (1)	9.9 (9)	11.3 (10)

Five sites in 100 Mile House TSA and seven sites in Kamloops TSA were lost to wildfire in 2017. On average, trap catches in all TSAs increased in 2016, and again in 2017 (Table 5). Synergy lures were generally catching more moths than the other two types. A site at Heffley Creek in Kamloops TSA (near the defoliation noted in 2017) had the highest trap catches in 2016 and 2017, at 26.6 and 37.7 male moths, respectively. The only other site with consistently high catches was Olalla in Okanagan TSA, with 21.2 in 2016 and 29.2 in 2017. To determine lure efficacy or to recalibrate trap catch numbers with expected defoliation, traps must be deployed and evaluated through a complete outbreak cycle. Pine tussock moths were also caught in the traps at various sites this year. Defoliating larvae caught in three-tree beatings continued to be relatively low.

DAMAGING AGENTS OF SPRUCE

Spruce beetle, *Dendroctonus rufipennis*

The last large spruce beetle outbreak in BC peaked in 2003, with 315,953 ha of damage. Observed disturbances have remained relatively low since then; however in 2014, a sharp increase was noted. This trend has continued for three consecutive years, with attack almost doubling from 2016 to 501,873 ha in 2017 (Figure 11). Intensity of mortality decreased to 220,131 ha (44%) trace, 191,503 ha (38%) light, 71,889 ha (14%) moderate, 16,830 ha (3%) severe and 1,519 ha (<1%) very severe. Generally, more large trace mortality disturbances were mapped on leading edges of infestations and fewer moderate intensity polygons were delineated. District staff trying to control spruce beetle infestations noted

that significant areas of attack are located in either riparian, inaccessible, or old growth management areas, or unharvested areas adjacent to recent harvesting, all of which are very difficult to manage.

The majority of the attack continued to occur in Omineca Region where 372,483 ha of spruce beetle damage was mapped, up from 218,406 ha in 2016. It was observed in localized, high spruce beetle population areas in this region that the spruce attacked in 2017 were turning red as early as September, and that some broods were in a one-year life cycle. This is far earlier than the usual 13 to 18 months it takes for attacked trees to turn (possible reasons are discussed in Forest Health Projects, Project 11).

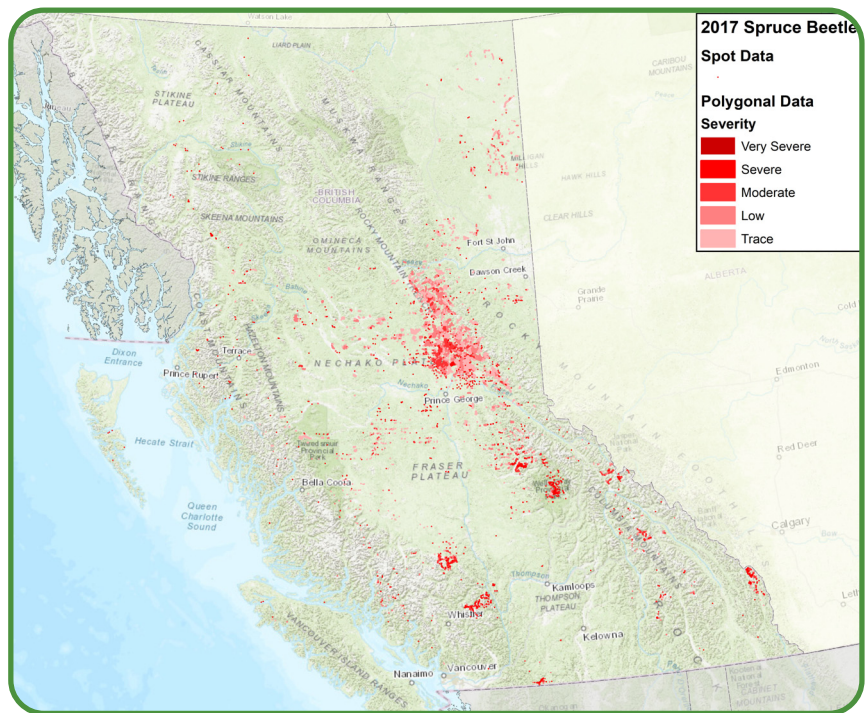


Figure 11. Spruce beetle infestations recorded in 2017 in BC, by severity rating class.

Prince George TSA sustained 275,108 ha of mortality. Most of the infestations continued to spread in the northern half of Prince George District. There were substantial increases in spruce beetle attack in the southern half of Fort St. James District as well. Infestations remained small and scattered in Vanderhoof District. All of the 90,193 ha mapped in Mackenzie TSA continued to occur in the southern third. However, for a third consecutive year, a large portion of the northern half of this TSA could not be surveyed due to poor weather so damage may be underestimated. Attack continued



Spruce beetle mortality in Kamloops TSA

to expand in Robson Valley TSA, particularly in the southern tip, with a total of 7,182 ha delineated.

After being the only region where spruce beetle damage declined last year, observed attack in Northeast Region increased six-fold to 64,029 ha. A substantial amount of this increase occurred in large trace polygons along the western edge of Dawson Creek TSA, where 39,838 ha were mapped. Infestations also grew and were more widespread in Fort St. John TSA with 17,980 ha of attack recorded. An increase of primarily trace intensity damage accounted for 6,211 ha in Fort Nelson TSA in the eastern third.

Spruce beetle damage doubled in Skeena Region since 2016 to 19,523 ha. The largest increase occurred in Lakes TSA, where infestations rose to 9,248 ha. Disturbances were concentrated around Fleming Creek in the north, Taltapin Lake in the mid TSA and Tetachuck Lake in the south. Damage in Bulkley TSA remained relatively static at 3,261 ha, primarily in the same areas as 2016, east of Fort Babine to Mount Seaton. In Bulkley TSA funnel traps were employed to monitor the spruce beetle and it was noted that the beetle flight continued into August, which was much later than normal. Morice TSA sustained a slight increase in spruce beetle damage to 2,911 ha, with concentrations east of Topley Landing, around Houston and on Troitsa Lake. Very scattered infestations observed during the AOS in Kalum TSA almost doubled to 1,900 ha. A subsequent low level detailed spruce beetle detection flight captured 4,200 ha of damage over a limited area of Kalum TSA. The remaining disturbances noted in Skeena Region were relatively small and scattered, accounting for 809 ha, 748 ha and 646 ha, in Kispiox, Cassiar and Nass TSAs, respectively.

Infestations continued to grow in Cariboo Region, where 18,928 ha were mapped, primarily in the same areas as 2016. All the large disturbances were noted in Williams Lake TSA, with a total of 13,815 ha attacked. Damage was concentrated in the northeast tip of the TSA and between Mount Tom and Black Dome Mountain in the south. Small, widely scattered infestations accounted

for 4,835 ha of mortality in Quesnel TSA. Most of the 278 ha of attack in 100 Mile House TSA occurred in the northeast corner.

After almost tripling in Thompson/Okanagan Region last year, spruce beetle attack remained relatively static in 2017 with 14,803 ha affected. Infestations continued to occur in the same general areas. Kamloops TSA sustained 9,778 ha of damage, primarily in Wells Grey Park in between the main park corridor and Murtle Lake, with most of the spruce stands in the area infested. A total of 4,918 ha of spruce beetle mortality was mapped in Lillooet TSA, mainly around Gott Peak and north of Cardtable Mountain. Lower elevation stands are becoming depleted of host trees but the beetle is still very active in higher elevation drainages. Infestations in the Manning Park area accounted for most of the 78 ha recorded in Merritt TSA and 29 ha in Okanagan TSA.

Spruce beetle mortality in Kootenay/Boundary Region declined 40% since 2016 to 9,153 ha. This could be an artificial decline however as Invermere TSA, which led the regional damage with 7,923 ha last year, was primarily not surveyed in 2017 due to smoke issues. Attack in Cranbrook TSA continued to rise, with 4,477 ha affected, mainly in the north tip of the TSA. Infestations also grew along the western edge of Golden TSA to 3,201 ha. Small scattered disturbances totalling 622 ha were noted in Revelstoke TSA. Dispersed spruce beetle damage in Arrow and Kootenay Lake TSAs was similar, with 397 ha and 383 ha affected, respectively. In the small portion of Invermere TSA that was surveyed, only 73 ha of damage were mapped.

South Coast Region spruce beetle attack doubled to 2,482 ha. Fraser TSA continued to sustain the majority of the damage, primarily at a moderate to severe intensity in Manning Park, with a total of 1,615 ha affected. Small, scattered infestations accounted for 782 ha of spruce beetle mortality in Sunshine Coast TSA. Almost all of the 85 ha mapped in Soo TSA were south of Cayoosh Mountain, which is an extension of the active Lillooet TSA infestation.

In Great Bear Rainforest, spruce beetle attack damage was very scattered and small in size, with 343 ha delineated in North TSA and 34 ha in South TSA.

Of the 95 ha of damage observed in West Coast Region, almost all (93 ha) were mapped in North Island TSA, north of Chamiss Bay. The remaining six spot infestations were observed in Haida Gwaii TSA.



Tree attacked by spruce beetle with signs of woodpecker feeding

Eastern spruce budworm, *Choristoneura fumiferana*

Suspected eastern spruce budworm defoliation was mapped in 2016 in the Northeast Region for the first time since 2005. The 250 ha spruce stand west of Maxhamish Lake in Fort Nelson TSA could not be ground checked, but it was definitely identified as defoliation, which historically is the damaging agent of spruce in this area. Eastern spruce budworm populations have been cyclical in nature here and damage was anticipated, since a decade has passed since it was last noted.

Similarly, 756 ha of moderate defoliation was identified in spruce and balsam with a low fly-by during the AOS in 2017. Three polygons were mapped west of Wargen Lakes in Fort St. John TSA in Northeast Region. Eastern spruce budworm has been mapped historically in this area and is the most likely damaging agent.

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

Large-spored spruce-labrador tea rust only infects current needles, and unless infections are heavy this disease is not usually visible from the AOS. However, in 2017, damage was visible over 131 ha in five young spruce stands. Two stands (50 ha, 38%) were severely affected and three stands (81 ha, 62%) had moderate damage. These stands were located between the main Williston Lake water body and Omineca Arm, in Mackenzie TSA of Omineca Region.

The damage was ground confirmed (see Forest Health Projects, Project 16), and it was noted that the infected area was more widespread than mapped, and included mature stands. Since current growth is a much smaller percentage of total tree foliage on older trees, the damage signature from the air was too subtle to detect at the height the AOS was flown.



Large-spored spruce-labrador tea rust infection



Large-spored spruce-labrador tea rust damage in Mackenzie TSA

DAMAGING AGENTS OF TRUE FIR

Western balsam bark beetle, *Dryocoetes confusus*

For the third consecutive year a portion of Omineca Region (where western balsam bark beetle damage is prevalent) could not be flown (Figure 2), hence the area affected provincially this year was likely underestimated. Total damage increased for the second consecutive year to 3,701,556 ha, up from 3,261,617 ha in 2016 (Figure 12). Intensity of mortality however decreased, with 2,935,818 ha (79%) trace, 744,723 ha (20%) light, 19,819 ha (1%) moderate and 1,196 ha (<1%) severe.

Western balsam bark beetle mortality continued to be highest in Omineca Region with 1,610,438 ha of attack, up 14% from 2016. The majority of the higher intensity disturbances noted provincially were also in this region. A total of 943,516 ha were damaged in Prince George TSA. A lot of this attack was mapped in large polygons in Fort St. James District and the northern half of Prince George District. Disturbances were generally smaller and more scattered in the southern half of Prince George District and Vanderhoof District. Mackenzie TSA sustained 590,356 ha of damage, with highest concentrations in the southern third. Infestations were scattered throughout Robson TSA, totalling 76,566 ha.

Attack in Skeena Region continued to increase, up a third since 2016 to 1,531,656 ha. The majority of the disturbance was rated as trace intensity in this region. Morice TSA continued to be the most affected, with 344,736 ha mapped. Bulkley TSA sustained 278,815 ha of damage. Infestations in Cassiar TSA increased dramatically to 246,939 ha, primarily because more of the TSA was surveyed this year. The most active (light to moderate intensity) infestations in the region were observed in this TSA near Nahta Cone. Kispiox TSA sustained 239,446 ha of western balsam bark beetle attack. Infestations in Nass TSA totalled 215,432 ha, mainly in the northeastern portion of the TSA. The majority of the 168,897 ha affected in Lakes TSA were mapped in the southern third. Kalum TSA was least affected with 37,392 ha delineated, mostly in the northern tip. In the Skeena/Stikine District (Kispiox and Bulkley TSAs) opportunities for under-planting in some lower elevation sites that have been significantly impacted by years of balsam bark beetle attack are being explored. Stands infested in Coast Mountain District (Nass and Kalum TSAs) are generally in upper watershed areas where, due to a number of constraints, salvage harvesting is unlikely to occur.

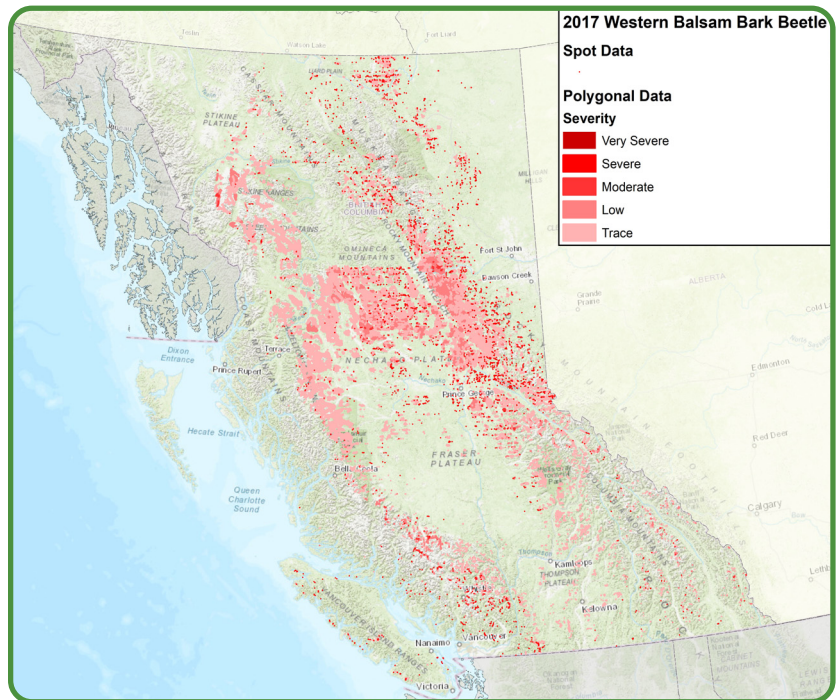


Figure 12. Western balsam bark beetle damage mapped in 2017, by severity rating class.

Balsam bark beetle attack covered 267,205 ha in Northeast Region, up from 227,605 ha. Dawson TSA contained 188,766 ha of disturbances, primarily along the western edge of the TSA. Fort Nelson infestations totalled 65,536 ha, with concentrations north of Liard River. Scattered attack in the western half of Fort St. John TSA accounted for the remaining 12,903 ha of damage in the region.

After a large increase in 2016, infestations in Thompson/Okanagan Region declined by half to 114,016. Disturbances were delineated in the same scattered host stands but the size of polygons generally decreased. Kamloops TSA continued to sustain the most damage in the region with 59,727 ha mapped. Attack in Okanagan TSA totalled 26,742 ha. Lillooet TSA contained 19,125 ha of balsam bark beetle mortality, while Merritt had 8,422 ha of damage delineated.

Area affected by balsam bark beetle attack remained relatively stable in Cariboo Region at 93,966 ha. Williams Lake TSA sustained 51,135 ha of damage. Infestations were most active in the Chilko and Taseko Lakes area where relatively high elevation valleys interconnect and areas of chronic attack have spread and intensified. Attacked stands totalled 37,161 ha in Quesnel TSA, with concentrations in the eastern third. Infestations were most active around the Bowron Lakes area. Almost all the 5,670 ha delineated in 100 Mile House TSA was around the Mica Mountain area.

Great Bear Rainforest sustained 47,951 ha of attack, with most (47,419 ha) located along the eastern border of North TSA. The majority of the 532 ha of South TSA mortality was confined to a light intensity infestation south of Wilderness Mountain.

Infestations in Kootenay/Boundary Region were small and scattered throughout host stands in areas similar to 2016 but damage shrunk to less than a third with 22,090 ha mapped. Golden, Invermere and Cranbrook TSAs sustained the most damage with 6,465 ha, 4,645 ha and 3,726 ha mapped, respectively. Attack in Arrow and Kootenay Lake TSAs was similar at 2,945 ha and 2,019 ha, respectively. Infestations totalled 1,747 ha in Revelstoke TSA and Boundary TSA contained 542 ha of damage.



Western balsam bark beetle mortality in Bulkley TSA

Balsam bark beetle mortality in South Coast Region was observed on 12,638 ha. All attack was small and scattered, with a high number of spot infestations mapped. So0 TSA was most affected, with 6,780 ha of damage. Disturbances in Fraser TSA totalled 3,788 ha and Sunshine Coast TSA had 2,070 ha delineated.

West Coast Region had minor damage from balsam bark beetle attack, with 1,598 ha mapped. Almost all (1,456 ha) was contained in Arrowsmith TSA, with the remaining 142 ha of mortality identified in North Island TSA.

Two-year-cycle budworm, *Choristoneura biennis*

Two-year-cycle budworm defoliation doubled provincially this year to 376,100 ha (Figure 13), which is the highest recorded damage since a peak of 392,316 ha in 2009. Intensity of damage also increased substantially with 139,259 ha (37%) light, 227,338 ha (60%) moderate and 9,503 ha (3%) severe. The majority of the defoliation occurred in the northern interior, where this budworm is primarily in the second year of its two-year life cycle. However, a significant amount of defoliation was also observed during the AOS (and confirmed with some ground checks) in the southern interior. Since the budworm is only in its first year in the south, high levels of defoliation are predicted for 2018.

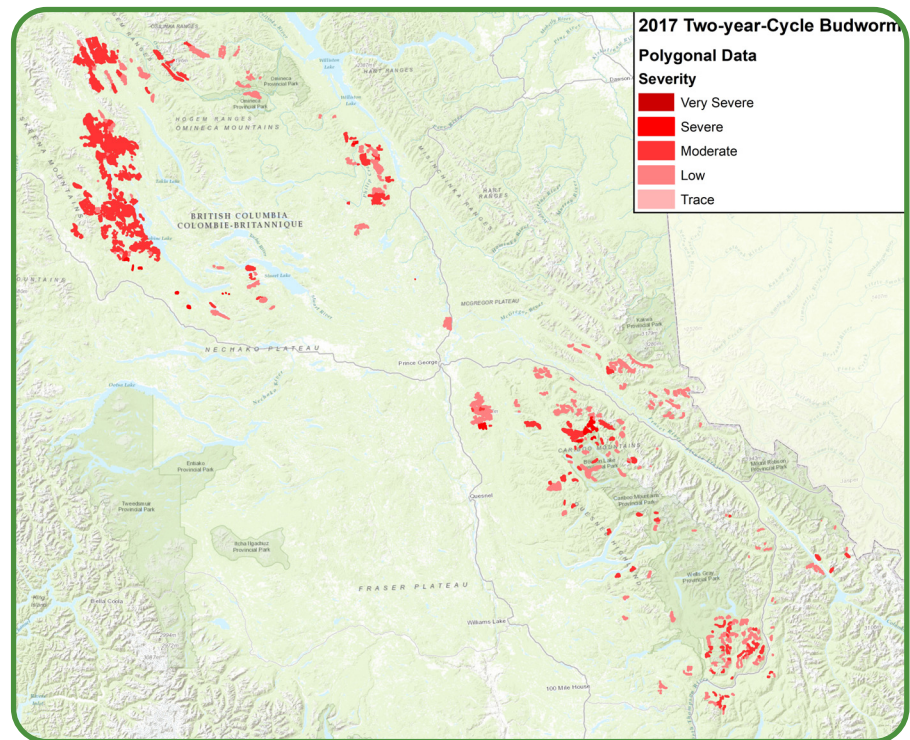


Figure 13. Two-year-cycle budworm defoliation mapped in 2017, by severity rating.

Omineca Region sustained 179,294 ha of two-year-cycle budworm defoliation in 2017. Prince George TSA had 120,613 ha of attack, with the largest, highest intensity disturbances mapped in Fort St. James District around Azuklotz Lake area. Substantial damage also occurred east of Red Rock in Prince George District. Some of this defoliation was noted last year in areas where the budworm is usually on an even year, high defoliation cycle. The rest of the damage in this region

was not visible in 2016. The remaining 36,303 ha in the region was mapped in the southwest portion of Mackenzie TSA.



Two-year-cycle budworm defoliation in Bulkley TSA

Two-year-cycle budworm in Skeena Region increased from 74 ha last year (when the budworm were small early instar larvae) to 138,546 ha in 2017. Almost all the defoliation was rated as moderate intensity. Morice TSA sustained 70,111 ha of damage in the northern tip. Disturbances in Bulkley TSA totalled 64,986 ha, located in the eastern half of the TSA. Defoliation of 3,400 ha in Lakes TSA was mapped around the

Taltapin Lake area. The infestation in Bulkley TSA just crossed the boundary into Kispiox TSA, resulting in a 50 ha disturbance.

Defoliation increased from 24,635 ha in 2016 to 32,405 ha in Thompson/Okanagan Region. All of the disturbances were observed in Kamloops TSA, primarily south of Murtle Lake to Dunn Peak.

All the 25,855 ha of defoliation recorded in Cariboo Region occurred in the eastern portion of the region, where most of the host trees grow. This is less than half of last year but far higher than the 106 ha mapped during 2015. Quesnel TSA sustained 17,021 ha of attack, from Wells east to the TSA boundary. Defoliation in Williams Lake TSA covered 6,135 ha, scattered along the eastern edge. Damage occurred on 2,699 ha in 100 Mile House TSA near Hendrix Lake, Spanish Creek and Windy Mountain.

Balsam Woolly Adelgid, *Adelges piceae*

Observed balsam woolly adelgid damage doubled over 2016 to 164 ha this year, all mapped in the Great Bear Rainforest TSAs. Severity of damage was noted as 140 ha (86%) trace, 24 ha (14%) light, and two spot infestations rated severe. The majority of the damage continued to be seen in the same general coastal areas as has historically been documented. A total of 123 ha were mapped in Great Bear Rainforest South TSA, east and west of Glacier Bay in Knight Inlet. The remaining 41 ha in Great Bear Rainforest North TSA was identified in one disturbance near Kilbella Bay in Rivers Inlet. Damage due to balsam woolly adelgid is very difficult to identify from the height of the AOS, and therefore generally underestimated. Ground surveys to identify the extent of the range of balsam woolly adelgid continued in 2017 (see Forest Health Projects, Project 5).

DAMAGING AGENTS OF HEMLOCK

Western hemlock looper, *Lambdina fiscellaria lugubrosa*

The last western hemlock looper outbreak occurred in the southern interior, with a peak of 8,103 ha of defoliation in 2012. Damage rapidly declined after that, and no new defoliation has been recorded during the AOS for four years.

Since 2003, western hemlock looper populations have been monitored at permanent sampling sites in three TSAs, with a combination of pheromone traps (six traps per site) and three-tree beatings. In 2017 trap catches on average were higher than 2016 in all TSAs, well below 2012 levels (Table 6). In Kamloops and Okanagan TSAs very few other defoliating insects were found in the three-tree beatings. For Revelstoke TSA, sawflies were the main defoliating insects collected in the three-tree beatings. Diversity of insects increased slightly from the past few years and numbers caught were average.

Table 6. Average number of western hemlock looper male moths caught per trap at various FLNRORD monitoring sites (6-trap clusters per site), 2011 - 2017.

Year	TSA (# sites)		
	Kamloops ⁽⁶⁾	Okanagan ⁽¹⁰⁾	Revelstoke ⁽¹¹⁾
2011	697.7	852.5	724.7
2012	130.1	564.9	483.9
2013	6.4	74.9	80.2
2014	3.6	35.3	14.5
2015	22.0	61.6	6.2
2016	1.2	10.4	2.5
2017	49.9	26.7	8.6

DAMAGING AGENTS OF LARCH

Larch needle blight, *Hypodermella laricis*

Larch needle blight infected just over 30,000 ha in 2011 and 2012, but damage has been relatively low for five consecutive years. In 2017, a total of 2,169 ha of damage were mapped, with intensities of 1,480 ha (68%) light, 502 ha (23%) moderate and 187 ha (9%) severe. Infections were all in western larch stands and disturbances were small and scattered.

Kootenay/Boundary Region continued to sustain the majority of the damage, where 1,986 ha were mapped. Kootenay Lake TSA contained disturbances totalling 630 ha, primarily from Lardeau south through the West Arm of Kootenay Lake. Arrow TSA had 622 ha of damage and 519 ha were observed in Boundary TSA, chiefly along the eastern border. Cranbrook TSA contained 205 ha of larch needle blight disturbances, and 11 ha were noted in Invermere TSA.

Larch needle blight damage in Thompson/Okanagan Region continued to be low, with 183 ha mapped. Five polygons totalling 147 ha were observed in Okanagan TSA, with an additional 28 ha (one disturbance) in Lillooet TSA and 8 ha (three small polygons) recorded in Kamloops TSA.



Current and old larch needle blight damage

Larch needle cast, *Meria laricis*



Spring larch needle cast damage

Larch needle cast damaged 26 ha in Okanagan TSA of Thompson/Okanagan Region in 2017. Intensity of damage was equally assessed as light and moderate. The disturbances were mapped just north of Kingfisher and a ground check confirmed the identity of the pathogen.

Larch needle cast damage is rarely recorded during the AOS, as infected needles are usually cast before the survey is conducted. However, in 2017, these damaged stands were mapped during an early-season AOS pilot (see Forest Health Projects, Project 1).

DAMAGING AGENTS OF CEDAR

Yellow-cedar decline

In 2017, yellow-cedar decline observed in coastal BC was the same as 2016 at 56,563 ha (Figure 13). Intensity of damage was similar with 35,669 ha (63%) trace, 15,488 ha (27%) light, 3,474 ha (6%) moderate and 1,933 ha (4%) severe. Due to time constraints and weather, surveyors were unable to fly into the Kwatna River drainage (Great Bear Rainforest North TSA) or Tezwa River drainage (Kalum TSA), where substantial damage was noted in previous years. Surveyors also noted that most yellow-cedar decline polygons are well established and it is rare to see new polygons developing. Some existing polygons now have only old mortality with no current damage to map, and observed new mortality appears to be gradually decreasing.

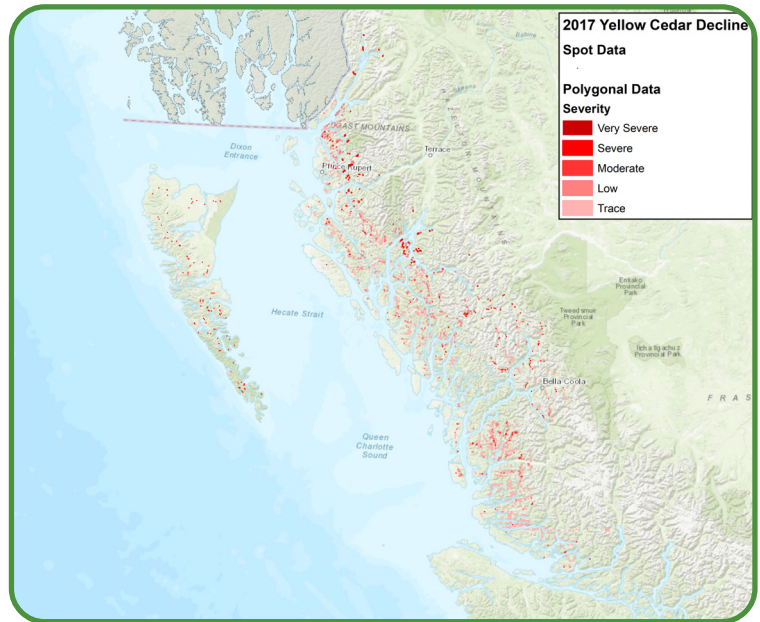


Figure 14. Yellow-cedar decline damage mapped in 2017, by severity rating class.

Damage continues to be highest in Great Bear Rainforest North TSA with 45,959 ha affected mainly along coastal inlets and drainages. Intensity of mortality was highest from Tide Mountain south to Mount Hayward and around Moses Inlet. Disturbances in South TSA were primarily trace with 6,390 ha mapped, mainly around Belize Inlet.



Yellow-cedar decline damage

Skeena Region contained 3,228 ha of yellow-cedar decline damage, all in the southwestern portion of Kalum TSA. Mortality was highest around Devastation Channel.

West Coast Region sustained 987 ha of damage, all in Haida Gwaii TSA. Many of these were scattered spot disturbances, with most of the polygons delineated from Awan Lake on Graham Island and south to Mount Kermode on Moresby Island.

Western redcedar flagging

Western redcedar flagging increased from 156 ha in 2016 to 3,800 ha in 2017. Western redcedar flagging is the natural death of older foliage but when visible during the AOS it suggests an unusually high amount of foliage is affected. It is suspected that the unusual amount of visible flagging this year was associated with drought. Intensity of damage was rated as 3,140 ha (83%) light and 660 ha (17%) moderate.

Thompson/Okanagan Region contained 2,614 ha of western redcedar flagging damage. Most of this (2,145 ha) was observed in Kamloops TSA, particularly from North Barriere Lake south to Little Shuswap Lake and around Clearwater Lake. The damage continued into Okanagan TSA around Shuswap Lake and Skimikin Creek, with 469 ha delineated.

All the western redcedar flagging observed in Cariboo Region was of light intensity, and totalled 1,186 ha. Williams Lake TSA had 971 ha of damage, all around the Summit Lake area. The remaining 215 ha were noted in 100 Mile House TSA in the Pendleton Lakes area.



Western redcedar flagging

DAMAGING AGENTS OF DECIDUOUS TREES

Aspen (serpentine) leaf miner, *Phyllocnistis populiella*

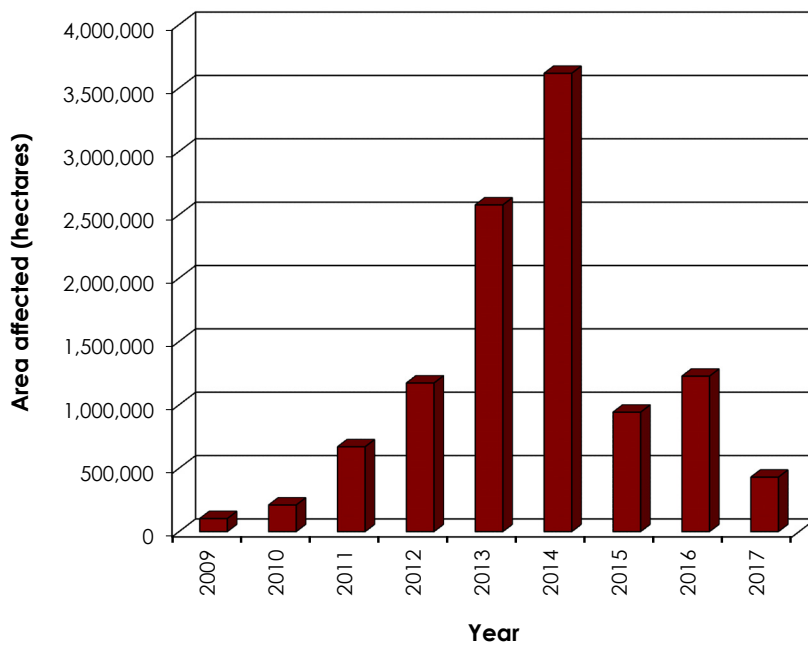


Figure 15. Aspen leaf miner defoliation damage in BC from 2009 to 2017.

Aspen leaf miner has been causing widespread damage throughout BC since 2009, with a record peak of 3.6 million hectares in 2014 (Figure 15). Defoliation decreased to a third of that recorded provincially in 2016 to 429,280 ha, with declines noted in every affected region (Figure 16). This is the lowest level of aspen leaf miner damage mapped since 2010. Intensity of attack for this agent is categorized in the same way as mortality factors, as a percentage of trees affected in a polygon, rather than intensity per tree. Intensity of attack decreased over last year as well, with 106,401 ha (25%) light, 219,258 ha (51%) moderate and 103,621 ha (24%) severe. For the past

several years ground observations have indicated that aspen leaf miner populations are generally on the decline, with lighter intensity of attack at the tree level, and lower moth abundance. For the past two years, some stands in various regions were observed to be entirely uninfested, which has not been the case for several years. Anecdotal ground observations noted that the uninfested stands appeared to be in the drier ecosystems, particularly along the edge of open range. Trembling aspen continued to be the primary host but 36,871 ha (9%) of the stands contained a component of cottonwood, primarily in Prince George TSA of Omineca Region.

Consecutive years of aspen leaf miner damage, combined with damage from other defoliators, diseases and drought, continues to result in aspen tree decline in the form of slower growth, smaller leaves, thinner crowns and even mortality in various locations, particularly in the Northeast Region this year.

Stands infested with aspen leaf miner were highest in Skeena Region, where 245,889 ha were attacked. Damage increased slightly in Lakes TSA to 118,458 ha with most of the defoliation continuing to occur in the northern half. Kispiox was the only other TSA provincially that had an increase in damage to 43,995 ha, primarily along Skeena, Kitwanga, Kispiox, Babine and Cranberry Rivers. Disturbances in Cassiar TSA were a third of 2016 at 42,626 ha, despite the AOS covering a much higher percentage of the TSA this year. Damage in Morice TSA continued to occur in the same general areas, but infestations decreased by almost half to 35,715 ha. Attack levels in Bulkley TSA fell to 4,302 ha, primarily located south of Smithers around Round Lake. Kalum and Nass TSA sustained low aspen leaf miner damage, with 752 ha and 42 ha mapped, respectively.

Provincially, the Omineca Region had the most aspen leaf miner damage in 2016, but attack fell to less than a third with 116,382 ha mapped this year. Most of the decline occurred in Prince George TSA, where infestations remained widespread but at much reduced sizes, with a total of 82,390 ha affected. All defoliation in Mackenzie TSA continued to occur in the southern tip with 29,123 ha mapped. Most of the 4,869 ha of damage in Robson Valley TSA continued to be observed along the Fraser River.

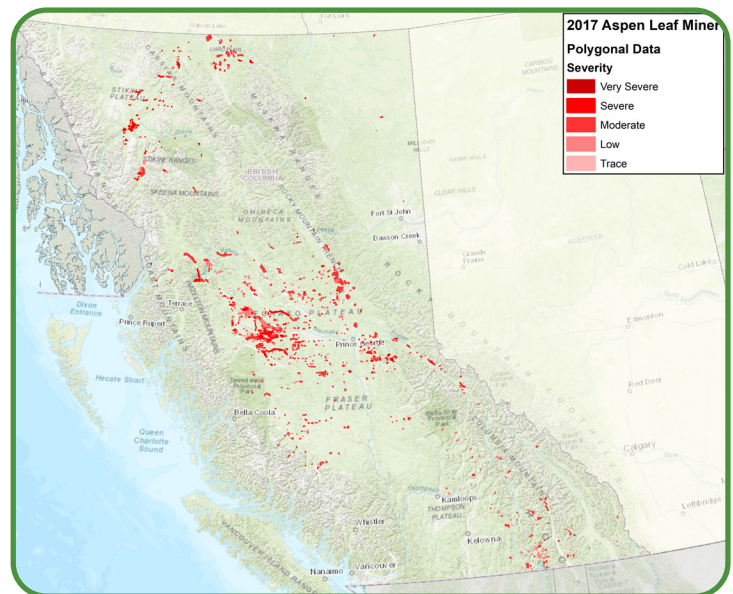


Figure 16. Aspen leaf miner defoliation mapped in 2017, by severity rating class.



Stand severely affected by aspen leaf miner

Aspen leaf miner defoliation decreased eight-fold in Cariboo Region to 21,689 ha. Historically, most of the damage has been mapped in the eastern portion of the region, where the highest proportion of aspen stands occur. However, this year the attack was primarily mapped in small scattered polygons in the west. It is important to note that aspen leaf miner damage was observed to be more widespread from ground observations than was mapped but due to wildfires most of the survey was conducted in late September when fall leaf colour changes mask the damage signature. Delineated disturbances were of similar size in Williams Lake and Quesnel TSAs with 11,344 ha and 10,123 ha mapped, respectively. Only two polygons totalling 222 ha were found along the northern edge of 100 Mile House TSA.

Damage observed in Kootenay/ Boundary Region decreased to 21,007 ha. Arrow TSA sustained the most damage, with 11,194 ha noted primarily in the southern half of the TSA. Disturbances in Kootenay Lake TSA were similar to 2016, with 6,018 ha scattered across the TSA. Infestations primarily along Revelstoke and Upper Arrow Lake accounted for 1,885 ha in Revelstoke TSA. A few small disturbances were mapped in Cranbrook, Golden and Boundary TSAs with 1,087 ha, 426 ha and 398 ha affected, respectively.

Aspen leaf miner infestations dropped thirteen-fold in Northeast Region to 16,560 ha. Since this area was flown mid-summer under reasonable visibility conditions, the reduction in damage was not a factor of AOS limitations. Most of the mapped defoliation was in the northwest corner of Fort Nelson TSA, with 16,478 ha delineated. Three small polygons in Fort St. John TSA accounted for the remaining 81 ha of damage.

Disturbances in Thompson/ Okanagan Region were small and scattered with 6,962 ha mapped. Kamloops TSA sustained 4,508 ha of damage, and 2,453 ha were infested in the northern half of Okanagan TSA.

Aspen leaf miner defoliation remained low in coastal areas, with only a few small polygons totalling 790 ha delineated in the Great Bear Rainforest North TSA, along the border with Lakes TSA.



Aspen leaf miner damage

Satin moth, *Leucoma salicis*

Satin moth, a native of Europe and Asia, was introduced to BC in the early 1900's. Since then, observed infestations have been relatively small and scattered, affecting primarily aspen and cottonwood. The first large infestation occurred in Cariboo Region in 2002 and 2003, with a record peak 45,070 ha defoliated in 2002. Damage then returned to endemic levels until 2016, when disturbance rose sharply to 9,122 ha, primarily in Prince George TSA of Omineca Region.

In 2017, infestations continued to grow rapidly, with a record total of 160,085 ha affected (Figure 17). Intensity of defoliation also increased, with 45,039 ha (28%) light, 81,509 ha (51%) moderate and 33,537 ha (21%) severe. Areas near Smithers, Fort St. James and west/north of Prince George were ground checked to confirm this defoliator.

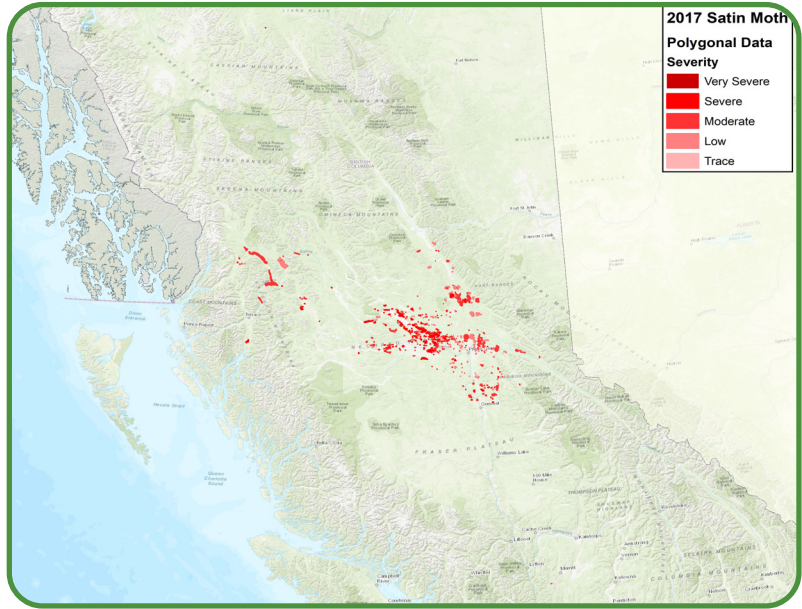


Figure 17. Satin moth defoliation mapped in BC by severity class in 2017.

Omineca Region continued to sustain the most damage with 107,002 ha affected. Most of this damage (99,387 ha) was recorded in the southern half of Prince George TSA. The highest intensity defoliation occurred around Necoslie River, Stuart Lake and McLeod Lake. Primarily lighter intensity disturbances moved north into Mackenzie TSA, with a total of 7,615 ha mapped as far north as Weston Arm on Williston Lake. Reports were made this fall of 1st and 2nd instar larvae causing visible defoliation around the Fraser Lake area in Prince George TSA, which indicates that damage will continue to be significant in 2018.



Satin moth larva



Satin moth pupal case



Satin moths

Defoliation in Skeena Region rose from only 394 ha in 2016 to 47,596 ha. Satin moth was first confirmed in this region in the Terrace area in 2007, though last year was the first time satin moth damage was recorded during the AOS, in Bulkley and Morice TSAs. In 2017, Kispiox TSA sustained 38,242 ha of primarily light to moderate damage in a few large disturbances, chiefly along Kitwanga and Kispiox Rivers. Infestations along the eastern edge of Lakes TSA totalled 5,211 ha with the majority of the damage occurring along the eastern end of Babine Lake where severe defoliation was mapped. Bulkley TSA contained 1,489 ha of damage around the Smithers area. Four polygons in the southern tip of Nass TSA totalled 1,408 ha. A further 1,153 ha were mapped in Kalum TSA, primarily near Kitimat and Dorreen on the Skeena River. Minor infestations affected 65 ha in Morice TSA and 28 ha in Cassiar TSA.



Satin moth defoliation west of McLeod Lake, Prince George TSA

Cariboo Region sustained 5,474 ha of satin moth attack, all in the Quesnel TSA along the northeast boundary. The remaining 12 ha of defoliation was noted in Merritt TSA of Thompson/Okanagan Region.

Venturia blights, *Venturia* spp.

After a large increase in *Venturia* blight damage (also known as aspen and poplar leaf and twig blight) in 2016 to 55,049 ha, disturbances declined to 12,067 ha, a level similar to 2015. However, intensity of damage increased to 573 ha (5%) light, 1,454 ha (12%) moderate and 10,040 ha (83%) severe. Trembling aspen continued to be the most commonly affected host with a few disturbances noted in cottonwood.

The majority of the infections continued to be recorded in Skeena Region, where 9,309 ha were mapped. Last year some of the damage called *Venturia* blight in this region had an unusual reddish/brown aerial signature that the regional pathologist could not confirm but suspected was still a type of *Venturia* blight damage, possibly combined with cottonwood leaf rust. The aerial signature in 2017 was a more typical light brown colour. Most of the regional damage occurred in Kalum TSA, where 7,527 ha were affected, mainly along the Nass River with smaller infection centers northwest of Rosswood. Small scattered disturbances accounted for 1,427 ha in Cassiar TSA. Disturbances in Nass TSA totalled 280 ha, clustered just north of Stewart. Lakes TSA contained the remaining 75 ha in the region on the Endako River at the eastern boundary of the TSA.

Venturia blight damage in Northeast Region totalled 1,593 ha in 2017. Disturbances covering 842 ha in Fort Nelson TSA were small and scattered. Infection centers in Fort St. John TSA were primarily noted in the southeast, accounting for 724 ha. This damage continued into the northeast corner of Dawson TSA, where 27 ha were mapped. Great Bear Rainforest North TSA contained 795 ha of *Venturia* blight damage, primarily at the north end of Observatory Inlet. All observed *Venturia* blight damage in Omineca Region was in Prince George TSA, with 370 ha affected. The disturbances were clumped in six polygons just north of Francois Lake.

Gypsy moth, *Lymantria dispar*

In 2017 over 5,000 traps set by the Canadian Food Inspection Agency's for annual monitoring and delimiting trapping, augmented with FLNRORD recreation site trapping, captured 98 male moths at 14 locations on southern Vancouver Island and the Lower Mainland and, for the first time, in a recreation site near Queen Charlotte City on Haida Gwaii. Table 7 describes the distribution of the positive trap catches. All but one male moth was North American strain of European gypsy moth (NAGM). The lone Asian gypsy moth (AGM) was found inland from Cowichan Bay. Sources of NAGM are usually from outdoor household articles and vehicles originating from eastern Canada where the insect has been firmly established since the early 1980's. The AGM's source has yet to be determined. The BC Gypsy Moth Technical Advisory Committee reviewed the trapping results in late October and recommended a 94 ha aerial spray be conducted in Courtenay and ground sprays in North Surrey, Agassiz and Campbell River (Table 7). The Saanich aerial spray at Bear Hill Regional Park successfully eradicated the moth population with no moths trapped. Unfortunately, the North Surrey site which was treated by ground spray crews in May 2017 failed. This treatment was hampered by thick foliage and steep terrain that prevented the ground application from penetrating far enough into the forested slope north of treatment block. A more aggressive ground spray approach is planned for 2018.

Table 7. Numbers of male gypsy moths caught in pheromone traps in BC in 2017 by location and BC GMTAC management recommendations.

Location	Male Moths Caught	Management Recommendation
Agassiz,	8	41 ha Ground spray
Port Coquitlam	1	Delimit trap
Pitt Meadows	1	Delimit trap
Surrey – Fraser Heights	51	46 ha Ground spray
Surrey – Guilford	4	Delimit trap
Surrey – Johnson Heights	2	Delimit trap
Richmond	1	Delimit trap
Victoria	1	Delimit trap
Arbutus Ridge	3	Delimit trap
Spectacle Lk	1	Delimit trap
Cowichan	1	Delimit trap - AGM
Courtenay	15	94 ha Aerial spray
Campbell R.	8	45 ha Ground spray
Queen Charlotte City	1	Delimit trap

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 in Williams Lake TSA

Aspen decline damage was recorded for the seventh consecutive year in BC. Area affected grew almost five-fold since 2016, though observed sites moved from the southern interior to the northeast interior. A total of 25,892 ha were mapped, at intensities of 10,834 ha (42%) light and 15,058 ha (58%) moderate.

All aspen decline damage in 2017 was observed in Northeast Region. Fort Nelson TSA contained the majority with 21,550 ha mapped in polygons scattered from the Liard River east to Sahtaneh River. A total of 3,562 ha of aspen decline damage were located in northern Dawson Creek TSA around the

Moberly River area. Fort St. John TSA contained 780 ha of damage around Lynx Creek and Flatrock Creek in the southern portion of the TSA. There are plans to further study aspen decline in this region (see Forest Health Projects, Project 3).

The majority of the damage in 2016 was noted in Cariboo Region where none was observed this year. Damage was noted from the ground in some low elevation stands in the southern end of 100 Mile House TSA but visibility challenges associated with the wildfires likely interfered with mapping these stands during the 2017 AOS.

Septoria leaf spot, *Mycosphaerella populicola*

Septoria leaf spot damage was first detected during the AOS last year when 1,305 ha were mapped in the Bella Coola Valley of Great Bear Rainforest North TSA. Samples were collected during ground checks that were confirmed to be infected with Septoria leaf spot. In 2017, damage caused by this disease spread, with 9,197 ha delineated. Overall, severity was assessed as 1,097 ha (12%) light, 7,981 ha (87%) moderate and 119 ha (1%) severe, which was lower than in 2016. Damage continued to occur in the same TSA, but was observed from the Noeick River off South Bentinck Arm north to the north tip of Dean Channel, with the largest concentrations still along Bella Coola Valley. Black cottonwood was the host species and damage was confined to valley bottoms, the host is mainly located.

Bruce spanworm, *Operophtera bruceata*

After a peak of 22,452 ha in Northeast Region, Bruce spanworm damage dropped to only 241 ha scattered throughout Dawson Creek TSA last year. In 2017, defoliation rebounded to 4,456 ha, all located around Dawson Creek in Dawson Creek TSA. Intensity was rated as 469 ha (11%) light, 2,322 ha (52%) moderate and 1,665 ha (37%) severe.

For the second consecutive year Peace Forest District staff have also received calls regarding Bruce spanworm damage near Fort St. John and Cecil Lake in Fort St. John TSA, though this damage was not visible during the AOS.

Birch leaf miner, *Fenusa pusilla*

After a peak of 12,458 ha of birch leaf miner damage in 2016, defoliation declined to 2,003 ha, which was similar to the level observed in 2015. Damage intensity was rated as 837 ha (42%) light, 1,063 ha (53%) moderate and 103 ha (5%) severe.

Despite the provincial decline in birch leaf miner damage, defoliation doubled in Robson Valley TSA of Omineca Region to 1,842 ha. Infestations were mapped in the same general area as last year around Dunster, however ground observations noted defoliation from McBride south to Valemount along Highway 5, particularly at the toe of slopes.

Damage in Thompson/Okanagan Region totalled 161 ha. At the south end of Adams Lake in Kamloops TSA, 91 ha of defoliation in two polygons were identified. In Okanagan TSA, 70 ha were mapped in polygons west of Fly Hill and along Whiteman Creek.



Birch leaf miner and aspen leaf miner damage in Robson Valley TSA

Most of the 2016 defoliation was recorded in Northeast Region, but no damage was noted in this region in 2017.

Large aspen tortrix, *Choristoneura conflictana*

Aspen defoliation was mapped in Northeast Region for the first time since 2013, with a total of 1,521 ha delineated. The disturbances were not ground checked but large aspen tortrix has historically been the most common aspen defoliator in the affected areas. Intensity of defoliation was rated as 135 ha (9%) light, 1,351 ha (89%) moderate and 35 ha (2%) severe. Almost all the damage (1,386 ha) was noted in Fort Nelson TSA south of Mount Sandin and Snake Creek. The remaining 135 ha was mapped just east of Wonowon in Fort St. John TSA.

Western winter moth, *Erannis* spp.

Western winter moth defoliation was mapped during the AOS for the first time in 2016, with 49,582 ha noted in Omineca Region. Localized damage was also observed from the ground in several areas of the Skeena Region. In 2017 these populations appear to have declined, with no reports of defoliation.

Birch in one stand on the south edge of the City of Quesnel in Cariboo Region was severely defoliated in 2017 by western winter moth. Ground confirmation was made in the spring when the larvae were feeding and it was noted that birch and miscellaneous shrubs were affected but adjacent aspen and cottonwood were not fed on. By the time the AOS could be conducted in the fall, this damage was not visible aerially.



Western winter moth larva

DAMAGING AGENTS OF MULTIPLE HOST SPECIES

Abiotic injury and associated forest health factors

Wildfire damage was the highest in recorded history in BC with 1,210,171 ha burned, a twelve-fold increase over 2016. Almost all the damage (1,202,906 ha) was rated as severe by default, though 7,115 (1%) was assessed as very severe. An unusually cold, wet spring encouraged abundant plant growth. This was followed by a very dry, hot summer which dried out forest fuels. Multiple wildfires then ignited (primarily from lightning strikes) and were driven by robust winds. It was also a record year for evacuations and major transportation route closures due to the wildfires.

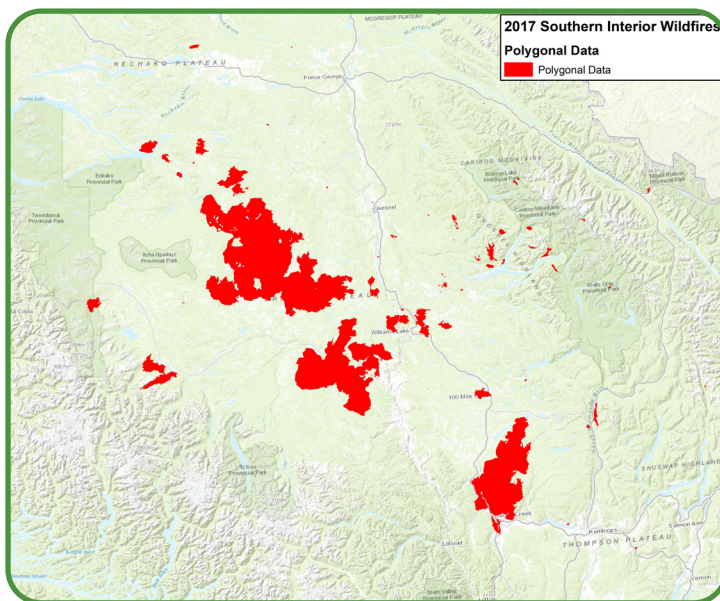


Figure 18. Southern interior wildfire damage mapped in BC in 2017.

The majority of the fires occurred in the southern interior (Figure 18) with Cariboo Region most affected (979,852 ha burned). Williams Lake TSA contained 533,157 ha of damage, with two large fires mid TSA and several other scattered wildfires, particularly in the eastern half of the TSA. Almost all the 310,325 ha of damage in Quesnel TSA was contained in one large complex fire mid TSA. Similarly, most of the 136,371 ha affected in 100 Mile House TSA occurred in one large fire in the south.

Wildfires were smaller and more scattered in Kootenay/Boundary Region, where 101,872 ha burned. Cranbrook and Invermere TSAs were most affected, with

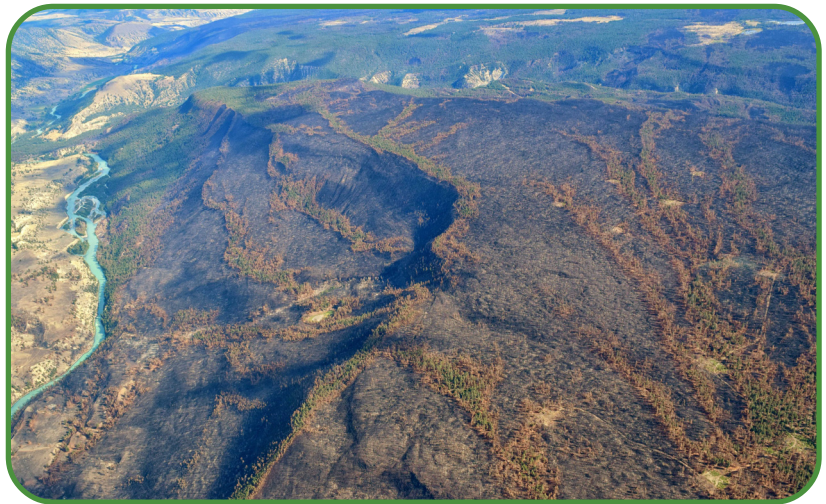
41,083 ha and 34,424 ha damaged, respectively. Kootenay and Golden TSAs sustained similar levels of damage with 11,218 ha and 9,670 ha burned, respectively. Damage in the other TSAs was under 3,000 ha per TSA.

Of the 85,294 ha burned in Thompson/Okanagan Region, most of the damage (66,540 ha) occurred in Kamloops TSA. The majority of this damage occurred in one wildfire that ignited in Kamloops TSA and burned northward into 100 Mile House TSA. Okanagan TSA sustained 11,696 ha of damage, primarily from four wildfires in the south. Two wildfires in the southern half of Merritt TSA accounted for most of the 6,970 ha damaged in this TSA. Minor damage (88 ha) occurred in Lillooet TSA.

Omineca Region sustained 30,606 ha of wildfire damage. Most of these fires (27,568 ha) occurred in Prince George TSA, in the Vanderhoof District. Two wildfires in Robson Valley TSA accounted for most of the 2,866 ha burned. Mackenzie TSA damage was low with 172 ha affected.

Northeast Region had small, scattered wildfires totalling 5,870 ha. The only fire of significant size occurred in Fort Nelson TSA west of July Lake: a total of 5,563 ha were affected in this TSA.

The only coastal wildfire of significance was along Hotnarko River in the Great Bear Rainforest North TSA, where 5,356 ha were damaged. Wildfire disturbances in all other regions were small and scattered, affecting less than 1,000 ha per region.



Wildfire damage in Kamloops TSA

Post-wildfire damage refers to mortality of trees due to a complex of factors that result from prior wildfire damage. After a peak of 147,638 ha recorded in 2015, mapped disturbances declined for the second consecutive year to 26,183 ha. Intensity of damage remained similar with 3,080 ha (12%) light, 12,167 ha (46%) moderate and 10,935 ha (42%) severe. Mortality was observed in all ages of trees, and primarily conifers were damaged. Lodgepole pine continued to be the most commonly affected tree species.

Damage in Northeast Region grew to 12,694 ha, with almost all (10,992 ha) observed in Fort Nelson TSA. Most of the disturbances were clumped around Wadin Creek in the west. Most of the 1,412 ha mapped in Fort St. John TSA occurred near the eastern border, south of Osborn River. Dawson Creek TSA disturbances totalled 290 ha, located north of Mount McAllister and south of Chinook Ridge.

Post-wildfire damage in Skeena Region dropped to 7,533 ha. All of the 4,404 ha of damage observed in Lakes TSA occurred in the southern end of the TSA, particularly along Tetachuck Lake. Most

of the 3,129 ha mapped in Cassiar TSA was an extension of the Fort Nelson TSA damage near Wadin Creek.

Omineca Region sustained 5,419 ha of post-wildfire damage. The majority (5,086 ha) was noted in Prince George TSA in two main areas: east of Entiako River and west of Norman Lake. The remaining 333 ha of damage in the region was mapped in Mackenzie TSA near Peace Reach of Williston Lake and Paddy Creek.

Kootenay/Boundary Region contained small, scattered disturbances totalling 464 ha.

Post-wildfire damage was minimal (under 40 ha per region) in the rest of the province. This included Cariboo Region, where damage dropped from 8,387 ha last year to only 28 ha. It was noted that many of the previously affected areas were re-burned in 2017 which made it impossible to differentiate old damage. It is anticipated that post-wildfire damage will increase substantially in Cariboo Region over the next few years.

Flooding damage in BC more than doubled since 2016 to 42,075 ha. However, intensity of disturbances were less with 100 ha (<1%) trace, 8,049 ha (19%) light, 30,960 ha (74%) moderate, 2,949 ha (7%) severe and 17 ha (<1%) very severe. Most disturbances were small and widely dispersed.

Northeast Region continued to sustain the majority of the flooding damage with 38,289 ha delineated. Tree species most affected were aspen, with minor mortality to cottonwood and spruce stands. Fort Nelson TSA had 33,455 ha of damage, primarily in the eastern half. A total of 3,359 ha were mapped in Fort St. John TSA with some larger disturbances on Gutah Creek and Etthithun River. Most of the 1,475 ha of flooding damage in Dawson TSA was observed between Pine and Moberly Rivers.



Flooding damage in Williams Lake TSA

Flooding disturbances in the rest of the province were small and dispersed, affecting a wide variety of primarily conifer species. Omineca Region contained 1,475 ha of damage, mainly in Prince George TSA where 1,337 ha were mapped. A total of 756 ha of minor flooding damage was scattered throughout Skeena Region. Coast Mountain District experienced multiple storm events in the fall of 2017 which delivered a combined total of 95 cm of precipitation near Kitimat and 57 cm near Terrace, causing flooding and landslide damage. It is expected this damage will be documented in the 2018 AOS. Flooding damage was under 400 ha per region in the rest of BC.

Drought damage (causing mortality) declined four-fold for the second consecutive year to 4,045 ha. However, intensity of damage increased substantially to 217 ha (5%) trace, 845 ha (21%) light, 2,190 ha (54%) moderate and 794 ha (20%) severe. The most commonly affected tree species continued to be western redcedar, primarily in the coastal regions. Affected stands were primarily on exposed sites with thin, rocky soil. Almost all the remaining damage was to a variety of conifer species with a very minor amount of aspen damage. Most of the observed damage was in

mature stands. In some drought impacted lodgepole pine stands in Cariboo and Thompson/Okanagan Regions, dying dwarf mistletoe infections and Ips bark beetle activity were complicating the aerial signature. Ground observations in Robson Valley TSA noted that cottonwood located on slopes with thin, rocky soil were turning yellow in early August from drought, after the AOS was conducted.

Drought disturbances in Skeena Region totalled 1,978 ha, of which the majority (1,960 ha) was observed in Kalum TSA west of Terrace along the Skeena River. South Coast Region sustained 838 ha of drought damage in widely scattered spots and small polygons. A total of 555 ha were mapped in Fraser TSA, 237 ha in Soo TSA and 46 ha in Sunshine TSA.

Kootenay/Boundary Region had 483 ha of drought damage. Cranbrook TSA sustained disturbances totalling 255 ha around the Fernie Area, and Kootenay Lake TSA had 119 ha near Riondel and west of Mount Stone. Other TSAs had minor damage in the region. Great Bear Rainforest had 421 ha of observed drought damage, primarily (316 ha) in North TSA near Spinel Peak, and 105 ha in South TSA near Apple River and Treble Mountain. Other small disturbances less than 150 ha per region were noted in Omineca, West Coast, Cariboo and Thompson/Okanagan Regions.

A substantial amount of young tree drought damage that occurred in the southern interior in 2017 was not captured during the AOS. This was primarily due to the height flown and possibly the flight timing. Weyerhaeuser collected information on the damage during survival surveys in Okanagan TSA. Around Princeton they observed greater than 50% mortality on 2017 planted sites, covering approximately 100 hectares. All sites planted in the Interior Douglas-fir (IDF) biogeoclimatic zone were affected, and the Engelmann Spruce/Subalpine Fir (ESSF) biogeoclimatic zone where soils were rocky and shallow. In the Okanagan area they found approximately 90 hectares of planted trees with greater than 50% mortality and less significant losses on another 40 ha. Montane Spruce (MS) and IDF biogeoclimatic zones were also affected. Lodgepole pine and larch sustained the highest damage, with some Douglas-fir and spruce also affected. Industry foresters believe more damage from the 2017 drought will show on planted blocks over the next two years. Damage was also observed in established young stands (mainly under 10 years of age) of primarily lodgepole pine in the IDF biogeoclimatic zone in the Westwold/Falkland area of Okanagan TSA, in Red Lake/Sawmill Lake area of Kamloops TSA and in various Merritt TSA areas. Understory Douglas-fir was also impacted in some areas. In other higher elevation biogeoclimatic zones, drought was also noted to be affecting subalpine fir, with small trees dying and older trees becoming more susceptible to secondary insect attack.



Drought damage to young lodgepole pine in Okanagan TSA

In Fort St. John TSA damage in aspen stands developed over the summer that was suspected to be caused by drought (not mapped during the AOS). Ground observations noted aspen that looked healthy in the spring started dying at the stump in late summer, and later with wind/snow events branches were snapping off. This phenomenon will be monitored next year.

Suspected drought damage (no mortality) was also mapped on 3,571 ha during the 2017 AOS. Intensity of damage was noted as 3,154 ha (88%) light, 401 ha (11%) moderate and 16 ha (1%) severe. This damage was coded as generic “N” (abiotic) damage, since the present code for drought damage is reserved for mortality. The observed damage signature was excessive older needle death, which led stands to have a reddish cast. All AOS mapped damage was in lodgepole pine, primarily in regenerated stands between 20 and 40 years old. Ground checks were conducted in select stands and samples were collected for examination by regional pathologists. Minor amounts of *Lophodermium* were present in some areas and may have contributed to the excessive needle shedding. This phenomenon was only mapped in the southern interior but it was observed from the ground in various stands in the Omineca Region as well.



Suspected drought damage in 100 Mile House TSA

A total of 2,184 ha were damaged in Thompson/Okanagan Region in Okanagan TSA, south of Cherryville to Lightning Peak. This damage continued into adjacent stands in Kootenay Boundary TSA where 979 ha were mapped with an additional 880 ha in Boundary TSA and 99 ha in Arrow TSA. The remaining 408 ha of disturbances were observed in the Windy Creek area of 100 Mile House TSA in Cariboo Region.

Aside from the damage mapped in relatively young lodgepole pine stands, excessive interior needle damage was also noted in mature lodgepole pine and Douglas-fir in various areas, particularly in the IDF.

Windthrow damage affected 4,524 ha in 2017, down from 6,077 ha in 2016. Intensity of damage was rated as 181 ha (13%) light, 1,153 ha (35%) moderate, 2,196 ha (52%) severe and 10 ha (<1%) very severe. A variety of conifers were affected throughout the province, with aspen damaged in Northeast Region as well. Disturbances were all small and widely scattered. Trees downed by snow or ice are included in this category, which affected 777 ha (17% of the damage) in 2017. Windthrow is often underestimated during the AOS, as understorey and scattered single tree events are not readily visible.

Northeast Region continued to have the most windthrow damage mapped with 2,226 ha, although this was half of the observed damage in 2016. Fort Nelson TSA sustained 1,763 ha and Fort St. John TSA 463 ha. Disturbances in Cariboo Region rose to 810 ha, with almost all (804 ha) mapped

in 100 Mile House TSA. Windthrow damage in Omineca Region rose slightly to 538 ha, split between Prince George TSA (276 ha) and Mackenzie TSA (262 ha). All other regions in the province sustained less than 400 ha of windthrow damage each.

Slide damage increased by 40% since 2016 to 2,637 ha. Intensity levels remained relatively static, at 31 ha (1%) light, 304 ha (12%) moderate, 1,744 ha (66%) severe and 558 ha (21%) very severe. Disturbances remained relatively small in size. Almost all slide mortality occurred in conifer stands, with spruce, cedar, subalpine fir and western hemlock most affected. Slide damage due to snow avalanches remained low, with only 171 ha (6%) attributed to this causal agent.

Slide damage was highest in West Coast Region with 988 ha mapped. Almost all (915 ha) occurred throughout Haida Gwaii TSA. A total of 610 ha of damage were noted in Northeast Region. Fort Nelson TSA had 480 ha of slide damage, primarily near the Muskwa River and West Klua Creek. Fort St. John and Dawson TSAs had 92 and 38 ha of damage, respectively. Slides in all other regions accounted for less than 300 ha of scattered damage per region.

Unknown foliage disease

Foliage disease where the responsible pathogen could not be determined affected 4,015 ha in the southern interior in 2017. All damage occurred in young lodgepole pine stands, and intensity was assessed as 3,356 ha (84%) light and 659 ha (16%) moderate.

Thompson/Okanagan Region sustained 2,297 ha of damage. Most of this damage was identified in the early spring AOS pilot (Project 1). It was noted that the damage is probably either pine needle cast or *Dothistroma* needle blight. Disturbances in Okanagan TSA totalled 1,227 ha, primarily located from Lumby to Kettle River. In Kamloops TSA 1,070 ha were affected just south of Little Fort.

In Kootenay/Boundary Region 1,718 ha of foliage damaged by disease was observed. Most of the damage (1,624 ha) occurred in Arrow TSA from Fosthall Creek to Arrow Park. Some of the disturbances were ground checked and samples given to the regional pathologist showed minor evidence of *Phaeoseptoria* needle cast. However, the damage was quite extensive with very thin crowns caused by multiple years of infections and it is suspected *Dothistroma* needle blight was the primary damaging agent, though this could not be confirmed. One polygon (94 ha) of light damage was also mapped south of Ainsworth Hot Springs in Kootenay Lake TSA.



Unknown foliage disease in Arrow TSA

Animal damage

Animal damage is difficult to observe from the height the AOS is flown and is known to be underestimated. Only substantial feeding that causes significant top kill or tree mortality is detectable.

Black bear (*Ursus americanus*) damage decreased to 3,168 ha affected which is similar to 2015 observations. However, severity of mortality increased with 850 ha (27%) trace, 1,652 ha (52%) light, 543 ha (17%) moderate and 123 ha (4%) severe. The preferred host continued to be young to intermediate aged lodgepole pine with a minor Douglas-fir and western redcedar component. Disturbances were predominantly small (under 100 ha) with the exception of one coastal polygon.

Black bear caused mortality continued to be highest in Cariboo Region, with 1,584 ha affected. Mortality was in the same general areas, but area of damage decreased. Williams Lake TSA sustained 903 ha of damage in the east from Cariboo Lake south to Crooked Lake. A total of 661 ha were observed to have bear mortality in 100 Mile House TSA, mainly in the northeast tip around Mount Hendrix.

Disturbances were very small and widely scattered in Kootenay/Boundary Region, with 716 ha mapped. Boundary TSA contained 243 ha, with a small concentration west of Mount Chochrane. Cranbrook and Arrow TSAs were similarly affected, with 190 ha and 172 ha observed, respectively. Minor damage occurred in Revelstoke and Invermere TSA, with 75 ha and 37 ha delineated, respectively.

South Coast Region had 453 ha of black bear caused mortality. Most occurred in Sunshine TSA (376 ha), primarily around Ramsay Arm. A total of 75 ha of damage was noted in Fraser TSA and 5 spots in So0 TSA.

Black bear damage was minor in other regions with less than 160 ha affected per region.

Snowshoe hare (*Lepus americanus*) feeding mainly occurs at the base of very young trees; hence is not detected during the AOS. However, minor damage (under 400 ha/year) has been recorded in northern BC, first in 2013 and now for three consecutive years. Several areas have been ground checked and damage is a result of stem feeding in the upper portion of 12 to 15 year old lodgepole pine trees, when snow was deep. Small scattered disturbances totalling 390 ha were recorded in 2017. Intensity of damage was 66 ha (17%) light, 102 ha (26%) moderate and 221 ha (57%) severe. The majority were located in Lakes and Morice TSAs, with one polygon noted in each of Bulkley and Prince George TSAs.



Unusual hare feeding on intermediate age lodgepole pine tree

No snowshoe hare damage was mapped in Thompson/Okanagan or Cariboo Regions but various anecdotal ground observations concluded that populations were high last winter (2016/2017). Particularly in late fall in Kamloops TSA, snowshoe hare sightings were very frequent. As a consequence of this population increase, many dense lodgepole pine stands ranging from 8 to 30 years old were substantially damaged. Even basal feeding on larger trees occurred, which is very unusual. Stands exhibited bands of stem feeding at different heights reflecting the increasing snow depth as the winter progressed. The population cycle appears to have peaked last winter however, with only normal sightings occurring in the summer and fall of 2017.

Porcupine (*Erethizon dorsatum*) feeding often results in topkill damage of intermediate to mature trees, particularly in northern BC. Due to the scattered nature of the attack, it is often not identified during the AOS. A total of 62 ha of porcupine damage was mapped in the north this year. Almost all of the damage continued to be noted in Fort Nelson TSA in scattered spots. The only polygon of attack was 49 ha of moderate intensity, located at the confluence of Fort Nelson and Prophet Rivers. Two additional spots of damage were noted in Cassiar and Mackenzie TSAs. The damage was not ground truthed but surveyors felt the damage signature most emulated porcupine, though some bear damage may have been involved as well.

Armillaria root disease, *Armillaria ostoyae*

Armillaria root disease caused damage is greatly underestimated during the AOS, due to its subtle signature and the height at which the AOS is flown. Most of the damage recorded during the AOS is due to local ground knowledge by the surveyors. Damage mapped in 2017 decreased slightly to 152 ha. Many of the disturbances were noted in young Douglas-fir stands. Damage intensity was rated as 84 ha (55%) trace, 62 ha (41%) light and 6 ha (4%, all spots) severe. Spot damage was widely scattered, with a few polygons delineated.

South Coast Region sustained the most damage, with 96 ha mapped. Most of this (78 ha) occurred in Fraser TSA, primarily in two polygons south of Yale. A total of 17 ha were noted in Sunshine Coast TSA, mainly in a disturbance south of Toba Inlet. Soo TSA had 2 spots mapped.

All 53 ha of Armillaria root disease damage in Great Bear Rainforest were located in South TSA in two disturbances on West Thurlow Island.

West Coast Region had only five spot disturbances observed in each of Arrowsmith and North Island TSAs.



Armillaria root disease centers in Okanagan TSA

Unknown defoliator damage

Unknown defoliator damage quadrupled since 2016 to 1,343 ha. Intensity of infestations were rated as 1,113 ha (83%) light, 204 ha (15%) moderate and 26 ha (2%) severe. All observed defoliation was on mature western or mountain hemlock. The cause of defoliation could not be confirmed on the ground due to stand inaccessibility, but it was likely due to either western hemlock looper, western blackheaded budworm or conifer sawflies.

Skeena Region continued to be the most impacted, with 1,304 ha of damage. All of the defoliation occurred in Kalum TSA north of Lava Lake. One severe polygon of 26 ha was delineated in the North TSA of Great Bear Rainforest west of Mount Hayward. The remaining moderately affected 13 ha disturbance was mapped near Mount Louie in Sunshine Coast TSA of South Coast Region.

MISCELLANEOUS DAMAGING AGENTS

Miscellaneous damaging agents were identified during the 2017 field season by ground checks, general observations, forest health surveys and low level flights. Some of the damage was also observed during the AOS, but commercial tree species were not affected, hence the damage was not recorded in the AOS data.

Fir-fireweed rust (*Pucciniastrum epilobii*) was observed to be affecting subalpine fir to a significant degree near Salmo in Kootenay/ Boundary Region this year.

Poplar and willow borer (*Cryptorhynchus lapathi*) has been observed to be active the past several years, particularly in some areas of Thompson/Okanagan Region and widespread in Skeena Region. The regional biologist in Skeena Region observed that infestations have moved further north this year, with some clusters of trees nearing 90% mortality. He noted it would be

timely to map the new distribution in consideration of possible negative implications to moose populations in the area. Willow is important winter forage biomass for moose and infested stems do not provide the same nutritional values as healthy ones.



Poplar and willow borer damage



Unknown spruce tree damage

Unknown spruce plantation damage was first noted in 2016, affecting needles in free growing stands in coastal transition areas along the upper Copper River and upper Kitseguella River drainages in Bulkley TSA. The regional pathologist visited the area again in 2017 as a causal agent still has not been determined. He noted that the trees were not as chlorotic this year but they have not yet recovered.

Willow leaf blotch miner (*Micurapteryx salicifoliella*) defoliation was still prevalent for the eighth consecutive year in Northeast Region, though a ground check also found evidence of minor leaf beetle feeding.

Willow leaf rust damage was observed throughout willow clumps on the old Niskonlith Fire east of Kamloops in 2017. It most likely was caused by a *Melampsora* rust though positive identification was not made.

FOREST HEALTH PROJECTS

1. An assessment of early-season, foliar disease-specific fixed-wing aerial surveys

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

Kevin Buxton, Forest Health Specialist, Thompson/Okanagan Region

Joan Westfall, Forest Health Consultant, EntoPath Management

Background:

Foliar diseases of conifer stands are often not well captured by the standard aerial overview surveys which take place in July and August. The best time to detect foliar disease from the air is earlier in the summer when red needles are still present and before the trees have flushed. A project was initiated in the spring of 2017 to assess the ability of early-season aerial surveys to detect foliar diseases. There were two main goals:

1. to determine if early-season flights are better at detecting foliar disease.
2. to determine if low-intensity “coarse” surveys that use a much wider line spacing than standard aerial overview surveys, are effective for detecting foliar diseases.

To meet these goals, the trial assessed the relative effectiveness, efficiency, and cost of three types of aerial fixed-wing surveys for capturing damage by conifer foliar diseases: regular summer operational aerial overview surveys, early-season aerial overview-intensity surveys (both using a 9.5km line spacing), and early-season coarse-intensity surveys (using a 12-18 km line spacing). The main pathogens targeted were foliar diseases of pines, such as pine needle cast (*Lophodermella concolor*) and Dothistroma needle blight (*Dothistroma septosporum*). Other conifer needle diseases were also recorded if visible – i.e. larch needle blight and/or cast (*Hypodermella laricis*, *Meria laricis*).

A series of aerial overview survey-intensity and low-intensity coarse surveys were conducted in three separate areas of the Thompson/Okanagan Region on June 3rd, 4th, and 5th, 2017. The three survey areas covered a total of 1.64 million hectares.

Ground Check Results:

Ground checks were conducted on a sub-sample of mapped sites, to verify aerial survey calls and assess the accuracy of the early-season aerial surveys. Forty-five stands were visited between June 17th and June 28th. The primary goal of the ground check stand walkthroughs was to identify foliar disease agent(s) presence, damage incidence and damage intensity, and collect general site

information such as biogeoclimatic zone/subzone, elevation, average slope, stand age, and species composition.

Eighteen of the ground checked stands were identified as pine needle cast in the aerial surveys. Of these, fifteen were verified as pine needle cast. The remaining three stands had very low levels, but were probably below the threshold visible from the air. The damage signature in these three stands was attributed to bud candling and/or heavy pollen cone crop.

Seven of the ground checked stands were identified as Dothistroma needle blight in the aerial surveys. It was difficult to check more of the suspected Dothistroma stands, due to severe access limitations. Of these seven stands, four were verified as Dothistroma needle blight, two were verified as larch needle cast, and one was affected by a mix of pine needle cast and Dothistroma needle blight.

In several areas, suspected foliar disease activity was mapped during the early-season aerial surveys, but definitive identification of a specific foliar disease was not possible. Seventeen of these stands were ground checked. Ten were verified as pine needle cast, and four as Dothistroma needle blight. Three of the stands had little to no foliar disease present, and the damage signature was attributed to bud candling and/or heavy pollen cone crop.

Three additional stands, which were not mapped during the early-season aerial surveys, were ground checked incidentally. Two of these stands were affected by Dothistroma needle blight, and one was affected by larch needle blight.

Elytroderma needle cast (*Elytroderma deformans*) was verified as a secondary pathogen at seven of the walkthrough sites. The infections did not appear to be causing major growth or survival impacts on the trees, but they could be having significant impact on wood quality and knot size in the lower portion of the trees.

The results of these ground checks were then used to correct the aerial survey data and to provide specific foliar disease information for areas where the disease agent was unknown at the time of the aerial survey. These corrections/adjustments to the aerial survey data were all done prior to any subsequent analysis.

Four ground checked pine needle cast and four ground checked Dothistroma needle blight infected stands were chosen to study incidence and severity of damage at a more detailed level. Results were compared to the aerial surveys. However, the primary goal of the aerial survey was to detect and map damage, with less emphasis on severity ratings.

Aerial Survey Results:

As expected, early-season aerial surveys captured more pine foliar disease area than regular operational aerial overview surveys; however, the benefits were variable. Survey timing (i.e., how well the early-season surveys were matched with peak damage signature) and the specific foliar disease being mapped both appeared to affect the outcome. In areas where the early-season surveys were well timed (occurring at the peak damage signature), early-season aerial overview-intensity surveys were very effective at detecting foliar disease damage and providing accurate and precise mapping of outbreaks. They increased the total area mapped by 350% – 900%, compared to the area captured during the regular summer aerial overview surveys. However, in areas

where the early-season surveys were not as well timed, they only increased the total area mapped by 128% - 250%, and thus the benefit was lower. Early-season aerial overview survey-intensity surveys had a cost comparable to that of the regular summer aerial overview surveys, averaging \$8,500 per million hectares.

Early-season coarse-intensity surveys also captured more pine foliar disease area than regular summer aerial overview surveys. In areas where the early-season surveys were well timed, early-season coarse-intensity surveys increased the total area mapped by 230% - 450%, compared to the regular summer aerial overview surveys. The early-season coarse-intensity surveys were able to reliably detect large foliar disease outbreaks, and were only 38% of the cost of aerial overview-intensity surveys on a cost per area base (average of \$3,200 per million hectares). However, the data obtained by the coarse-intensity surveys were generally less accurate and missed much of the area that was recorded by the early-season aerial overview-intensity surveys.



Photos of an immature lodgepole pine stand affected by pine needle cast near O'Connor Lake, in Kamloops TSA. Left photo: taken on June 4 during the early-season aerial surveys, with the damage signature readily visible from the air. Right photo: taken on September 11 during the regular operational aerial overview survey – the damage signature is no longer visible.

Recommendations:

Depending on the goals of an early-season aerial survey, a combination of coarse-intensity surveys and aerial overview-intensity surveys could be utilized. A stratified approach, with coarse-intensity surveys providing initial cost-effective disease detection over very large areas, and aerial overview-intensity surveys providing more accurate and complete mapping in areas where foliar disease outbreaks were detected, would give the greatest possible coverage for a given budget, while still supplying valuable foliar disease outbreak information. Another option would be to only do spring flights after wetter than average years when foliar diseases are more likely to be widespread, and/or limit annual spring flights to areas where foliar pathogens have historically been problematic.

Spring aerial mapping can improve our knowledge of foliar disease impacts over time. As with all monitoring, the costs of doing it must be weighed against the potential benefits of collecting better, more informative data.

2. Armillaria ringbarking project

David Rusch, Regional Pathologist, Cariboo and Thompson/Okanagan Regions

Daniel Sklar, Masters student UNBC

Ringbarking, or the removal of a single strip of bark, phloem, and cambium around a tree, has been one method attempted in the past to control *Armillaria* root disease. In theory, this practice has the potential to limit the transportation and storage of sugars within a treated tree's root system. This may in turn make it harder for *A. ostoyae* to colonize roots once the tree is felled, and may inhibit the pathogen's ability to compete with saprophytic fungal colonizers that invade the roots of recently killed trees (Chapman and Schellenberg 2015, Leach 1939).

We set out to assess if ringbarking in the early summer prior to the clearcutting of *A. ostoyae* centers in the winter or fall would influence *Armillaria*'s post-harvest inoculum flush and disease spread following harvesting. The objectives of this research are to quantify and compare post-harvest starch reserves and *A. ostoyae* colonization within root systems from trees in ringbarked and control plots.



Ringbarking of plot trees

Twelve circular plots, each containing 15 sample trees, were setup along the edges of *A. ostoyae* centers at each of three research sites within the Cariboo and Thompson/Okanagan Regions. This includes an SBS site at UBC's Alex Fraser Research Forest near Gavin Lake, an ICH West Fraser logged site near Horsefly Lake, and an IDF Gilbert Smith Forest Products logged site near Monte Lake. Plots were paired based on their similarity and then one of the pair was randomly selected for ringbarking. Ringbarking was conducted during the spring of 2016 by hand and chainsaw to all trees over 7.5 cm DBH. Sites were harvested

during the following fall and winter. Stumps from both control and ringbarked plots were intended to be removed with an excavator during the summer of 2017, however fires delayed their removal until the fall. Root samples were collected for starch analysis over the winter, and some preliminary work was done to quantify the amount of root colonization of stumps by *A. ostoyae*. We will go back next spring to more thoroughly examine and compare the root colonization in ringbarked and control stumps. We would like to thank the UBC research forest, West Fraser Williams Lake, and Gilbert Smith Forest Products for providing study sites and assisting in this project that was funded by research money through FLNRORD.

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3. Aspen health

Jewel Yurkewich, Forest Pathologist, Omineca and Northeast Regions

In 2016, reports of aspen decline (on *Populus tremuloides*) in the Yukon and Northwest Territories caught our attention. The NRCAN project on *Climate Impacts on Productivity and Health of Aspen* (CIPHA) highlighted that these observations were being collected for many years in other provinces and territories; however, there are very few records of aspen decline captured by the AOS in the Omineca or Northeast Regions since 1999.

In the Northeast, the 2017 AOS captured an unprecedented 25,892 ha of aspen decline. This is concerning because the largest area reported prior to 2017 was 1,329 ha in 2013; this represents a 19.5 fold increase in affected area. This has not gone unnoticed by staff in the Northeast. We received calls regarding aspen stands with similar symptoms, further supporting our collective observation that the Northeast has passed the tipping point in regards to the health of aspen. In addition to the abiotic stressors that are summarized as aspen decline, many insect defoliators of aspen were captured by the AOS in the Northeast. The area affected by aspen serpentine leaf miner decreased to 16,559 ha from the 2016 area of 223,469 ha; the decrease in population may be related to the decreased health of its primary host, aspen. Large aspen tortrix was captured in the 2017 data for the first time since 2014. The area infested was relatively small (1,521 ha) compared to the 2014 levels of 891,154.4 ha. In this case, history may be used as an indicator what the population that could be previously supported by the aspen trees. This is a population we will be monitoring.

Although there was no aspen decline reported in the Omineca Region in 2017, the prevalence of satin moth is of concern. According to our AOS records since 1999, the first occurrence of satin moth was reported in 2016 with 9,122 ha reported, possibly representing the most northern occurrence recorded. The 2017 AOS captured an alarming 107,002ha which represents an 11.7 fold increase from last year. While conducting rust assessments, we also identified a large expanse of infested aspen in Fort Fraser and extending past the western border of the Omineca Region. Mirroring the collapse of the aspen serpentine leaf miner in the Northeast, the area affected by aspen serpentine leaf miner decreased to 116,383 ha from the 2016 area of 387,484 ha. At this time, it is not possible to obtain measurements to support the overall decline of aspen in the north but the combination of these observations provides support for increased monitoring.

It is crucial that we monitor winter temperatures and the variation in spring temperatures in order to anticipate how the populations will respond. If the satin moth is able to complete its life cycle under northern temperature and conditions this may indicate that we can expect to see other insect populations increase as well. In order to clarify the situation in the Northeast Region, the organization of a 2018 field tour is underway and will focus on selecting representative sites to serve as case studies. The purpose of the case studies will be to increase our understanding of the changing environment, and more specifically to document and describe information on aspen decline.



Stand affected by aspen decline

4. Assessing post-harvest retention of endangered whitebark pine

Michael Murray, Forest Pathologist, Kootenay-Boundary Region

Whitebark pine (*Pinus albicaulis*) is known as a keystone species at many high elevation habitats in BC where its large nutritious seeds are prized by wildlife including bears, squirrels, foxes, nutcrackers, jays, and ravens. Due to its hardy character in harsh environments, its reputation as a timberline tree is well-earned. Whitebark pine also occurs well below timberline environments in mixed conifer stands. Often, these stands are within the upper elevations of the timber harvest land base.

Due to the introduced pathogen, *Cronartium ribicola*, known to be decimating whitebark pine (white pine blister rust), this tree species was listed as federally endangered in 2012. Thus, forest practitioners have a responsibility to be stewards of whitebark pine by protecting healthy individuals and promoting recovery of this valuable species.

Where whitebark pine exists in timber harvest units, the tenure holder may opt to leave healthy mature trees. The survivorship, health, and growth of retention trees in harvest units are poorly understood. In the post-harvest environment, which trees are most vulnerable to being blow

down? Are they more prone to health impacts such as disease or mountain pine beetle? Do retention trees grow well and expand their crowns?



Post-harvest retention of whitebark pine near Sparwood, BC

Three harvest units have been selected to assess whitebark pine retention. These cut blocks are located on the Rocky Mountain District and range in age from 6 – 17 years. A graduate student is preparing to conduct the field surveys in 2018. A combination of tree assessment, mapping, and dendrochronology techniques will be used. Insight can help guide future harvesting techniques.

5. Balsam woolly adelgid surveys – year 2

Tim Ebata, Provincial Forest Health Officer

Lorraine Maclauchlan, Regional Forest Entomologist, Thompson/Okanagan Region

Don Heppner, Pacific Ecological Services

Since the discovery of balsam woolly adelgid (BWA) on a golf course Rossland in 2014 and in Christmas tree plantations in the Okanagan valley in 2015, FLNRORD has conducted surveys in subalpine fir stands to determine the current range of this invasive insect. The Balsam Woolly Adelgid regulation was established by Ministry of Agriculture to prevent the movement of nursery stock from known infested areas of the province into uninfested areas. The utility of this regulation is in doubt with the discovery of BWA throughout the TOR in 2016 and last summer, surveys further north and east revealed the insect was positively identified in the Cariboo Region as far as Horsefly and in the Kootenay/ Boundary Region as far east as Trail. A final survey in late 2018 will look even further east to Cranbrook and Kimberly and into the Omineca and Skeena Regions. This insect is very difficult to identify. A field guide is being prepared for silviculture and inventory surveyors to aid in identification of the more obvious signs and symptoms of BWA infected subalpine fir. The unexpected increase in BWA's range is likely an artefact of the lack of obvious host symptoms which makes it difficult to determine how long the insect has been in the interior and if it will have a significant impact on its host.

6. Black stain in young pine stands

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

Black stain (*Leptographium wageneri* var. *ponderosum*) occurs on pines and spruce. Literature suggests that pine stands between the ages of 60-110 years old are susceptible. This summer a 28 year old black stain infected lodgepole pine stand in the ICHwk2 was surveyed on the ground using a 5m transect survey. The stand was first detected during an aerial root disease survey. The stand had previous mortality from mountain pine beetle. The incidence of black stain was 17%. The black stain was clumpy in distribution and associated with areas of shallow rocky soil. Drought may have made these trees more susceptible to attack by secondary root feeding insects that vector the disease. In 2016, black stain was also found in a 24 year old lodgepole pine stand in the SBSdw2 in areas with shallow rocky soils and in association with *Armillaria* in areas of deeper soils. Black stain may be more common in young pine stands than previously thought, especially in stands subject to drought stress. Black stain is difficult to detect because it requires chopping into the roots or root collar and the stain quickly fades within a couple of years of tree mortality. Older mortality can easily be masked by previous mountain pine beetle damage in young pine stands.

7. Death of white pine seed orchard trees

Harry Kope, Provincial Forest Pathologist, Victoria

Background:

Seed orchard western white pine (*Pinus monticola*) death has been recognized and investigated as early as 2011. At the Skimikin Seed orchard (Tappen, BC) symptoms on a 2 and a 5 year old white pine included rapid death, red coloured needles that remain affixed to their branches, and roots that are easily stripped of their epidermis and cortical tissue, leaving the vascular bundle intact. These symptomatic trees were investigated for disease causing fungi. (A report produced in July 2011 by AFS Limited of Victoria BC, found *Dothistroma* on needles, and *Pythium*, *Cylindrocarpon*, *Fusarium*, *Verticillium*, *Rhizoctonia*. sp. on the roots.)

At the Puckle Road Seed Orchard, (Saanich, BC), mature (10+ years old), and young (2 years old) root stock white pine tree death was occurring frequently within the seed orchard. The dead trees behaved in a manner similar to those reported in 2011 at Skimikin; rapid death and red coloured needles that remain affixed to their branches. Since the white pine trees died rapidly it was supposed that some water-borne root disease fungi, like *Pythium* spp. or *Phytophthora* spp. could be the causal agent. Water-borne fungi are implicated in rapid plant death in agriculture and horticulture.

Sampling:

In August and November 2017, in conjunction with the University of British Columbia (Dr. Nicolas Feau) and the West coast Region forest pathologist (Stefan Zeglen) a sampling protocol was set up to investigate whether a water-borne root disease was present. Samples included two mature dead trees and one young root stock tree, which were pulled up from their planting spot to expose the roots, and the stem was cut transversely at the root collar.

Samples taken from each tree included;

- Green and partially green and yellowing needles
- Soil samples –soil from around damaged fine roots was collected.
- Fine root samples - roots in the soil and attached to the root ball were collected.
- Large root samples - roots were clipped from the root ball and smaller sections collected.
- Wood chips – woods chips and larger wood samples were taken from the collar and from major large roots.

Results:

Two species of *Phytophthora* were found on both the mature trees' and young root stocks' roots. *Phytophthora* species are known to kill roots and to cause plant die-back of floriculture and horticulture hosts. Their presence on coniferous hosts and the associated tree death suggest that these fungi could be the causal agents. However, Koch's postulates still need to be carried out to confirm that they are indeed the causal agents.

In addition to the fungi isolated, nematodes were collected from the roots. Which nematode and whether they are involved in the tree death or in the transmission of the disease, this still needs to be determined.

Next Steps:

For water-borne fungi, long distance spread is via infected soils and/or infected roots of suitable hosts. Infection over shorter distance, such as within a seed orchard would occur through movement of soil, water run-off from irrigation or flooding after rain falls. The timing of wet events (heavy rain or irrigation) has to correspond with the disease cycle of the pathogen such that infective propagules (spores, etc.) are at the correct time for movement and infection of new material.

Further sampling of dead or dying seed orchard white pine trees is to be done to confirm that fungal pathogens and/or nematodes present.

Samples from other white pine seed orchards that show the same kind of tree die-back (interior seed orchards) will be done. This would be to confirm whether the same problem is associated with these trees.

At the Puckle Road Seed orchard, soils from other areas with other tree species that are in close proximity to the affected white pine stand will be sampled.

Validate the Koch's postulates with *Phytophthora* spp. to determine that it is causal agent of the white pine death.



Dead white pine (*Pinus monticola*) at the Puckle Road Seed Orchard (Saanich, BC)

8. Forest health assessments in young pine stands

Dean Christianson, Stewardship Forester, Selkirk District

A Selkirk District co-op student sampled spaced and some spaced/pruned young (31 to 51 years old, average 40 years) lodgepole stands primarily in Boundary TSA and a few in Arrow TSA to determine forest health damage agents and mortality. Transect and plot sampling was used. We found a significant percentage of damage on these sites due to black bear and mountain pine beetle (Figures 19 and 20). Transect data showed spaced/pruned stands have 3% damage with damage primarily by bears followed by mountain pine beetle and windthrow. Spaced only stands show 7% damage primarily from mountain pine beetle. The second most important agent is bear attack. Significantly higher damage was noted in the plot data with 37% affected in pruned stands and 43% in un-pruned stands (not all trees were dead).

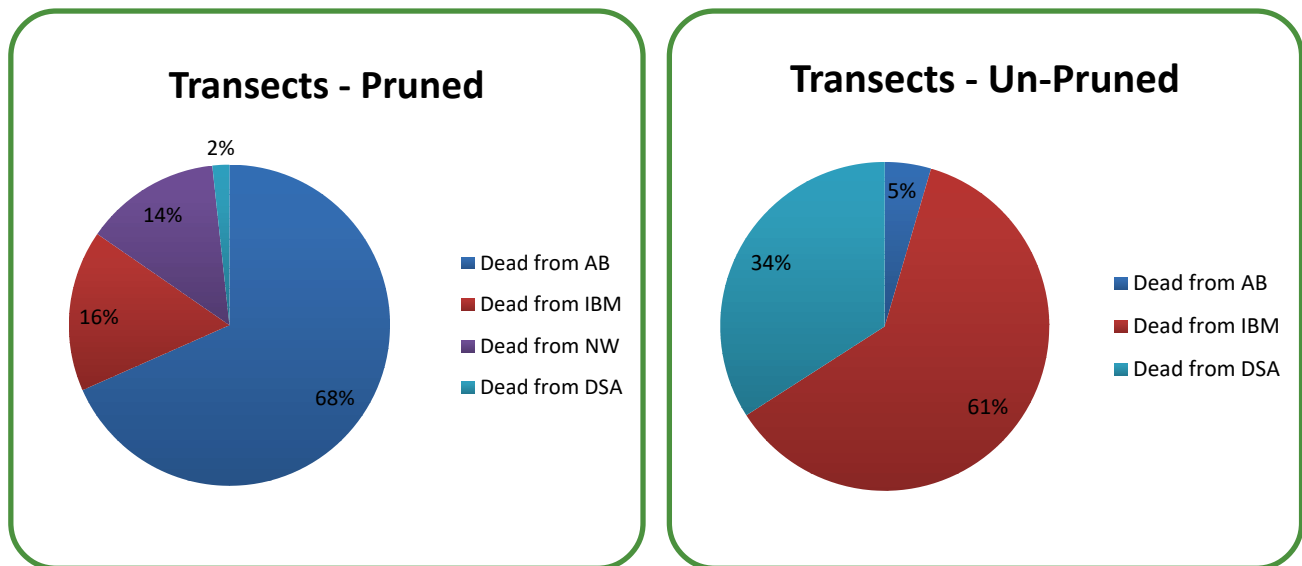


Figure 19. Forest health factors of importance noted in transects (total 3,541 pruned trees, 598 un-pruned trees).

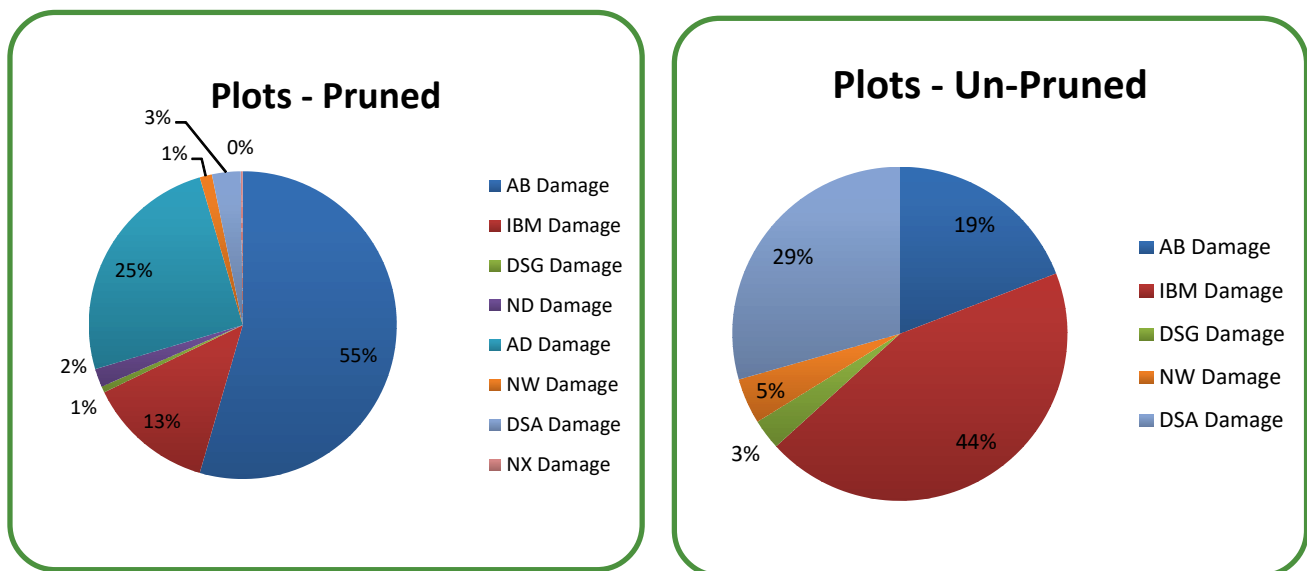


Figure 20. Forest health factors of importance noted in plots (total 1,274 pruned trees, 157 un-pruned trees).

9. Hard pine stem rusts

Jewel Yurkewich, Forest Pathologist, Omineca and Northeast Regions

Annual assessments of both the Comandra Screening Trial and Pine Progeny trial were conducted and completed in 2017. The Comandra Screening Trial was completed with help from Meaghan Dinney (Field Research Assistant), Rebecca Bowler (Research Technician), Jordan Low (Aboriginal Youth Intern) and the in-kind contribution from Feiko van Zadelhoff (visiting international student). The majority of the Pine Progeny trial assessments were completed by Richard Reich (NSERC Industrial Research Chair in Forest Health at the College of New Caledonia) and his team of 9 Field Assistants. The collaboration between the BC Government – Omineca Region, the College of New Caledonia, and Richard Reich has proven to be extremely valuable.



Comandra blister rust: aeciospore stage (left) and multi-year infection with pycnial fluid stage (right)

During the rust assessments observations warranted a conclusion that the 2017 sporulation window had expanded compared to previous years. The relevant observations included: 1) the pycnial fluid was produced in early May, and 2) the blisters of comandra blister rust (*Cronartium comandrae*) and stalactiform blister rust (*Cronartium coleosporioides*) remained active and spore-filled into mid-November. Although, it is reasonable to expect variation in developmental rates from year to year, the infections were not active or sporulating during November 2015 or 2016 at the Holy Cross site. The exact drivers for initial infection and disease progression are not well understood but documenting observations of site specific disease development is one more piece of this complex management puzzle.

10. Northeast region *Ips* case study – old, ailing spruce doesn't always mean spruce beetle!

Jeanne Robert, Forest Entomologist, Omineca and Northeast Regions

In the Northeast Region, west of Dawson Creek, I was asked to ground check a mature spruce standing located on a woodlot as a potential source of new spruce beetle. The stand is a good candidate for spruce beetle infestation – patches of large, ailing spruce are ideal spruce beetle habitat. After checking the stand however, we identified very few spruce beetles at the site, but several patches of standing live trees were heavily attacked by the Northern Spruce Engraver Beetle, *Ips perterbatus*.

The Northern Spruce Engraver is common secondary bark beetle that primarily attacks dead and dying trees. Very rarely does an *Ips* species attack standing live trees. The presence of an active *Ips* infestation in standing live trees at this site indicates high levels of host tree stress, potentially due to a localized change in soil moisture regime, lack of winter precipitation, nutrient deficiency from historical high-grade harvesting, or root disease.

Given the larger context of climate change and other forest health concerns in the Northeast Region (for example see Forest Health Project 3), the unusual outbreak of *Ips* in this stand is potentially a “canary in the coal mine” for the effects of climate change. Changes in soil moisture regime stemming from longer warmer growing seasons and mild winters may underpin a general decline in stand health without much sign of regeneration in this case.

11. Omineca spruce case study – local beetles on fast forward?

Jeanne Robert, Forest Entomologist, Omineca and Northeast Regions

At the southern edge of the main outbreak areas, localized high populations of spruce beetle resulted in an unusually rapid pattern of foliage colour change from green to red, and then to grey. Normally, spruce beetle-killed trees take approximately 13-18 months to change from a healthy-looking green colour to red and then to grey. This signature foliage colour change is part of the reason that spruce beetle-killed trees are difficult to monitor – often the tree dies the year before we can detect the ‘red and dead’ from the air. In the area around McEwan Lake, north of Prince George, we uncovered a patch of trees showing evidence of a 2017 attack, but turning red as early September 2017. In addition, a walkthrough sampling of the brood showed exclusively a one-year life cycle.

The ‘early turning’ trees were heavily attacked, and so the acceleration of colour change is likely the result of one, or some combination, of the following factors: 1) very high beetle attack densities rapidly interrupted translocation of water up the bole and accelerated tree death, 2) the community of associated blue stain fungus species may have demonstrated increased pathogenicity, and/or 3) host tree stress, due to drought or other



One-year cycle immature adult under the bark

environmental factors, reduced the tree's ability to hang on and fight the attack. This is potentially an early example of complex forest health implications in a changing climate; high beetle populations, combined with several warmer-than-normal years, may cause unusual symptoms of attack. Further, the altered symptoms of attack co-occurring with the prevalence of one-year life cycle beetles suggest the potential for an increasingly aggressive outbreak. We will be monitoring overwintering brood success in the area and will be following up on additional reports of accelerated colour change through 2018.



Trees infested with spruce beetle turning early

12. Red band (*Dothistroma*) needle blight (*Mycosphaerella pini*)

Jewel Yurkewich, Forest Pathologist, Omineca and Northeast Regions

This year, our AOS Contractors prioritized the areas of suspected *Dothistroma* infection and were able to capture the visible signature during the optimal window for detection from the air. This was an improvement over previous years. Conducting the assessments during the appropriate window helped to confirm the presence of *Dothistroma* and allowed for the areas to be properly identified and delineated by aerial surveyors. The improved survey captured 18,731 ha of infected lodgepole pine (*Pinus contorta* var. *latifolia*) which is 3.3 times greater than the 5,694 ha recorded in 2016. Synchronizing the aerial survey with the biology of the pathogen has increased our confidence in being able to capture this foliar disease from the air.

After the initial flights, I joined Joan and our pilot in the air for formal AOS training and gained experience in identifying many different damage signatures of abiotic and biotic forest health factors including spruce beetle, Douglas fir beetle, western balsam bark beetle, satin moth, and flooding. After the flights, I visited and ground truthed some of the areas infected by *Dothistroma*.

Please notify Jewel Yurkewich (Jewel.Yurkewich@gov.bc.ca) if you are aware of other areas with suspect *Dothistroma* infections, where *Dothistroma* has been identified in new areas or where the severity of infection is of concern. Formal surveys and sample collection for DNA analysis are planned for spring 2018.



Needles with *Dothistroma* infections

13. Response of animals to changes in Douglas-fir forests due to fungal pathogens

Brendon Carswell and Roy Rea, University of Northern British Columbia
David Rush, Forest Pathologist, Thompson/Okanagan and Cariboo Regions

Little is known about how fauna of the central interior respond to changes in Douglas fir (*Pseudotsuga menziesii*) forests due to fungal pathogens such as Armillaria (*Armillaria ostoyae*) and laminated (*Phellinus weirii*) root diseases. Beginning in the summer of 2017, we set out to investigate differences in habitat use by various wildlife species (with a focus on mule deer) between Armillaria and laminated root rot centers and the surrounding control forests. Three study areas were chosen (two with laminated and one with Armillaria root disease with associated control sites), in and around the Alex Fraser Research Forest near Gavin Lake. Within each of the six sites, an average of eight transects and thirty plot centers were established systematically (e.g., Figure 21).

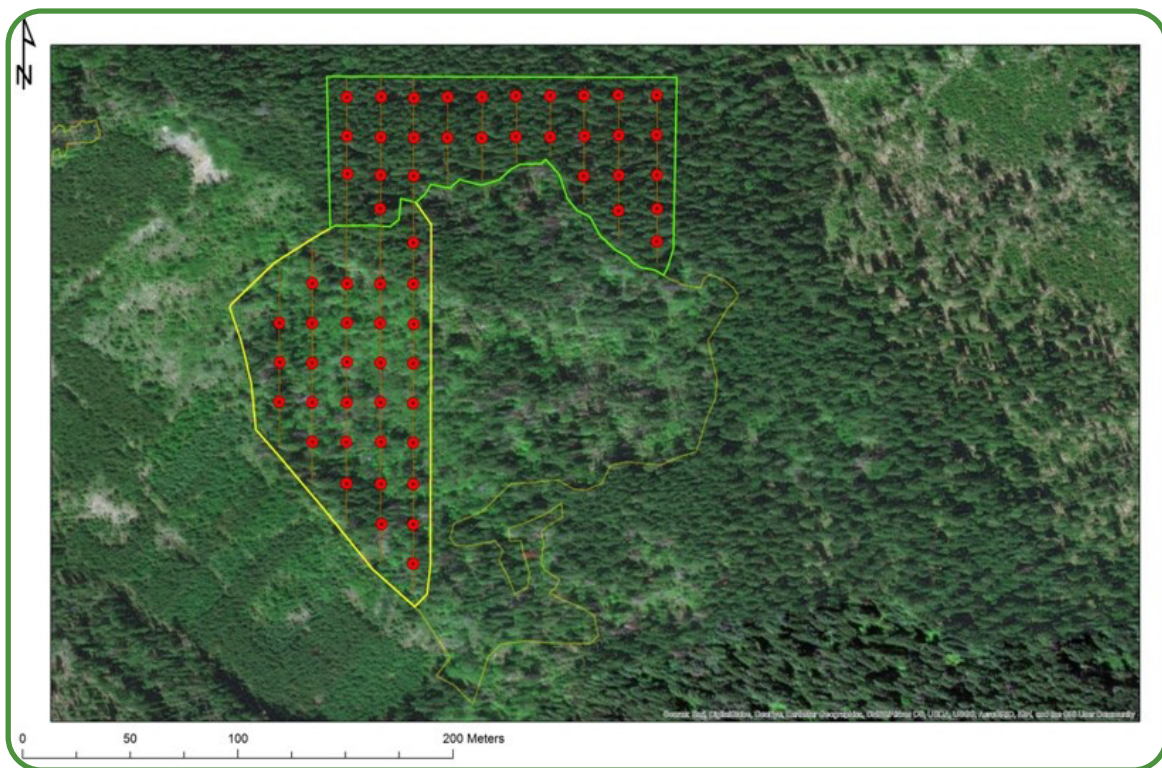


Figure 21. An example of one pair of our research sites (Armillaria in yellow and adjacent control in green) showing transects and plot centers established within each site.

In mid-June of 2017, 11 motion- and infrared-activated camera traps were established on game trails throughout the six sites. These cameras collected data on wildlife movements during the summer 2017 fires (Figure 22). These cameras were to be set up temporarily until late July when we were going to conduct vegetation surveys and establish more cameras on each site. Wildfires prevented us from conducting vegetation surveys and installing more cameras during the summer.



Figure 22. Some photographs of animals captured on our wildlife cameras in root rot centers and control sites during the summer of 2017.

Camera data collected between June and September 2017 suggests that there is a difference in species use between root disease centers and control sites with species such as moose, squirrels, bears and lynx using root centers more than control forests, while cattle, deer, and hares were found more often in control forest types (Figure 23).

In September of 2017, those 11 camera traps were replaced with four cameras per site (for a total of 24 cameras) and were left to collect images until the summer of 2018. In December of 2017, we will conduct our first of two (second count scheduled in February of 2018) track counting surveys in all 6 sites in which we will document the tracks of all species bisecting our transects. In December, we will also collect photo data from and do maintenance checks on all of our cameras.

During the spring of 2018, Daubenmire plots will be used to determine shrub layer species composition and over winter browse use along all transects. At each plot center, we will use a 7.98m radius plots to determine tree composition and conduct coarse woody debris surveys as well as describe wildlife tree characteristics in each plot.

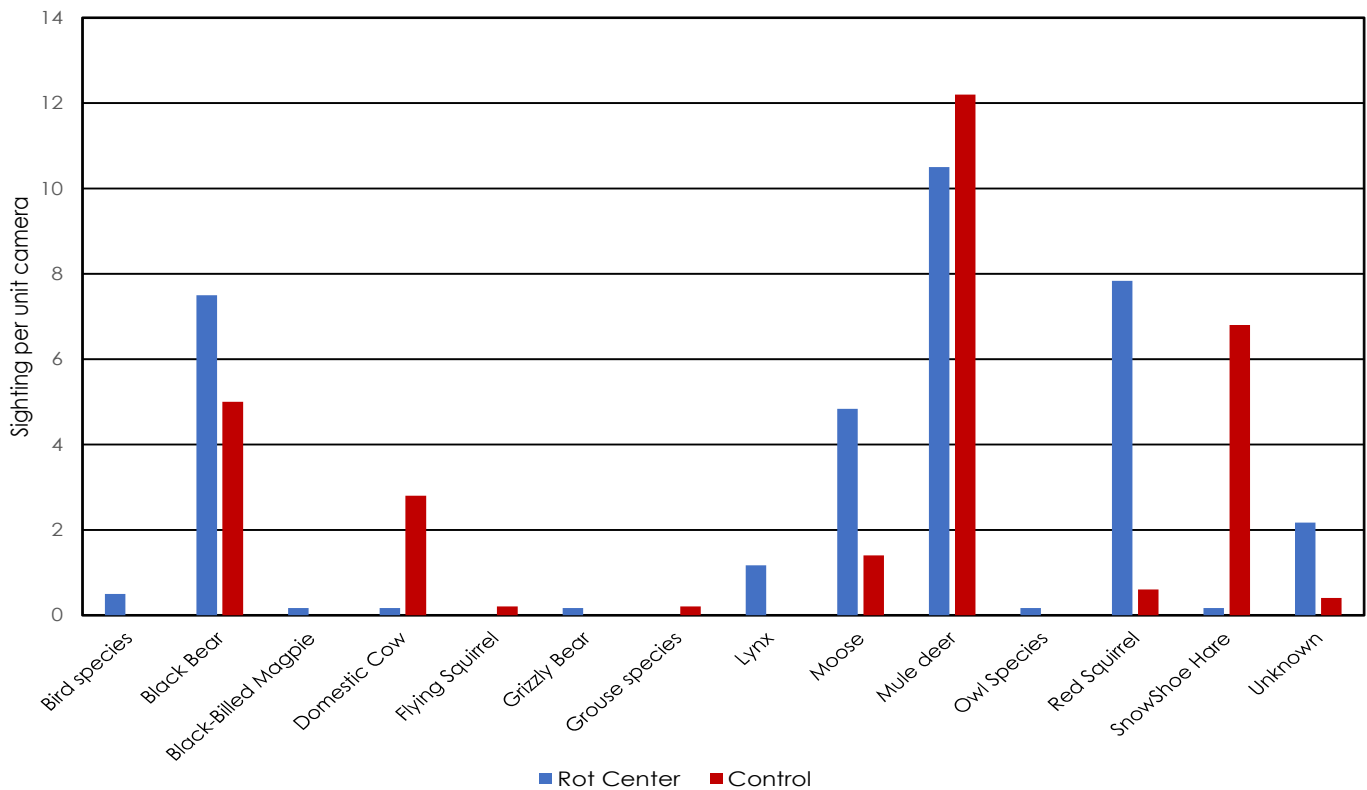


Figure 23. Wildlife sightings per unit camera (between June and September 2017) broken down by species within rot centers and control areas.

By the end of the 2018 season, we will compile vegetation and tree and coarse woody debris survey data to describe differences in habitat elements between rot center and control sites and use camera trap data, track counts and browse surveys to establish differences in habitat use by various species.

14. Root rot transects in the Thompson/Okanagan ICH and IDFW to assess root rot impacts

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

Seven of twenty-six selected stands were assessed for root disease using transect surveys (Table 8). This was part of a pilot to look at root disease impacts in stands in the ICH and IDFW that have Douglas-fir as a primary species (20% or more). The selected stands were from Vegetation Resource Inventory (VRI) polygons that contained Change Monitoring Inventory (CMI) plots. The 5 ha portion of the VRI polygon surrounding the CMI plot was surveyed at a sample intensity of between 1 and 5 % (0.05-0.25ha plot size) depending on the stand density. All trees 4cm dbh or greater were measured. The CMI plots were also reassessed for root disease and other forest health factors, but not destructively sampled. CMI plots are nested circular plots in which trees over 4cm are measured in a 0.01 ha circular plot and trees over 9cm dbh are measured in a 0.04ha circular plot with the same plot center. The incidence of armillaria (Figure 24) and laminated root disease (Figure 25) on Douglas-fir is shown for the seven sites. The rest the sites will be assessed

Table 8. CMI plot number, BEC zone, VRI Age, total transect area, and species label and tree density (trees 4cm dbh or greater) by site.

Site #	CMI plot	BEC	VRI age (yrs)	Transect area (ha)	Species Label (3 leading species >4cm dbh)	Density >4cm dbh (sph)
1	0114-3831	ICHdw3	95	0.225	Sx41A†27Fd5	378
2	0114-0716	ICHdw3	115	0.15	Cw58Sx13Fd9	707
3	KMHY-0246	ICHmw3	40	0.075	Fd67Cw21Sx5	1613
7	0114-4481	ICHmw3	115	0.065	Cw63Fd30Ep3	1677
10	KMHY-0216	ICHmk2	24	0.05	Sx51Fd27Ep9	2740
14	0223-1364	ICHwk1	144	0.05	Hw47Fd22Cw19	3800
22	0223-8886	IDFmw1	55	0.25	Cw45Ep31Fd11	2032

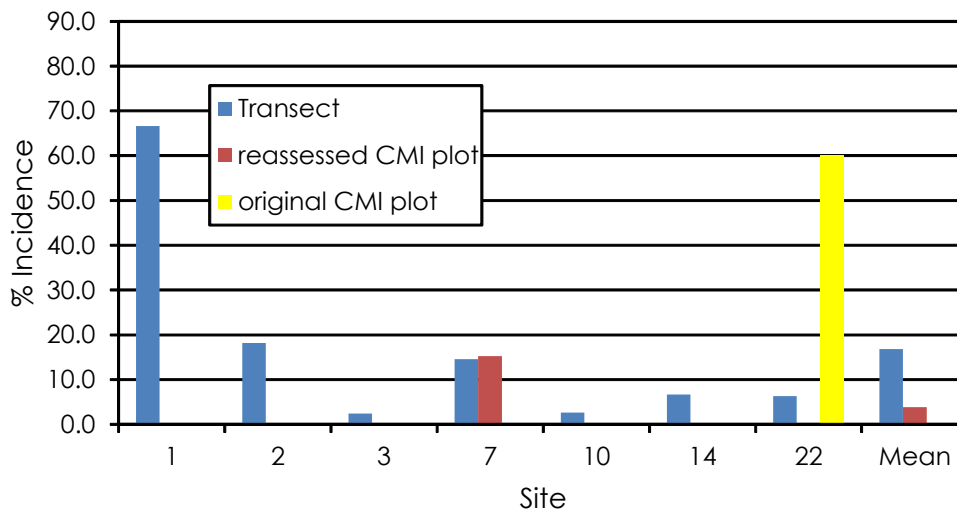


Fig. 24 Incidence of Armillaria on Douglas-fir by site.

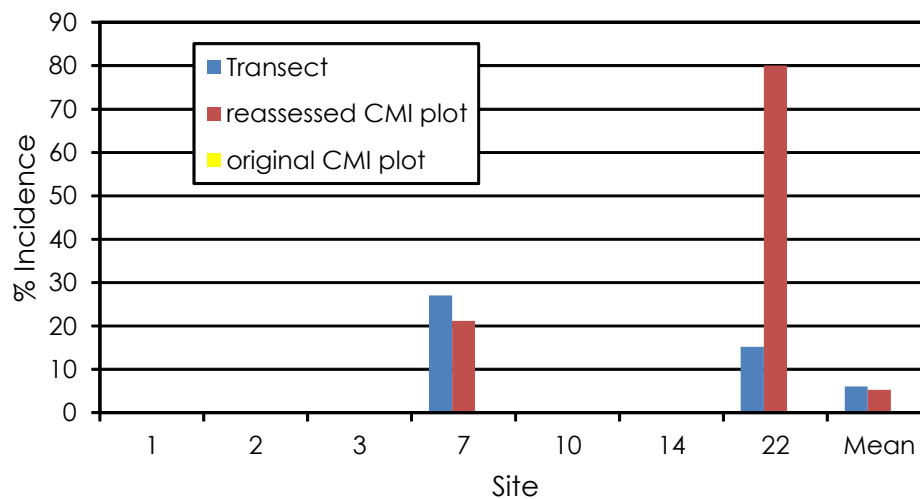


Fig. 25. Incidence of laminated root disease on Douglas-fir by site.

from root disease. Root disease was under reported and not correctly identified to species in two of the eight CMI plots. At one of the CMI plots, some trees had more than one root disease, making identification much more challenging. As expected, there was a higher occurrence of root rot in the transects than in the CMI plots. The mean incidence of root disease on Douglas-fir in the transect surveys was about twice the mean incidence of root disease recorded in the original CMI plots and 1.4 times the incidence in the reassessed CMI plot (Figure 26).

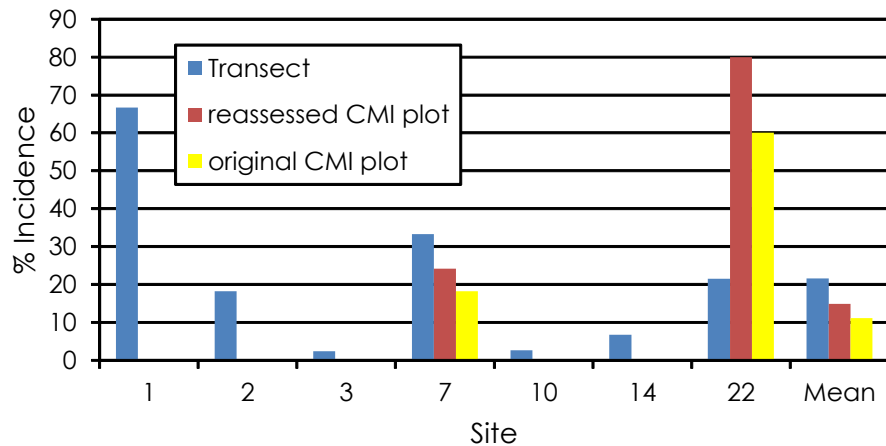


Fig. 26. Incidence of root disease on Douglas-fir by site.

15. R-values as a tool for calculating spruce beetle overwintering success: a critical evaluation

Jeanne Robert, Forest Entomologist, Omineca and Northeast Regions

During a bark beetle outbreak, the key indicators of population increase are 1) overwintering brood success and 2) the prevalence of a one-year life cycle versus a two-year life cycle. One method used to assess overwintering brood success is an R-value calculation. The R-value and the associated development index (D) give the ratio of living offspring that overwintered for each mated pair of parents and the ratio of one and two-year life cycle beetles under the bark.

Although this was a common assessment method for the determining the success of mountain pine beetle, there is much less data on the effectiveness of using R-value to indicate overwintering success in both spruce beetle and Douglas-fir beetle. We collected data from two sampling crews in order to do a critical analysis of R-value determination for spruce beetles. The report is currently being drafted with the aim to publish the critical review in spring 2018.

16. Spruce-Labrador tea needle rust (*Chrysomyxa ledicola*)

Jewel Yurkewich, Forest Pathologist, Omineca and Northeast Regions

In late summer (2017), the first calls regarding *Chrysomyxa* began and were followed by inquiries by our AOS Contractors. Two areas in the Mackenzie TSA were identified. The first site was near the tip of the Omineca Arm (west side of Williston Reservoir) and the second site was on the east side of the Williston Reservoir. Jeanne Robert, Regional Entomologist, and I visited the first area and were able to positively identify the fungal species on hybrid spruce (*Picea glauca* X *engelmannii*) and the alternate host, Labrador tea (*Ledum groenlandicum*). The second area was not easily accessible by road, and therefore was not ground truthed.



Spruce infected with Chrysomyxa



Alternate host Labrador tea

Since 1999, the only recorded occurrence of *Chrysomyxa* identified during the AOS was in 2011 and 2012

with 12,153 ha and 3,354 ha of infection in the Fort Nelson TSA (Northeast Region), respectively. This year the AOS captured 131 ha in the Mackenzie TSA (Omineca Region). Due to the abundance of inoculum on the alternate host an increase is expected for 2018. At this time, this is not considered a threat to stand productivity or merchantability; however, if severe infection occurs over many consecutive years there may be site specific growth implications.

17. Tomentosus in spruce plantations

Alex Woods, Forest Pathologist, Skeena Region

I am making progress with analyzing the data from 10 one hectare stem mapped plots located in randomly located mid-rotation spruce plantations in the Kispiox TSA. I have height and diameter measurements and tomentosus root disease assessments from over 10,000 trees at two time periods, plot establishment and 15 years later. The incidence of tomentosus infected trees has doubled to tripled between the two assessments (stand ages 20-30 and 35-50) at all 10 plots.

18. Tomentosus root disease stumping trial

Alex Woods, Forest Pathologist, Skeena Region

I collected the 20th season growth measurements from my Nichyeskwa Creek tomentosus root disease stumping trial. The trial is located on a very productive spruce site and the tallest trees are now over 11m. At the end of the field season I discovered that in 2018 I will need to increment core all of the spruce trees in the trial in order to accurately assess current root disease incidence because some trees that appeared completely healthy are already significantly decayed by the root pathogen. Throughout the history of this trial I have been assessing trees based only on crown symptoms. The trial consists of 11 stumped plots and 11 controls and in order to identify if stumping has improved the health of the site I will need to core all of the trees. At first glance it appears that stumping has improved the growth of the trees but perhaps not their root disease status.

19. What is the shelf life for beetle-killed spruce?

Jeanne Robert, Forest Entomologist, Omineca and Northeast Regions

The current spruce beetle outbreak is raising concerns about the mid-term timber supply and the efficient use of near-term beetle-killed spruce. In order to maximize efficiency and economic returns where harvesting of beetle-killed spruce is ecologically feasible, the useable 'shelf life' of standing dead spruce must be defined.

In order to address the question within the context of the current outbreak, we sampled 20 stands of hybrid white spruce containing standing beetle-killed trees attacked in 2014, 2015, 2016, as well as healthy trees (see Figure 26). We examined the frequency and magnitude of decay affecting wood



Shelf life samples in the snow

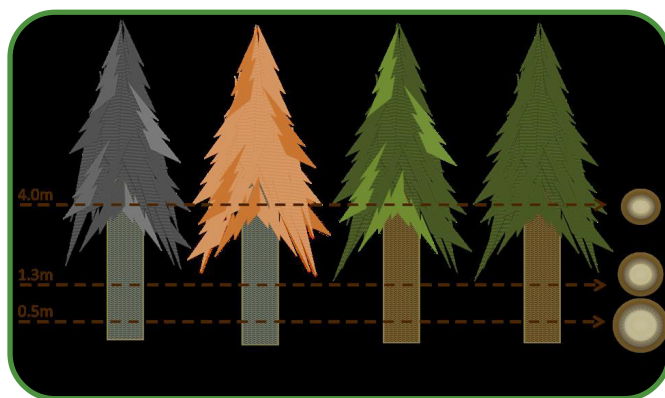


Figure 26. Sampling design for shelf life study. A range of trees were sampled, and cookies were cut at 0.5 metres, 1.3 metres, and 4.0 metres up the bole of the tree. Decay characteristics were measured on each cookie and related to the time of attack.

quality, analyzed the amount of checking, and measured the wood moisture content over the attack years.

The samples were collected in March of 2017, processed during the summer of 2017, and we are aiming to publish a full report in early spring of 2018. In addition, based on feedback from forest professionals, we are planning additional sampling and methods in March 2018 for a second study, ideally to gather information on the rate of decay in spruce harvested from wetter ecotypes.

FOREST HEALTH MEETINGS/WORKSHOPS/PRESENTATIONS

British Columbia whitebark pine status and policy update

Michael Murray, Forest Pathologist, Kootenay/Boundary Region

Joanne Vinnedge, Ecosystems Biologist, Omineca Region

Kevin Hoekstra, Senior Ecosystems Biologist, Omineca Region

Venue:

Annual whitebark pine science & management workshop. Jasper, Alberta. September 2017.

Abstract:

This is a yearly international conference sponsored by the Whitebark Pine Ecosystem Foundation. About 95 people attended from a variety of backgrounds (US Forest Service, Canadian Wildlife Service, academia, provincial/state agencies, Parks Canada, and more) to share information with presentations and a fieldtrip. Our presentation highlighted the following topics: legal protections, management challenges, blister rust resistance screening, and harvest retention research.

Climate change and monitoring of Swiss needle cast

Stefan Zeglen, Forest Pathologist, Coast Regions

Venue:

Coastal Silviculture Committee Summer Workshop, Mission BC, June 2017

Abstract:

Phaeocryptopus gaeumannii, the causal agent of Swiss Needle Cast, is a native fungus that periodically causes defoliation of Douglas-fir. The disease causes two-year and older foliage to shed prematurely, potentially affecting tree growth. Although recognized and collected in BC since the 1930's, it is only in the last decade that the disease has been considered more than a pathological also ran. Why the change? This talk focused on the big picture – the SNC experience in Oregon, some of the research findings from the Swiss Needle Cast Co-operative run by Oregon State University, the changes in climate and reforestation choices here on the Coast and our understanding of the shift in risk for planting coastal Douglas-fir.

Douglas-fir beetle biology and management: pre- and post-wildfire

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan and Cariboo Regions

Venue:

Various throughout the Cariboo and Thompson/Okanagan Regions, eight presentations and workshops were given on this topic.

Abstract:

Douglas-fir beetle is in outbreak throughout the southern interior with particularly high levels of mortality in the Cariboo Region. There were numerous requests both before and after the 2017 wildfires for training and workshops on biology and management of the beetle. The workshops focused on understanding host selection mechanisms and the population dynamics of Douglas-fir beetle and other insects in burnt wood. Landscape and site specific planning, monitoring and management tools (trapping, baiting, MCH, harvest) were all covered.

Forests for tomorrow (FFT) planning and delivery workshop:

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan and Cariboo Regions

Venue:

Forests for Tomorrow (FFT) Planning and Delivery Workshop: Implications of Fire on Forest Health, Richmond, BC, Oct. 3-4, 2017.

Abstract:

Approximately 60 individuals, including BC MFLNRO staff and staff from other organizations that are involved or interested in the FFT reforestation program attended the workshop. The goal of the workshop was to identify the post-wildfire challenges and define reforestation needs.

Summary: Wildfires in Douglas-fir ecosystems often trigger Douglas-fir beetle (DFB) outbreaks. In the southern interior, particularly the Cariboo, we are faced with the worst case scenario – outbreak levels of DFB beetle plus large areas of fire scorched host material. DFB likes to colonize burnt wood as these damaged trees have minimal resistance to attack. DFB prefers stressed trees so the 2017 drought plus fire damage has exacerbated an already challenging situation. New DFB attack in stands is difficult to detect until trees turn red, at which point the beetles have left those trees and moved on. Within fire perimeters crown symptoms are unreliable for aerial detection techniques therefore attack must be identified by ground surveys and bole symptoms.

To prioritize fire salvage and beetle management it is recommended that fire severity maps be overlayed with existing hazard rating maps and aerial surveys for Douglas-fir beetle to provide guidance into the highest risk stands. Treatment options for DFB include: targeted harvest of burnt wood containing beetles; pheromone trapping in burnt areas; and application of MCH (a repellent) to protect live, green trees in special areas. The rapid management of current DFB populations and protection of green timber is key.

Forest health impact on the TSR

Stefan Zeglen, Forest Pathologist, Coast Regions

Venue:

Coastal Silviculture Committee Winter Workshop, Nanaimo BC, February 2017

Abstract:

Currently there are three typical ways that pest damage can be accounted for in timber supply reviews – as non-recoverable loss estimates, operational adjustment factors (OAF) and as landscape-level or catastrophic loss estimates. Each of these is derived differently and influences timber supply in its own unique fashion. Examples were provided as to how each method has been incorporated into the TSR process and how pest impacts might be better accounted for in the future. Some discussion of the value and limitations of forest model inputs and the value of mid-rotation monitoring for quantifying forest health damage occurred.

Insect pest management in the 21st century forest environment – the bigger picture. How climate change exposes stands to different stresses.

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan and Cariboo Regions

Venue:

Winter SISCO, Kamloops, B.C. Feb. 13 – 14, 2018.

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 defences, 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; behavioural 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 is fundamental 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.

Needle disease workshop (foliage diseases demystified)

David Rusch, Forest Pathologist, Cariboo and Thompson/Okanagan Regions
Richard Hunt, Phytopathologist, Ret., Natural Resources Canada

Venue:

BC Kalamalka Tree Improvement Centre and field trips, Vernon BC, June 14th and 15th 2017

Abstract:

Identifying foliage diseases can be a challenge even for the so called “experts”. Many foliage diseases produce similar symptoms, and diagnostic fruiting bodies are not always present. This year, Dr. Rich Hunt, retired forest pathologist from the Canadian Forestry Service, was hired to help improve the diagnostic skills of BC regional forest health specialists. Attendees visited a number of field sites in and around Vernon. The microscopic identification part of the training was held at the Kalamalka Tree Improvement Centre in Vernon and was accompanied by a tour of the facility to look at projects designed to screen for pest resistance. Despite the hot dry fire year in 2017, 2016 and the spring of 2017 were fairly wet and there was a high incidence of foliage diseases to look at including *Lophodermella* and *Elytoderma* needle casts, *Dothistroma* needle blight, larch needle blight and needle cast, rhabdocline and Swiss needle cast on Douglas-fir, and *Chrysomyxa weirii* on spruce. The training was a chance for forest health specialists to brush up on their microscopy skills and become more familiar with using diagnostic keys. At one of the sites in the ICH, Douglas-fir and other natural regeneration was replacing planted lodgepole pine exposed to multiple years of



Dr. Rich Hunt examining an infected needle

Dothistroma infection, highlighting the importance of foliage diseases in species selection. It also became evident that *Elytoderma* needle cast was very widespread in the lower crowns of lodgepole pine over a wide variety of ecosystems and was reducing wood quality by causing large elongated knots from large diameter upturned branches. Many thanks to Rich Hunt for sharing his vast knowledge and diagnostic skills and Ward Strong for making time to show us around the Kalamalka Tree Improvement Centre.



Some of the workshop attendees

2nd Annual spruce beetle summit

Jeanne Robert, Forest Entomologist, Omineca and Northeast Regions

Venue:

Prince George Civic Centre, Prince George, BC, October 25th, 2017

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 were the target audience for our 2nd annual Spruce 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 year's Summit topics revolved around our keen awareness that the future of forestry in Northern British Columbia will play out with a background of climate change, projected drought, rapidly changing local and global conditions, and bark beetle outbreaks. The facilitation of formal information sharing from academics, forest professionals, and government experts contributes to our 'toolbox' for managing spruce beetle into the future. This year, speakers were invited from across Canada and the western United States, including speakers from Alaska, Alberta, Nova Scotia, and California. Local industry foresters also spoke about the issues and constraints that licensees must take into account when planning harvesting activities for managing forest health problems like spruce beetle under the 'professional reliance' model, including how industry forest managers are attempting to balance multiple high-value resources in their day-to-day decisions.

The Summit was well-attended, with standing room only for much of the day. Future Summit topics suggested by the audience included an interest in understanding the impact of spruce beetle on communities and the economy of Northern BC.



Keynote speaker, Dr. Christopher Fettig, Research Entomologist and Team Leader, from Pacific Southwest Research Station United States Forest Service addresses the audience at the 2017 Spruce Beetle Summit.

Spruce beetle ground survey training in Prince George

Robert Hodgkinson, Forest Entomologist (Ret.), Northeast/Omineca Regions

Venue:

UNBC Prince George, BC, September 12th - 14th, 2017

Abstract:

A *Spruce Beetle Ground Survey Course* was delivered via the University of Northern British Columbia's Continuing Studies Program. The course consisted of a 3.5 hour lecture, a four hour field trip to examine attacked spruce near McEwan Lake north of Prince George, and a one hour optional exam. Attendees learned about spruce beetle identification and biology, signs and symptoms of attack, how to conduct walkthroughs and probes, how to classify attacked trees and summarize data, hazard and risk rating, and control options. Attendees included a total of 29 personnel from 2 forestry consulting companies, 9 staff from FLNRO Resource District Offices, 9 employees from forest licensee companies, 2 staff from the Province of Alberta, and 1 independent.

Swiss needle cast in British Columbia

Stefan Zeglen, Forest Pathologist, Coast Regions

Venue:

Swiss Needle Cast Co-op annual meeting, Corvallis OR, November 2017

Abstract:

A summary of the extent of Swiss needle cast in BC was given along with a listing of the activities that are being undertaken with regard to this foliar disease. Efforts around both current and proposed aerial and ground monitoring were outlined including the recent installation of long-term monitoring plots. A brief synopsis of work being undertaken by collaborators working on SNC including geneticists, tree breeders and university researchers was provided. The future use of some potential tools available to model SNC impact was also discussed.

Swiss needle cast working group

Harry Kope, Provincial Forest Pathologist, Victoria

Venue:

Swiss Needle working group meeting, Saanichton, BC, October 25th, 2017

Abstract:

Swiss Needle Cast (SNC) is an endemic foliar pathogen of both coastal and interior Douglas-fir, which was previously considered an insignificant disease in British Columbia. However, over the past number of years some increase in disease occurrence and incidence has been observed in coastal BC.

To investigate these occurrences, preliminary research, some of it following on from investigations done in the western US (Oregon - Swiss Needle Cast Cooperative, [SNCC] and some work in Washington), have been initiated in BC, with the intent of complementing the existing SNCC data, as well as, expanding the geographic range of data on SNC for the pacific northwest.

With SNC studies in BC being at an early phase, a one day meeting is envisaged as being a useful setting to understand the different planned research areas and projects in BC. The goal is to capture as many as possible of the current researchers and their areas of interest/research on SNC in BC, which can allow for knowledge gap identifications as well collaborations where identified.

Participants:

BC Ministry of FLNRORD:

Forest Analysis and Inventory Branch (Victoria) - Derek Sattler

Forest Improvement and Research Management Branch (Victoria) - Michael Stoehr/Alvin Yanchuk

Resource Practices Branch (Victoria) - Harry Kope

West Coast Region (Nanaimo) - Stefan Zeglen

Natural Resources Canada (Victoria) - Brenda Callan

Swiss Needle Cast Cooperative (Corvallis, Oregon) - Gabriela Ritokova/Dave Shaw

UBC (Vancouver) - Nicolas Feau/Richard Hamelin

UVIC (Victoria) - Jürgen Ehling/Jessica Wyatt/David Noshad

Topics:

Swiss Needle Cast Cooperative: An overview of SNC in Oregon

Biology, ecology and epidemiology of SNC: Disease cycle, SNC worldwide, past records of SNC in BC

Disease Distribution and Severity in BC

Disease Monitoring: Aerial overview and on the ground SNC monitoring, and climatic monitoring in BC

Tree Improvement: Douglas-fir breeding program and SNC in BC

Modelling of SNC: Could SNC in BC be modelled in TASS?

SNC fungal and host pathogenicity genetics: Tree-pathogen-climate interactions in BC

The ever-changing health of our forests: old pests and new challenges

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan and Cariboo Regions

Venue:

Winter SISCO, Kamloops, B.C. Jan. 31st – Feb. 1, 2017

Abstract:

Once again bark beetles are the major disturbance factors in the southern interior of BC. In 2016, the Douglas-fir bark beetle and spruce beetle saw significant increases in activity throughout all three southern regions. Western balsam bark beetle also remains at high and increasing levels in the Cariboo and Thompson/Okanagan Regions, affecting over 406,000 hectares in the southern interior.

Coniferous defoliation increased from 21,413 hectares in 2015 to 104,123 hectares in 2016 but this was due to the two year cycle budworm being in its “on” year. Western spruce budworm saw another steep decline in 2016 with only 3,429 hectares of defoliation mapped. Annual population monitoring of Douglas-fir tussock moth in historic outbreak areas suggest populations are starting to build once again and we could see an outbreak within two years. Other observations on insect population response to drought and climate change in mature and young stands were highlighted.



*Female Douglas-fir tussock moth
with egg mass*

The 65th western international forest disease work conference

Harry Kope, Provincial Forest Pathologist, Victoria

Venue:

Parksville, BC, October 2nd – 6th, 2017

Abstract:

Doors swung open at 3 o'clock in the afternoon on October 2nd and thus began the 65th WIFDWC in Parksville BC. Over the next 5 days the conference hummed along with something for every one of the 65 international attendees. Sixty-five years previous to this meeting the first WIFDWC in 1953, which was hosted in Victoria BC, making for an interesting comparison of the discipline and its work of the past 65 years.

The meeting opened with a presentation by Diane Nichols, British Columbia's Chief Forester. She spoke on the subject of BC's forests: Opportunities and Challenges. Following this was the graduate student 'Flash-and-Dash' where each of the 15 students from Canada and the US introduced themselves and presented a short synopsis of their current research.

Over the course of the 5 days the following 4 pathology themed panels with invited speakers anchored a major portion of the meeting:

Assisted Migration (A changing climate and assisting gene flow)

Emerging Douglas-fir Issues (Populations and population genetics of native, emerging and introduced pathogens)

Drought and Pathogens (Drought and its effect on foliar and root diseases, on forest declines, and modelling mortality for forest productivity)

Madrone Diseases (What's affecting Madrone)

Of the 5 days, one and a half of those days were field trips, which provided up close and at hand examples of forest pathogens and other forest problems:

Root disease, mistletoe, white pine blister rust, Phytophthora decay, mushrooms

Madrone diseases, Cryptococcus, drought, old growth and danger trees

White pine blister rust

Swiss needle cast

Breakfasts and lunches were occupied with committee meetings (rusts, twig and foliage pathogens, nursery pathogens, root rot, hazard trees, dwarf mistletoe), during which more informal discussions occurred and where much more detail was talked over. Evenings were either a working meal, such as the Climate Change Committee, or they were social events (banquet dinner or an ice cream social with poster viewing, a silent auction and a photo contest).



WIFDWC field trip

As the doors slowly closed at 12:30pm on October 6, the attendees were thanked for participating and wished happy trails as they made their way home. It was a jam-packed 5 days, full of very valuable information on pathology, and to a pathologist it's easy to see why WIFDWC is valued so much. The conference was a great success based on comments during and after the meeting, but to make it a success it took the active involvement of almost all the attendees to bring it off.

Special thanks goes to the BC regional pathologists - **Michael Murray, David Rusch, Alex Woods, Jewel Yurkewich, Stefan Zeglen** - they either had formal roles within the meeting as committee chairs or they presented their research work, and in addition all of them acted as informed hosts answering questions about forest pathology in British Columbia.

The organization and meeting logistics were overseen by the WIFDWC 2017 planning team;
Stefan Zeglen (BC Forest pathologist, West coast Region) - Local facilities and field trips,
Dave Shaw (Oregon State U) - Program chair,
Sarah Navaroo (Oregon Department of Forestry) - Poster session, silent auction,
Holly Kerns - (US Forest Service) Treasurer,
Betsy Goodrich (US Forest Service) - Grad students, poster session, silent auction,
Christy Cleaver - (US Forest Service) - Secretary,
Harry Kope (BC Provincial Forest Pathologist) - Conference Chair.

Unravelling the biology of *Pissodes striatulus*: a tree-killing weevil in subalpine fir forests of southern British Columbia

Lorraine Maclauchlan, Forest Entomologist, Thompson/Okanagan and Cariboo Regions

Venue:

67th Western Forest Insect Work Conference 2017. Jackson Hole, Wyoming, U.S.A. May 1-4, 2017.

Abstract:

One of the predominant tree species in high elevation forests of British Columbia is subalpine fir. These forests can be found as uneven-aged climax stands, mixed with spruce, or even-aged, pure stands of subalpine fir. The western balsam bark beetle, *Dryocoetes confusus* Swaine, is the predominant mortality agent of subalpine fir throughout its range in BC. However, other organisms also affect this species, including a bark weevil *Pissodes striatulus* (Fabricius, 1775). Very little is known of this weevil other than some reports from eastern Canada where it has been found attacking dead and dying balsam fir, severely defoliated by budworm. *Pissodes striatulus* has been increasingly noted in subalpine fir forests in BC in years of drought stress and at the lower elevation range of its host where presumably summer drought is a more common event. Sampling and observations in 2015-16 show this weevil has a one year life history at low elevations (1375 m) with mating and oviposition commencing late June to early July. The weevil is attracted to fresh stumps but will also mass-attack up to 9 m on standing, live trees. Larvae create galleries straight up or down, occasionally moving circumferentially around the tree. Larvae overwinter as late instars and continue development the following spring. Larvae excavate diagnostic chip cocoons, pupate July-August and adults emerge late July-September. Will this weevil become a more dominant factor in lower elevation, mixed species subalpine fir forests as more effects of climate change take effect?



Pissodes striatulus feeding on fresh stump

Warning signals of adverse interactions between climate change and native stressors in British Columbia forests

Alex Woods, Forest Pathologist, Skeena Region
Richard Hamelin, Professor, UBC

Venue:

UVic Forest Biology Symposium in Victoria, BC April 28, 2017

Abstract:

We examined the direct effects of multiple disturbance agents on individual tree development and stand productivity in 15–40-year-old managed forests in British Columbia, Canada. Our primary interest was to establish a baseline assessment of damage in these forests and, especially, to focus on the degree to which biotic and abiotic stressors cause physical damage and diffuse mortality. Based on extensive climate data for the study area and the ecology of the disturbance agents we explored possible interactions between individual stressors and climate. Mean annual temperature increased by over 1 °C in the last century and annual precipitation increased by 8%, with that in the summer increasing by 18%. Disturbance agents were a central driver of mortality, growth and physical damage and their combined impact in lodgepole pine stands was as much as four times greater than expected particularly in the dominant trees most counted upon for stand productivity and timber supply. Climate-mediated disturbances accounted for five of the top six damage agent categories in terms of percent of basal area impacted but the lack of long-term disturbance monitoring data, a global information gap, limits our ability to conclusively link high damage rates to climatic changes.

Whitebark pine: implications of drought and a high-mountain ecosystem

Michael Murray, Forest Pathologist, Kootenay/Boundary Region

Venue:

Crown Managers Partnership Forum: “Improving Drought Resilience - Forest to Valley Bottom”. Choteau, Montana, March 2017.

Abstract:

Accelerated decline of whitebark pine populations is occurring due to more frequent and intense hot droughts, blister rust, beetles, mistletoe, and pine engravers. The loss of high-mountain canopies may lead to decreased snowpack retention later in the growing season, thus lowering streamflows in late summer. This forum brought together about 100 representatives from agency, non-agency, tribes, and First Nations managers/land owners of forested, range/agricultural, and riparian systems; in addition to, scientists and other organizations that assist land managers in understanding and applying climate and drought information. The workshop enhanced awareness and understanding of the vulnerabilities of drought to key resources within forest, range/agriculture, and riparian systems. We shared information about adaptation strategies and actions.

2017 annual gypsy moth review

Tim Ebata, Provincial Forest Health Officer

Venue:

Hotel Indigo, Savannah, Georgia, November 6-10, 2017

I attended this annual gathering of about 80 operational, policy and research specialists from across North America who are dedicated to gypsy moth management. I provided the most recent gypsy moth trap catch results and the treatments proposed to prevent establishment of growing populations of the moth. Other speakers provided similar information on the status of both North American strain of European gypsy moth (NAGM) and Asian gypsy moth and their management efforts to either eradicate or slow the expansion of the current range of NAGM. The conference provided an excellent mix of information from USDA and CFIA policy updates to recent research on gypsy moth population dynamics, remote sensing applications to track defoliation events in real time, to industry presentations on new products and application methods and spray tracking systems. Information relevant to B.C.'s invasive and native insect management was summarized and distributed to regional entomologists and the members of the BC Gypsy Moth Technical Advisory Committee.

FOREST HEALTH PUBLICATIONS

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- MacLauchlan, L. E.** 2017. Best Practices for Managing Douglas-fir Beetle. 1) Introduction and Biology; 2) Management Strategies and Tactics; 3) Douglas-fir Beetle and Wildfire; 4) Landscape and Stand Level Planning. BC MFLNRORD Internal Report.
- Woods, A.J.**; Coates, D.C.; Watts, M; Foord, V.; and Holtzman, E.I. 2017. Warning Signals of Adverse Interactions between Climate Change and Native Stressors in British Columbia Forests. *Forests* 8, 280; doi:10.3390/f8080280
- Woods, A.J.** 2017. Managing for Climate Change: Climate Change and Forest Health. BC Forest Professional. November – December 24.
- Liu, J; Williams, H.; Li, X.R.; Schoettle, A.W.; Snieszko, R.A., **Murray, M.**; Zamany, A. Roker, G.; Chen, H. 2017. Profiling methyl jasmonate-responsive transcriptome for understanding induced systemic resistance in whitebark pine (*Pinus albicaulis*). *Plant Molecular Biology*. 95(4-5):359-374.
- Moody, R., and **M.P. Murray** 2017. Whitebark pine health of southern British Columbia. In: Goodrich, B. & P. Palacios (compilers). *Proceedings of the 64th Annual Western International Forest Disease Work Conference (WIFDWC)*; 2016 May 9-13, Sitka, AK. 115-119.

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Photographs:

Alex Woods (unknown spruce foliar issue)
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Lorraine Maclauchlan (pine needle cast Kamloops TSA, Neodiprion sawfly, poplar and willow borer, western balsam bark beetle trees, spruce beetle tree, Douglas-fir tussock moth, western spruce budworm egg mass, Pissodes striatulus)
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