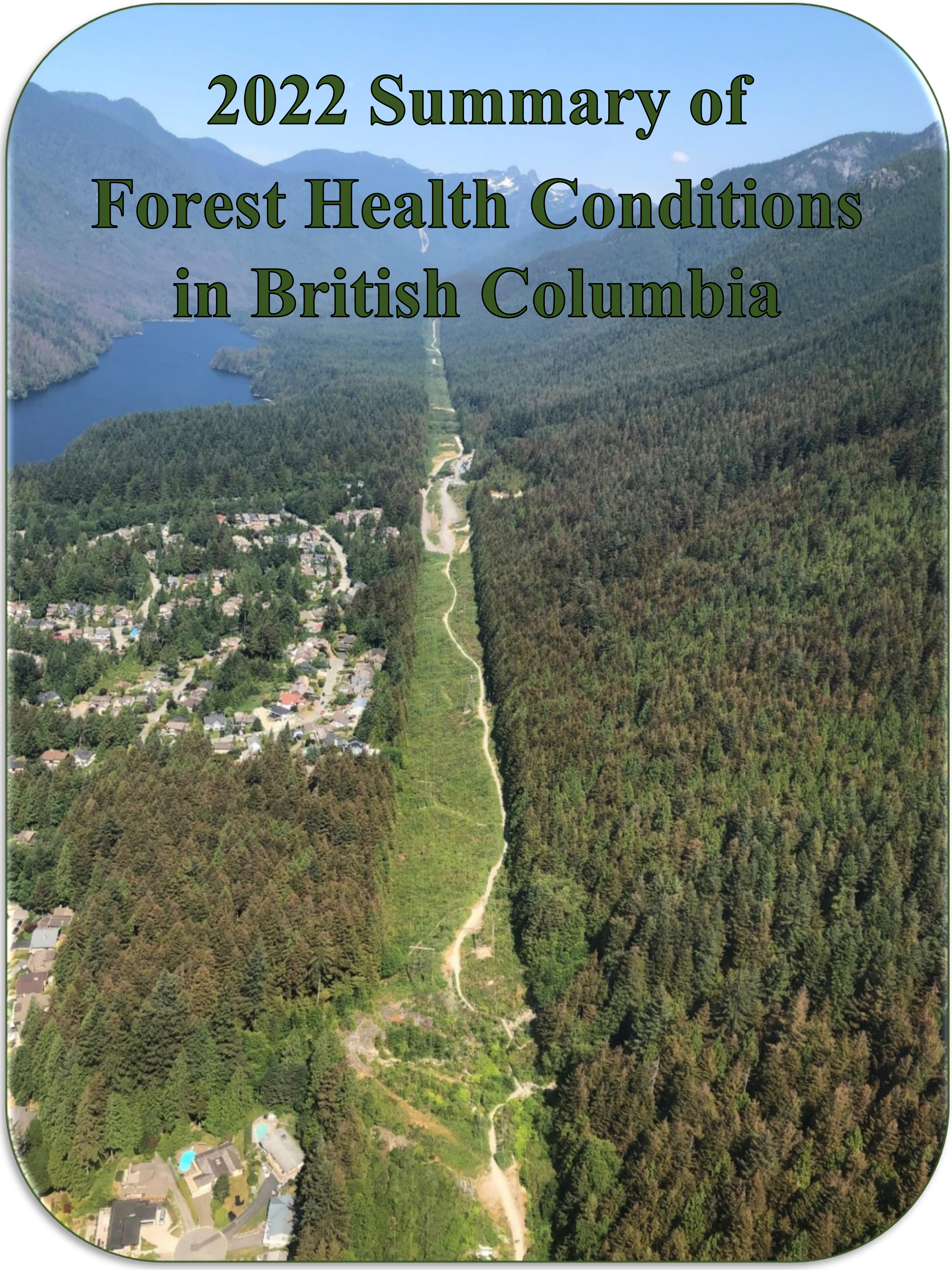
# 2022 Summary of Forest Health Conditions in British Columbia



BRITISH COLUMBIA | Ministry of Forests

# 2022 Summary of Forest Health Conditions In British Columbia

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# Introduction

## Background

Since 1999, the Ministry of Forests (FOR) has annually completed aerial overview surveys (AOS) across the province to capture current and visible forest health impacts caused by insects, pathogens, animals and abiotic factors. The aerially captured data are supplemented with additional forest health information that is collected from detailed helicopter surveys, ground surveys, insect trapping/tree beatings, a review of damage samples, and ground checks that are completed by trained personnel.

Approximately 60% of British Columbia (B.C.) is forested, covering close to 55 million hectares (ha). Currently, 22 million ha are public forest lands that are subject to forest management agreements (also referred to as the timber harvesting land base). The annual AOS program objective is to survey as much forested land as possible, regardless of land ownership or tenure, and cover a minimum of 80% of the province (~76 million ha). Surveying is completed by certified contractors in each forest region (Coast, Thompson Okanagan, Cariboo, Omineca, Skeena, Northeast and Kootenay Boundary) between June and October. Upon completion of the survey, the spatial data are digitized, reviewed and collated. Data are summarized by forest health factor, forest region and timber supply area (TSA, **Figure 1**).

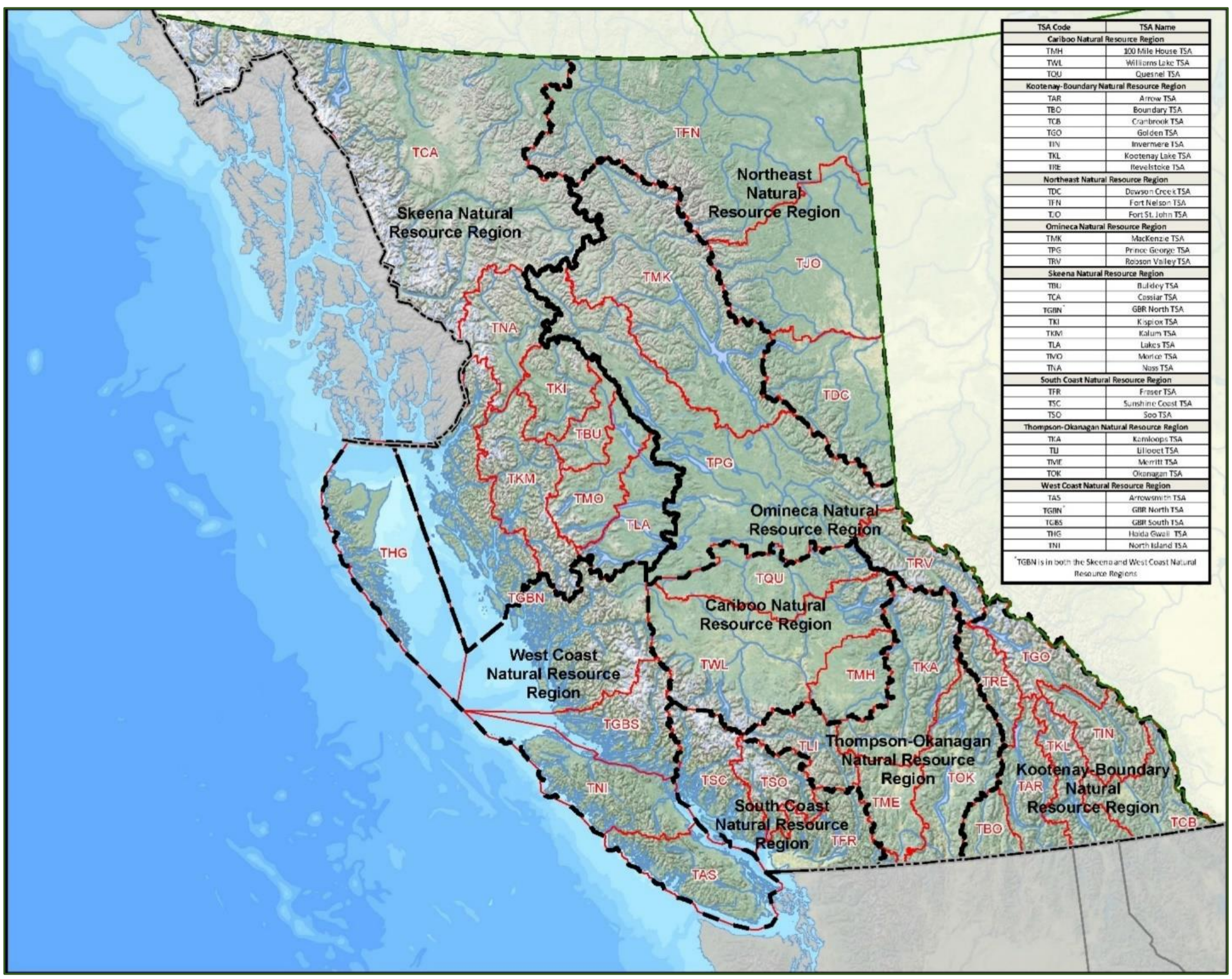



*Figure 1. Map of British Columbia Ministry of Forests Timber Supply Areas and Forest Region Boundaries.*

The AOS data are a valuable source of forest health information that is collected in a timely and cost-effective manner, and is the cornerstone of forest health monitoring in B.C. However, it is important to note that there are limitations with how and when the data is collected. Not all damage is captured considering not all forest health factors produce distinct aerial signatures. Additionally, visibility, survey timing and the elevation at which surveying is completed can result in not capturing all forest health damage, plus there is variability in the spatial accuracy of mapped impacts. The AOS data is a coarse dataset and the annually captured data are not cumulative (see Methods section).

The AOS datasets provide invaluable historical information on the patterns of disturbance across the forested land base and this information is utilized for a variety of purposes by government agencies, industry, academia and the public. The AOS is used to guide FOR's strategic objectives and management efforts related to forest health, for input into timber supply analyses and analyses related to climate change and carbon accounting. Additionally, the data are included as national indicators for sustainable forest management[7] and input into the National Forest Pest Strategy[8].

This report summarizes the results of the 2022 AOS, forest health operations, special surveys and research projects completed by each forest region.

## 2022 Summary

A total of 620.6 hours of fixed-winged aircraft flying time (includes surveying and ferrying times) over 113 days were completed between July 9 and November 2, 2023 (**Table 1**). Approximately 73,714 ha were surveyed, covering 78% of the province. The annual objective is to survey a minimum of 80% of the province however surveying was hindered in select regions due to poor weather and smoke. The mapped area for 2022 (flight lines) is illustrated in **Figure 2**.

For 2022, the leading damage agents were biotic, considering it was not a significant wildfire or drought year (**Figure 3**). In the past ten years, wildfire seasons of note have included 2017, 2018 and 2021. Wildfire and drought related mortality significantly declined in 2022, impacting 7,059 ha and 799 ha respectively. Bark beetle impacts also declined in 2022, with the least amount of area impacted in over ten years (2,308,602 ha; **Figure 4**). This is attributed to drastic decreases in mountain pine beetle (*Dendroctonus ponderosae*; IBM), spruce beetle (*Dendroctonus rufipennis*; IBS) and Douglas-fir beetle (*Dendroctonus pseudotsugae*; IBD) activity. At the peak of the IBM outbreak in 2007, 10M ha of pine were killed and as stand susceptibility increases across the province, impacts will increase. Spruce beetle impacts peaked in 2020 (525,270 ha impacted), during the Omineca outbreak but has drastically declined with 143,569 ha of mortality recorded for 2022. Douglas-fir beetle is the principal killer of mature Douglas-fir in B.C. and it typically attacks stressed or dying trees but as populations increase they do infest and kill large numbers of healthy trees; however, outbreaks are typically short-lived. Douglas-fir beetle related mortality peaked between 2016 and 2021, and drastically declined in 2022 (45,613 ha) where the majority of IBD related mortality was mapped in the Cariboo and Thompson Okanagan Regions. Western balsam bark beetle (*Dryocoetes confusus*; IBB) is the most destructive pest of subalpine fir and is the primary driver of succession in high elevation subalpine fir stands. After a peak in 2017 with 3.7M ha of mapped damage, impacts have steadily declined over the past five years with approximately 2.07 ha of damage mapped in 2022. Western balsam bark beetle impacts are typically light or trace in severity as it is not like other bark beetles where populations quickly build and erupt, rather the impacts are more chronic. However, it is important to note that the impact over several years equates to significant levels of in-stand mortality (L. Maclauchlan, personal communications, 2022).

[7] Canada's National Forest Database: http://nfdp.ccfm.org/en/index.php
[8] Pest Strategy Information System: www.ccfm.org/pdf/PestStrat_infosys_2012_en.pdf

*Table 1. Aerial Overview Survey mapping completed in 2022 by trained contractors across B.C.*

| Region | Survey Window | Number of Survey Days | Total Flight Hours | Surveyor |
|---|---|---|---|---|
| Coast – South | July 21 – Sept. 9 | 6 | 40.8 | B.A. Blackwell & Associates Ltd. |
| Coast - North | August 26 – Sept. 26 | 4 | 25.5 | HR GISolutions Ltd. |
| Coast – Haida Gwaii | September 12 | 1 | 5 | Ministry of Forests – Haida Gwaii Regional Staff |
| Cariboo - South | July 14 - July 28 | 12 | 59.9 | Zimonick Enterprises |
| Cariboo - North | July 26 - Aug. 19 | 10 | 43.5 | Industrial Forestry Service Ltd. |
| Kootenay Boundary | July 9 – Oct. 2 | 26 | 124.2 | Nazca Consulting |
| Thompson Okanagan | Aug. 2 – Aug. 12 | 10 | 57.2 | Zimonick Enterprises |
| Omineca / Northeast | July 26 -Nov. 2 | 36 | 173 | Industrial Forestry Service Ltd. |
| Skeena | July 13 – Sept. 21 | 13 | 91.5 | HR GISolutions Ltd. |
| | **Total:** | **118** | **620.6** | |


*Figure 2. Flight tracks for the 2022 aerial overview survey.*

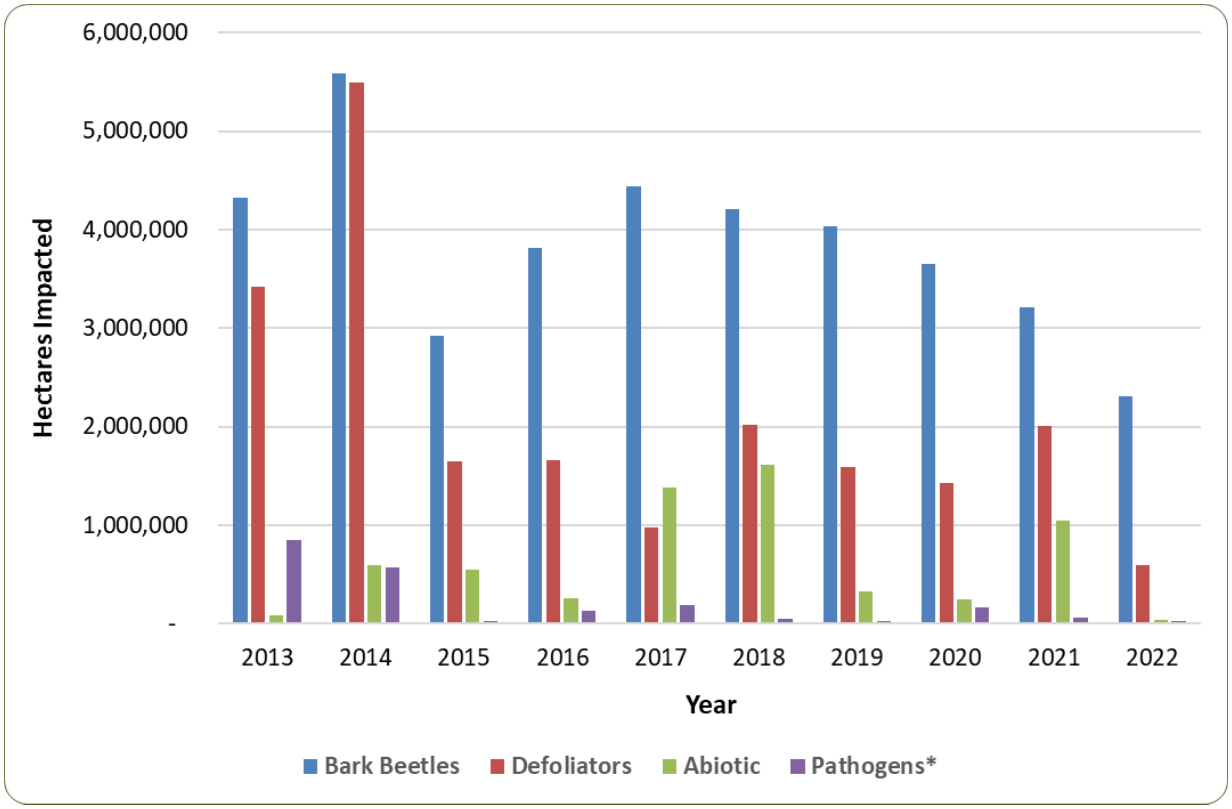



*Figure 3. Summary of forest health impacts by leading forest health factors captured by the Aerial Overview Surveys between 2013 and 2022. Damage is not cumulative over the years and pathogens are not visible and fully captured by the survey.*

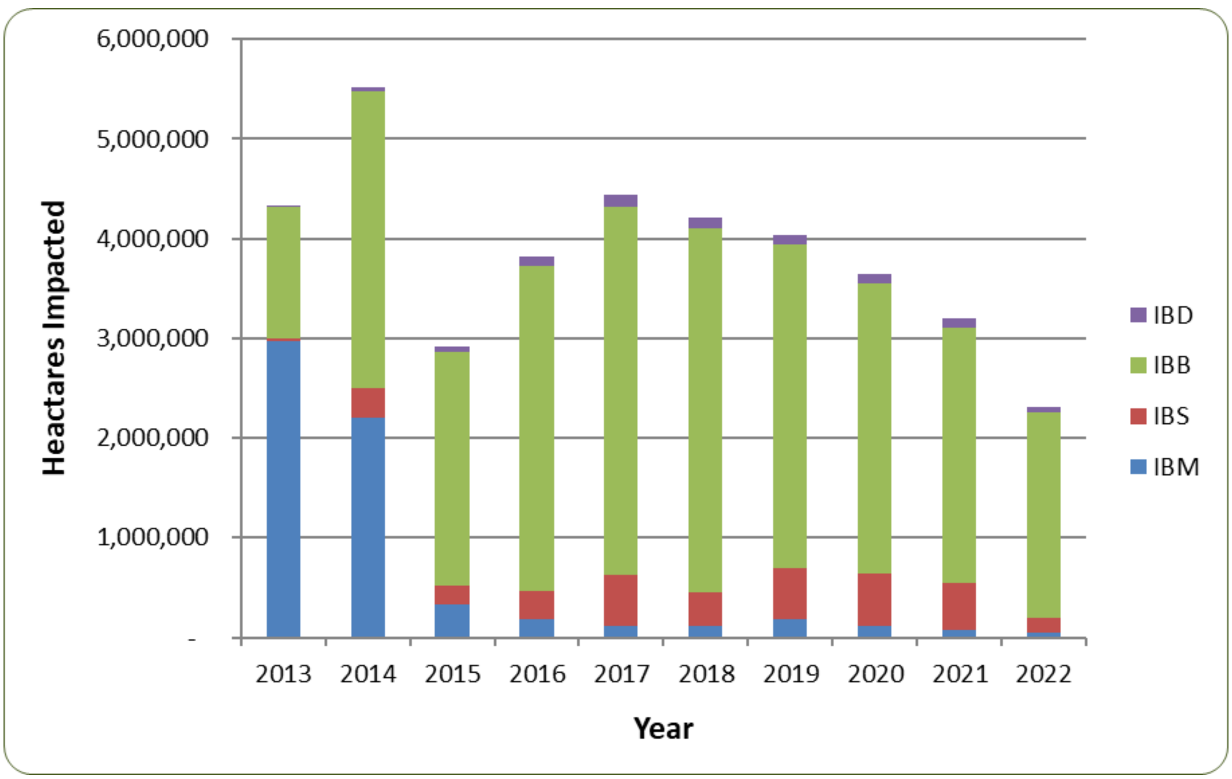



*Figure 4. Bark beetle mortality captured by the Aerial Overview Surveys between 2013 and 2022.*

The leading conifer defoliators across the province included western spruce budworm (IDW; *Choristoneura freemani*; 141,611 ha), two-year-cycle budworm (IDB; *Choristoneura biennis*; 60,584 ha), western hemlock looper (IDL; *Lambdina fiscellaria lugubrosa*; 37,639 ha) and blackheaded budworm (IDH; *Acleris gloverana*; 19,103 ha). Western spruce budworm populations have been slowly increasing across the southern interior since 2016, with damage tripling from 2021 to 2022 (141,611 ha). A spray program was completed in the Cariboo to control western spruce budworm populations in high priority Douglas-fir stands (see South Area section). Two-year cycle budworm (*Choristoneura biennis*; IDB) peaked in 2021 (310,049 ha) but dramatically declined this year. Western hemlock looper populations started building in the southern interior in 2019 and on the coast in 2020; populations are crashing following a peak in 2021 (51,093 ha).

Deciduous related damage was primarily attributed to aspen leaf miner (257,477 ha) and large aspen tortrix (IDX; *Choristoneura conflictana*; 12,199 ha). A significant portion of mapped defoliator damage was not identified to species in the Great Bear Rainforest Region and Skeena Forest Region (55,645 ha). Surveying was completed late in the season in the two regions, which made tree species identification difficult, and no ground verifications were completed due to timing.

A total of 47 disturbance agents were mapped in 2022, and included localized damage caused by a host of abiotic factors and pathogens (non-leading forest health damage agents). Detailed summaries of the leading damage agents are summarized by area, and abstracts for special projects completed by the Forest Health Program specialists are outlined in this report.

# Methods

The AOS is completed with small (minimum four seats), high-wing configuration aircraft that are approved by FOR and meet all the requirements set-out by Transport Canada. Surveying is conducted when the symptoms of forest health factors are most visible and flight conditions are suitable. Surveying is completed between June and October by experienced, FOR Certified Surveyors[9] in each region of the province. The primary surveyor is typically seated in the front (next to the pilot) and is responsible for navigating and mapping all visible forest health factors on the right side of the aircraft. The second surveyor maps from the back left seat of the aircraft. Surveying usually does not exceed 5 – 6 hours. Flight lines are recorded with recreational quality Global Positioning Satellite (GPS) receiver units and flight tracks from each survey are collected weekly to monitor progress. The following aircrafts were used to survey each region:

- Coast – South: Cessna 206
- Coast – North: Cessna 206
- Thompson Okanagan: Cessna 210C
- Cariboo: Cessna 182
- Kootenay Boundary: Cessna 337
- Omineca & Northeast: Cessna 182 and Cessna 210
- Skeena: Cessna 185

Visible forest health damage is hand sketched by two surveyors on customized 1:100,000 scale paper mapsheets (colour Landsat 8 satellite images with additional digital features). Surveying is conducted at

[9] FOR Certified Surveyors must complete the FOR training course followed by a minimum of 15 hours of trainee mapping to qualify as a second seat surveyor. Primary surveyors must have completed one season of surveying as the second seat with a minimum of 50 hours.

an aircraft speed between 140 – 250 km/hour (depending on mapping complexity, and wind speed and direction) and at approximately 700 – 1,400 m above ground level. Over relatively flat terrain a grid is flown with parallel lines 7 – 14 km apart but can vary with pest incidence and visibility. In mountainous areas, surveying usually follows drainages and is dictated by the terrain.

Visible forest health damage includes tree mortality and foliar damage from the current year. Tree mortality is typically attributed to bark beetles, balsam woolly adelgid, animal feeding, root disease and select abiotic factors such as drought and yellow cedar decline. Tree mortality and defoliation are detected by distinct changes in the foliage colour. With tree mortality, the complete tree crown will appear as different shades of red and/or brown. Trees with current year foliar damage caused by insect feeding, foliage pathogens and select abiotic factors will have foliage that appears faded (pink tinge) and may not be uniform across the crown.

When mapping small clumps of up to 50 dead or dying trees, they are mapped as a point (spot infestation). When digitized, a point of 1 – 30 trees is delineated to 0.25 ha and a point with 31 – 50 trees is 0.5 ha, and the impacted area is assigned with 'severe' intensity rating. Polygons are used to delineate larger, continuous areas of impact and the surveyor assigns the severity rating based on the proportion of the trees impacted (**Table 2**). Points or polygons are used to capture tree mortality and polygons are usually used to map foliar damage, with some exceptions. In mixed stands with scattered deciduous components, foliar damage can be mapped as a point (i.e., Venturia blight damage may only affect a clump of less than 50 trees). For each forest health factor, surveyors record host, damaging agent (using a three-digit code[10]), extent (point or polygon) and severity.

All forested lands are surveyed, regardless of land ownership and surveys are carried out using the standardized *Provincial Aerial Overview Survey Protocols*[11] As sketch mapping is completed on each mapsheet, surveyors transfer the mapped points and polygons onto clear Mylar mapsheets. The Mylars are then digitized, reviewed and a final annual dataset and geodatabase (GDB) are published on the public FOR FTP site[12].

[10] https://www.for.gov.bc.ca/hfp/publications/00026/fs708-14-appendix_d.htm#ad_29
[11] http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys/methods
[12] www.for.gov.bc.ca - /ftp/HFP/external/!publish/Aerial_Overview/

*Table 2. Aerial overview survey severity rating classes for capturing current forest health damage.*

| Disturbance Type | Severity Class | Description |
|---|---|---|
| **Tree mortality** | Trace | <1% of trees in the stand recently killed |
| | Light | 1-10% of trees in the stand recently killed |
| | Moderate | 11-29% of trees in the stand recently killed |
| | Severe | 30-49% of trees in the stand recently killed |
| **Foliar damage** | Light | Some branch tip and upper crown defoliation, barely visible from the air. |
| | Moderate | Thin foliage, top third of many trees severely defoliated, some completely stripped |
| | Severe | Bare branch tips and completely defoliated tops, most trees sustaining >50% total defoliation |
| **Decline syndromes** | Light | Decline with no mortality - the first detectable stage, characterized by thin crowns and no individuals without visible foliage |
| | Moderate | Decline with light to moderate mortality - thin crowns are accompanied by individuals devoid of foliage. Greater than an estimated 50% of individuals have some foliage. |
| | Severe | Decline with heavy mortality - crowns are very thin and greater than 50% of standing stems are devoid of foliage. |

Further details on the AOS standards, methods, survey limitations and data capture, and a list of pest codes are outlined in the *Forest Health Aerial Overview Standards for British Columbia* report[13].

13 https://www.for.gov.bc.ca/ftp/HFP/external/!publish/Aerial_Overview/Data_stds/AOS%20Standards%202019.pdf

# Coast Area

For the Coast Area (South Coast and West Coast Forest Regions), 31 damage agents were mapped in 2021. Damage impacts of 37,912 ha, across six TSAs were mapped, 61,579 ha less than 2021. The majority of the West Coast Forest Region was flown late in the survey season, resulting in potentially missed aerial signatures and missed opportunities to ground truth unknown damage agents; hence this may have contributed to the decline in captured damage impacts between 2021 and 2022.

The extent and severity of forest health impacts are generally not as significant on the Coast as they are in other regions. Generally, incidence and severity of biotic forest health agents are more significant in the sub-maritime (leeward side of the coast mountains) and warm (sub-continental, interior areas) climatic classes of the Coast, and the leading biotic forest health agents in these areas have historically included Douglas-fir beetle (IBD), mountain pine beetle (IBM), western balsam bark beetle (IBB), western spruce budworm (IDW) and western hemlock looper (IDL). The leading abiotic factors across the Coast area are typically windthrow (NW) and slides (NS), and more recently included drought (ND), drought flagging (NDF) and drought related mortality (NDM).

Between 2013 and 2022, bark beetle related mortality declined across the Coast. The main decline in bark beetle impacts have been due to the reduction in area impacted by western balsam bark beetle, following a peak in 2016 where just under 48,800 ha of IBB related mortality was mapped. Western balsam bark beetle impacts are light or trace in severity, and usually observed in overmature subalpine fir and occasionally in amabilis fir. Mountain pine beetle is most active in the South Coast Forest Region however, following a peak in 2010 (21,700 ha) and 2020 (5,479 ha), impacts have been minimal over the past decade.

A total of 19,103 ha of defoliation was mapped for 2022 across the West Coast Region and 9,109 ha in the South Coast Region. Defoliator damage increased in 2022, due to the start of a blackheaded budworm (IDH) outbreak in the Haida Gwaii TSA where 1,896 ha of damage was mapped. The last IDH outbreak peaked in 2010 where approximately 87,500 ha of damage were mapped. Western hemlock looper decreased for a final year with 583 ha impacted in the Fraser TSA (South Coast Region), following an outbreak that started in 2019. The outbreak lasted three years and was restricted to the Sunshine Coast and Metro Vancouver area. Impacts during the outbreak were mapped in North Vancouver, West Vancouver, the Powell River Community Forest, within the Rainy River and Brittain River drainages in the DSC and within TFL 39. Damage was still present in Stanley Park however, it is expected the population will crash (**Figure 5**).

Abiotic damage was mapped across 2,547 ha with 483 ha of wildfire damage (NB; West Coast Region only), 806 ha of yellow cedar decline (NCY), 345 ha of NDM and 519 ha of NW.

Approximately 198 ha of laminated root rot (DRL; *Phellinus weirii*) was mapped (primarily in the Sunshine Coast TSA) and 509 ha of white pine blister rust (DSB; *Cronartium ribicola*; primarily in the North Island TSA/Campbell River Forest District). It is important to note that root disease impacts captured by the AOS are a drastic underestimation considering it is difficult to detect at the elevation and speed of fixed-wing surveying, and the impacted areas captured by the AOS are attributed to ground knowledge.

*Figure 5. Western hemlock looper defoliation and mortality in Stanley Park.*

### Haida Gwaii TSA

Surveying of Haida Gwaii TSA was completed by Haida Gwaii Forest District staff (Erica Reid and Sean Muise) using a De Havilland Beaver DHC-2 float plane on September 12$^{th}$. Spruce beetle was mapped over 1,730 ha, mostly in the northern half of the district, comparable to 2021 (1,700 ha). Mountain pine beetle damage was concentrated at the northern end of Graham Island and increased from 13 ha in 2021 to 166 ha.

Western black headed budworm populations started to build, and defoliation covered 19,103 ha, increasing by 18,886 ha since 2021. The last recorded IDH outbreak occurred from 2008-2012, and peaked at 37,378 ha. Historically, IDH outbreaks have lasted between two and five years. The current outbreak is currently concentrated in the southern half of the TSA, along the east coast. On Graham Island, IDH impacts were most visible between Eden and Ian Lake. Conifer sawfly (IDS; *Neodiprion abietis*) impacted 467 ha, close to the shoreline of the island. It was detected on Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*) and shore pine (*Pinus contorta*). Increases in IDS populations are often associated with IDH outbreaks.

Yellow cedar decline was predominantly mapped in the northern half of the TSA and the damage covered 707 ha, a decrease from 2,763 ha 2021. Other captured abiotic factors included NS (477 ha), NF (41 ha), and NW (83ha). The larger NW impacted areas were around the north end of Lyell Island.

### North Island TSA

There were no significant forest health impacts captured in the North Island TSA. It is common for the AOS to capture small, localized impacts from IBD, IBB, DSB, DRL, balsam woolly adelgid (IAB; *Adelges piceae*) and select abiotic factors such as NW or ND related impacts. Approximately 8.5 ha of IBD related mortality was mapped as points across the TSA. Scattered incidence of DSB related mortality was mapped and amounted to 276 ha of impact.

### Arrowsmith TSA

There were no significant forest health impacts captured in the Arrowsmith TSA. Historically, it is common to capture small, localized impacts from IBD, IBB, DSB, DRL, IAB and select abiotic factors such as windthrow and drought. In 2021, 768 ha of IBD damage was mapped and in 2022 less than 7 ha were mapped across the TSA (mapped as points) and no IBB damage was captured. Approximately 378 ha of abiotic damage was mapped and primarily attributed to drought mortality, and 295 ha of pathogen related damage was mapped and primarily attributed to DSB in both young and old stands (mapped as points).

### Fraser TSA

Forest health impacts across the Fraser TSA were minimal. The leading damage agents were IBB (551 ha) which declined for the third year in a row, IBD (393 ha) which was primarily mapped as spot infestations, and IDW (578 ha) which drastically declined following the outbreak that started in 2020 and peaked in 2021 (10,297 ha).

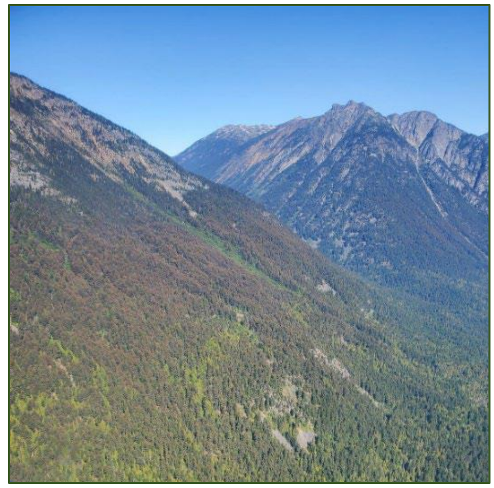


*Figure 6. Western spruce budworm defoliation in the Sea to Sky Forest District.*

### Soo TSA

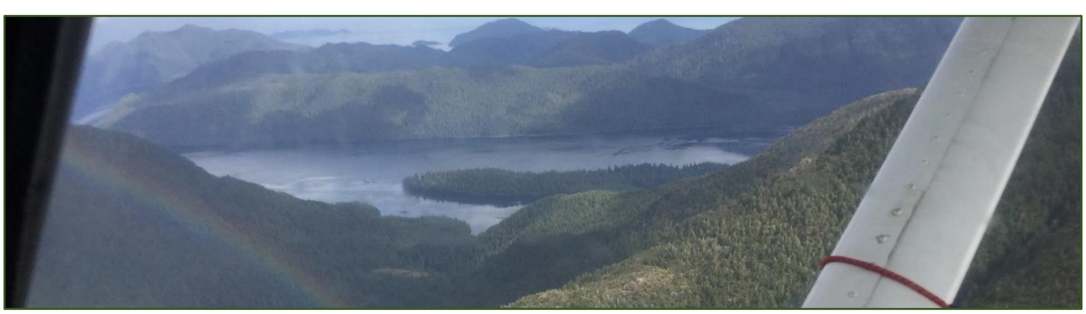
The most significant forest health impact across the Soo TSA was IDW defoliation (4,462 ha), where populations and impacts appear to be building following a drastic increase in damage between 2021 (129 ha) and 2022. Impacts associated with IDW were mapped for the first time since 2006 in Squamish Forest District (DSQ; **Figure 6**). Defoliation was visible around Birkenhead Lake, D'Arcy, north end of Lillooet River, south side of Mount Athelstan and south of Anderson Lake.

Bark beetle related mortality was minimal across the Soo and the only significant impacts were associated with IBB (1,693 ha) which has drastically declined since 2019 (27,638 ha).

### Sunshine Coast TSA

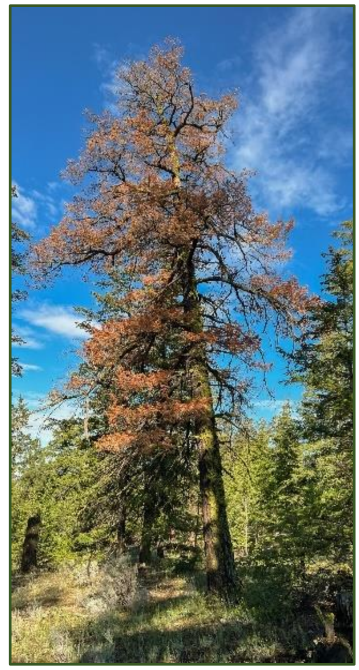
No IDL impacts were mapped following the collapse of the outbreak that lasted between 2019 and 2021. Bark beetle mortality was minimal and primarily attributed to IBB (783 ha), followed by IBM (295 ha). Following multiple years of drought over the past several years, the incidence of drought mortality and foliage loss/damage due to drought stress significantly increased. Drought related mortality was primarily observed on western redcedar (*Thuja plicata*) and coastal Douglas-fir (*Pseudotsuga menziesii*).

Localized root disease impacts are common but not adequately captured. Laminated root rot related mortality in mature Douglas-fir stands were mapped in Toba Inlet near Mount Powell and on the southern end of Texada Island (135 ha). Scattered patches of DSB impacts on western white pine (*Pinus monticola*) were also captured but minimal.



# South Area

For the South Area (Cariboo, Thompson Okanagan and Kootenay Boundary Forest Regions), 28 damage agents were mapped in 2022, compared to 33 in 2021. The mapped damage affected approximately 534,994 ha over 15 TSAs (including the Cascadia TSA near Revelstoke), nearly 949,428 ha less than what was mapped in 2021, representing a 64% decline (Table 3). A significant proportion of the 2022 decrease in damage recorded was due to less wildfire activity and 88.5% less deciduous defoliation being mapped.



Total area affected by bark beetles declined by 31,906 ha to 291,351 ha damaged in 2022. This decline was solely due to decreased infestations of Douglas-fir beetle in 9 of 15 TSAs, decreasing from 100,029 ha in 2021 to just 45,092 ha in 2022. Overall, spruce beetle increased by 8,869 ha over 2021 primarily due to substantial increases in the Quesnel TSA, although declines were observed in the Williams Lake, Golden and Kamloops TSAs. Western balsam bark beetle and mountain pine beetle both increased nominally by 8% and 2%, respectively. Very small infestations of western pine beetle (<4 ha total) were mapped in four TSAs. Damage caused by insect defoliators declined by 32% in 2022, affecting 225,001 ha. The decline was mainly due to an 88% decline in aspen serpentine leafminer activity across most of the south area. Only 28,526 ha of aspen serpentine leafminer defoliation was mapped in 2022 as compared to 247,794 ha in 2021. Small pockets of satin moth were detected in the Kamloops, Merritt and Okanagan TSAs (71 ha) and 68 ha of Douglas-fir tussock moth were recorded in the Williams Lake TSA. Western spruce budworm defoliation increased in six TSAs in the Cariboo and Thompson Okanagan Regions, from 53,895 ha mapped in 2021 to 137,149 ha in 2022, with the largest increases in area affected in the 100 Mile House and Williams Lake TSAs.

Abiotic damage (drought, fume kill, windthrow, aspen decline, cedar flagging, post-fire mortality) was mapped on 19,073 ha in 2022, down substantially from the 96,813 ha mapped in 2021. Post-fire mortality affected 1,786 ha with the largest areas affected in the 100 Mile House and Quesnel TSAs at 659 and 405 ha, respectively (Table 3). Fume kill affected 2,219 ha in seven TSAs, mainly in the Williams Lake TSA. Relatively minor areas of foliage damage due to drought and wind throw were mapped. Aspen decline was mapped over 387 ha, with little change from 2021. Cedar flagging was detected in 5 TSAs affecting 14,142 ha. This is likely an under-representation of the amount due to much of the discoloration not becoming obvious until late summer after the aerial surveys have been completed.

Very little foliar disease damage was observed in 2022 with just small amounts of larch and *Dothistroma* needle blight mapped on 1,785 ha. About 327 ha of bear damage was mapped in seven TSAs.

*Heavy cone crops.*

*Wood borer and bark beetle attack in fires.*

*Wood borer attack followed by heavy woodpecker activity.*

## Southern Interior Overview

### Insect Defoliators, General

#### Methods Used to Monitor Defoliator Populations

There are several methods used to monitor or predict defoliator populations. Brief descriptions of the most regularly used methods are described below and more detailed information is provided within separate defoliator sections.

Methods include:

1. Aerial overview and detailed mapping of defoliation – provides the most current information on extent and severity of defoliation. Detailed aerial surveys are conducted when planning control programs.
2. Annual trapping with pheromones at permanent sample sites (PSPs) – provides trends in populations and can predict imminent defoliation. Trapping is conducted annually for Douglas-fir tussock moth and western hemlock looper.
3. Three-tree beatings – is an assessment of species richness and abundance. This is a technique conducted annually to collect defoliator larvae at permanent sample sites (often coupled with trapping). Three-tree beatings are conducted at Douglas-fir tussock moth and western hemlock looper PSPs throughout the southern interior and at an additional thirteen PSPs established in the East Kootenays to monitor western spruce budworm and other defoliating insects.
4. Egg mass surveys – conducted late summer or fall. These surveys provide an estimate of predicted defoliation (defoliator population) in the next season. Egg mass surveys are most often conducted

for western spruce budworm and Douglas-fir tussock moth, and occasionally western hemlock looper, as part of the planning process for control programs.

In 2022, approximately 225,001 ha of deciduous and coniferous forests were impacted by insect defoliators, down from 334,024 ha mapped in 2021 (Figure 1). Conifer defoliation increased 2.3-fold over 2021, damaging 196,404 ha. Deciduous tree defoliation saw a precipitous decline from 248,732 ha in 2021 down to only 28,597 ha in 2022. This decrease was due to a 219,268 ha decline (almost 9-fold) in aspen serpentine leafminer defoliation over 10 TSAs (Appendix A: Forest Health Damage Summary Tables for the South Area). Only the Boundary, Cranbrook and Merritt TSAs saw small increases in aspen serpentine leafminer defoliation.

Area affected by western spruce budworm continued to increase in both the Cariboo and Thompson Okanagan Regions in 2022, reaching 137,149 ha defoliated compared to 53,895 ha in 2021. The most significant increases were observed in the 100 Mile House, Williams Lake and Lillooet TSAs. Western hemlock looper defoliation was mapped over 36,467 ha in 2022 compared to 24,202 ha in 2021. The largest increase occurred in the Okanagan TSA where there was more than a 20-fold increase in area affected, with 10,277 ha defoliated. Some TSAs saw moderate increases in area defoliated whereas others such as Revelstoke and Williams Lake declined (Table 3). The Okanagan saw an increase in area defoliated in 2022, primarily in the eastern portion of the TSA near Sugar and Mabel Lakes. The expansion of hemlock looper damage was outside the areas treated with *B.t.k.* in 2021 (**Figure 7**and **Figure 8**). This year (2022) is likely the final year of this outbreak cycle.

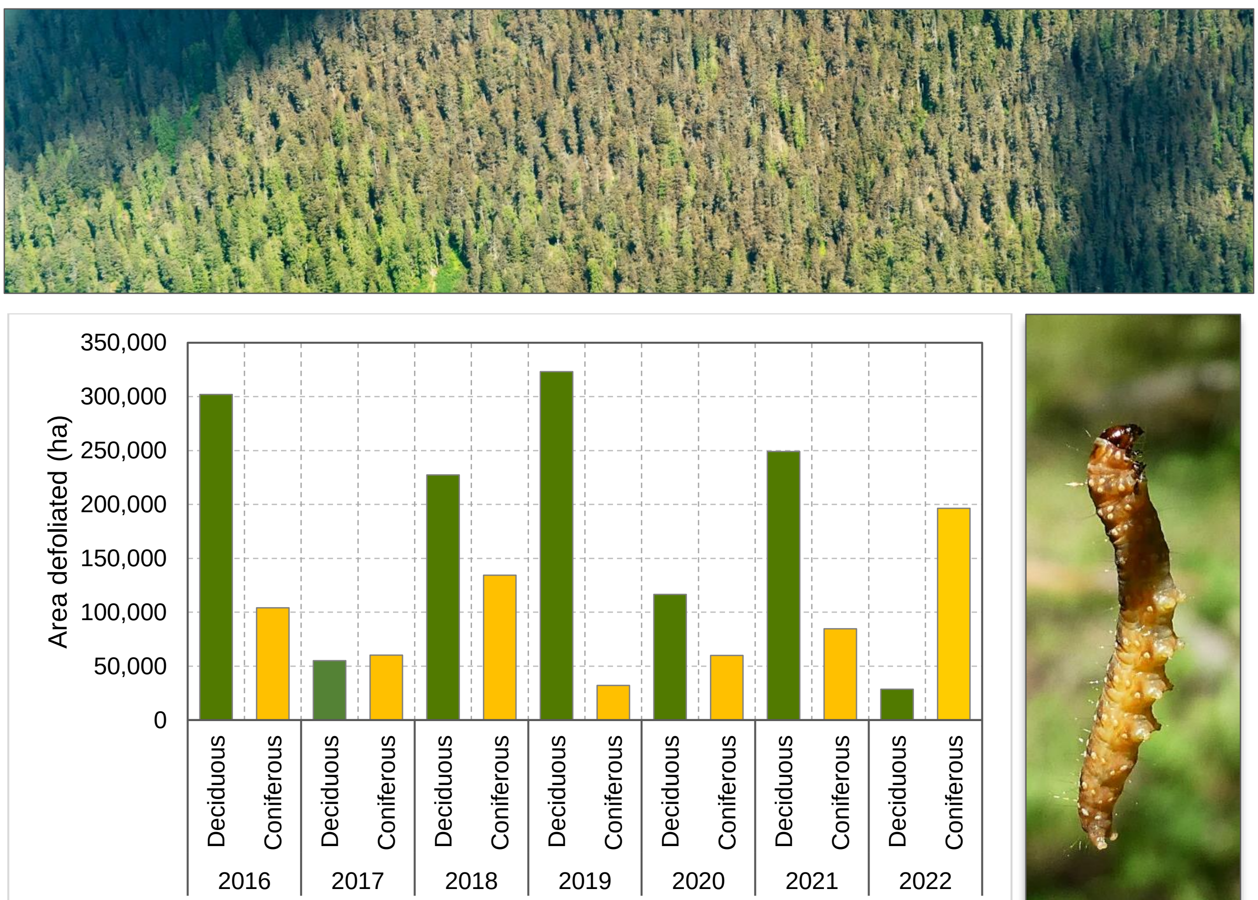



***Figure 7. Area of deciduous and coniferous defoliation in the southern interior of B.C., 2016-2022.***

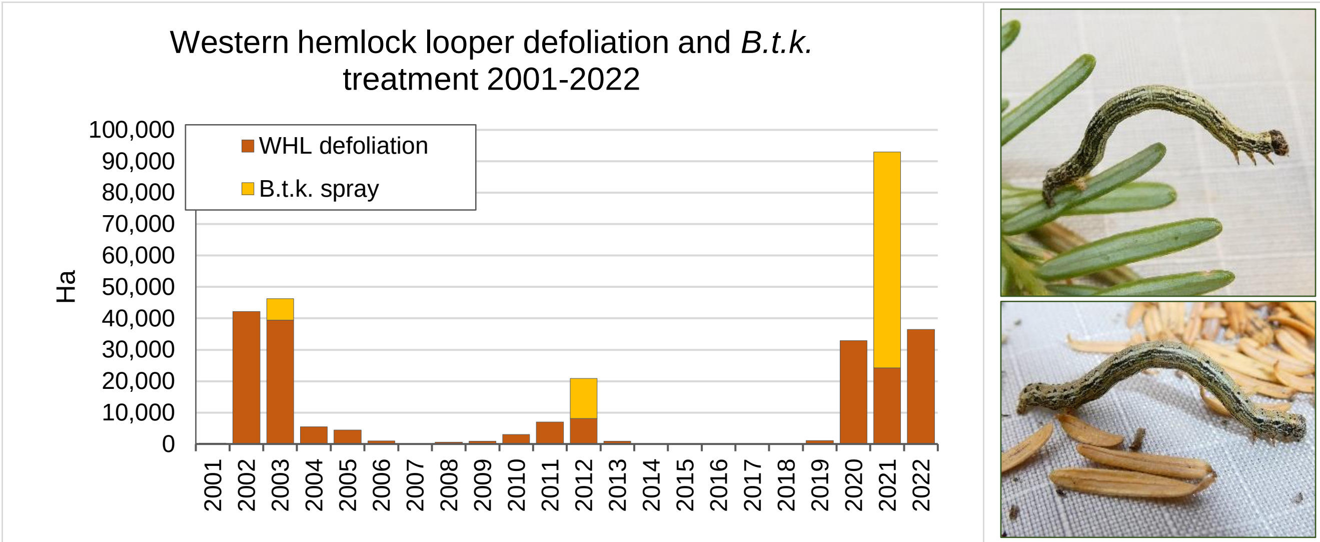



*Figure 8. Area (ha) defoliated by western hemlock looper and ha sprayed with B.t.k. in the south area, 2001-2022.*

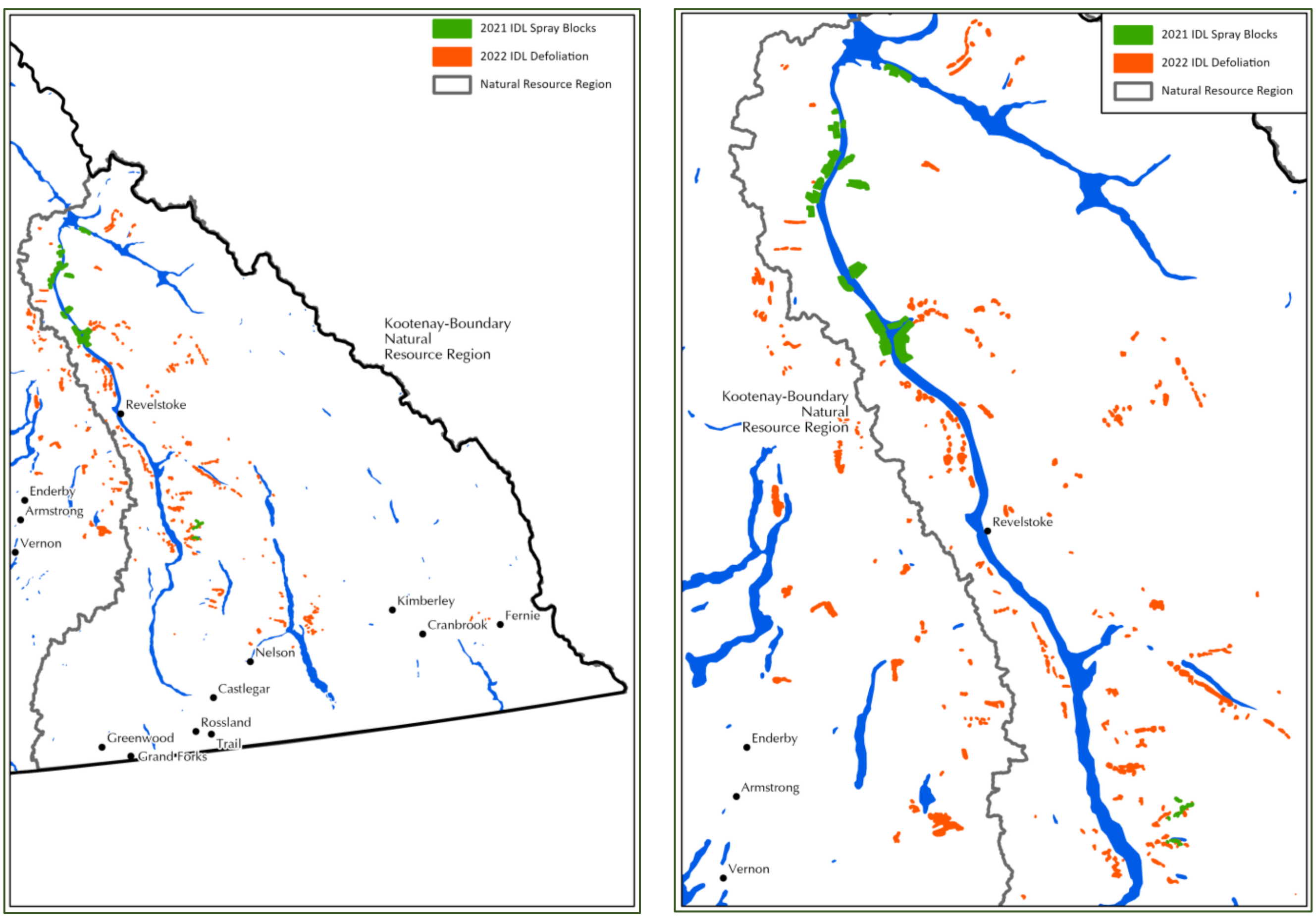



*Figure 9. Areas in southeast B.C. defoliated by western hemlock looper in 2022 (red) and treated with B.t.k. in the Kootenay Boundary Region in 2021 (green).*

**Figure 10** illustrates the population cycles of four major conifer defoliators in the southern interior from 2012 to 2022. In 2012, all four defoliators were active. Then, over the next 10 years, two-year cycle budworm and Douglas-fir tussock moth populations declined. More recently, western hemlock looper and western spruce budworm populations have increased but with western hemlock looper having a more eruptive cycle, infestations of this insect will likely decline within the next year.

Only two species of deciduous defoliators were observed in 2022, with the aspen serpentine leafminer (*Phyllocnistis populiella*) being the most prevalent affecting 28,526 ha, although significantly lower than in previous years in all but the Lillooet and Cascadia TSAs. Satin moth (*Leucoma salicis*) was mapped on 71 ha within the Thompson Okanagan Region.

*Western hemlock looper*

*Looper defoliation near Avola*

*Western spruce budworm*

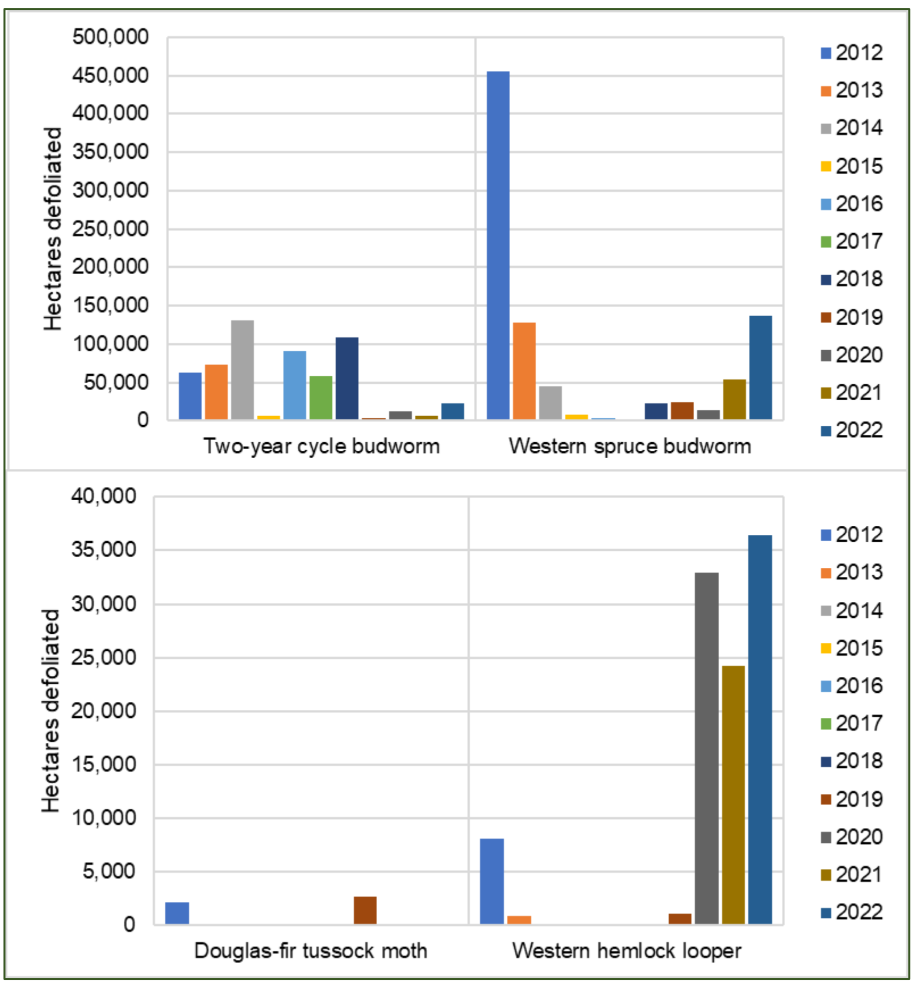



*Figure 10. Ha affected by four major conifer defoliators in the southern interior of B.C. (2012-2022).*

Five species of coniferous defoliators were recorded, with western spruce budworm (*Choristoneura freemani*) affecting the largest area of southern interior forests. It affected 137,149 ha, a 2.5-fold increase over 2021, with most of the increase seen in the 100 Mile House and Williams Lake TSAs, at 44,737 ha and 72,571 ha respectively. Two-year cycle budworm (*Choristoneura biennis*) was in its $2^{nd}$ year, defoliating 22,674 ha a 3.6-fold increase over 2021. Western hemlock looper (*Lambdina fiscellaria lugubrosa*) increased by 12,265 ha in 2022 for a total of 36,467 ha affected, similar in ha affected to that mapped in 2020. In 2021, 68,768 ha were sprayed with *B.t.k.* to control high populations of western hemlock looper. Very light or no defoliation was mapped within the treated areas in 2022. The most notable increases in defoliation occurred in the Kootenay Boundary Region (24,035 ha defoliated), with moderate defoliation mapped in the Thompson Okanagan (10,448 ha defoliated) and Cariboo (1,985 ha defoliated) Regions. As noted in the "2021 Overview of Forest Health Conditions in Southern British Columbia" the heat dome did not seem to affect insect populations as severely in hemlock-dominated stands in the Interior Cedar Hemlock (ICH) biogeoclimatic zone. The main areas of defoliation mapped in 2022 in the Kootenay Boundary Region occurred near Kootenay Lake, south of Crawford Creek, Gray Creek and Coffee Creek; west of Slocan Lake on the south side of Nemo Creek; along Arrow Lake near Kuskanax Creek between Nakusp and Wilson Lake, and along Leon Creek; south of Trout Lake and along the west side of Upper Arrow Lake in the Revelstoke TSA. In the Thompson Okanagan Region, defoliation was mapped near Sugar Lake, Mabel Lake, the north end of the Perry River and along the Anstey Arm of Shuswap Lake. Very small patches of defoliation were detected near the west arm of Quesnel Lake in the Williams Lake TSA within the Cariboo Region. This will likely be the last year of significant defoliation in this outbreak cycle.

### Western Spruce Budworm, *Choristoneura freemani*

Western spruce budworm defoliation of Douglas-fir was mapped in six TSAs in the south area in 2022 (Table 3) for a total of 137,149 ha defoliated. All these TSAs had an increase in ha defoliated over 2021. The most significant increases occurred in the 100 Mile House and Williams Lake TSAs, with increases of 31,712 and 35,179 ha respectively, over 2021. This outbreak spanned the Lillooet TSA near French Bar Creek, along the Fraser River north through the 100 Mile House and Williams Lake TSAs to De Sousa Creek, affecting vast expanses of interior Douglas-fir forests. Western spruce budworm increased substantially in the Lillooet TSA affecting 7,798 ha in 2022 up from 315 ha in 2021. Most of the active populations in the Lillooet TSA were along Seton and Anderson Lakes and near Gold Bridge, along Gun Lake and Tyaughton Lake. There were also increases noted in the Merritt TSA near Mamit Lake and in the south, east of Princeton near August Lake.

The Cariboo Region sprayed 34,750 ha of priority Douglas-fir stands with the biological insecticide Foray 48B B (*Bacillus thuringiensis var. kurstaki;* P.C.P. No. 24977) in July 2022 to mitigate damage from western spruce budworm defoliation (

**Table 3**; **Figure 11**). Five blocks were treated between July $6^{th}$ and July $10^{th}$, at 2.4 litres per hectare. Western Aerial Applications Ltd. conducted the aerial applications using two 315B Lama helicopters and two Hiller UH12ET helicopters, each equipped with four Beecomist 361 ultra-low volume hydraulic sprayers. The spray operations were conducted from five staging sites where the *B.t.k.*, mobile fuel trucks and loading crews were positioned. Spray conditions were optimal due to overcast conditions and cool temperatures.

*Table 3. 2022 Western spruce budworm spray blocks in the Cariboo Region, showed treated area, litres of B.t.k. and date sprayed.*

| Spray Block Location | Ha sprayed | Litres *B.t.k.* | Date Sprayed |
|---|---|---|---|
| 1. Williams Lake Community Forest | 1,695 | 4,068 | July 6-7 |
| 2. Joes Lake Road | 19,534 | 46,882 | July 6-9 |
| 3. 2700 Road | 5,087 | 12,209 | July 9-10 |
| 4. Dog Creek Dome | 2,288 | 5491 | July 8-9 |
| 5. Big Bar Mountain | 6,146 | 14,750 | July 9-10 |
| **Total** | **34,750** | **83,400** | |

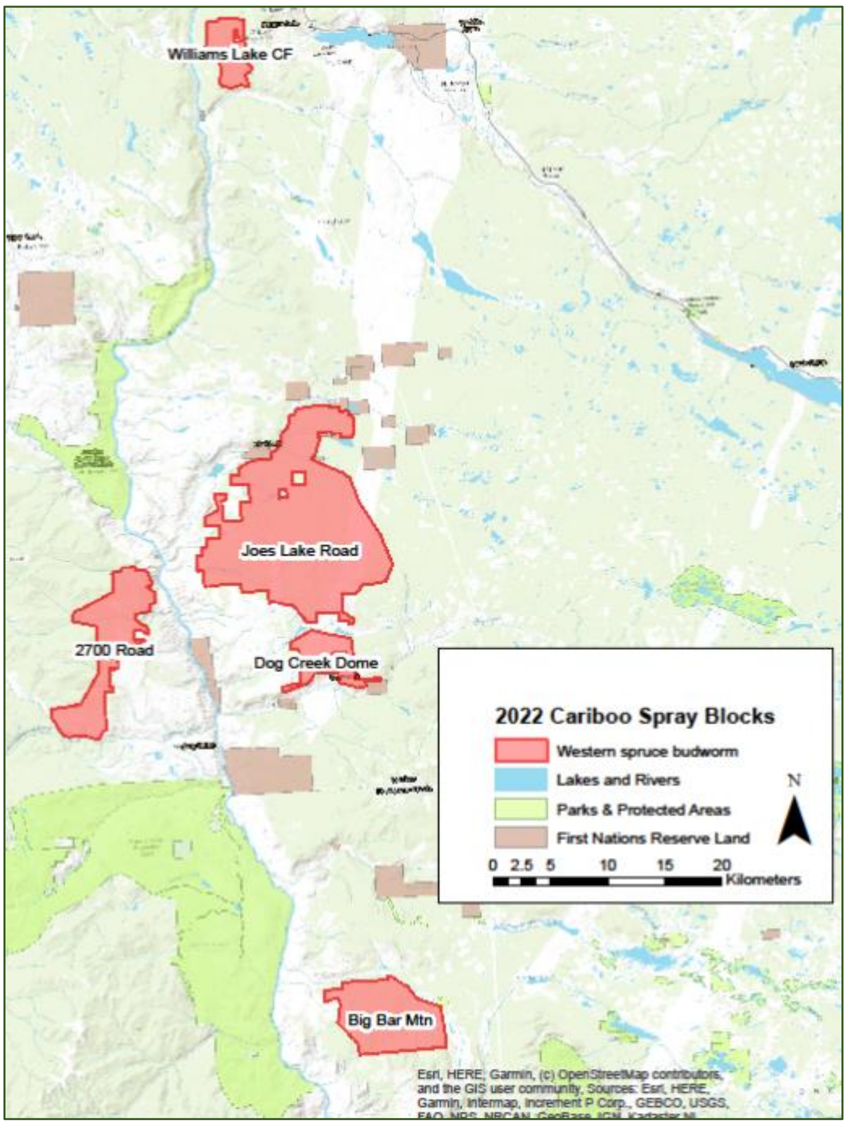


*Figure 11. Western spruce budworm 2022 spray blocks in the Cariboo Region.*

### Efficacy assessment

Pre- and post-spray larval sampling was done within the 2700 Road and Williams Lake Community Forest spray blocks and comparable unsprayed areas to determine larval density and treatment efficacy. Pre-spray sampling was done the day before treatment, and post-spray sampling was done at 5-7 day intervals after treatment.

Budworm larval density at the pre-spray sampling time ranged from 4.5 to 42.3 larvae per $m^2$ foliage and by the final post-spray sampling, there were no larvae found in spray blocks and an average of 14.3 larvae per $m^2$ foliage at control sites (**Table 4**). The *B.t.k.* treatment achieved very high larval mortality.

***Table 4. Pre- and post-spray larval sampling conducted in the 2700 Road and Williams Lake Community Forest spray blocks and comparable unsprayed areas to determine treatment efficacy.***

| Sample Location | Budworm larvae density (# larvae per $m^2$ foliage) | | | | % Mortality | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Uncorrected | | | Corrected | | |
| | Pre-Spray | 1st post | 2nd post | 3rd post | 1st post | 2nd post | 3rd post | 1st post | 2nd post | 3rd post |
| 2700 Road | 20.8 | 17.6 | 1.5 | 0 | 15.6 | 93.0 | 100 | - | 87.7 | 100 |
| 2700 Road Control | 42.3 | 34.9 | 24.0 | 23.0 | 17.5 | 43.4 | 45.5 | 50.5 | - | |
| Williams Lake CF | 4.5 | 7.5 | 0.8 | 0 | - | 81.6 | 100 | - | 52.1 | 100 |
| Williams Lake CF Control | 15.7 | 5.6 | 6 | 5.6 | 64.2 | 61.6 | 64.1 | 64.1 | 61.6 | 64.1 |

### 2023 Defoliation Predictions

Fall egg mass sampling is conducted to predict defoliation in the following year and to determine whether stands will require treatment with *B.t.k.* Current, historic, and predicted defoliation are taken into consideration when determining population trends and determining which areas are most at risk for continuing defoliation and damage. 231 sites were sampled for western spruce budworm egg masses in the south area, (no sampling was conducted in the Chilliwack area in 2022) (Table 6). Defoliation estimates are based on the number and density of egg masses found. Of all sites sampled, 33% predicted no defoliation in 2023, 56% had predictions of light defoliation and 11% had predictions of moderate defoliation, a substantial increase in defoliation severity predicted over that of 2022. In the Thompson Okanagan Region, the Lillooet and Merritt TSAs remain the key areas where budworm populations are active and increasing; however, no spray treatments are planned in the Thompson Okanagan region in 2023.

*Western spruce budworm needle mining.*

*Western spruce budworm larva feeding.*

*Western spruce budworm egg masses.*

***Table 5. Results of the fall 2022 western spruce budworm egg mass sampling in the southern interior.***

| Region and TSA | 2023 predicted defoliation (No. sites) | | | | No. egg masses | |
|---|---|---|---|---|---|---|
| | Nil | Light | Moderate | Total# sites | Avg. | Max. |
| **Cariboo** | | | | | | |
| 100 Mile House | 12 | 24 | 10 | 46 | 26.0 | 88 |
| Williams Lake | 33 | 28 | 1 | 61 | 8.7 | 73 |
| **Total** | **45** | **52** | **11** | **108** | **16.3** | |
| **Kootenay Boundary** | | | | | | |
| Boundary | **18** | **0** | **0** | **18** | **0** | **0** |
| **Thompson Okanagan** | | | | | | |
| Kamloops | 7 | 12 | 0 | 19 | 5.1 | 19 |
| Lillooet | 3 | 30 | 6 | 39 | 21.7 | 82 |
| Merritt | 1 | 35 | 9 | 45 | 31.6 | 91 |
| Okanagan | 2 | 0 | 0 | 2 | 0.0 | 0 |
| **Total** | **13** | **77** | **15** | **105** | **22.5** | |
| **2022 Total** | **76** | **129** | **26** | **231** | | |

*Number of sites indicating nil, light or moderate defoliation in 2023 is listed by TSA, with the average number of egg masses per 10m$^2$ foliage per tree (10 trees sampled per site) by TSA and the maximum number found at a site. Nil = 0 egg masses; Light = 1-50 egg masses; Moderate=51-150 egg masses.*

No western spruce budworm egg masses were found in any of the 18 sites sampled in the Boundary TSA, Kootenay Boundary Region, in 2022 (**Table 5**).

Of the 108 sites sampled for egg masses in the Cariboo Region in the fall of 2022, less than half (45 sites) had no egg masses (Table 6). Fifty-two sites (48%) predicted light defoliation and 11 sites (10%) predicted moderate defoliation in 2023, with the most sites predicting moderate defoliation located in the 100 Mile House TSA. High priority sites in the Cariboo Region indicating an increase in budworm population will be treated with *B.t.k.* in 2023.

### Western Hemlock Looper, *Lambdina fiscellaria lugubrosa*

Western hemlock looper defoliation was mapped on 36,467 ha in nine TSAs within the southern interior in 2022 (Appendix A: Forest Health Damage Summary Tables for the South Area). No defoliation was mapped in the Quesnel and Invermere TSAs in 2022 indicating the collapse of all outbreaks recorded in these TSAs in 2021. Mapped defoliation increased by 12,265 ha in 2022 over 2021, mainly due to expanding populations in the Arrow, Kootenay Lake and Okanagan TSAs. In the Kootenay Boundary Region, defoliation by western hemlock looper increased from 13,209 ha in 2021 to 24,035 ha in 2022. Defoliation was still widespread throughout the Revelstoke TSA, impacting 6,509 ha. In the Cariboo Region, the area of defoliation decreased by 8,089 ha in the Williams Lake TSA. This decrease was largely due to targeted *B.t.k.* spray programs in 2021 and the natural collapse of localized populations. 2022 will most likely be the final year in the outbreak cycle and we predict that very little new defoliation will occur in 2023. No sites in Interior Douglas-fir (IDF) stands were damaged by hemlock looper in 2022.

**Trapping and three-tree beating**

Western hemlock looper and associated defoliators are monitored annually at permanent sampling sites using a combination of three-tree beatings and/or moth trapping (six uni-traps placed per site) (**Figure 12**). Three-tree beatings and moth trapping were done at 16 sites in the Thompson Okanagan Region. In the Kootenay Boundary Region, three-tree beatings were done at 25 sites, while moth trapping was done at 10 sites. In the Cariboo Region, three-tree beatings were done at 10 sites, while moth trapping was done at 14 sites. The Coast Region did moth trapping in 14 sites, of which 11 sites were newly established in 2022. Three-tree beatings were undertaken in early to mid-July at all sites and traps were placed at this time. A 60 cm x 90 cm drop cloth and a 2.5-meter pole were used to conduct the tree beatings. All defoliators, both primary and secondary, were recorded in the three-tree beating samples. Traps were collected late September through early October 2022.

The average number of western hemlock looper moths caught per trap declined dramatically in 2022 in the Thompson Okanagan, Kootenay Boundary and Cariboo Regions (**Table 6**; **Figure 13**; **Figure 14**). As noted in the "2021 Overview of Forest Health Conditions in Southern British Columbia", there was a slight increase in moth catches from 2020-2021, indicating that further defoliation was expected in 2022. This defoliation was observed and recorded in the 2022 aerial overview surveys (**Figure 13**; **Figure 14**). However, due to the decline in trap catches in 2022 to below 200 moths per trap, little or no defoliation is expected in 2023. The three sites in the Coast Region that have a trapping history still had moderate trap catches, with the Capilano Watershed site catching an average of 1,036 moths, indicating there could still be defoliation next year.

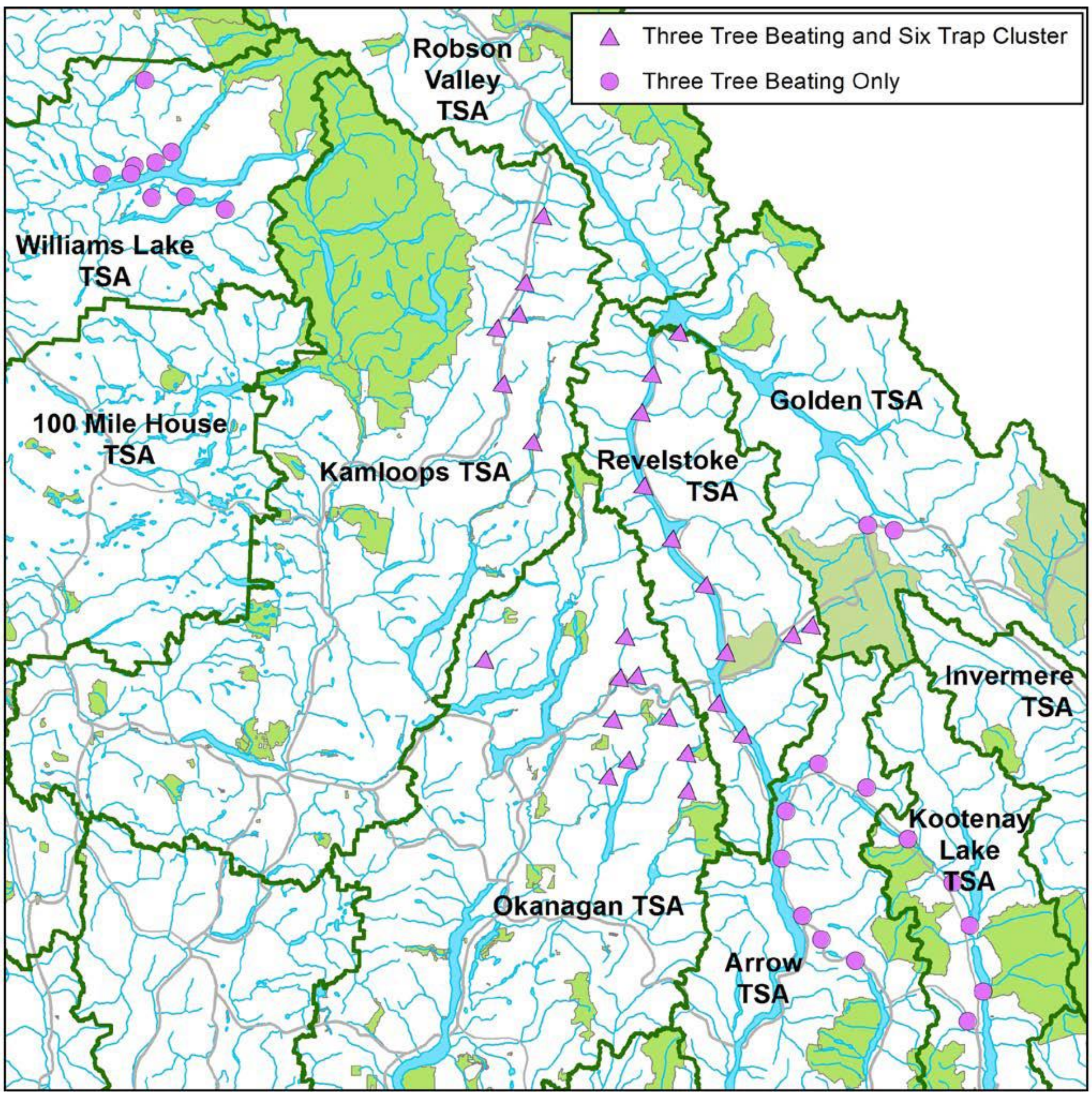




*Figure 12. Locations of western hemlock looper permanent sampling sites in southern British Columbia.*

*Table 6. Average number of western hemlock looper moths caught per six-trap cluster in the Thompson Okanagan, Kootenay Boundary, Cariboo and Coast Regions (2016-2022).*

| Site # | Location | Average moth catch per trap | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| **Thompson Okanagan Region** | | | | | | | | |
| 1 | Serpentine River | 1 | 9 | 18 | 38 | 448 | 541 | 89 |
| 2 | Thunder River | 2 | 34 | 146 | 107 | 489 | 266 | 88 |
| 3 | Mud Lake | 1 | 14 | 294 | 120 | 549 | 442 | 30 |
| 4 | Murtle Lake | 3 | 51 | 134 | 316 | 533 | 1,130 | 15 |
| 5 | Finn Creek | 0 | 14 | 43 | 237 | 356 | 37 | 5 |
| 7 | Scotch Creek | 4 | 34 | 311 | 222 | 844 | 108 | 15 |
| 8 | Yard Creek | 17 | 72 | 29 | 145 | 121 | 139 | 89 |
| 9 | Crazy Creek | 2 | 32 | 143 | 146 | 660 | 14 | 6 |
| 10 | Perry River North | 10 | - | 302 | 197 | 289 | 121 | 32 |
| 11 | Three Valley Gap | 8 | 55 | 234 | 291 | 314 | 68 | 27 |
| 12 | Perry River South | 8 | 30 | 156 | 233 | 128 | 99 | 5 |
| 13 | Kingfisher Creek | 27 | 50 | 241 | 211 | 260 | 51 | 10 |
| 14 | Noisy Creek | 12 | 47 | 128 | 178 | 88 | 19 | 21 |
| 15 | Shuswap River | 6 | 49 | 161 | 422 | 848 | 40 | 16 |
| 16 | Greenbush Lake | 11 | 81 | 140 | 515 | 724 | 138 | 130 |
| 17 | Adams River/Tum Tum | 0 | 39 | 84 | 119 | 716 | 142 | 55 |
| | **Average of sites** | **7** | **41** | **160** | **219** | **460** | **209** | **40** |
| **Kootenay-Boundary Region** | | | | | | | | |
| 66 | Sutherland Falls | 1 | - | 72 | 235 | 1,195 | 1,234 | 1 |
| 72 | Tangier FSR | 1 | 19 | 98 | 56 | 196 | 67 | 5 |
| 73 | Martha Creek | 3 | 23 | 86 | 33 | 439 | 1,121 | 24 |
| 74 | Goldstream River | 3 | 42 | 55 | 257 | 1,631 | 2,213 | 27 |
| 75 | Downie Creek | 9 | 9 | 35 | 246 | 2,387 | 1,062 | 50 |
| 76 | Bigmouth Creek | 1 | 26 | 25 | 88 | 375 | 1,784 | 52 |
| 78 | Carnes Creek | 3 | 15 | 8 | 257 | 766 | 1,354 | 15 |
| 83 | Begbie Creek | 0 | 50 | 97 | 658 | 1,283 | 2,775 | 28 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 84 | Pitt Creek Rec. Site | 2 | 50 | 60 | 342 | 1,555 | 2,449 | 138 |
| 85 | Kinbasket Lake | 2 | 20 | 145 | 518 | 967 | 703 | 106 |
| 87 | Jumping Creek | 5 | 41 | 68 | NA | - | - | - |
| | **Average of sites** | **3** | **29** | **68** | **269** | **1,079** | **1,476** | **45** |

**Table 6** continued.

| | | Average moth catch per trap | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Site #** | **Location** | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** |
| **Cariboo Region** | | | | | | | | |
| N1 | | | | | | 302 | 12 | 0 |
| N2 | | | | | | 99 | | |
| N3 | | | | | | 18 | 47 | 0 |
| N4 | | | | | | 828 | 9 | 0 |
| N5 | | | | | | 41 | 18 | 1 |
| N6 | | | | | | 29 | 9 | 2 |
| N7 | | | | | | 183 | 2 | 0 |
| N8 | | | | | | 50 | 43 | 0 |
| S1 | | | | | | 105 | 9 | 0 |
| S2 | | | | | | 466 | 42 | 0 |
| S3 | | | | | | 5 | 15 | 1 |
| S4 | | | | | | 5 | 5 | 0 |
| S5 | | | | | | 46 | | |
| S6 | | | | | | 5 | 23 | 1 |
| S7 | | | | | | 3 | 68 | 5 |
| S8 | | | | | | 7 | 9 | 0 |
| | **Average of sites** | | | | | **137** | **22** | **1** |
| **Coast Region** | | | | | | | | |
| 1 | Chehalis River | | | | | | | 17 |
| 2 | Statlu Creek 9km | | | | | | | 11 |
| 3 | Statlu Creek 10km | | | | | | | 16 |
| 4 | Salsbury | | | | | | | 4 |
| 5 | Burke Prov. Park | | | | | | | 5 |
| 6 | Belcarra | | | | | | | 52 |
| 7 | Seymour Prov. Park | | | | | | | 6 |
| 8 | Lynn Creek | | | | | | | 125 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | Rainy River 3km | | | | | | | 3 |
| 10 | Rainy River 4km | | | | | | | 7 |
| 11 | Rainy River 5.5km | | | | | | | 9 |
| 12 | Coquitlam watershed | 191 | | 52 | 1,054 | 1,731 | 30 | 118 |
| 13 | Seymour watershed | | | 71 | 897 | 1,925 | | 295 |
| 14 | Capilano watershed | | | 18 | 1,045 | 1,450 | | 1,036 |
| | **Average of sites** | | | | | **1,702** | **30** | **122** |

**Figure 13** and **Figure 14** clearly show that when the threshold of ±200 moths per trap per site is met or exceeded, visible defoliation can be expected the following year. The individual graphs by Region (**Figure 14**) show this relationship between average moth catch and expected defoliation in more detail. This is a valuable tool that the Forest Health program is now able to use to better predict and plan for operational control programs.

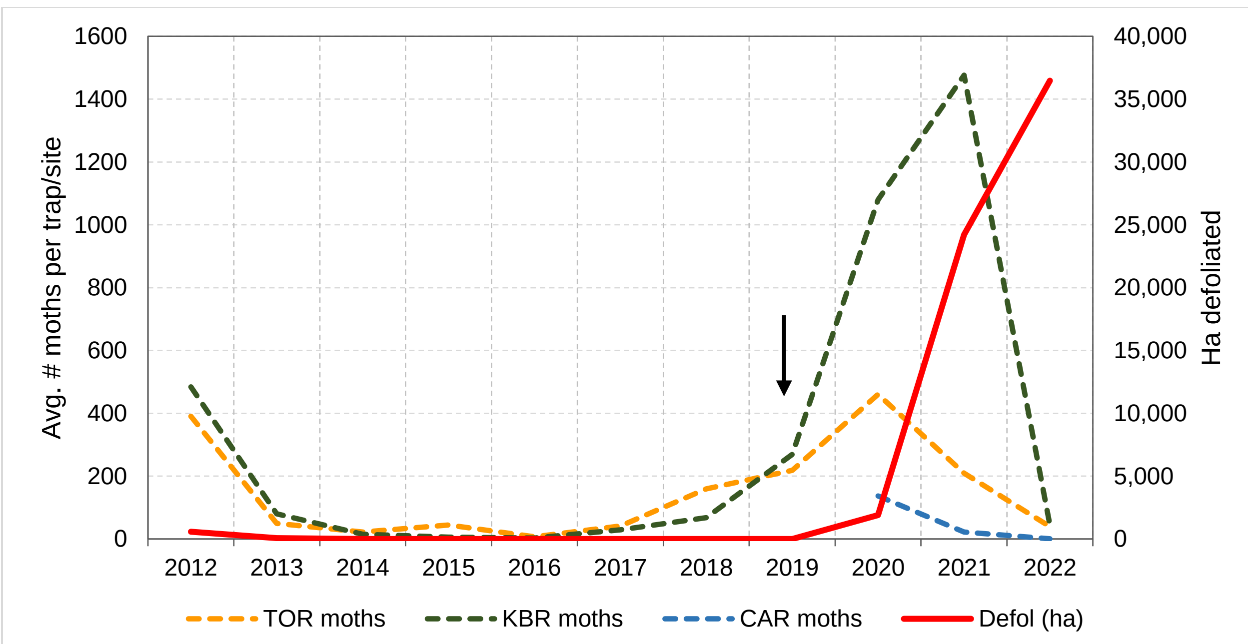



*Figure 13. The annual average number of western hemlock looper moths caught per trap per site in the Thompson Okanagan, Kootenay Boundary and Cariboo Regions and the ha defoliated in the south area (3 regions combined) from 2012 to 2022.*

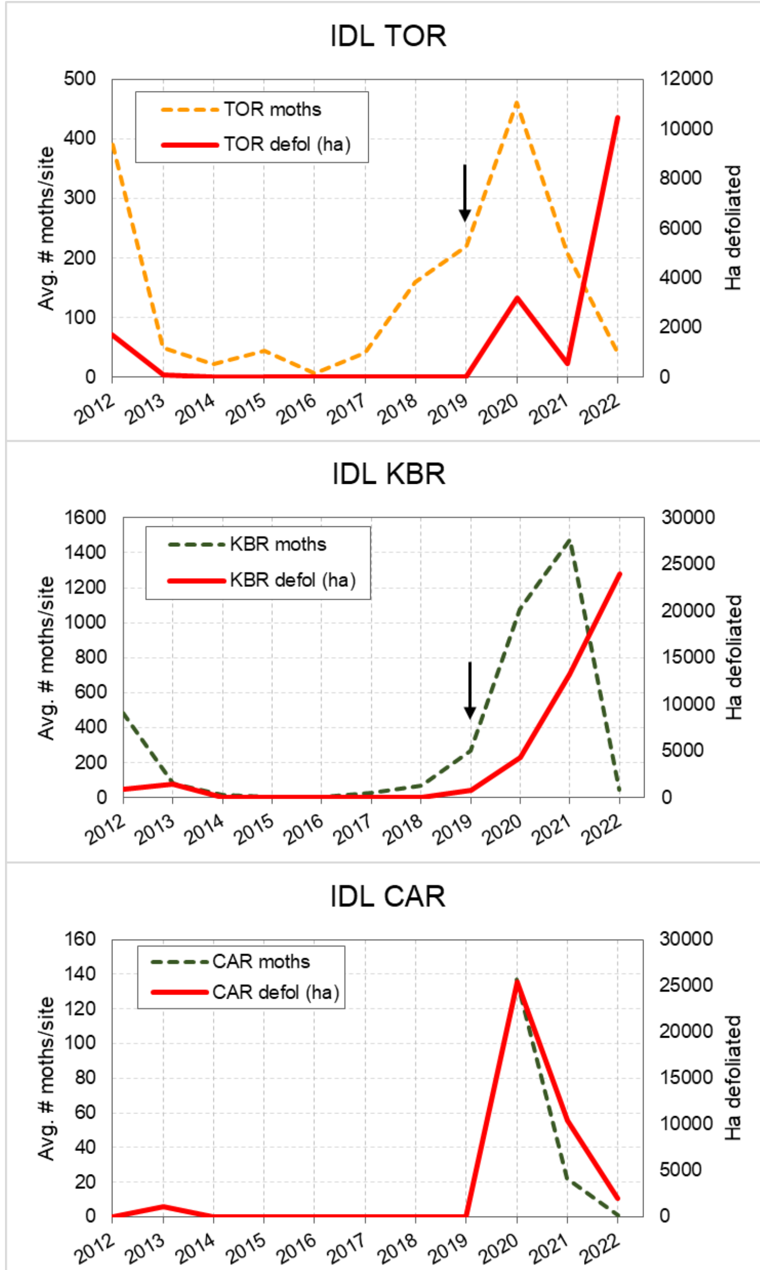



*Figure 14. The annual average number of western hemlock looper moths caught per trap per site and ha defoliated in each of the three south area regions (2012-2022): Thompson Okanagan (top graph); Kootenay Boundary (middle graph); and Cariboo (lower graph). The arrow shows the year when traps caught an average of ≥200 moths/trap/site.*

In the Kootenay Boundary Region, the western hemlock looper larvae in beating samples decreased from 475 in 2021 to 42 in 2022, with only 50% of sites positive for western hemlock looper (**Table 7**). Western blackheaded budworm populations increased slightly from 2 positive sites in 2021 to 14 positive sites in 2022, and total larval counts increased from 5 to 51. Sawfly populations were similar to 2021, with the highest numbers recorded at Martha Creek. Defoliator diversity was also similar to 2021 with 9 species recorded. The richness of insect diversity remained static in the Thompson Okanagan samples, but overall numbers declined significantly from 2021, with sawflies being the predominant insect followed by western hemlock looper. Only 25% of sites were positive for western hemlock looper in 2022 compared to 50% positive in 2021 (**Table 7**). Only three of 10 sites visited in the Cariboo Region had any western hemlock looper larvae and abundance at these sites was very low (**Table 7**).

***Table 7. Results from the 2022 three-tree beatings at permanent sample sites located in areas of historic western hemlock looper defoliation in the Kootenay Boundary, Thompson Okanagan and Cariboo Regions. The table shows the total number of specimens of the dominant insect species collected.***

| Site # | Location | Western Hemlock Looper (*Lambdina fiscellaria lugubrosa*) | Black-headed budworm (*Acleris gloverana*) | Sawflies (*Neodiprion, Anoplonyx*) | Green-striped forest looper (*Melanolophia imitata*) | Western False Hemlock Looper (*Nepytia freemani*) | Gray Forest Looper (*Caripeta divisata*) | Saddleback Looper (*Ectropis crepuscularia*) | Filament Bearer (*Nematocampa resistaria*) | Western spruce budworm (*Choristoneura freemani*) | *Semiothisa unipunctaria* | *Eupithecia olivacea* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Kootenay Boundary** | | | | | | | | | | | | |
| 30 | Keen Creek | | | 1 | | | | | | | | |
| 38 | Hills | | 1 | | | | | | | | 2 | |
| 58 | Halfway River | 1 | 10 | | 1 | | | | | | | |
| 61 | Box Lake | | 1 | | | | | | | | | |
| 62 | Kuskanax Creek | | 8 | | | | | | | | | |
| 65 | Shelter Bay Ferry | | | 4 | | | | | | | | |
| 66 | Sutherland Falls | 1 | 1 | | | 2 | | | | | | |
| 69 | Quartz Creek | 1 | | | 1 | | | | | | | |
| 70 | Gerrard | | | 68 | | | | | | | | |
| 71 | Trout Lake | | | 1 | | | | | | | | 1 |
| 72 | Tangier FSR | | 1 | 6 | | | | | | | | |
| 73 | Martha Creek | 1 | | 182 | | | | 1 | 1 | | | |
| 74 | Goldstream River | 5 | 3 | 12 | | | | | | | | |
| 75 | Downie Creek | 2 | | 2 | | | | | | | | |
| 76 | Bigmouth Creek | 16 | 3 | 15 | | 1 | | | | | | |
| 78 | Carnes Creek | 1 | 8 | | | | | | | | | |
| 79 | Lardeau FSR | | 1 | | | | | | | | | |
| 80 | Meadow Creek | | 5 | | 2 | | | | | | | |
| 81 | Schroeder Creek | | 1 | | | | | | | | | |
| 82 | Beaton | | 5 | | | | | | | | | |
| 83 | Begbie Creek | 3 | | | 1 | | | 1 | | | | |
| 84 | Pitt Creek Rec Site | 9 | 3 | 24 | | | | | | | | |
| 85 | Kinbasket Lake | 1 | | 57 | | | | | | | | |
| 86 | Beaver River | 1 | | | | | | | | | | |
| | **Total insects** | **42** | **51** | **372** | **5** | **3** | **0** | **2** | **1** | **0** | **2** | **1** |

**Table 7** Continued

| Site # | Location | Western Hemlock Looper (*Lambdina fiscellaria lugubrosa*) | Black-headed budworm (*Acleris gloverana*) | Sawflies (*Neodiprion, Anoplonyx*) | Green-striped forest looper (*Melanolophia imitata*) | Western False Hemlock Looper (*Nepytia freemani*) | Gray Forest Looper (*Caripeta divisata*) | Saddleback Looper (*Ectropis crepuscularia*) | Filament Bearer (*Nematocampa resistaria*) | Western spruce budworm (*Choristoneura freemani*) | *Semiothisa unipunctaria* | *Eupithicia olivacea* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Thompson Okanagan** | | | | | | | | | | | | |
| 1 | Serpentine-Lempriere | 2 | 1 | 1 | | 1 | | | | | | |
| 2 | Thunder River | | | | | | | | | | | |
| 3 | Mud Lake | | | 1 | | | | | | | | |
| 4 | Murtle Lake Road | | | | | | | | | 1 | | |
| 5 | Finn Creek | | 1 | | | | | | | | | |
| 7 | Scotch Creek | | | | | | | | | | | |
| 8 | Yard Creek Road | | | | | | | | | | | |
| 9 | Crazy Creek Road | | | | | | | | | | | |
| 10 | Perry River North | | | | | | | | | | | |
| 11 | Three Valley Gap-Wap Creek | | | | | | | | | 1 | | |
| 12 | Perry River South-Eagle River | 1 | | | | | | | | | | |
| 13 | Kingfisher Creek Road | | | | | | | | | | | |
| 14 | Noisy Creek-Kingfisher Creek | | | | | | | | | | | |
| 15 | Shuswap River | 1 | | 1 | | | | | | | | |
| 16 | Greenbush Lake | 3 | | 6 | | | | | | | | |
| 17 | Adams River/Tum- Tum | | | | | | | | | | | |
| | **Total insects** | **7** | **2** | **9** | **0** | **1** | **0** | **0** | **0** | **2** | | |
| **Cariboo** | **Total insects (10 sites)** | **7** | | | | | | | | | | |

## Douglas-fir Tussock Moth, *Orgyia pseudotsugata*

In 2019, the Douglas-fir tussock moth began its outbreak cycle in the southern interior, with numerous single-tree epizootics and patches of defoliation recorded for a total of 2,708 ha. In 2020 to 2022, there was a dramatic decline in the area of active tussock moth defoliation throughout the southern interior. There were only 68 ha of defoliation mapped in 2022 in the Williams Lake TSA.

### Annual monitoring with six-trap clusters

Outbreak periodicity of Douglas-fir tussock moth varies by Outbreak Area (geographic location) and can range from 5 to over 40-year intervals between outbreaks. Typically, in the southern interior, we experience an outbreak in one or more of the Outbreak Areas every decade. When a consistent upward trend of moths caught in monitoring traps is found in a stand for 2 to 3 years (average over 10 moths per trap), or if an average of 25 moths or more per trap has been caught, ground surveys for egg masses are recommended and defoliation may occur the following summer. The most recent outbreak cycle was centred in the Cariboo, beginning in 2019 and collapsing by 2021.

Douglas-fir tussock moth lures from three chemical companies were deployed in 6-trap clusters at each trapping site between 2016 and 2019, to compare the efficacy of the three lure types in attracting tussock moth and accurately predicting imminent outbreaks: Scotts® (Solida); WestGreen Global Technologies (ChemTica); and, Synergy Semiochemicals®. Scotts® is now no longer supplying the same lure, so only two lure types have been used since 2019. All lures have a loading of 5µg pheromone. In 2022, two lines (one line per lure supplier) of 6 traps each were set at each trapping site in the Thompson Okanagan (39 sites) (**Figure 15**) and Cariboo (15 sites) Regions. The Kootenay Boundary Region had 9 trapping sites and used only the WestGreen Global Technologies (ChemTica) lure. There is some variation among average trap catches each year by the ChemTica and Synergy lures, but both are good at predicting defoliation events and/or increases in tussock moth population in the general area where traps were placed.

Overall, average trap catches remained low in all Outbreak Regions (**Table 8**), well below threshold levels predicting defoliation.

Trap catches in the Kootenay Boundary Outbreak Region in 2022 increased, with an average of 2.8 moths/trap up from 0.3 moths/trap in 2021. Only Johnstone Creek had notable numbers, with a total of 128 moths, accounting for 89% of all moths caught. This is up from 10 moths at this site in 2021. As with previous years, both rusty tussock moth and pine tussock moth were present, found at 7 of 9 sites in the Kootenay Boundary Outbreak Region.

Monitoring will continue but we do not expect much tussock moth activity for the next few years in the southern interior.

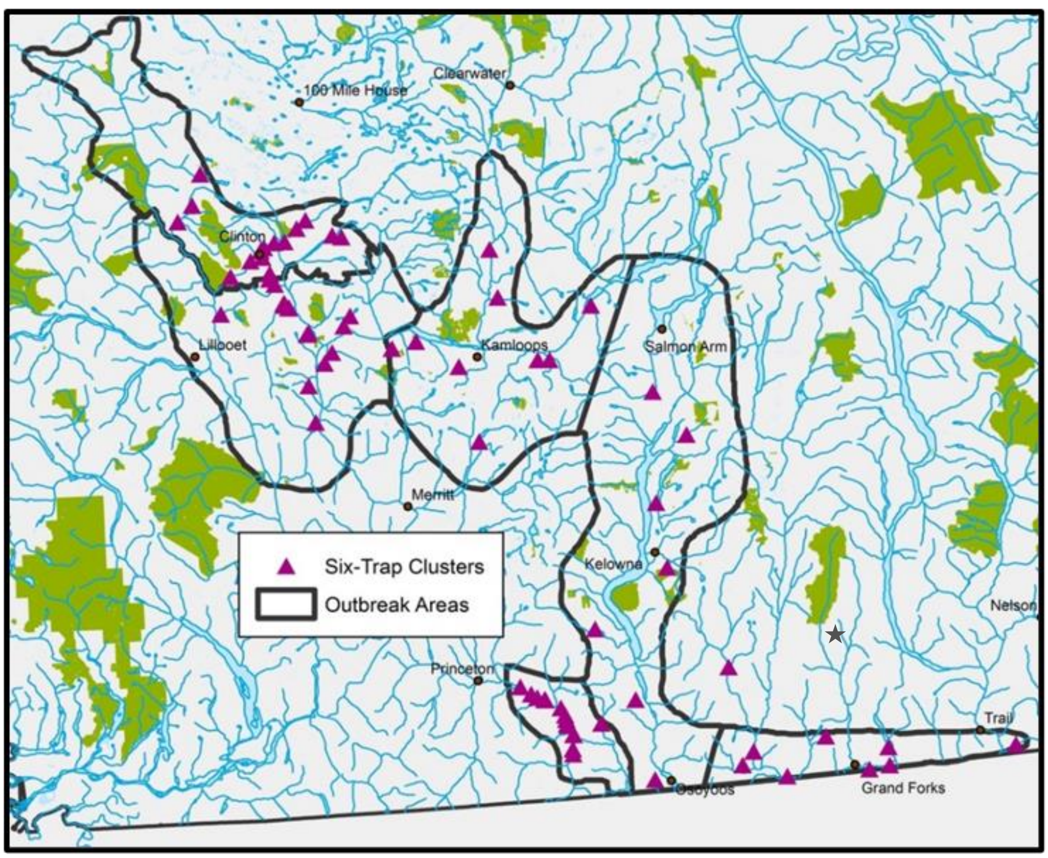



*Figure 15. Location of Douglas-fir tussock moth 6-trap clusters throughout the southern interior.*

In the Thompson Okanagan and Cariboo Regions, lures from three suppliers (Scotts (Solida), ChemTica (WestGreen Global Technologies), and Synergy Semiochemicals) were compared in 2016-2019. In 2020-2022, the Thompson Okanagan and Cariboo Regions deployed WestGreen Global Technologies and Synergy lures.

*Table 8. Average number of Douglas-fir tussock moths caught per 6-trap cluster in the Thompson Okanagan and Cariboo Regions (2016-2022).*

| Site | Location | Average moth catch per site | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| **Kamloops (KA)** | | | | | | | | |
| 1 | McLure | 5.5 | 9.1 | 10.9 | 21.2 | 6.5 | 1.2 | 3.6 |
| 2 | Heffley Creek | 26.6 | 26.8 | 32.4 | 18.6 | 40.4 | 0.0 | 1.9 |
| 3 | Inks Lake | 0.1 | 0.1 | 0.0 | 0.2 | 0.0 | 0.0 | 0.8 |
| 4 | Six Mile | 3.4 | 3.8 | 9.9 | 23.1 | 32.3 | 0.2 | 0.4 |
| 9 | Stump Lake | 0.0 | 0.3 | 0.1 | 1.3 | 0.0 | 0.1 | 0.1 |
| 10 | Monte Creek | 3.8 | 6.4 | 7.8 | 20.1 | 30.3 | 0.0 | 0.7 |
| 11 | Chase | 1.7 | 0.3 | 3.4 | 5.9 | 2.0 | 0.3 | 0.1 |
| 48 | Haywood-Farmer | | | 9.6 | 20.3 | 2.6 | 0.1 | 1.4 |
| 49 | Buse Lake | | | 5.4 | 14.1 | 14.5 | 0.0 | 0.6 |
| | **Average of sites** | **5.9** | **6.7** | **8.8** | **13.7** | **14.3** | **0.2** | **1.1** |
| **Okanagan (OK)** | | | | | | | | |
| 12 | Yankee Flats | 3.2 | 0.5 | 2.3 | 1.2 | 2.4 | 0.0 | 1.1 |
| 13 | Vernon | | 1.4 | 5.3 | 0.4 | 0.1 | 0.6 | 2.0 |
| 14 | Wood Lake | 7.6 | 17 | 41.3 | 17 | 31.2 | 4.3 | 8.9 |
| 15 | June Springs | 0.5 | 1.1 | 2.0 | 2.7 | 0.1 | 0.0 | discontinued |
| 16 | Summerland | 0.7 | 0.9 | 0.3 | 1.6 | 0.1 | 0.1 | 0.0 |
| 17 | Kaleden | 4.9 | 6.2 | 4.4 | 7.5 | 12.1 | 0.0 | 1.2 |
| 18 | Blue Lake | 11.5 | 17.3 | 34.4 | 18.3 | 1.7 | 0.8 | 6.1 |
| 45 | Glenmore | 5.3 | 9.0 | 25.4 | 20.1 | 19.5 | 0.0 | discontinued |
| | **Average of sites** | **4.8** | **7.1** | **14.4** | **8.6** | **8.4** | **0.9** | **3.2** |
| **Similkameen (SIM)** | | | | | | | | |
| 19 | Stemwinder Park | 8.6 | 8.2 | 29.8 | - | 18.1 | 1.7 | 0.3 |
| 32 | Olalla | 21.2 | 21.6 | 40.4 | 29.1 | 23.3 | 0.1 | discontinued |
| 33 | Red Bridge | 8.8 | 7.4 | 9.3 | 9.4 | 10.9 | 0.0 | 1.5 |
| 36 | Hwy 3 Lawrence Ranch | 10.7 | 11.2 | 30.4 | | | | no access |
| 38 | Hwy 3 Bradshaw Creek | 17.7 | 10.3 | 29.2 | 36.8 | 22.1 | 0.3 | 0.7 |
| 39 | Hwy 3 Winters Creek | 7.6 | 7.6 | 27.7 | 17.4 | 13.8 | 0.2 | 0.8 |
| 40 | Hwy 3 Nickelplate Road | 8.8 | 9.7 | 31.3 | 18.7 | 21.7 | 0.1 | 1.1 |
| 41 | Stemwinder | 11.4 | | 34.2 | 26.5 | 13.0 | 0.5 | 0.2 |
| 42 | 11.8 km Old Hedley Rd | 0.3 | 0.4 | 2 | 3.8 | 1.8 | 0.2 | 0.5 |
| 43 | Pickard Creek Rec Site | 5.5 | 6.8 | 31.6 | 14.5 | 20.2 | 0.0 | 0.8 |
| 44 | 5.7 km Old Hedley Rd | 3.9 | 4.3 | 20.4 | 7.6 | 10.8 | 0.3 | 0.1 |
| | **Average of sites** | **9.5** | **8.8** | **26** | **18.2** | **15.6** | **0.3** | **0.6** |

| Site | Location | Average moth catch per site | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| **West Kamloops (WK)** | | | | | | | | |
| 5 | Battle Creek | 0.3 | 0.7 | 0.9 | | | | no access |
| 6 | Barnes Lake | 2.5 | 9.9 | 7.7 | 25.4 | 16.2 | burnt | |
| 7 | Carquille/Veasy Lake | 10.9 | burnt | | | | | |
| 8 | Pavilion | 1.6 | 7.7 | 7.1 | 20.7 | 4.4 | 0.0 | 0.5 |
| 21 | Spences Bridge | 2.5 | 7.3 | 8.6 | 14.5 | 10.1 | 0.0 | 0.0 |
| 22 | Veasy Lake | 9.7 | burnt | 1.7 | 13.7 | 16.2 | 0.0 | 0.5 |
| 23 | Veasy Lake | 5.8 | burnt | 3.1 | | | | |
| 24 | Veasy Lake | 6.2 | burnt | 6.7 | | 18.6 | 0.0 | 0.4 |
| 25 | Hwy 99 | 8.7 | burnt | | | | | |
| 26 | Venables Valley | 0 | 1.4 | 0.2 | 4.6 | 5.9 | 0.0 | 0.2 |
| 27 | Maiden Creek | 0.2 | 1 | 1.6 | 6.6 | 8.1 | 0.0 | 0.9 |
| 28 | Hwy. 99 | 2.2 | 8.1 | 9.2 | 28.6 | 39.8 | 0.0 | 1.3 |
| 29 | Cornwall 79 | 1.1 | burnt | | | | | |
| 30 | Cornwall 80 | 0.7 | burnt | | | | | |
| 31 | Barnes Lake | 0.6 | 2.7 | 0.8 | 9.1 | 1.3 | 0.5 | 0.2 |
| 46 | Studhorse Road | | | 2.2 | 11.2 | 2.4 | 0.1 | 0.7 |
| 47 | Stinking Lake | | | 0.3 | 6.8 | 0.5 | 0.0 | 0.6 |
| | **Average of sites** | **3.5** | **4.9** | **3.9** | **14.1** | **11.2** | **0.1** | **0.5** |
| **Boundary (KT)** (9 sites in 2022) | | **0.6** | **1.3** | **2.3** | **5** | **5.7** | **0.3** | **2.8** |
| **Cariboo (CAR)** (16 sites in 2022) | | **1.6** | **2.4** | **1.8** | **5** | **0.5** | **0.3** | **1.8** |

### Three-Tree Beatings

Three-tree beating is a procedure for sampling defoliating forest insect larvae, which involves beating the foliage of low hanging branches and collecting the fallen insects on a tarpaulin. Three-tree beating provides temporal and spatial information on the richness and diversity of defoliating insects and is conducted annually from mid-June to early July.

In 2022, three tree beatings were conducted at 31 of the 37 monitoring sites in the Thompson Okanagan Region. All defoliators present on the drop cloth were identified and recorded. Only 4 insects were collected in the Similkameen and West Kamloops Outbreak Regions (**Table 9**), none of which were Douglas-fir tussock moth. This is the lowest numbers of defoliators recorded since the establishment of these monitoring sites. Seven insects were recorded in the Kootenay Boundary Outbreak Region, down from 19 insects in 2021, 76 insects in 2020, and 81 insects in 2019.

**Table 9. Defoliators recorded in 2022 three-tree beatings in IDF forests within the Thompson Okanagan and Kootenay Boundary Regions.**

| Outbreak Region | No. beating sites | Western spruce budworm | Sawflies | *Cladara limitaria* | *Anoplonyx laricivorus* | *Dichelonyx backi* | Total larvae |
|---|---|---|---|---|---|---|---|
| Kamloops | 7 | 0 | 0 | 0 | 0 | 0 | **0** |
| Okanagan | 5 | 0 | 0 | 0 | 0 | 0 | **0** |
| Similkameen | 6 | 0 | 1 | 0 | 0 | 0 | **1** |
| West Kamloops | 9 | 2 | 1 | 0 | 0 | 0 | **3** |
| Kootenay Boundary | 9 | 0 | 1 | 1 | 3 | 2 | **7** |
| **Total** | **36** | **2** | **3** | **1** | **3** | **2** | **11** |

### Black Army Cutworm, *Actebia fennica*

Black army cutworm (IDA) was a major pest in the 1980s, frequently associated with prescribed burns. With abundant wildlife activity and tight timelines for reforestation, increased monitoring is required to ensure this defoliator does not affect recently planted areas. Larvae feed from April through June on a variety of hosts causing “shot-hole” type defoliation. They prefer a variety of shrubs and herbaceous plants, and will feed on western larch, Douglas-fir, Engelmann/hybrid spruce and lodgepole pine. When populations are low, black army cutworm feeds on its preferred hosts as well as larch; however, at moderate and outbreak populations, feeding switches to conifer seedlings such as Douglas-fir, Engelmann/ hybrid spruce and lodgepole pine. Seedling mortality can occur within a single year depending on black army cutworm population density. Most seedlings can sustain moderate defoliation (i.e., less than 60%), with limited impact on their growth or survival. Moister sites recover more quickly than drier sites, which may experience reduced height growth and increased mortality due to moisture stress.

Increases in black army cutworm populations may be noticed the following spring after early season wildfires (April through June). Increase in IDA post late season fires (July through October) will generally occur the following summer. High-risk sites such as burned openings are the preferred egg laying areas. The more severe the burn (i.e. no to little vegetation remaining), the greater the likelihood of high levels of defoliation on natural or planted conifer seedlings the following year. ESSF, MS, SBS, ICH and IDF BEC zones are the highest risk areas, especially the drought-prone sites in the drier subzones.

Management strategies for black army cutworm include.

1. Conducting spring surveys on the natural vegetation to determine presence of IDA.
2. Conducting adult pheromone monitoring in the summer (July 1 – September 15th) annually one to three years post-fire, using baited multi-pher or unitraps.
3. Depending on population levels, avoid spring planting or delay planting for one to three years following a burn.

Predicted defoliation risk the following year using multi-pher traps can be categorized as low for <350 moths/ trap, moderate >350-1200 moth per trap and high >1200 moths per trap.

Place traps at least 200 meters apart, well within the burn area, away from stand edges, with a Vapona strip placed inside. Check and empty traps weekly. If possible, place traps at 0.5 m to 1 m height on south-facing slopes, in a line across prevailing winds.

Kootenay Boundary Region has been monitoring black army cutworm in various locations since 2018 using multi-pher traps **Table 10**; **Figure 16**). Trap catch numbers for the Meachan 2018 fire near Kimberley and the Doctor Creek 2020 fire near Invermere are down. Numbers are low for the new trapping areas in Arrow and Boundary TSAs. The highest trap catches in 2022 were associated with the Lavington area of the Doctor Creek burn.

***Table 10. Results from 2018-2022 black army cutworm moth trapping program in the Kootenay Boundary Region.***

| Year | TSA | Location | # Traps | Average moths per trap |
|---|---|---|---|---|
| 2022 | Arrow | Selkirk | 4 | 16 |
| 2022 | Boundary | TFL23[a] | 54 | 37 |
| 2022 | Boundary | TFL8 - Bunchgrass FSR | 3 | 12 |
| 2018 | Cranbrook | Etna Creek | 4 | 20 |
| 2018 | Cranbrook | Linklater | 4 | 1 |
| 2019 | Cranbrook | Lost Dog | 6 | 93 |
| 2019 | Cranbrook | Meachan | 6 | 218 |
| 2020 | Cranbrook | Meachan | 2 | 240 |
| 2021 | Cranbrook | Meachan | 4 | 322 |
| 2022 | Cranbrook | Meachan | 4 | 15 |
| 2018 | Cranbrook | Soowa | 4 | 39 |
| 2019 | Cranbrook | Wickman Creek | 4 | 36 |
| 2021 | Invermere | Doctor Creek | 9 | 433 |
| 2022 | Invermere | Doctor Creek | 9 | 72 |
| 2022 | Invermere | Lavington/ Bear FSR | 3 | 319 |
| 2018 | Invermere | White - Middle Fork | 4 | 127 |
| 2018 | Invermere | White - North Fork | 4 | 29 |
| 2018 | Revelstoke | RCFC | 4 | 40 |
| 2018 | Revelstoke | Revelstoke | 2 | 80 |

[a] Edgewood (Octopus fire), Gladstone, Enterprise Creek

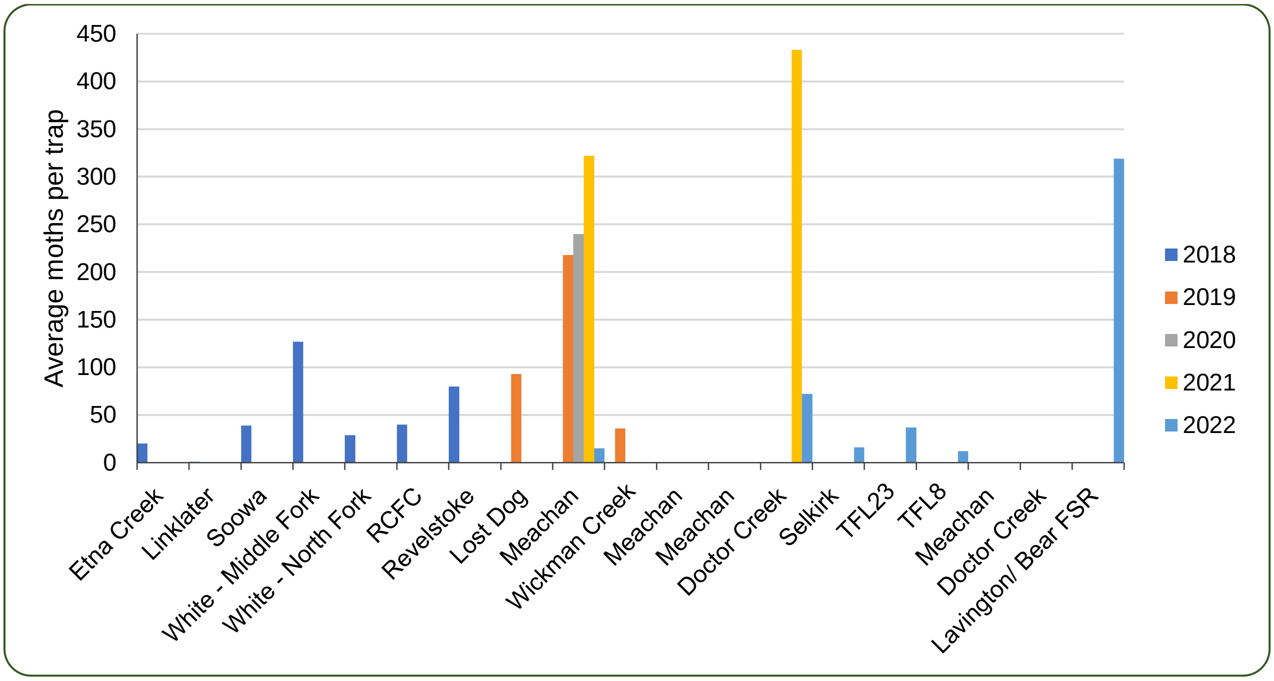



*Figure 16. Black army cutworm trap catches by site in Kootenay Boundary from 2018-2022.*

Seven fires were monitored for black army cutworm activity in 2022 in the Thompson Okanagan Region. Sites within 6 fires (112 sites) were established May 17 through June 9, 2022, and 20 sites in the McKay Creek fire were established July 13, 2022. All sites except the McKay Creek fire sites were checked, moths collected, and lures replenished once between establishment and final collection. Final collections were done between July 31st and September 1st, 2022. The number of IDA moths caught per site ranged from zero (2 sites) to 249 moths, with an average of almost 40 moths per site over all sites (**Table 11**). Sites within the Tremont Creek fire had the highest moth counts averaging 101 moths, and two sites along the Pennie Lake - Haywood Farmer Road caught over 200 moths. If there are fewer than 350 moths caught per trap (site), then severe damage to conifer seedlings is unlikely. Some sites within the Tremont Creek fire will be monitored again in 2023.

*Table 11. Number of black army cutworm traps established in each of the 2021 fires within the Thompson Okanagan Region in 2022.*

| Fire | No. sites | Range of moths caught per site | Avg. # moths per site |
|---|---|---|---|
| Garrison Lake | 15 | 4-52 | 18.9 |
| July Mountain | 8 | 0-63 | 24.1 |
| McKay Creek | 20 | 0-46 | 18.5 |
| Sparks Lake | 29 | 3-148 | 41.9 |
| Thomas Creek | 13 | 3-112 | 20.8 |
| Tremont Creek | 20 | 1-249 | 101.2 |
| Whiterock Lake | 27 | 1-128 | 33.1 |
| **Total** | **132** | | 39.8 |

## Thompson Okanagan Region Summary

The Thompson Okanagan portion of the Aerial Overview Surveys was carried out between Aug. 2nd and Aug. 12th, 2022. The surveys were completed in 57.2 hours, over 10 flight days. The weather was good during the flights and damage symptoms were clearly visible. There was a very large cone crop on several conifer species, particularly Douglas-fir and spruce. It was sometimes difficult to discern whether foliar discoloration was insect defoliation or cone crops. Some areas mapped as defoliation were corrected as they were later determined to be cone crops during detailed aerial surveys. All surveys were conducted by Barbara Zimonick (Zimonick Enterprises) and Karen Baleshta, and utilized a Cessna 210C operated by AC Airways Ltd., of West Vancouver, B.C.

### Kamloops TSA

Douglas-fir beetle was mapped on 4,867 ha, down from 5,055 ha in 2021, and most was mapped as trace infestation (**Appendix A: Forest Health Damage Summary Tables for the South Area**; **Figure 17**). In the west portion of the TSA, populations were mapped in the Hat Creek to Cornwall Hills and Allen Creek. Populations were still active north of Kamloops Lake along the Tranquille River to Black Pines. Pockets of Douglas-fir beetle continued along the west side of the North Thompson River from Darfield to Little Fort and Latremouille Creek. On the east side of the Thompson River, Douglas-fir beetle was mapped along Louis Creek, Cahilty Creek and north to Blucher Hall and Garrison Mountain. There are active populations of Douglas-fir beetle and wood borer in the 2021 fires in the Kamloops TSA, which are expected to attack green, live Douglas-fir in 2023 either within or outside the fire perimeter.

***Figure 17. Douglas-fir beetle damage near Lyons Lake, Kamloops TSA.***

Spruce beetle declined again in 2022 to just 464 ha mapped compared to 3,832 ha in 2021. Small pockets of infestation were recorded in Wells Gray Park. Western balsam bark beetle increased slightly from 20,482 ha in 2021 to 27,936 ha in 2022. The more concentrated populations were located in the Trophy and Table Mountains areas, Chu Chua Creek, Granite Mountain and Dunn Peak, with scattered populations in the North Thompson River area north to Allan Creek and Adolph Creek. Only one hectare of mountain pine beetle was observed in two discrete locations (**Figure 18**).

Western spruce budworm remained very low in the Kamloops TSA affecting 426 ha in 2022. Western hemlock looper increased slightly in 2022 to 171 ha affected, mostly within Wells Gray Park near Flourmill and Donald Creeks and at the southwest end of Hobson Lake. Two-year cycle budworm was in its "up" year of its cycle, mapped on 11,786 ha, an increase of 10,265 ha from 2021. The majority of defoliation was observed north from Emar Lakes Park to Taweel Park, in the Grizzly Lakes and Swayback Ridge area, and around Italia and Corsica Lakes. There were no recorded infestations in the southern portion of the Kamloops TSA.

Aspen serpentine leafminer activity declined by 73% in the Kamloops TSA, recorded on only 6,975 ha in 2022 compared to 25,190 ha in 2021. Some of this decline could have been caused by larval mortality during the 2021 heat dome. The most notable defoliation was mapped north of Thuja Lakes, between Allan Lake and Powder Lake, with scattered spots of defoliation around Bonaparte Lake. Satin moth was the only other deciduous defoliator active in the Kamloops TSA, affecting 2 ha.

No foliar pathogens were detected in the 2022 aerial overview flights in the Kamloops TSA.

### Lillooet TSA

Damage was mapped on 29,185 ha in the Lillooet TSA in the 2022 aerial overview survey, a significant decline from the 109,438 ha mapped in 2021, which was largely wildfire damage. Of this, 73% was bark beetle damage, 27% was damage caused by western spruce budworm, plus a minor amount of windthrow. The area affected by western balsam bark beetle increased slightly in 2022, with active populations mapped on 10,406 ha, compared to 8,731 ha in 2021. Western balsam bark beetle was active in most high elevation subalpine fir sites near Lost Valley Creek, Copper Creek to Machute Creek, Texas Creek, Devils Lake, and Gott Creek. It remained active in the Stein Valley Heritage Park and along Kwoiek Creek and near Big Sheep Mountain in the north of the TSA. Mountain pine beetle affected 6,413 ha, a 4.7-fold increase over 2021. The most active outbreaks of mountain pine beetle were mapped near Downton Creek, between Melvin and Gott Creek, and in Stein Valley Heritage Park along the North Stein River.

Spruce beetle was mapped on 4,312 ha, an increase of 1,646 ha over 2021. It continued to kill small patches of spruce in the Leckie Creek, upper Gun Creek, and Tyaughton Creek drainages. A very active population is expanding in the Van Horlick to Cottonwood Creek area.

Douglas-fir beetle affected 243 ha, a slight increase from 118 ha in 2021. Populations persisted in 2022 along the Yalakom River west, east of Beaverdam Creek and near Askom Mountain.

Western spruce budworm expanded significantly in 2022, affecting 7,798 ha in the Lillooet TSA. Populations were mapped from Shalath along the north edge of Anderson Lake and in the Gold Bridge area around Gun Lake, Tyaughton Lake and Downton Lake. Egg mass sampling in the fall indicated moderate populations in 2023.

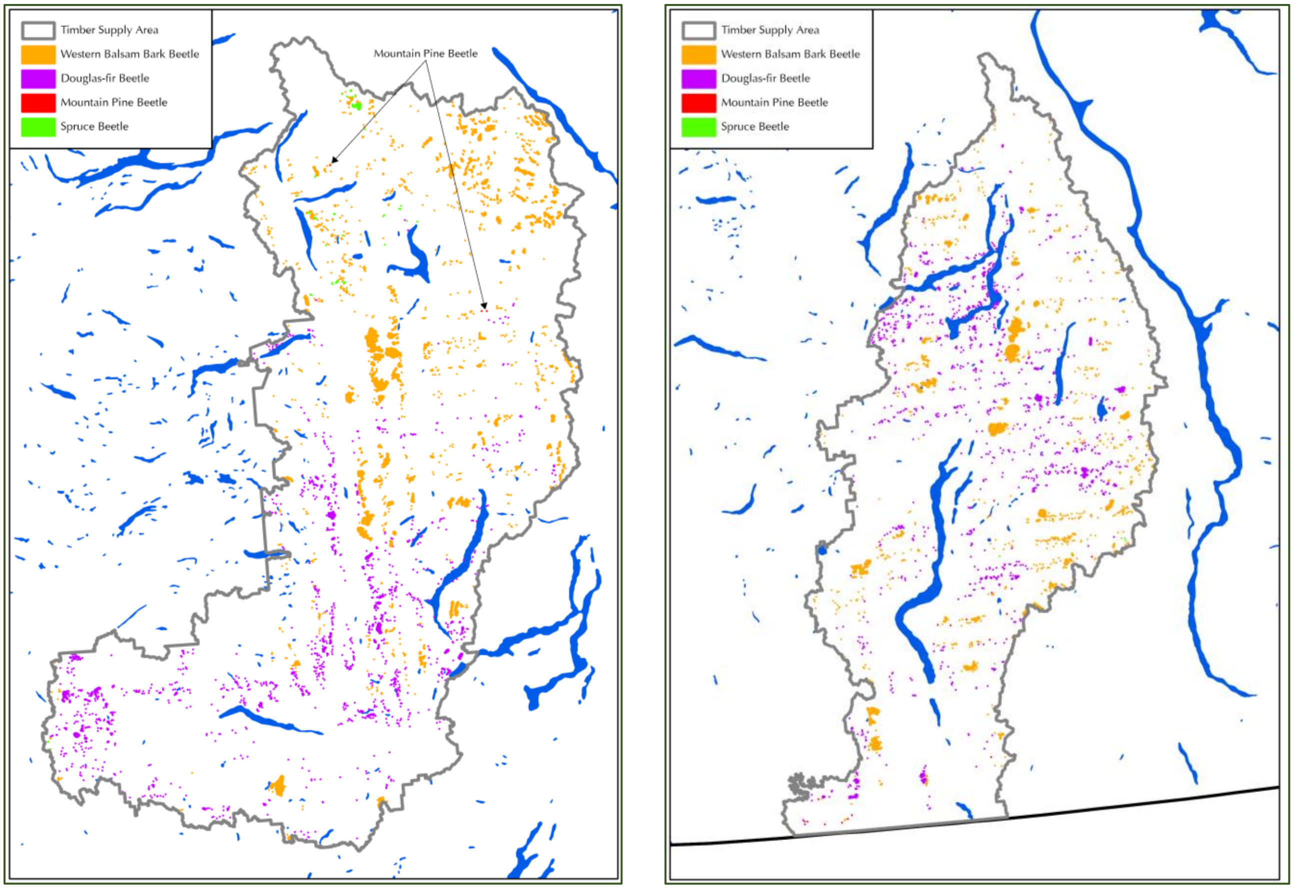



*Figure 18. Major bark beetles in the Kamloops (left) and Okanagan (right) TSAs.*

*Figure 19. Western spruce budworm defoliation near Seton Lake, Lillooet TSA.*

## Merritt TSA

A total of 13,619 ha of damage was mapped in the Merritt TSA. Bark beetles and defoliators were responsible for most of the damage observed, accounting for about 40% and 60%, respectively. Thirty-two percent of the damage was caused by western balsam bark beetle that was mapped on 4,337 ha, of which most was light severity. Active populations were mapped in subalpine fir stands in Copper Creek along the boundary of Manning Park, the east side of Brent Mountain Protected Area, between Iltcoola and Arcat

Creeks, along the Tulameen River, July Mountain, and in the Spius Creek and Stoyoma Mountain area. Douglas-fir beetle increased by 700 ha to 874 ha affected. Patches were detected near Brook Lake, Summers Creek, and between Rattlesnake and Paul Creeks. Mountain pine beetle was mapped as many, small scattered spots for a total of 78 ha. Locations of mountain pine beetle include west of Prospect Creek, Boot Lake, Skwum Creek to Britton Creek, Blakeburn Creek (south of Otter Lake), Placer Mountain, and west of the Pasayten River. Spruce beetle was detected on 92 ha in a few spots near Juliet Creek, Podunk Creek and the Tulameen River.

Western spruce budworm defoliation made up 48% of the damage mapped in the Merritt TSA, covering 6,574 ha, a two-fold increase over 2021. Defoliation increased west of Mamit Lake near Quinville and Tolman Creeks, and in the south of the TSA around near Agate Mountain and Lorne Lake. Two year cycle budworm was mapped in the Maka Creek area on 1,100 ha ("up" year). Small pockets of aspen serpentine leafminer were mapped throughout the central portion of the Merritt TSA affecting 368 ha. Defoliation was noted from Aspen Grove to Loon Lake, Dillard Creek and along the Summerland-Princeton Road near Link Lake. Sixty ha of satin moth was mapped in 2022.

### Okanagan TSA

Damage was mapped on 40,630 ha in 2022, with 62% caused by bark beetles and 38% caused by defoliators. There were minor amounts of abiotic damage detected (e.g. drought, fume kill, post-fire damage, aspen decline). Douglas-fir beetle increased significantly in 2022 affecting 3,967 ha, compared to 741 ha in 2021. Most infestations were mapped as trace severity. Douglas-fir beetle was active from the south end of the TSA to the Shuswap. Patches were mapped near Cawston, along Mission Creek to Tress Creek, Sandberg Creek, in the Lumby area from Ferry Creek to Heckman Creek and in the Trinity Hills on Sowsap Creek. In the Shuswap, small patches and spots were noted near Skimikin, Gleneden, Canoe, Sorrento, Scotch Creek and Squilax Mountain. The MCH program continued in Herald Provincial Park and other high priority areas to protect trees from attack by Douglas-fir beetle.

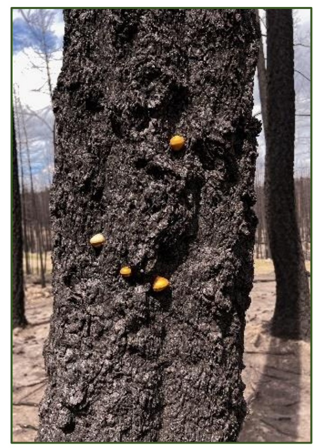


*Figure 20. Douglas-fir beetle along Adams Lake, Okanagan TSA.*

The area affected by western balsam bark beetle increased almost 50% to 21,009 ha of mostly severe attack, which is notable because typically this bark beetle manifests as trace or light pockets spread over the landscape. Most high elevation subalpine fir sites had some scattered attack. The most active attack was recorded near Pukeashun Mountain and Blurton Creek to Cooke Creek in the north. Other notable areas included Silver Star Mountain, Mount Gottfriedson, Little White Mountain, south of Municipal Creek and in the Apex Mountain area near Mount Riordan and Nickel Plate Lake.

Mountain pine beetle infestations remain low, mapped on 4 ha in small spots near Dee Lake, Chute Lake, Little White Mountain, Wilkinson Creek and north of Mount Baldy. Small spots of spruce beetle (2 ha) were mapped near Campbell Creek and Harris Creek. Western pine beetle and woodborer damage was reported near Oliver (within 2022 fire).

Western hemlock looper, increased significantly, affecting 10,277 ha in 2022 up from 497 ha in 2021. The largest areas of defoliation were mapped near Sugar Lake and Mable Lake with small patches near Mara Lake and Yard Creek, and at the north end of Anstey Arm, Perry River and north Seymour River. No defoliation was observed in the areas treated with *B.t.k.* in 2021. This will probably be the last year of significant defoliation by this insect until its next outbreak cycle. Aspen serpentine leafminer and satin moth defoliation was minimal in 2022.

Minimal abiotic damage from drought or post-fire mortality was observed.

## Cariboo Region Summary

The Cariboo Region Aerial Overview Survey was completed between July 14th and August 19th. The Cariboo Region was flown in two sections (north and south) by two separate contractor teams. The southern portion of the Region was surveyed by Barbara Zimonick and Karen Baleshta, and the northern portion by Nathan Atkinson and Scott Baker. Both teams used a Cessna 182 provided by Cariboo Air Ltd in the south and Guardian Aerospace Holdings in the North.

A total of 21 damage agents were recorded affecting 276,250 ha of forest land. Biotic damage agents affected the most area, with western spruce budworm (117,308 ha), western balsam bark beetle (53,260 ha) and mountain pine beetle (31,919 ha) being the most predominant. Flooding (4369 ha) and post fire mortality (2323 ha) were the most dominant abiotic factors.

### 100 Mile House TSA

Douglas-fir beetle decreased from 39,769 to 6,953 ha affected. Mapped polygons were located in the south-west corner of the TSA between Marble Range Park and Chasm Park. Smaller populations of point data were located throughout the TSA. Western balsam bark beetle declined to just 213 ha from 440 ha mapped in 2021. No mountain pine beetle or spruce beetle activity were recorded in the TSA.

Western spruce budworm continued to increase in the western edge of the TSA near China Gulch and Canoe Creek, affecting 44,737 ha up from 13,025 ha detected in 2021. Two-year cycle budworm increased from 4,626 ha in 2021 to 9,762 ha mapped in 2022. Aspen serpentine leafminer was mapped at 1,622 ha in 2022, a 53.5-fold decrease over 2021.

### Quesnel TSA

Douglas-fir beetle saw a sharp decline from 2021 with only 6 ha mapped as scattered points within the TSA. The area affected by western balsam bark beetle decreased slightly, from 31,078 ha in 2021 to 28,434 ha in 2022. The largest area of infestation south of Barkerville. Spruce beetle increased to 19,089 ha with the majority mapped as light infestation and overlapped the same area as western balsam bark beetle. Mountain pine beetle was mapped on 1 hectare up from zero in 2021.

Insect defoliators were observed damaging 3,785 ha in 2022 with aspen serpentine leafminer affecting 3768 ha plus 16 ha of unknown defoliation.

Dothistroma needle blight was detected on 72 ha east of Blackwater River and south of Batnuni Road Other damaging agents recorded in the TSA in 2022 included post fire mortality (405 ha).

### Williams Lake TSA

Nineteen damage agents were recorded in the Williams Lake TSA in 2021, affecting 159,724 ha. Bark beetles (72,312 ha) and defoliators (85,077 ha) were the predominant damage agents. All four bark beetles declined in area affected. Douglas-fir beetle populations declined further this year from 41,273 ha affected in 2021 to 12,334 in 2022.

Spruce beetle decreased from 10,482 ha in 2021 to 2,447 mapped in 2022, with the majority mapped as light. Mountain pine beetle infestations declined slightly in 2022 to 32,918 ha, down from 34,457 ha in 2021. The largest populations of mountain pine beetle were from Tatlayoko, Chilko and Taseko Lakes. Western balsam bark beetle mortality declined from ha in 2021, the majority of active patches were mapped as trace (23,059 ha).

The aspen serpentine leafminer decreased from 69,990 ha in 2021 to 10,385 ha primarily in the Horsefly and Tyee Lake areas. Western spruce budworm increased significantly in 2022, affecting 72,571 ha, up from 37,392 ha in 2021. Defoliation was mapped east of the Fraser River from Springhouse, Alkali Lake, to Dog Creek and west of Marble Range. On the west side of the Fraser River south of Junction Sheep Range and along the western and southern edge of Churn Creek Protected area. Douglas-fir tussock moth remained at very low levels in 2022, with 68 ha affected. Western hemlock looper was recorded on 1,985 ha down from 10,074 ha in 2021 near Quesnel Lake.

## Kootenay Boundary Region

The Kootenay Boundary portion of the Aerial Overview Surveys was carried out between July 9th and October 2, 2022. The surveys were completed in 124.2 hours, over 26 flight days. The weather was good during the flights and damage symptoms were clearly visible. Surveys were conducted by Neil Emery as the lead surveyor and either Adam O'Grady or Jason Lessard as the second seat surveyor, and utilized a Cessna 337 (F-GBWT) operated by Babin Air Ltd. of Cranbrook, B.C.

A total of 14 damage agents were recorded affecting 114,335 ha of forest land. Table 13 lists the top ten damage agents (by ha affected in 2022) in the Region. Biotic damage agents affected the most area, with western balsam bark beetle (40,949 ha), western hemlock looper (24,035 ha), and Douglas-fir beetle (15,849 ha) being the most predominant (**Table 12**). Cedar flagging (14,142 ha) and post fire (521 ha) were the most dominant abiotic factors (**Table 12**).

***Table 12. Top ten damage agents in 2022 in Kootenay Boundary Region.***

| Pest Ranking | Forest Health Factor | Ha affected |
|---|---|---|
| 1 | Western Balsam Bark Beetle (IBB) | 40,948.61 |
| 2 | Western Hemlock Looper (IDL) | 24,034.53 |
| 3 | Douglas-fir Beetle (IBD) | 15,849.10 |
| 4 | Cedar Flagging (NE) | 14,142.39 |
| 5 | Spruce Beetle (IBS) | 6,084.48 |
| 6 | Mountain Pine Beetle (IBM) | 5,584.88 |
| 7 | Aspen Leaf Miner (ID6) | 5,260.69 |
| 8 | Larch Needle Blight (DFH) | 1,676.84 |
| 9 | Post Fire (NBP) | 520.79 |
| 10 | Bear (AB) | 114.8 |

The following two tables and one figure summarizes the area of attack of the four major bark beetles into the three TSA groupings: Rocky Mountain, Selkirk North and Selkirk South for 2022 and 2021.

***Table 13. 2022 Summary of bark beetle hectares of attack for the Kootenay Boundary Region by TSA groupings.***

| TSA Grouping | IBD | IBS | IBM | IBB | Total |
|---|---|---|---|---|---|
| **Rocky Mountain** (Cranbrook and Invermere TSAs) | 5,887 | 5,075 | 4720 | 22,683 | **38,365** |
| **Selkirk North** (Golden and Invermere TSAs) | 905 | 348 | 137 | 12,451 | **13841** |
| **Selkirk South** (Arrow, Boundary, Cascadia, and Kootenay Lake TSAs) | 9,056 | 945 | 728 | 17,065 | **27,794** |
| **Total Hectares** | **15,848** | **6,368** | **5,585** | **52,199** | **80,000** |

*Table 14. 2021 Summary of bark beetle hectares of attack for the Kootenay Boundary Region by TSA groupings.*

| TSA Grouping | IBD | IBS | IBM | IBB | Total |
|---|---|---|---|---|---|
| **Rocky Mountain** (Cranbrook and Invermere TSAs) | 2,972 | 3,506 | 6017 | 17,904 | **30,399** |
| **Selkirk North** (Golden and Invermere TSAs) | 1201 | 2214 | 228 | 13,494 | **17137** |
| **Selkirk South** (Arrow, Boundary, Cascadia, and Kootenay Lake TSAs) | 8,406 | 639 | 2047 | 6,434 | **17,526** |
| **Total Ha** | **12,579** | **6,359** | **8,292** | **37,832** | **65,062** |

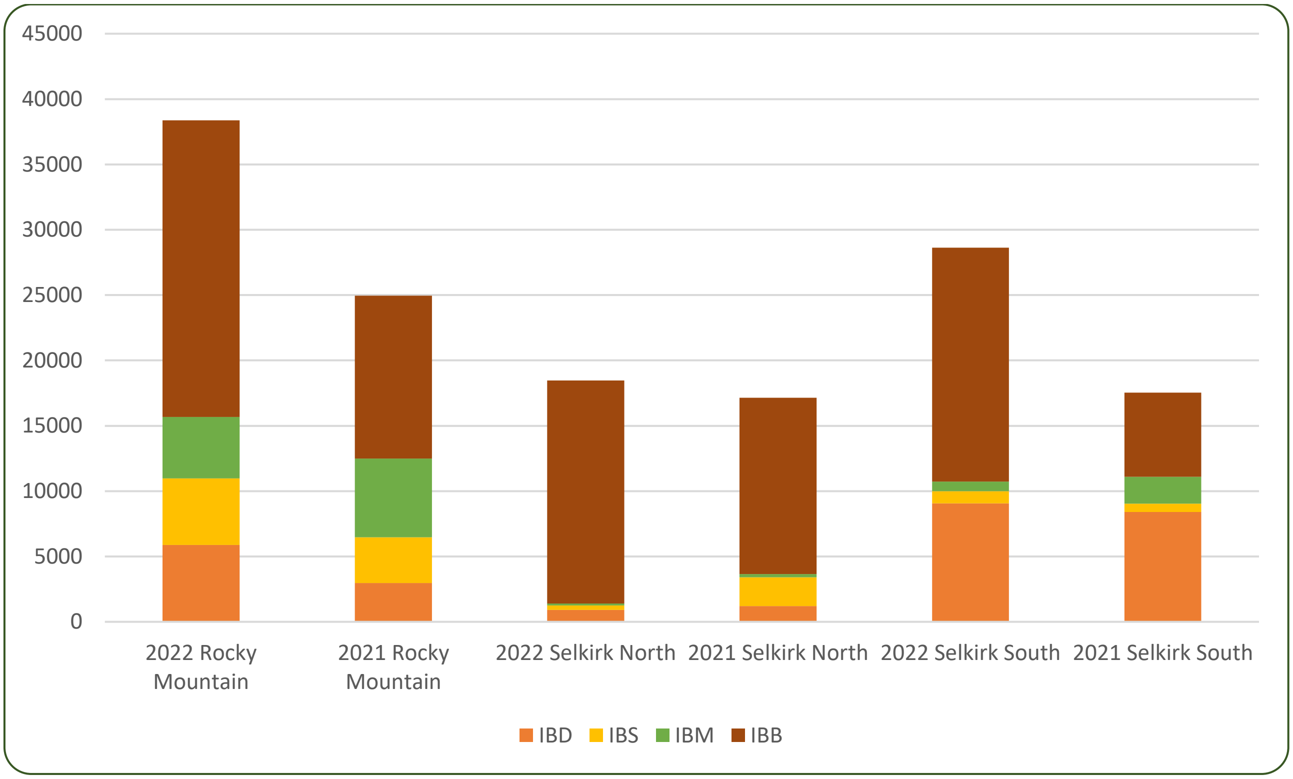



*Figure 21. The four major bark beetles (IBD, IBS, IBM, and IBS) ha of attack comparison by TSA groupings for Kootenay Boundary Region, 2022 and 2021.*

## Rocky Mountain: Cranbrook and Invermere TSAs

The four major bark beetles affected 38,365 ha in the Cranbrook and Invermere TSAs in 2022, a 7,966 hectare increase from 2021. Western balsam bark beetle continues to have the highest levels of attack at 22,683 ha, which is also the largest ha of the three TSA groupings. Douglas-fir beetle follows at 5,887 ha, then spruce beetle at 5,075 ha and lastly spruce beetle at 4,720 ha.

Douglas-fir beetle infestations increased from 2,972 ha in 2021 to 5,887 ha in 2022, with an over 3,000 hectare increase in the Cranbrook TSA and a slight decline in the Invermere TSA. Infestations were detected throughout the Rocky Mountain Trench, and near Lake Koocanusa, Gold Creek, Grasmere and Inverted Ridge.

Mountain pine beetle infestations decreased in both TSAs, from 1,975 to 1,091 ha in the Cranbrook TSA and from 4,042 to 3,629 ha, in the Invermere TSA. In the Cranbrook TSA, large patches of attack were detected near Mount Baker, Moyie Mountain and Tepee Creek and in the Invermere TSA, populations were active in the Thunder Creek, Toby Creek, Dutch Creek and Forster Creek areas.

Spruce beetle attack increased in both TSAs, going from 2,119 and 1,387 ha in 2021 to 3,599 and 1,476 ha in 2022 in Cranbrook and Invermere TSAs, respectively. Spruce beetle was mapped near Elk River, Mount Bleasdale, Riverside Mountain, Mount Queen Mary and South Toby Creek.

*Figure 22. Spruce beetle attack in the Elk Valley.*

Western balsam bark beetle increased to 22,683 ha, up 4,779 ha in the two TSAs combined, increasing in both the Cranbrook and Invermere TSAs. It was detected in most high elevation sites along the western boundary of the Invermere TSA. In the Cranbrook TSA, it was scattered throughout subalpine fir forests, with the most notable infestations occurring from Sparwood to Profile Mountain.

Aspen serpentine leafminer defoliation declined for the second year in a row from 3,300 to 2,374 ha affected. The most active areas were on the north side of Highway 3 between Elko and Fernie, near Mt. Fernie.

Western hemlock looper defoliation increased to 219 from 131 ha near Harrogate.

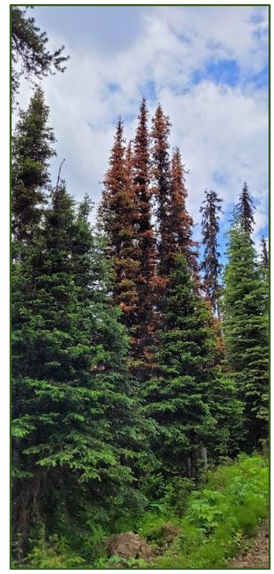
Other damage agents include bear (42 ha), larch needle blight (113 ha), post fire damage (161 ha), cedar flagging (404 ha), flooding (15 ha), and windthrow (48 ha).

The black army cutworm (*Actebia fennica*) monitoring program using pheromone traps was continued in 2022 at the Meachan and Doctor Creek sites (**Table 11**), where traps continued to catch high numbers of moths.

### Selkirk South: Arrow, Boundary, and Kootenay Lake TSAs

The four major bark beetles affected 27,794 ha in the Arrow, Boundary and Kootenay Lake TSAs in 2022, a 10,268 hectare increase from 2021.

Douglas-fir beetle affected 9,056 ha in the three TSAs, with 5,355 mapped in the Arrow TSA, a decrease of 358 ha from 2021. The largest increase was observed in Boundary TSA where 1,935 ha were mapped at as increase of 1,285 ha. Patches of Douglas-fir beetle were scattered along the West Arm of Kootenay Lake, Slocan River and Lake, most side drainages of Lower Arrow Lake, near Whatshan Lake, Burton Creek and Rendell Creek, Christina Lake, and scattered throughout southern Boundary TSA.



Western balsam bark beetle had a cumulatively area affected in the three TSAs of 17,065 ha, a 376 hectare decrease from 2021. Almost the entire area mapped was in the trace category. Western balsam bark beetle was observed in most high elevation subalpine fir sites, with the most active populations noted near Cortiana Creek, Galloping Creek, Carpenter Creek, Keen Creek and Irvine Creek.

Spruce beetle populations increased slightly in the three TSAs to 945 ha, with the Hamill Creek population being the most active.

Mountain pine beetle area affected decreased significantly at 728 ha in 2022, compared to 2,047 ha in 2021. The areas south of Yahk, Summit Peak, north of Bonanza Creek, Comb Mountain and Glacier Creek are the most active populations. Mountain pine beetle mortality continues in both lodgepole pine and whitebark pine stands.

Aspen serpentine leafminer activity continued to decline significantly in 2022 with 642 ha affected compared to 7,384 ha in 2021.

Western hemlock looper increased to 14,030 ha in 2022 compared to 3,325 ha in 2021 in the Arrow and Kootenay Lakes TSAs, with large populations surrounding Arrow, Kootenay, and Trout Lakes, as well as the west side of Slocan Lake.

Other damage agents include larch needle blight (1,563 ha), Dothistroma needle blight (27 ha), post fire mortality (359 ha), cedar flagging (9,770 ha), and windthrow (42 ha).

### Selkirk North: Golden and Revelstoke TSAs

The four major bark beetles affected 13,841 ha in the Golden and Revelstoke TSAs in 2022, a 3,296 hectare decrease from 2021.

Douglas-fir beetle decreased in both the Golden and Revelstoke TSAs, to 599 and 306 ha, respectively in 2022. Active populations were mapped along Kinbasket Lake, near Revelstoke and Golden.

Mountain pine beetle (136 ha) was mapped in Revelstoke TSA and spruce beetle (348 ha) was mapped only in the Golden TSA in 2022. Mountain pine beetle was detected along Revelstoke Lake and spruce beetle was found in Glacier National Park.

Western balsam bark beetle increased slightly in the Golden TSA (11,790 ha in 2022 from 11,046 ha in 2021), but decreased significantly in the Revelstoke TSA, from 2,448 ha in 2021 to 661 ha in 2022. Western balsam bark beetle remained active at higher elevations throughout both TSAs.

Western hemlock looper increased in the Golden TSA 1,509 ha in 2021 to 3,275 ha in 2022 and decreased in the Revelstoke TSA from 8,243 ha in 2021 to 6,509 ha in 2022. Defoliation was mapped along both sides of the Columbia River drainage, from Revelstoke north to Mica Creek, and along the Beaver River in the Golden TSA as well as in the Cummings drainage.

Other damage agents include bear (71 ha), aspen leaf miner (2,164 ha), cedar flagging (3,966 ha), slide (0.75 ha), and windthrow (10 ha).

# North Area

The AOS was conducted from 13 July to 4 November in the North Area. In 265 flight hours, 32 forest health factors were mapped across 14 TSAs. The total area covered changed little from 2021 (increased approximately 101,287 ha), however, the coverage within two regions varied drastically from the previous year. Due to excellent flying conditions throughout the season, total area covered in the Skeena Region increased 44% while the Northeast decreased by 64% due to an unavoidable delayed outset. This should be considered in interpreting annual changes in area affected by certain forest health factors in some areas.

Despite the overall decrease in area affected by bark beetles to 1,994,472 ha (from 2,815,925 ha 2021), they remain the dominant forest health factors affecting the North Area:

- Mountain pine beetle (IBM): 4,868 ha (from 23,235 ha 2021),
- Spruce beetle (IBS): 108,482 ha (from 444,383 ha 2021),
- Western balsam bark beetle (IBB): 1,871,740 ha (from 2,346,238 ha 2021), and
- Douglas-fir beetle (IBD): 108 ha (from 2,069 ha 2021).

Spruce beetle remains the primary focus in the Omineca, the epicenter of the outbreak in BC that began in 2014. The area affected in this region is the lowest since the outbreak began (51,366 ha) with most activity mapped around Bear and McLeod Lakes up to the Mackenzie District. Fresh attack is occurring in age classes 4 and 5 spruce. In the Skeena, areas affected by IBM, IBS, and IBB were recorded as increasing in the Cassiar and Nass TSAs. Notably, area affected by IBB increased significantly, likely due to extended survey coverage, indicative of its widespread occurrence throughout the Region. IBB is usually recorded at trace to light severity, however more moderate and severe polygons were recorded in 2022, particularly in Nadina District. In the Omineca Region, area affected by IBB decreased 49.5%.

The total area affected by defoliators decreased to 299,179 ha (from 1,653,517 ha). This is likely due to IDB being in an ‘off’ year in the North. However, an increase in area affected by IDB was recorded in Robson Valley. IDX and ID6 decreased significantly in the Northeast and Omineca Regions but increased in the northern Skeena Region (Cassiar). Extensive defoliation by IEB was recorded in Kalum (13,457 ha), Cassiar (2,780 ha), and Kispiox (2537 ha) TSAs. No defoliation by IEB was recorded in 2021.

The total area affected by diseases decreased to 21,572 ha (from 37,101 ha 2021). The cause of the majority of the damage is unidentified as many diseases are difficult to confidently identify using AOS. Area affected by foliar diseases, i.e. DFS (Skeena) and DLV (Skeena and Omineca) decreased.

The total area affected by abiotics decreased to 16,017 ha (from 197,151 ha 2021) due to significant decreases in NB and NF. The total area affected by animals decreased to 150 ha (from 3,033 ha 2021), primarily due to a decrease in AB damage. This was offset only slightly by a minor increase in AH and AP damage.

## Skeena Region

The Skeena Region AOS was conducted from 13 July to 21 September by Sean McLean (lead Surveyor) and Lynn Van Cadsand (second seat) using a Cessna 185 operated by Alpine Lakes Air Ltd. In 91.5 flight hours, the team covered approximately 16,383,325 ha, 65.6% of the entire Region (vs. 29.0% in 2021), detecting 24 forest health factors affecting 1,629,101 ha across 7 TSAs. Due to excellent flying conditions throughout the season, total area covered in the Skeena Region increased 44%, and area affected increased accordingly. Western balsam bark beetle was the predominant forest health factors (1,320,697 ha), followed by the aspen leaf miner (207,381 ha). Defoliation by the hemlock sawfly was not recorded in 2021 but affected 19,024 ha in Kalum (13,457 ha), Cassiar (2,780 ha), Kispiox (2,537 ha) and Nass

(119 ha) in 2022 (**Table 15**). The predominant abiotic forest health factors were fire (6,511 ha) and post-fire (4,369 ha).

*Table 15. Pest ranking of the top ten forest health factors by area affected (ha), Skeena Region, 2022.*

| Pest Ranking | Forest Health Factor | Area affected (ha) |
|---|---|---|
| 1 | Western Balsam Bark Beetle (IBB) | 1,320,697 |
| 2 | Aspen Leaf Miner (ID6) | 207,381 |
| 3 | Spruce Beetle (IBS) | 34,796 |
| 4 | Hemlock Sawfly (IEB) | 19,024 |
| 5 | Diseases (D) | 13,648 |
| 6 | Large Aspen Tortrix (IDX) | 8,107 |
| 7 | Fire (NB) | 6,511 |
| 8 | Dothistroma Needle Blight (DFS) | 6,245 |
| 9 | Post Fire (NPB) | 4,369 |
| 10 | Mountain Pine Beetle (IBM) | 1,919 |

## Bulkley, Cassiar and Kispiox TSAs

Three of the four major bark beetles occur in the Skeena-Stikine District (DSS): IBB, IBM, and IBS (**Table 16**) affecting 686,885 ha total. IBB affected the largest area 659,145 ha, about 96% of total bark beetle area, primarily at trace-low severity. However, small polygons of moderate and severe severity were recorded in all three TSAs. The increase in IBB, IBM, and IBS is likely attributable to the increased survey coverage in the Cassiar which is indicative of their widespread presence in the Region.

*Table 16. Area affected (ha) by bark beetles by District, Skeena Region, 2022.*

| District | TSA | IBB | IBD | IBM | IBS | TOTAL |
|---|---|---|---|---|---|---|
| **Skeena-Stikine (DSS)** | Bulkley | 245,982 | 0 | 1,273 | 1,459 | **248,714** |
| | Cassiar | 183,984 | 0 | 2,030 | 17,409 | **203,423** |
| | Kispiox | 229,179 | 0 | 0 | 5,569 | **234,748** |
| **Coast Mountain (DCM)** | Kalum | 21,551 | 0 | 0 | 461 | **22,012** |
| | Nass | 153,353 | 0 | 0 | 6,772 | **160,125** |
| **Nadina (DND)** | Lakes | 130,930 | 178 | 11 | 2,879 | **133,998** |
| | Morice | 346,656 | 0 | 432 | 222 | **347,310** |
| **TOTAL** | | **1,311,635** | **178** | **3746** | **34771** | **1,350,330** |

There was an overall decrease in area affected by defoliators. The predominant defoliator in these TSAs is the aspen serpentine leaf miner (ID6) (82,254 ha)), however the only TSA that recorded an increase was the Cassiar. The large aspen tortrix (IDX) was not mapped in 2021 but was recorded in the Cassiar in 2022 (8107 ha). The hemlock sawfly (IEB) was also not mapped in 2021 but caused notable defoliation on western hemlock in the Kispiox (2537 ha) and Cassiar (2780 ha) in 2022.

Dothistroma (DFS) is one of the few diseases that has an aerial signature for mapping. Dothistroma needle blight affected 5794 ha in the Kispiox.

### Kalum and Nass TSAs

There was an overall decrease in the area affected by bark beetles in the Coast Mountain District (DCM; 175,365 ha; **Table 16**), however an increase in area affected by IBB was recorded in the Kalum, and both Kalum and Nass TSAs recorded an increase in IBS (**Table 16**) from 2021. IBB was primarily recorded in trace to light severity; however, small polygons of moderate and severe severity were recorded in both TSAs.

Defoliators are important in DCM. Area affected by ID6 generally declined but increased in the Nass (3,215 ha). Hemlock sawfly was mapped over a larger area in DCM (13,576 ha) than DSS, with most of the area defoliated occurring in the Kalum (13,457 ha) (**Figure 23**).

Small polygons of DFS were mapped in Kalum (682 ha) and Nass (1,497).

*Figure 23. Western hemlock defoliation by hemlock sawfly (IEB) along the North Copper, Coast Mountain District, 2022.*

### Lakes and Morice TSAs

Area affected by bark beetles decreased overall in the Nadina District (DND), affecting 481,308 ha in total. Small increase in the area affected by IBM was recorded in the Lakes (11 ha) and Morice (192 ha). Douglas fir is not a dominant tree species in the Skeena Region but does occur in relatively small but ecologically significant areas. IBD was only recorded in Lakes TSA (178 ha), primarily in the Babine Lake Marine Provincial Park.

Area affected by defoliators decreased overall in DND. The satin moth (IDU) was not mapped in 2021 but 176 ha was recorded in the Lakes TSA in 2022. Although it was an 'off' year for the 2-year cycle budworm (IDB), a small area was recorded in the Lakes TSA (19 ha).

## Omineca and Northeast Regions

Aerial overview surveys of the Omineca and Northeast Regions took place between July 26 and November 2. A total of 173 hours of flying, were completed for the survey staged from four hubs; Prince George, Mackenzie, Fort St John and Fort Nelson. Surveys were conducted by Tom Foy, Nathan Atkinson and Barry Mills (Industrial Forestry Service Ltd.) and were utilizing a Cessna 182 and 210 operated by Guardian Aerospace, flying a total of 82 hours, and a Cessna 206 operated by Airborne Energy Solutions, flying a total of 91.7 hours. Although weather was favorable in 2022, a late start to the flights resulted in eight letter blocks, encompassing almost the entirety of the Fort Nelson district, not being surveyed.

In the Omineca, 17 damage agents were mapped during the 2022 surveys. Approximately 605,475 ha of area was affected, of which approximately 560,025 was affected by bark beetles (**Table 17**). This is a sharp decline from 2021 where 1,338,474 ha was affected by bark beetles. This decline was seen in each bark beetle species. This is the first year since the outbreak began in 2014 where the total area affected fell below 100,000 ha, only seeing 51,366 ha affected in 2022.

*Table 17. Pest ranking of the top ten forest health factors by area affected (ha), Omineca Region, 2022.*

| Pest Ranking | Forest Health Factor | Area affected (ha) |
|---|---|---|
| 1 | Western Balsam Bark Beetle (IBB) | 505,610 |
| 2 | Spruce Beetle (IBS) | 51,366 |
| 3 | 2-Year Cycle Budworm (IDB) | 22060 |
| 4 | Aspen Leaf Miner (ID6) | 20588 |
| 5 | Mountain Pine Beetle (IBM) | 2946 |
| 6 | Satin Moth (IDU) | 1260 |
| 7 | Post Fire (NPB) | 602 |
| 8 | Western Hemlock Looper (IDL) | 589 |
| 9 | Drought Foliage (NDF) | 202 |
| 10 | Fume kill (NF) | 108 |

In the Northeast, thirteen damage agents were mapped in 2022, affecting 100,373 ha. Bark beetles accounted for approximately 76,840 ha of the damage mapped (**Table 18**). As a result of an unavoidable delayed outset in the AOS for the Northeast, there was a decrease in 64% of the total area mapped compared to 2021. This area accounts for the entire Fort Nelson TSA not being mapped in 2022.

*Table 18. Area affected (ha) by bark beetles by TSA, Northeast Region, 2022.*

| Timber Supply Area | Western Balsam Bark Beetle | Douglas-fir Beetle | Mountain Pine Beetle | Spruce Beetle | Total (ha) |
|---|---|---|---|---|---|
| Dawson Creek | 52,325 | 0 | 1.5 | 21,817 | 74,145 |
| Fort St. John | 1,728 | 0 | 1 | 525 | 2,254 |
| Fort Nelson | 440 | 0 | 0 | 0.25 | 441 |
| Total | 54,494 | 0 | 2.5 | 22,343 | 76,840 |

## Prince George TSA

Bark beetle damage was mapped on 362,600 ha in the Prince George TSA, making up 46% of the total damage mapped in the TSA, a decrease from 860,500 ha mapped in 2021.

Spruce beetle declined significantly from 2021, with a decrease in 242,276 ha to a total of 45,311 ha mapped in 2022. Most infestations were mapped as light severity. Much of the activity continues to be mapped north of Prince George up to the Mackenzie District. Western balsam bark beetle populations also decreased, with 313,311 ha mapped in 2022 down from 571,023 ha mapped in 2021. Douglas-fir beetle was mapped on 37 ha, down from 1,885 ha in 2021. Active infestations were identified along the Blackwater and around Punchaw in the Prince George District. Douglas-fir beetle could also be found around Stuart Lake near Fort St James. Mountain pine beetle saw a slight increase in 2022, with 2,939 ha mapped in 2022, and increase of 2,935 ha from 2021.

Insect defoliator populations saw a decline in 2022 with 27,744 ha affected from 212,961 ha affected in 2021. Aspen serpentine leaf miner, which continues to be the main defoliator in the TSA, saw a large population decrease in 2022, with only 19,435 ha mapped in 2022 compared to 154,252 ha mapped in 2021. Two-year cycle budworm was mapped to 6,592 ha, down 44,360 ha from 2021 (50,953 ha). Western hemlock looper was declined from 4,187 ha in 2021 to 455 in 2022. Satin moth was down to 1,260 ha in 2022 from 3,568 ha in 2021.

### Mackenzie TSA

In the Mackenzie TSA, bark beetle populations saw a decline in area affected, from 364,389 ha in 2021 to 121,611 ha in 2022. Spruce beetle populations saw a sharp decline of 27,423 ha affected from 30,891 in 2021 to 3,468 ha. Western balsam bark beetle decreased to 118,143 ha from 333,352 ha. Active populations of western balsam bark beetle sill remain at trace to light severity. No active mountain pine beetle populations were identified in 2022.

Only a single insect defoliator was seen in the Mackenzie TSA for 2022, with 1,153 ha affected. This was a sharp decline from 55,663 ha recorded in 2021. Aspen serpentine leaf miner decreased from 45,235 ha to 1,153 ha. There was no recorded 2-year cycle budworm defoliation in 2022 (2021: 9,938 ha) or large aspen tortrix defoliation (2021: 489 ha).

### Robson Valley TSA

The Robson Valley TSA saw a decline in active bark beetles, from 113,584 ha affected in 2021 to 75,812 ha in 2022. Spruce beetle was the only bark beetle to show an increase in area affected, with 2,586 ha affected from 779 ha in 2021. Western balsam bark beetle saw a slight decrease to 73,156 ha mapped from 97,097 ha in 2021. Mountain pine beetle saw a decrease of 15,695 ha mapped, from 15,702 ha in 2021 to 7 ha in 2022.

An overall increase in insect defoliators was seen, with an increase from 5,834 ha affected to 15,602 ha. The 2-year cycle budworm accounted for this increase with 15,467 ha of defoliation being mapped. No activity was seen in 2021. Western hemlock looper activity was down from 1,897 ha affected in 2021 to 134 ha in 2022. No aspen serpentine leaf miner was recorded in the area.

### Dawson Creek TSA

In the Dawson Creek TSA, spruce beetle was mapped on 21,817 ha, a reduction in 39,882 ha from 61,700 ha in 2021. There are still active populations mapped in and around the Pine Le Moray Provincial Park and along the border of the Prince George TSA. Spruce beetle activity can still be seen located north of Tumbler Ridge largely as point data with couple of light polygons. Western balsam bark beetle decreased 116,103 ha from 2021 to 52,325 ha being mapped in 2022. Much of the activity (trace and light polygons) was mapped along the western portion of the TSA affecting the Engelmann spruce—subalpine fir biogeoclimatic zones of the TSA. Mountain pine beetle was only mapped on 1.5 ha in 2022 in the southern portion of the TSA, down from 368 ha in 2021.

In 2022, there was no mapped aspen serpentine leaf miner, which was a significant decrease from the 25,559 ha mapped in 2021. Large aspen tortrix also saw a decrease of mapped area affected, with 4091 ha being mapped in 2022, down from 22,257 ha mapped in 2021. Activity was recorded, moderate and severe polygons, around Moberly Lake. Two-year cycle budworm populations remain similar to 2021, with 15,830 ha being mapped in 2022, up 283 ha from 15,547 ha in 2021. Defoliation was mapped in the southern portion of the TSA, with light and moderate polygons being mapped from the Wapiti Lake Provincial Park to Kakwa Provincial Park.

### Fort St. John TSA

The Fort St John TSA saw spruce beetle populations decline to 525 ha affected, down from 8,863 ha in 2021. Activity was mapped in the northern portion of the TSA (Block E), with light polygons east of the

Sikanni Chief Canyon Protected Area. Western balsam bark beetle also saw a decline with only 1,728 ha being mapped, down 10,074 ha from 11,802 ha in 2021. Populations were mapped east of the Sikanni Chief Canyon Protected Area. Mountain pine beetle activity was only mapped to 1 hectare, down from 5.25 ha in 2021.

In 2022, there was no aspen serpentine leaf miner or large aspen tortrix mapped in the Fort St John TSA, decreasing from 53,399 ha and 59, 605 ha respectively of mapped infestation in 2021.

### Fort Nelson TSA

The delayed outset of the 2022 AOS in the Northeast resulted in no forest health information being gathered for the Fort Nelson TSA.

### Great Bear Rainforest North and South TSAs

Sixteen forest health factors were mapped across the Great Bear Rainforest Region, affecting approximately 68,582 ha across two TSAs (**Table 19**). The total area surveyed increased to 5,832,105 ha (from 4,348,713 ha).

***Table 19. Summary of area affected by forest health factors in the Great Bear Rainforest Region, 2022.***

| Pest Ranking | Forest Health Factor | Area Affected (ha) | | |
|---|---|---|---|---|
| | | GBR North TSA | GBR South TSA | Total (ha) |
| 1 | Hemlock Sawfly (IEB) | 31,737 | 4,468 | 36,205 |
| 2 | Western Balsam Bark Beetle (IBB) | 25,019 | 136 | 25,155 |
| 3 | Disease (unidentified) (D) | 2,399 | 295 | 2,694 |
| 4 | Yellow Cedar Decline (NCY) | 1,904 | 434 | 2,338 |
| 5 | Slide (NS) | 987 | 52 | 1,039 |
| 6 | Mountain Pine Beetle (IBM) | 479 | 0 | 479 |
| 7 | Spruce Beetle (IBS) | 351 | 20 | 371 |
| 8 | Fumekill (NF) | 113 | 42 | 155 |
| 9 | Balsam Woolly Adelgid (IAB) | 0 | 79 | 79 |
| 10 | Fire (NBP) | 61 | 0 | 61 |
| 11 | Bear (AB) | 0 | 2.75 | 2.75 |
| 12 | Douglas Fir Beetle (IBD) | 1.75 | 0 | 1.75 |
| 13 | Drought Mortality (NDM) | 0 | 0.5 | 0.5 |
| 14 | Laminate Root Disease (DRL) | 0 | 0.5 | 0.5 |
| 15 | Post Fire (NBP) | 0 | 0.25 | 0.25 |
| 16 | Drought Foliage (NDF) | 0 | 0.25 | 0.25 |
| | **Total** | **63,051.75** | **5,530.25** | **68,582** |

The predominant forest health factors in the Region were biotic agents: the hemlock sawfly (IEB) (36,205 ha) and the western balsam bark beetle (25,155 ha).

Total area affected by defoliators increased significantly to 36,284 ha (from 1163 ha 2021). This can be attributed to defoliation by IEB (36,205 ha), of which 87.5% occurred in the North TSA. IEB was not recorded in 2021. This is consistent with the distribution of IEB with neighboring TSAs in the Skeena

Region. There was a decline in IAB, and ID6 was only recorded in the North where it declined from 2021.

The total area affected by bark beetles decreased to 26,007 ha (from 52,081 ha in 2021). Generally, more area was affected in the North TSA, but small increases of IBS and IBB were recorded in the South TSA. Most of the area affected by IBB occurred in the North TSA, but area affected decreased significantly in 2022 (53.3%) and most was recorded at trace to light severity.

Area affected by yellow cedar decline (NCY) decreased to 2,338 ha (from 7,802 ha 2021) and approximately 77% occurred in the North TSA.


# Forest Health Projects

## Digital Mapping Pilot Project[14]

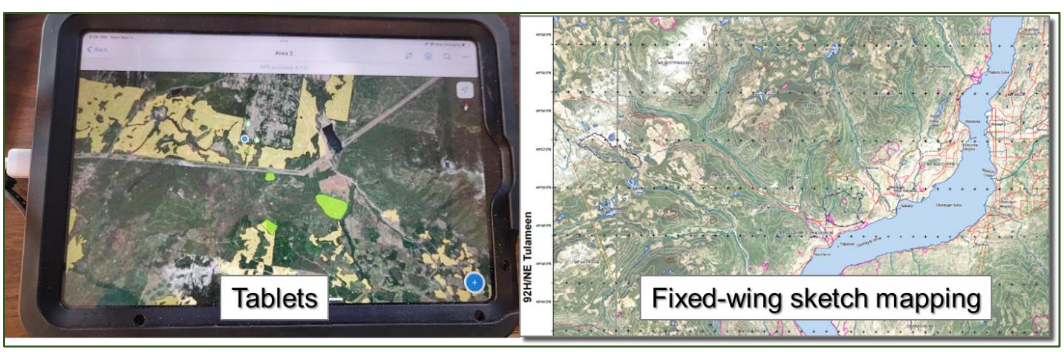
In the 2022 surveys, the ArcGIS Field Maps application on iPads was tested by some of the entomologists and aerial overview mappers and was compared to the standard mapping technique on paper maps. A route was mapped using the iPad and then re-flown and mapped using the standard technique. The following lists some of the pros and cons of the ArcGIS Field Maps application on iPads.

**PROS:**

1. The tracking feature worked well with mappers always knowing their location, thus improving the precision and location marking of forest health disturbances.
2. Landscape features and overall imagery were superior to paper maps, making it easier to see critical landscape features.
3. The iPad is less cumbersome and takes up less space than paper maps. It contains all the mapsheets for the region. Therefore, if flight plans change due to adverse weather, forest fire smoke or other conditions, mappers will always have the required mapsheet.
4. The Apple pencil is useful for writing notes (i.e., photo numbers next to the area of interest) directly on the moving map using the “Mark Up” feature.

**CHALLENGES:**

An ideal aerial overview forest health survey data-gathering application for the iPad would replicate the process we currently use with paper maps. It would allow mappers to mark forest health disturbances (either a polygon for large areas or an “x” for spot infestations), the damaging agent code, species, severity, number of trees, stand type and notes directly on the moving map using the Apple pencil. Unfortunately, the current process of dropdown menus to select whether it is a point or a polygon, then scrolling to set the damage code, the number of trees, severity or species is time-consuming. Mappers often missed seeing other damage agents because they were looking at the tablet screen for longer than if they had been marking the same damage on a paper map. In addition, accurately mapping multiple disturbances occurring in one area (i.e., large polygon to identify IDW with clumps of IBD requiring points within the polygon) is not attainable. Firstly, it is impossible to draw a polygon that accurately conveys the size and shape of the disturbance. The polygons are rigid and angular and do not accurately represent areas where damaging agents tend to follow contour lines. Secondly, marking and identifying each point within the polygon is time-consuming.




[14] Marnie Duthie-Holt, Acting Provincial Forest Entomologist (Kootenay Boundary Regional Forest Entomologist)

## Pest Incidence in Mid-Rotation Lodgepole Pine Stands in the Thompson Okanagan Region[15]

The Thompson Okanagan Region (TOR) is comprised of extensive areas of young, relatively even aged regenerating lodgepole pine and mixed species stands, which have developed due to logging, mountain pine beetle (MPB) outbreaks and wildfires. As part of a large long-term retrospective analysis on the impact of recent regeneration strategies and climate change in lodgepole pine forests, sixty mid-rotation age stands located in the TOR were chosen for study (**Table 20**). In total, almost 6,700 trees were assessed for pest incidence and severity (insect, disease, mammal and abiotic issues), tree growth, form and stand structure. The survey for pest incidence (SPI) protocol was used to conduct the surveys (Joy and Maclauchlan 2000). Each survey was 100 m in length and of varying widths, which enabled us to determine stand density. While this summary focuses primarily on pests of lodgepole pine, other conifer and deciduous tree species were included in the analysis to determine stand structure within the various ecosystems (**Table 21**).

***Table 20. Number of SPI surveys conducted in 2022 by TSA and BEC in the Thompson-Okanagan Region.***

| TSA | BEC | No. surveys 2022 |
|---|---|---|
| TFL15 | ESSF | 4 |
| | IDF | 3 |
| | MS | 5 |
| TFL49 | MS | 6 |
| Merritt | ESSF | 2 |
| | IDF | 3 |
| | MS | 14 |
| Penticton | ESSF | 2 |
| | MS | 14 |
| Vernon | ICH | 2 |
| | MS | 5 |
| | Total | 60 |

***Table 21. Stand composition of 60 mid-rotation aged stands in four ecosystems in the Thompson-Okanagan Region.***

| BEC | Average % tree species | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Deciduous | Bl[1] | Cw | Fd | Lw | Pl | Sx | Total N |
| ESSF | 0.0 | 15.6 | 0.0 | 1.3 | 0.0 | 68.9 | 14.2 | 1,044 |
| ICH | 23.5 | 0.0 | 8.4 | 0.7 | 6.3 | 61.1 | 0.0 | 285 |
| IDF | 4.0 | 0.0 | 0.0 | 3.2 | 8.5 | 82.8 | 1.7 | 603 |
| MS | 1.2 | 9.4 | 0.1 | 4.2 | 0.4 | 76.7 | 8.1 | 4,766 |

[1]Bl-subalpine fir; Cw-western redcedar; Fd-Douglas-fir; Lw-western larch; Pl-lodgepole pine; Sx-interior spruce

Every tree assessed in the SPI surveys was rated for form (good, fair, poor), including tree species other than lodgepole pine (**Table 22**). Interestingly, of 5,047 lodgepole pine assigned a tree form code only 12.6% rated a 'good', in contrast to subalpine fir, Douglas-fir and interior spruce, the majority of which had 'good' form (**Table 22**). In addition, ten randomly selected L1 and L2 lodgepole pines (**Table 23**) were

[15] Lorraine Maclauchlan, Thompson Okanagan Forest Entomologist

measured for height, diameter at breast height (dbh) and age in each SPI survey. In total, 600 trees were measured (**Table 24**). With the exception of the ICH, the trees were all very similar in height, dbh and age. Based on tree measurements, the L1 and L2 trees are from the same cohort. On average, 73% of trees assessed in each survey were L1 and L2.

***Table 22. Tree form noted for all surveyed trees.***

| | | Percentage (%) | | |
|---|---|---|---|---|
| **Species** | **Number** | **Good** | **Fair** | **Poor** |
| Pl | 5,047 | 12.6 | 36.8 | 50.6 |
| Bl | 610 | 83.9 | 8.5 | 7.5 |
| Fd | 235 | 89.4 | 6.0 | 4.7 |
| Sx | 543 | 69.4 | 17.5 | 13.1 |

***Table 23. Description of tree layers, categorized by diameter at breast height (dbh) and tree height (B.C. Ministry of Forests 1992).***

| | Description of trees in each layer | |
|---|---|---|
| **Layer** | **Diameter at breast height (cm)** | **Tree height (m)** |
| 1 | ≥ 12.5cm | any, given dbh ≥ 12.5cm |
| 2 | 7.5 to 12.4 cm | any, given dbh range of 7.5 to 12.4cm |
| 3 | 0 to 7.4 cm | ≥ 1.3m |
| 4 | any, given height restriction of < 1.3m | < 1.3m |

***Table 24. Diameter at breast height (dbh), height and age of 600 L1 and L2 lodgepole pine measured during the 2022 SPI surveys.***

| | Average | | | | | |
|---|---|---|---|---|---|---|
| | L1 Pl | | | L2 Pl | | |
| **BEC** | **DBH (cm)** | **Height (m)** | **Age (years)** | **DBH (cm)** | **Height (m)** | **Age (years)** |
| ESSF | 19.6 | 13.2 | 42.4 | 11.3 | 9.5 | 37.3 |
| ICH | 21.7 | 18.3 | 51.2 | 11.0 | 18.0 | 48.0 |
| IDF | 19.3 | 14.5 | 38.7 | 10.8 | 10.4 | 36.0 |
| MS | 19.8 | 14.6 | 41.9 | 11.4 | 10.6 | 39.8 |

We removed other conifer and deciduous species from the data set to summarize incidence and impact of pests on lodgepole pine. However, a full report is being prepared, which will include the impact of pests on all tree species and will be available later in 2023. **Table 25** summarizes the overall impact of forest health agents affecting lodgepole pine in four biogeoclimatic zones. Tree mortality was significant in all BEC and the majority of living lodgepole were affected by one or more pests. Stand density was similar across all BEC and included a small percentage of L4 lodgepole pine.

*Table 25. Percentage of L1-L3 lodgepole pine that is dead, live, clear or affected by one or more forest health factors, stand structure and average density (stems per hectare, sph) in the 2022 Thompson Okanagan surveys.*

| 2022 Surveys | | | Percent (%) Pl (L1-L3) | | | | Avg. percent (%) of total trees | | | Avg. sph Pl | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BEC | Number of Surveys | Total L1-L3 | Dead | Live | Clear | Affected | Pl (L1-L3) | Pl (L4) | Other spp. (L1-L4) | (L1-L3) | (L4) |
| ESSF | 8 | 719 | 12.8 | 87.2 | 8.8 | 78.4 | 67.2 | 2.4 | 30.4 | 1,928 | 254 |
| ICH | 2 | 174 | 26.4 | 73.6 | 12.1 | 61.5 | 61.1 | 0.0 | 38.9 | 1,740 | 0 |
| IDF | 6 | 499 | 12.4 | 87.6 | 7.4 | 80.2 | 76.8 | 7.2 | 16.0 | 1,711 | 185 |
| MS | 44 | 3,657 | 17.6 | 82.4 | 7.7 | 74.8 | 72.7 | 5.3 | 22.0 | 1,739 | 194 |

In 2022, the average number of lodgepole pine pests identified per survey was 11.1 in the ESSF, 12.0 in the IDF, 13.5 in the MS, and 16.5 in the ICH biogeoclimatic zones. The average number of pests per tree recorded in the surveys ranged from 0.7 to 1.8. Not all pests have an equal impact or severity; however, the sheer variety and abundance recorded in this study is cause for concern. Warmer temperatures and increased rainfall in the spring could lead to shorter life cycles for insects and increased infection capabilities for foliar and stem diseases.

Of 6,700 assessed trees, 889 trees were recorded as dead when the surveys were conducted, which equates to 13.3% mortality overall. L1-L3 lodgepole pine comprised the majority of dead trees (673), with a further 168 L4 lodgepole pine dead. Significant mortality agents included deer browse, western gall rust, Comandra blister rust and Armillaria root disease. The L4 layer was also susceptible to vegetation competition. Armillaria root disease and deer browse were the most significant pests of the other species such as spruce, subalpine fir and Douglas-fir that were surveyed. Abiotic mortality factors included drought, hail, windthrow and snow press; however, they had less of an impact than the biotic factors in 2022, averaging 1.5% mortality. Snow press and windthrow affected primarily the larger trees, while drought had an equal impact on all trees, no matter what size. Significantly, mountain pine beetle and other secondary beetles caused a minor amount of mortality. In total, only 23 trees died from beetles, despite many trees being an adequate size for attack (**Table 25**).

Aside from mortality, the percent of stems affected by insects and disease was significant in all biogeoclimatic zones (**Figure 24**). **Figure 24** illustrates the differences in the prevalence of insects, disease and animal damage in L1-L2 and L3-L4 lodgepole pine. Some biogeoclimatic zones were more affected than were others. Some pests had a greater impact on older trees than on the younger cohort and vice versa. Some pests were present at similar levels no matter the tree age (**Figure 24**).


*Figure 24. Comparison of vegetation competition, deer browse, atropellis stem canker, lodgepole terminal weevil, western gall rust and comandra blister rust in the 2022 surveys for pest incidence, Thompson Okanagan Region.*

Results from these surveys reveal that the presence of insects and disease are an ongoing issue with regard to tree infestation, infection, mortality and form. Further investigation into regeneration schemes, stand tending practices, and harvesting systems will perhaps lead to healthier and more resilient future stands. This study will build upon the Ministry's growing database of pests that affect young stands and their development following the free growing assessment date. It should also shed light on the impact of changing climate conditions.

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*Multiple Pissodes terminalis attacks on lodgepole pine.*

*Pissodes terminalis pupa in pith.*

*Lodgepole pine with poor form caused by Pissodes terminalis attack.*

## Spruce Weevil Attack on Lodgepole Pine in the Kamloops TSA[16]

The post-mountain pine beetle (IBM) and wildfire landscape is comprised of extensive areas of young to mid-age regenerating lodgepole pine (Pl) and mixed species stands. Harvest and regeneration strategies have changed significantly since the 1980's IBM outbreak. Harvesting of the 2000's IBM damage was far more extensive and continuous. Where ecologically appropriate, species mixtures were promoted; however, there remains a vast area of mid-rotation lodgepole pine throughout the Thompson Okanagan Region and province. In the Kamloops TSA, interior spruce (Sx), whether planted or natural ingress, is the most common species growing with lodgepole pine.

In the past two decades, B.C.'s interior has been experiencing warmer and more erratic climate regimes. Due to the 2017 drought, many regenerating lodgepole pine stands were killed. More recently in 2021, an unprecedented heat dome affected the province. These climatic events negatively affect both young and old forests of all species and exacerbate the incidence and severity of many damage agents.

While assessing young pine stands in the Jamieson Creek area, north of Kamloops, we noticed spruce weevil, *Pissodes strobi* (Peck) (IWS) attack on some lodgepole pine. The affected stand was located in the MSdm3 (Montane Spruce dry, mild) and was about 20 years old, having been regenerated following the 2000's IBM outbreak. There were small patches of planted spruce as well as some natural ingress, with lodgepole pine comprising the major component of the stand. Spruce weevil attack on the spruce was very high, with most spruce having poor form, severe defects and multiple tops, all of which were attacked.

The spruce weevil, also known as the white pine weevil in the eastern portion of its range, attacks many species of spruce and pine including lodgepole pine (Turnquist and Alfaro 1996). However, records of it attacking lodgepole pine in B.C. are extremely rare.

On lodgepole pine, the spruce weevil oviposited in the one-year-old terminal, similar to its habit on spruce. When oviposition and larval feeding occurs on the previous year's growth, it kills two years of terminal growth. There were numerous chip cocoons and emergence holes visible on the pine leaders. Attack, brood production and survival appeared to be successful in the pine. The attacks caused severe defects and poor stem form on all affected trees. This damage differs from that of the lodgepole pine terminal weevil, *Pissodes terminalis* (Hopping), which oviposits and feeds solely on the current year's growth in lodgepole pine.

To quantify the level and extent of attack by spruce weevil on pine, we conducted surveys and walk-through assessments in similarly aged stands within the MSdm3 biogeozone in the Jamieson Creek and Community Lake areas, Kamloops TSA.

### Methods

We established ten 3.99 m circular plots within the initial stand (Jamieson Creek) where spruce weevil attack on lodgepole pine was discovered. Five plots (Attack Plot) had a *P. strobi*-attacked lodgepole pine as the centre point and five plots (Control Plot) were randomly located within the stand. Basic information was recorded for each tree within each plot, including defect and form (**Table 26**). In six other stands, we conducted a general walk-through to look for the presence of spruce weevil attack on lodgepole pine and spruce.

[16] Lorraine Maclauchlan, Thompson Okanagan Forest Entomologist

*Table 26. Defect and form tree descriptors for lodgepole pine and interior spruce attacked by Pissodes strobi.*

| Defect # | Defect* | Form # | Form | Tree description |
|---|---|---|---|---|
| 1 | crease | 1 | good | straight bole, small branches |
| 2 | crook | 2 | moderate | some defects, branchy |
| 3 | fork | 3 | poor | major stem defects, large branches |
| 4 | staghead | | | |

* The worst defect is recorded for IWS on Sx.

**Results and Discussion**

There was no significant difference (t-test; $p<0.05$) in stems per hectare, percent spruce or percent spruce attacked by spruce weevil in the attack plots *vs*. the control plots at Jamieson Creek. There was significantly more spruce weevil attack on lodgepole pine in the attack plots than in the control plots (t-test; $p<0.05$) (Table 2). Lodgepole pine terminal weevil and western gall rust, *Endocronartium harknessii* (J.P. Moore) Y. Hiratsuka, (DSG) were also present in the stand (**Table 27**). Of the 68 lodgepole pine assessed (all plots combined), only 1 pine (1.5%) had both spruce weevil and lodgepole pine terminal weevil attack. The average height of attack by spruce weevil on lodgepole pine was 1.6m, thus affecting the most valuable portion of the tree bole.

*Table 27. Results of 3.99 m plots showing the percent of spruce and lodgepole pine attacked by spruce weevil and the defect resulting on pine from spruce weevil (IWS) attack. The number of lodgepole pine with lodgepole pine terminal weevil (IWP) and western gall rust (DSG) is also shown for each plot.*

| | | | IWS attack | | | | | No. Pl | |
|---|---|---|---|---|---|---|---|---|---|
| Plot | # Pl | # Sx | # Sx | # Pl | % Sx | % Pl | Pl defect | IWP | DSG |
| Atk-1 | 4 | 6 | 5 | 1 | 83.3 | 25.0 | 3 | | |
| Atk-2 | 7 | 6 | 4 | 1 | 66.7 | 14.3 | 2 | 3 | 1 |
| Atk-3 | 8 | 3 | 1 | 1 | 33.3 | 12.5 | 2 | 3 | 3 |
| Atk-4 | 6 | 2 | | 2 | 0.0 | 33.3 | 1, 2 | 1 | 2 |
| Atk-5 | 5 | 3 | | 1 | 0.0 | 20.0 | 2 | | |
| Control-6 | 8 | 1 | | | 0.0 | 0.0 | | 2 | 1 |
| Control-7 | 13 | 2 | 1 | | 50.0 | 0.0 | | 1 | 2 |
| Control-8 | 8 | 5 | 4 | 1 | 80.0 | 12.5 | 2 | 1 | |
| Control-9 | 5 | 3 | 2 | | 66.7 | 0.0 | | 2 | 1 |
| Control-10 | 4 | 3 | 1 | | 33.3 | 0.0 | | 1 | |

Spruce weevil attack on spruce in Jamieson Creek averaged 37% in attack plots and 46% in control plots. By comparison, 21% of lodgepole pine had spruce weevil attack in attack plots, while fewer than 3% of pine stems were attacked in control plots. Most of the spruce in these stands had multiple attacks and multiple tops. Most of the spruce weevil attack on lodgepole pine occurred about 2017-2018. A few new attacks also occurred in 2021, coinciding with very high attack in spruce and three very hot, long summers.

*Spruce weevil attack on lodgepole pine.*

Additional walkthrough assessments were conducted in the Community Lake area, but no plots were established. Four of the six randomly selected stands had spruce weevil attack evident on the lodgepole pine. Once again, it seemed that 2017-2018 were the most predominant years for attack on pine. Two of the affected stands were in the IDFdk2 (Interior Douglas-fir dry, cool) and two were in the MSdm3 (**Table 28**). Lodgepole pine terminal weevil attack was high in all stands, particularly most recently, in 2021 (**Table 28**).

*Lodgepole pine terminal weevil-attacked leader.*

*Lodgepole pine terminal weevil larvae (top) and pupa (bottom) in leader.*

*Table 28. Observations from six walk-though assessments conducted July 15, 2022, in the Community Lake area.*

| Stand # | BEC | Elevation (m) | 2021 *P. terminalis* attack | *P. strobi* attack on Pl | Comments |
|---|---|---|---|---|---|
| 1 | IDFdk2/MSdm | 1,423 | high | no | DSG in stand |
| 2 | IDFdk2 | 1,408 | high | yes | 2017-2018 *P. strobi* atk. on Pl |
| 3 | IDFdk2 | 1,400 | moderate | yes | 2017-2018 *P. strobi* atk. on Pl |
| 4 | IDFdk2 | 1,398 | high | no | |
| 5 | MSdm3 | 1,268 | high | yes | |
| 6 | MSdm3 | 1,282 | high | yes | |

Evidence from these surveys suggests that spruce weevil attack on lodgepole pine may be more common than previously thought. The attacks seemed to occur during or after particularly warm and dry growing seasons. Attack incidence by spruce weevil was high in these stands and given the longer developmental time available, brood can easily develop from egg to adult in one season (McMullen 1976). Therefore, the possibility exists for IWS populations to increase rapidly. However, because these stands are predominantly lodgepole pine, with only low levels of interior spruce, emerging weevils may resort to attacking lodgepole pine more frequently. More surveys should be conducted to determine the extent and frequency of this phenomenon.

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## Establishment of Balsam Woolly Adelgid, *Adelges piceae* (Ratzeburg), Impact Plot Assessment in Southeastern British Columbia[17]

Balsam woolly adelgid (IAB) is a lethal invasive insect that primarily kills subalpine fir. Subalpine fir is a key component in the timber harvesting land base and critical forest ecosystems, especially in the high elevation (E.g. caribou habitat, goshawk, etc.). Models predict that tree mortality will increase with climate change and an introduced mortality agent will exacerbate this process. It is imperative to understand the immediate risk and outcomes for subalpine fir ecosystems in the short and long terms. This project aligns with Provincial and Regional priorities for old growth management, habitat values for endangered species and timber supply for a major commercial species, especially in northern BC. The specific links to policy include ecosystem habitat values and old growth and alternative timber supply beyond spruce and pine.

### Introduction

Balsam woolly adelgid, *Adelges piceae* (Ratzeburg) (IAB), is a tiny, lethal invasive sap-feeding insect that was introduced to North America from Europe in the early 1900s, to the Northeastern United States and Southeastern Canada, with introductions into British Columbia in the 1950s (Ragenovich & Mitchell 2006). This pest was first noticed by the Forest Insect and Disease Surveys (FIDS) conducted by the Canadian Forestry Service north of Vancouver in 1958 (Harris and Dawson 1979). In British Columbia, IAB is widespread on the south Coast, Lower Mainland and along the East Coast of Vancouver Island with reports in BC's interior more recently in 2018, including east to Nelson and north to Horsefly (https://bcinvasives.ca/invasives/balsam-wooly-adelgid/). Range expansion is expected to continue especially in subalpine fir forests, which are particularly susceptible to this pest.

IAB hosts include all true firs, with susceptibility ranging from highly sensitive to resistant. In western North America, infestations occur mainly on subalpine fir (*Abies lasiocarpa* (Hook.), Pacific silver fir (*A. amabilis* (Dougl.) and grand fir (*A. grandis*) (Dougl.) in Oregon, Washington, Idaho and British Columbia (Ragenovich & Mitchell 2006), with *A. lasiocarpa* suffering the most damage, followed by *A. amabilis*, and *A. grandis* being the least susceptible to damage (Turnquist & Harris 1993). Host species in Europe are resistant and Asian firs are intermediate in susceptibility, with some being damaged while others are resistant (Ragenovich & Mitchell 2006). Previous infestations in the 1950s and 1960s in BC have caused extensive damage and mortality to *A. amabilis* and to a lesser degree *A. grandis* (Turnquist & Harris 1993). Infestations are most frequently located on moderately exposed boles along roadsides, trails, edges of logging or natural stand openings (Turnquist & Harris 1993).

Symptoms of attacks include two types of infestations: shoot or bole.

Shoot Infestations

Shoot infestations results in swelling or gouting of branch nodes and buds caused by the injection of toxic salvia resulting in exaggerated cell growth in the bark and cambium (abnormal cell division and malformed cells) (Balch 1952). Specifically, the xylem tissue of infestation trees contain a higher concentration of ray tissues and thickened cell walls resulting in reduced water flow and photosynthesis (Mitchell 1967). Thinning crowns, stunting of terminal growth as shown by the flattening appearance of

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the crown, top kill and reduced cone and seed production are all symptoms of shoot infestations (Ragenovich & Mitchell 2006).

Bole infestations

The more serious type of IAB attack is infestation along the main bole where populations can reach densities of 100 to 200 adelgids per square inch of bark surface (Ragenovich & Mitchell 2006). Bole infestations symptoms include yellowing of foliage, needle loss, irregular growth rings similar to compression wood, growth reductions upward of 50% and possibly tree mortality within two to three years with heavy infestations, as a result of disruptions of water conduction to the crown (Balch 1952; Ragenovich & Mitchell 2006). Gouting symptoms are usually not present in conjunction with stem infestations because of the short period of infestation prior to tree death. Some trees have been observed to have both gouting and stem attacks on the same tree, indicating that these trees can often survive with stem attacks for a decade or more (Ragenovich & Mitchell 2006). Severely affected trees are unsuitable for lumber due to uneven shrinkage and inferior quality pulp (Page 1975; Milne 1990).

All tree sizes, ages and vigor are susceptible to IAB attack. Larger trees are the most vulnerable, however understory trees are often an indication of the infestation occurring in the stand above (Turnquist & Harris 1993). Bole infestations tend to be present on the best growing sites with shoot attack occurring often on the poorer sites (Ragenovich & Mitchell 2006).

**Secondary forest health factors**

Secondary forest health factors such as bark beetles, particularly western balsam bark beetle, *Dryocoetes confusus* (Swaine) may expedite tree morality, turning the crown red so that it is clearly visible from the air (Turnquist & Harris 1993). As well, infestations of IAB may predispose trees to infection by root disease such as *Armillaria mellea* (Cah ex Fr.) Kummer (Hudak and Singh 1970). In eastern Canada, infestation by IAB has shown to affect defoliator populations of eastern spruce budworm, Chorist*oneura fumiferana* (Clem.) as attacked trees' physiology, morphology, growth, and chemistry are affected (Grégoire *et al.* 2015). It was shown that budworm larval weight was reduced when feeding on IAB infested trees (Grégoire *et al.* 2015). The same might be true for two-year cycle budworm, *Choristoneura biennis* (Freeman) in the west but has not been studied to date. Lepidopteran borers can also cause nodal swellings, but this damage can be identified by cutting the node to expose the larval mine (Turnquist & Harris 1993).

**Life cycle**

IAB life cycle consists of egg, three larval instars and adult female stages (Hain 1988). This insect is parthenogenic, meaning that the population is entirely comprised of females that do not need to mate to reproduce, allowing populations to increase exponentially (Ragenovich & Mitchell 2006). Upwards of 250 egg per female are oviposited (Hain 1988). The adult insects are very tiny (1mm) covered in a thick mass of waxy wool like material providing protection to eggs and adults. The first larval instar called "crawler" stage is the only mobile stage and is capable of crawling upwards of 30 meters (Turnquist & Harris 1993). Dispersal is achieved by contact with birds or other animals, wind, or transport of infested material. These insects can be disbursed by infested nursery stock, seedlings, Christmas trees, firewood or other infested tree products. The crawler stage inserts its piercing mouth parts into the bark injecting toxic salvia into its host. After insertion, the crawler stage, remains stationary for the remainder of its life cycle feeding throughout the summer. There are two to four generations per year dependant on location and elevation. Two generations per year are common in the mountainous west region of the United States and likely Canada (Ragenovich & Mitchell 2006). The overwintering stage is a dormant larval instar (or nymph) which resumes feeding in the spring, moulting two more times prior to becoming an adult.

**Materials and Methods**

Impact Plots

The study area is in Southern British Columbia between Greenwood and Rossland where three permanent sample impact plots were established in areas of historically know IAB populations between September 20-22, 2022. The aim was to establish a baseline and then re-measure these plots over time to allow predictions in rates of insect impacts and provide inferences to the potential impacts as IAB distribution progresses east and north within BC.

The three sites established include Jewel Lake near Greenwood (49.2$^0$N, -118.6$^0$W), Phoenix Ski Hill (Gibbs Creek FSR) (49.1$^0$N, -118.6$^0$W) near Grand Forks and Rossland (49.1$^0$N, -117.8$^0$W) all in the Kootenay Boundary Region in southern British Columbia. All plots contained a component of subalpine fir in the species mix, but several other tree species were present including western cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), Douglas-fir (*Pseudotsuga menziesii*), trembling aspen (*Populus tremuloides*) and interior spruce (*Picea engelmannii x glauca*). Elevations ranged from 997 meters at the Jewel Lake plot, to 1,118 meters for the Rossland site, to 1123 meters at the Phoenix Skill Hill plot near Grand Forks.

Infestation Data

Data captured for each site includes the timber supply area (TSA), date established, species composition, general UTMs, elevation (m), aspect, slope percentage, geographical location, access notes, and comments. A total of 20 sample trees per site were tagged with aluminum tree nails and plastic numbered tree tags at either diameter at beast height (DBH) or the base of the tree if the area had heavy recreational use. Data recorded for each sample tree within the plot included; tree number, UTMs, tree species, status of tree (live/ dead), DBH (cm to nearest 0.1 cm), presence of cottony tufts broken down into five categories based on percent of bole infested (very low or trace (VL=<1), low (L=>1-10), moderate (M=>10-30), high (H=>30-50), very high (VH=>50)), IAB symptoms including yellow needles, needle loss, red crown, swelling at branch nodes or terminal buds, flat tops, overall attack levels, presence of any other forest health factors and general comments. All sample trees were live subalpine fir as no other tree species were affected in the plots.

**Results**

Bole Infestations

The Jewel Lake site had the highest levels of cottony tuft symptoms covering the bole of the trees, with 50% of the sample trees having over 30% of their bole infested, followed by Phoenix Ski hill at 25% and lastly Rossland where no samples were over only trace amounts of infest (**Figure 25**).

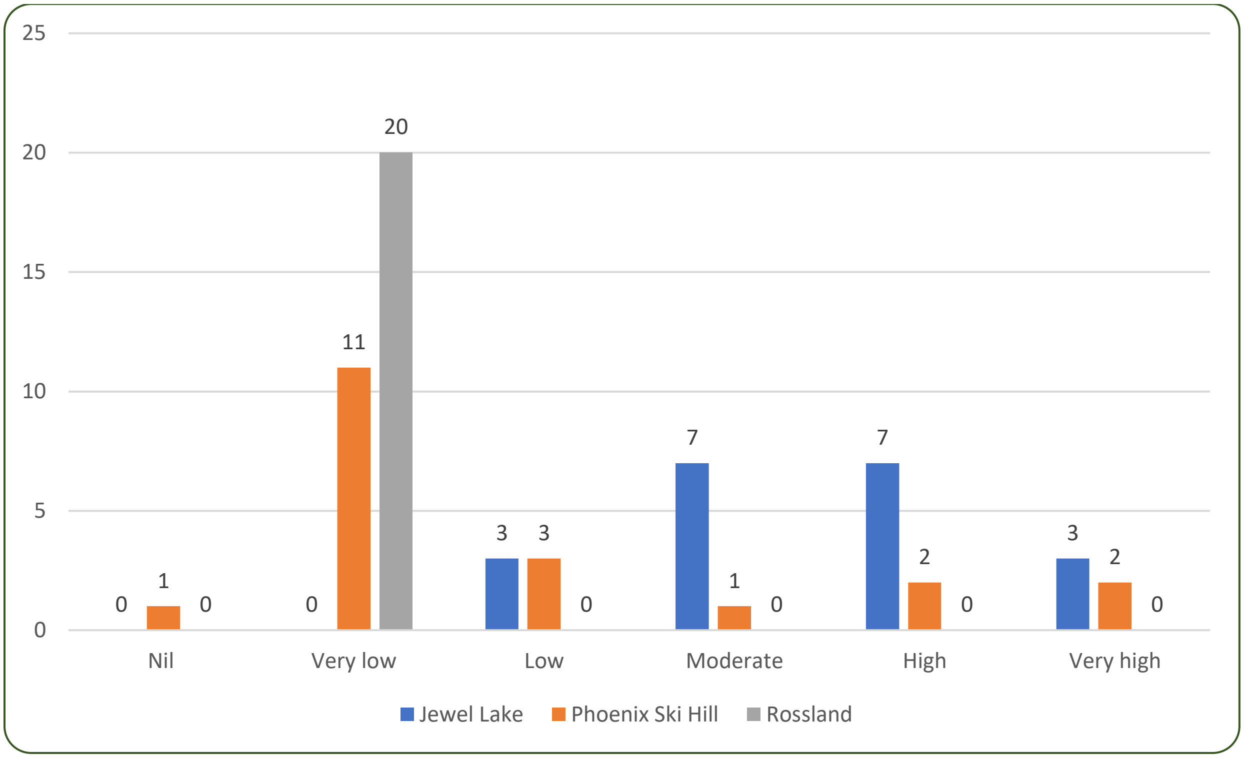


*Figure 25. Number of sample trees in each category by site containing bole infestations (i.e. cottony tuft symptoms).*

*Figure 26. Very high (>50% bole coverage) levels of bole infestations (Jewel Lake site, September 20, 2022).*


*Figure 27. High (30-50% bole coverage) levels of bole infestations (Phoenix Ski Hill Site, September 21, 2022).*

A high level of subalpine fir mortality was observed in the Rossland field site as shown in **Figure 29**.


***Figure 28. Very low or trace (<1% bole coverage) levels of bole infestations (Rossland Site, September 21, 2022).***

***Figure 29. Subalpine fir mortality of overmature trees in the Rossland field site (September 22, 2022).***

<u>Stem infestations</u>

Very few stem infestations were noted in the overstory trees in each of the three impact sites. However, subalpine fir understory was greatly affected, displaying symptoms such as gouting of buds and branch nodes as shown in the following **Figure 30**.

**Discussion**

<u>Stem infestations</u>

Very few stem infestations were observed in the dominant trees in each of the three impact sites. Stem infestations take years to develop, therefore it is likely that trees infested by bole attack were outright killed before they had time to develop symptoms of stem infestations. It was difficult to confirm this hypothesis since symptoms of bole attack (i.e. cottony tufts) on dead trees were no longer present. Ideally, additional sites in the initial stages of attack would be sampled to test this theory.

The level of gouting on understory trees was significantly higher than on dominant (overstory) trees similar to findings reported by Guillet *et al.* 2012. However, the focus of this study was dominant trees, so future studies should also include a sub-plot of the understory trees for a full assessment.

*Figure 30. Bud and branch node gouting on understory subalpine fir (Rossland site, September 22, 2022).*

Bole infestations

Bole infestation levels varied greatly between the three sites, indicating a timeline of introduction of balsam woolly adelgid to the stand, with the Jewel Lake site having the highest levels, followed by Phoenix Ski Hill and finally Rossland. This makes sense from a dispersal standpoint as the geographic locations of these sites runs west to east, corresponding with the eastern spread of this invasive insect across southern BC.

These impact plots will need to be re-measured to gain understanding of population pressure changes and impacts to the individual trees within the targeted stands.

**Management and Control**

Direct Control

Direct control with pesticides is impractical because IAB is protected by their woolly covering and feed in protected sites (Turnquist & Harris 1993). At this time, no pesticides are registered for use against IAB.

Biological Control

There are no known parasites but many generalist predators of IAB in North America (Ragenovich & Mitchell 2006). These generalist feeders are unreliable as control agents as they do not concentrate on the adelgid populations or react to increases in populations. Between 1960 and 1969, a predator release program consisting of eight species of exotic predators from Europe and Asia was initiated along the south coast of British Columbia (Harris and Dawson 1979).

Ten years later, four species including *Laricobius erichsonii* Rosen, *Pullus impexus* (Muls.), *Aphidoletes thompsoni* Mohn and *Cremifania nigrocellulata* Cz. were still found and the combination of these and native species reduced or eliminated bole infestations but did not reduce the tree damage related to stem infestations (Harris and Dawson 1979).

Climate/ Stand and Host Susceptibility

Weather is an important factor in adelgid survival particularly in the northern latitudes and higher elevations. Subalpine fir growing close to the timberline may not be as affected as trees at lower elevations because there is not enough heat accumulation for the insects to complete a second generation (Ragenovich & Mitchell 2006). Winter temperatures effect overwintering survival limited damage in colder regions in New Brunswick, where January temperatures were colder than -11ºC (Greenback 1970; Quiring *et al.* 2008) and Greenback (1970) reported that there was an 80 percent mortality rate for IAB when exposed to -34ºC for 24 hours. As we experience increases in global temperatures, we would expect to see greater survival of IAB in novel locations as the insect spreads.

Stand and host susceptibility appear to be related to environmental factors such as elevation, stand age, and site conditions (Ragenovich & Mitchell 2006). Grand fir is susceptible at low elevations but rarely attacked at higher elevations, while Pacific sliver fir and subalpine fir experience severe infestations at low elevations. At higher elevations subalpine fir experience heavy infestations, but adjacent Pacific sliver fir is rarely attacked (Ragenovich & Mitchell 2006).

Site, crown class and their interaction, along with shoot length are factors associated with tree gouting symptoms (Guillet *et al.* 2012).

Policy

In 1976, a regulation zone was created to stop the movement of infested material outside of the quarantine zone. October 22, 1992, a provincial Order in Council, expanded the zone to include most of the southern portion of the Coast Forest Region (Turnquist & Harris 1993). Included in the regulations were annual permits to grow and sell *Abies* spp. in British Columbia. The regulations prohibited the movement of *Abies* spp. from within to outside of the zone with only logs transported and stored in water and processed promptly being exempted from these regulations. The regulations also prohibited selling or movement of cut trees or foliage of *Abies* spp. anywhere in BC between January 31 and November 1.

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# Appendix A: Forest Health Damage Summary Tables for the South Area

*Table 29. Area affected (points and polygons) by damaging agents in the southern interior in 2022 by Timber Supply Area.*

| Timber Supply Area and Damaging Agent | Area of infestation (ha) | | | | |
|---|---|---|---|---|---|
| | Trace | Light | Moderate | Severe | Total |
| **Douglas-fir beetle** | | | | | |
| 100 Mile House | 6,422 | 288 | 24 | 218 | 6,953 |
| Quesnel | | | | 6 | 6 |
| Williams Lake | 10,881 | 856 | 257 | 340 | 12,334 |
| Arrow | 656 | 3,740 | 880 | 79 | 5,355 |
| Boundary | 297 | 1,218 | 367 | 53 | 1,935 |
| Cascadia | | 176 | | 3 | 179 |
| Cranbrook | 1,118 | 1,782 | 1,407 | 72 | 4,379 |
| Golden | 125 | 374 | 90 | 10 | 599 |
| Invermere | 309 | 1,052 | 115 | 33 | 1,508 |
| Kootenay Lake | 369 | 896 | 301 | 21 | 1,587 |
| Revelstoke | 163 | 140 | | 3 | 306 |
| Kamloops | 3,269 | 793 | 449 | 356 | 4,867 |
| Lillooet | 174 | 12 | | 58 | 243 |
| Merritt | 762 | 23 | | 88 | 874 |
| Okanagan | 3,090 | 388 | 211 | 279 | 3,967 |
| **Total** | **27,634** | **11,740** | **4,101** | **1,617** | **45,092** |
| **Spruce beetle** | | | | | |
| Quesnel | 8,864 | 10,217 | | 9 | 19,089 |
| Williams Lake | 2,059 | 376 | | 12 | 2,447 |
| Cascadia | 283 | | | 1 | 284 |
| Cranbrook | | 2,159 | 1,440 | | 3,599 |
| Golden | | 205 | 143 | | 348 |
| Invermere | 166 | 1,047 | 261 | 2 | 1,476 |
| Kootenay Lake | | 138 | 523 | | 661 |
| Kamloops | 456 | | 1 | 7 | 464 |
| Lillooet | 3,385 | 825 | 72 | 29 | 4,312 |
| Merritt | 65 | 24 | | 2 | 92 |
| Okanagan | | | | 2 | 2 |
| **Total** | **15,278** | **14,992** | **2,440** | **62** | **32,773** |

**Table 29** Continued

| Timber Supply Area and Damaging Agent | Area of infestation (ha) | | | | |
|---|---|---|---|---|---|
| | Trace | Light | Moderate | Severe | Total |
| **Mountain pine beetle** | | | | | |
| Quesnel | | | | 1 | 1 |
| Williams Lake | 30,525 | 2,221 | 110 | 62 | 32,918 |
| Arrow | | 70 | 16 | 4 | 90 |
| Boundary | 53 | 146 | 13 | 7 | 218 |
| Cranbrook | 160 | 593 | 285 | 54 | 1,091 |
| Golden | | | | <1 | <1 |
| Invermere | 538 | 1,896 | 1,152 | 44 | 3,629 |
| Kootenay Lake | 81 | 319 | | 19 | 420 |
| Revelstoke | 136 | | | | 136 |
| Kamloops | | | | 1 | 1 |
| Lillooet | 5,006 | 1,326 | 41 | 41 | 6,413 |
| Merritt | 74 | | | 4 | 78 |
| Okanagan | <1 | | | 4 | 4 |
| **Total** | **36,573** | **6,570** | **1,616** | **240** | **44,999** |
| **Western balsam bark beetle** | | | | | |
| 100 Mile House | 75 | 119 | 0 | 19 | 213 |
| Quesnel | 13,790 | 14,580 | 0 | 65 | 28,434 |
| Williams Lake | 23,059 | 1,381 | 47 | 126 | 24,613 |
| Arrow | 617 | 339 | 327 | 11 | 1,295 |
| Boundary | 886 | 44 | 0 | 8 | 937 |
| Cascadia | 9,609 | 1,262 | 0 | 9 | 10,880 |
| Cranbrook | 2,831 | 6,166 | 872 | 27 | 9,896 |
| Golden | 6,931 | 4,511 | 334 | 14 | 11,790 |
| Invermere | 5,993 | 6,242 | 536 | 17 | 12,787 |
| Kootenay Lake | 2,469 | 809 | 0 | 14 | 3,292 |
| Revelstoke | 446 | 212 | 0 | 3 | 661 |
| Kamloops | 25,093 | 2,626 | 21 | 196 | 27,936 |
| Lillooet | 8,344 | 1,971 | 21 | 71 | 10,406 |
| Merritt | 4,248 | 36 | 3 | 50 | 4,337 |
| Okanagan | 19,954 | 890 | 30 | 134 | 21,009 |
| **Total** | **124,344** | **41,187** | **2,190** | **761** | **168,483** |
| **Western pine beetle** | | | | | |
| Arrow | | | | 0.5 | 0.5 |
| Kootenay Lake | | | | 0.3 | 0.3 |
| Lillooet | | | | 0.3 | 0.3 |
| Okanagan | | | | 2.5 | 2.5 |
| **Total** | | | | **3.5** | **3.5** |

**Table 29** Continued

| Timber Supply Area and Damaging Agent | Area of infestation (ha) | | | | |
|---|---|---|---|---|---|
| | Trace | Light | Moderate | Severe | Total |
| **Western spruce budworm** | | | | | |
| 100 Mile House | | 4,682 | 40,039 | 16 | 44,737 |
| Williams Lake | | 21,116 | 51,103 | 353 | 72,571 |
| Kamloops | | 426 | | | 426 |
| Lillooet | | 2,513 | 5,285 | | 7,798 |
| Merritt | | 6,407 | 167 | | 6,574 |
| Okanagan | | 4,137 | 866 | 39 | 5,042 |
| **Total** | | **39,281** | **97,460** | **408** | **137,149** |
| **Two-year cycle budworm** | | | | | |
| 100 Mile House | | 619 | 9,143 | | 9,762 |
| Williams Lake | | 26 | | | 26 |
| Kamloops | 17 | 6,831 | 4,938 | | 11,786 |
| Merritt | | | 1,100 | | 1,100 |
| **Total** | **17** | **7,476** | **15,181** | **0** | **22,674** |
| **Western hemlock looper** | | | | | |
| Williams Lake | | 260 | 1,725 | | 1,985 |
| Arrow | | 2,488 | 3,669 | 353 | 6,511 |
| Cascadia | | 1,060 | 1,646 | 437 | 3,143 |
| Cranbrook | | 202 | 17 | | 219 |
| Golden | | 2,531 | 744 | | 3,275 |
| Kootenay Lake | | 2,136 | 2,054 | 187 | 4,377 |
| Revelstoke | | 3,515 | 2,994 | | 6,509 |
| Kamloops | | | 64 | 107 | 171 |
| Okanagan | | 6,909 | 2,361 | 1,007 | 10,277 |
| **Total** | | **19,102** | **15,275** | **2,090** | **36,467** |
| **Aspen serpentine leafminer** | | | | | |
| 100 Mile House | | 1,521 | 101 | | 1,622 |
| Quesnel | | 1,504 | 2,033 | 231 | 3,768 |
| Williams Lake | | 10,059 | 326 | | 10,385 |
| Arrow | | 76 | | | 76 |
| Boundary | | 388 | 149 | | 537 |
| Cranbrook | | 2,328 | 45 | | 2,374 |
| Golden | | 615 | 235 | | 850 |
| Invermere | | 80 | | | 80 |
| Kootenay Lake | | 29 | | <1 | 30 |
| Revelstoke | | 386 | 929 | | 1,314 |
| Kamloops | 4 | 6,960 | 11 | | 6,975 |
| Merritt | | 330 | 36 | 1 | 368 |
| Okanagan | | 140 | 6 | | 147 |
| **Total** | **4** | **24,419** | **3,871** | **232** | **28,526** |

**Table 29** Continued

| Timber Supply Area and Damaging Agent | Area of infestation (ha) | | | | |
|---|---|---|---|---|---|
| | Trace | Light | Moderate | Severe | Total |
| **Satin moth** | | | | | |
| Kamloops | | 1 | | 2 | 2 |
| Merritt | | 3 | 53 | 3 | 60 |
| Okanagan | | | 9 | 0 | 9 |
| **Total** | | **4** | **62** | **5** | **71** |
| **Pine needle sheathminer** | | | | | |
| 100 Mile House | | | | 4 | 4 |
| Williams Lake | | | | 41 | 41 |
| **Total** | | | | **45** | **45** |
| **Douglas-fir tussock moth** | | | | | |
| Williams Lake | | **68** | | | **68** |
| **Drought - general, foliage loss** | | | | | |
| 100 Mile House | | 11 | | | 11 |
| Williams Lake | | 6 | 115 | 246 | 367 |
| Okanagan | | | 14 | 1 | 14 |
| **Total** | | **17** | **129** | **247** | **392** |
| **Drought – mortality** | | | | | |
| 100 Mile House | | | | 3 | 3 |
| Williams Lake | | | | 1 | 1 |
| Okanagan | | 27 | | <1 | 28 |
| **Total** | | **27** | **0** | **5** | **32** |
| **Post fire mortality** | | | | | |
| 100 Mile House | | 181 | 407 | 70 | 659 |
| Quesnel | | 341 | 6 | 58 | 405 |
| Williams Lake | | | 83 | 15 | 98 |
| Boundary | | | | 266 | 266 |
| Cranbrook | | | 14 | | 14 |
| Invermere | | | 147 | | 147 |
| Kootenay Lake | | | 50 | 44 | 94 |
| Kamloops | | 5 | | 10 | 15 |
| Merritt | | 46 | 2 | 3 | 52 |
| Okanagan | | 7 | | 30 | 37 |
| **Total** | | **580** | **710** | **496** | **1,786** |

**Table 29** Continued

| Timber Supply Area and Damaging Agent | Area of infestation (ha) | | | | |
|---|---|---|---|---|---|
| | Trace | Light | Moderate | Severe | Total |
| **Flooding** | | | | | |
| 100 Mile House | | 16 | 33 | 337 | 385 |
| Quesnel | | | | 74 | 74 |
| Williams Lake | | 22 | 99 | 1,604 | 1,724 |
| Cranbrook | | | 15 | | 15 |
| Kamloops | | | | 5 | 5 |
| Merritt | | | | 1 | 1 |
| Okanagan | | 1 | | 13 | 14 |
| **Total** | | **38** | **146** | **2,034** | **2,219** |
| **Windthrow** | | | | | |
| Arrow | | | | 6 | 6 |
| Invermere | | 49 | | | 49 |
| Kootenay Lake | | 36 | | | 36 |
| Revelstoke | | | | 10 | 10 |
| Lillooet | | 12 | | | 12 |
| **Total** | | **97** | | **16** | **114** |
| **Aspen decline** | | | | | |
| 100 Mile House | | 173 | 44 | 2 | 219 |
| Williams Lake | | 47 | 50 | 4 | 102 |
| Kamloops | | 28 | 13 | | 41 |
| Merritt | | 21 | | | 21 |
| Okanagan | | | 4 | | 4 |
| **Total** | | **270** | **111** | **7** | **387** |
| **Bear damage** | | | | | |
| 100 Mile House | 90 | | 0 | | 90 |
| Williams Lake | 40 | | | 1 | 41 |
| Cranbrook | | 43 | 0 | 0 | 43 |
| Golden | | 72 | 0 | 0 | 72 |
| Kamloops | | 2 | 0 | 1 | 3 |
| Merritt[1] | 11 | 32 | 0 | 2 | 45 |
| Okanagan | 16 | 16 | 0 | 1 | 33 |
| **Total** | **158** | **165** | **0** | **4** | **327** |
| **Cedar flagging** | | | | | |
| Arrow | | 1,218 | 1,037 | 875 | 3,130 |
| Cascadia | | 618 | 278 | | 897 |
| Cranbrook | | 389 | 16 | | 405 |
| Kootenay Lake | | 1,878 | 3,164 | 702 | 5,744 |
| Revelstoke | | 1,710 | 2,181 | 76 | 3,967 |
| **Total** | | **5,812** | **6,677** | **1,653** | **14,142** |

**Table 29** Continued

| Timber Supply Area and Damaging Agent | Area of infestation (ha) | | | | |
|---|---|---|---|---|---|
| | Trace | Light | Moderate | Severe | Total |
| **Disease (unknown)** | | | | | |
| Cascadia | | **9** | | | **9** |
| **Larch needle blight** | | | | | |
| Arrow | | 222 | 79 | | 301 |
| Boundary | | 61 | 39 | 8 | 108 |
| Cranbrook | | 42 | 71 | | 113 |
| Kootenay Lake | | 572 | 583 | | 1,155 |
| **Total** | | **898** | **771** | **8** | **1,677** |
| **Dothistroma needle blight** | | | | | |
| Cascadia | | 27 | | | 27 |
| Quesnel | | | | 72 | 72 |
| **Total** | | **27** | | **72** | **99** |