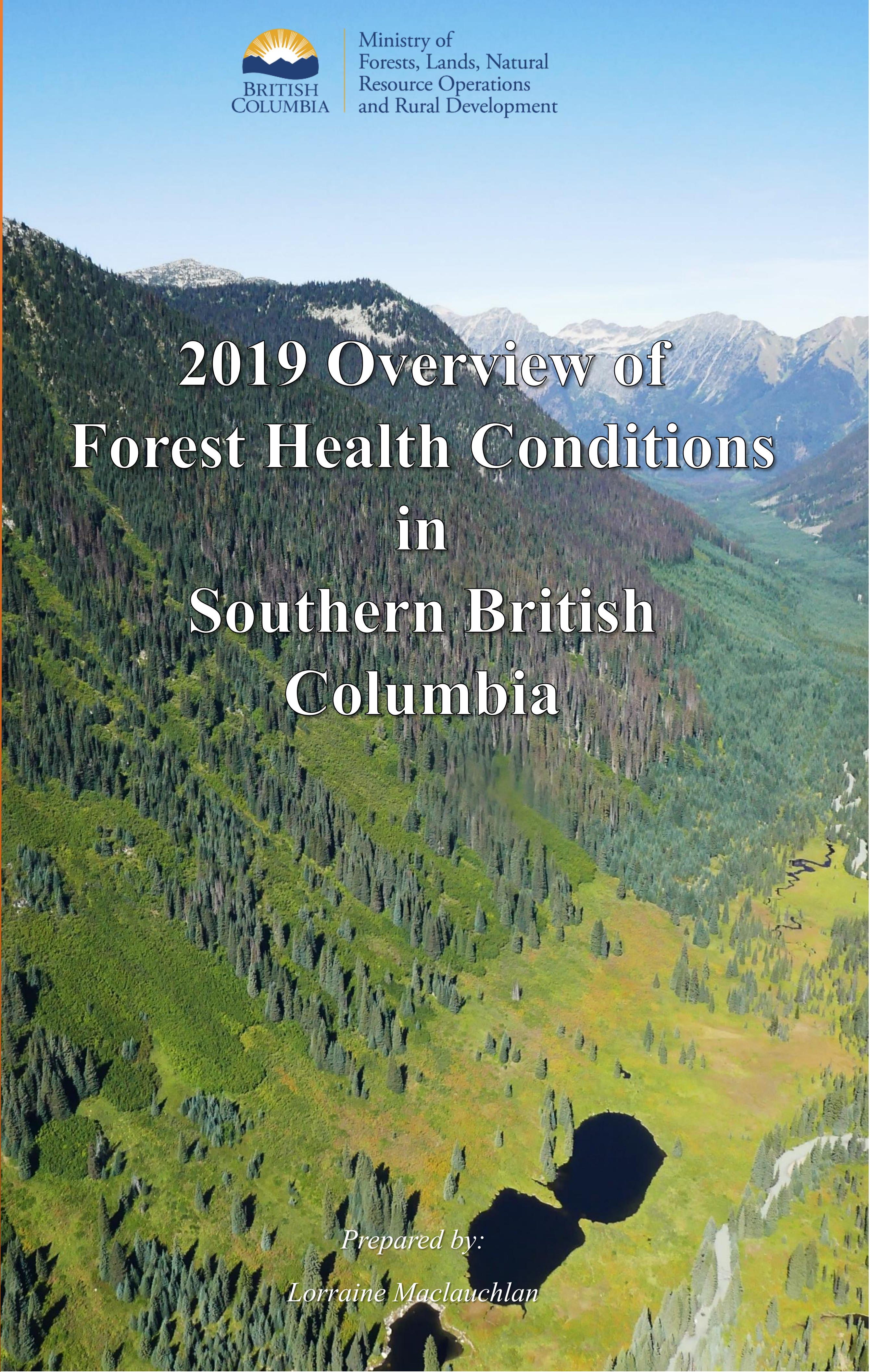

BRITISH COLUMBIA
Ministry of Forests, Lands, Natural Resource Operations and Rural Development

2019 Overview of Forest Health Conditions in Southern British Columbia

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Table of Contents

INTRODUCTION

This report summarizes the results of the 2019 Aerial Overview Surveys, forest health operations, and research projects conducted in the southern interior of British Columbia. The aerial overview survey is performed annually by the B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development and details forest damage due to bark beetles, defoliators, and other visible forest health factors, such as foliar diseases and abiotic damage. Surveys were carried out using the standardized Provincial Aerial Overview Survey protocols (*http://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys/methods*). Polygons are used to record larger areas of continuous damage and are assigned severity ratings as described in Table 1. Spots are used to record small, discrete groups of affected trees.

The 2019 surveys were completed between June 23rd and September 5th. In general, flying conditions were much more favorable in 2019 with clearer air quality due to fewer forest fires. A total of 249.6 hours of fixed-wing aircraft flying time over 47 days were required to complete the surveys, which covered all areas within the Cariboo, Thompson Okanagan, and Kootenay Boundary Natural Resource Regions. These three Regions cover more than 25 million hectares, of which over 15 million hectares are forested.

Approximately 1,016,993 hectares of damage were mapped over 14 TSAs during the 2019 surveys. Bark beetle infestations expanded slightly to 487,056 hectares, while defoliators decreased minimally to 355,298 hectares, mainly due to 2019 being the "off year" in the feeding cycle of the decline of some deciduous leafminers.

Abiotic damage was mapped on 170,202 hectares and included drought, post-wildfire mortality, cedar flagging and other minor issues. Drought foliar damage and mortality declined throughout the interior due to the moist summer but post-wildfire mortality, affecting 73,784 hectares primarily in the Cariboo Region, increased significantly.

Foliar disease activity declined slightly, with the total area mapped being just 3,409 hectares. Larch needle blight was the most prevalent, at 2,122 hectares mapped, mostly in the Cranbrook TSA. There were very few wildfires in 2019, which are tracked by the B.C. Wildfire Management Branch, damaging only 4,513 hectares.

Table 1. Severity ratings used in the aerial overview surveys.

Disturbance Type	Severity Class	Description
Tree mortality (including bark beetles, abiotic factors, and animal damage)	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
	Very Severe	50%+ of trees in the stand recently killed
Defoliation* (including defoliating insect and foliar disease 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.

* Serpentine leafminer defoliation is rated according to the percentage of trees in the stand that are affected, based on tree mortality classes.

Severe defoliation near Dog Creek by Douglas-fir tussock moth

Douglas-fir beetle attack, Mammit Lake,Merritt TSA

Table 2. Area affected by damaging agents in the southern interior in 2019.

Timber Supply Area	Area of infestation (hectares)					
and Damaging Agent	**Trace**	**Light**	**Moderate**	**Severe**	**Very Severe**	**Total**
Douglas-fir beetle						
100 Mile House	9,588	820	1,471	393	0	12,272
Quesnel	1,485	760	338	0	0	2,582
Williams Lake	38,639	13,164	2,259	479	0	54,541
Arrow	263	1,233	829	0	0	2,324
Boundary	217	548	327	9	0	1,101
Cranbrook	123	293	110	0	0	526
Golden	0	0	159	15	0	174
Invermere	182	560	645	57	0	1,443
Kootenay Lake	36	425	497	19	0	977
Revelstoke	9	153	95	0	0	258
Kamloops	372	857	1,109	688	84	3,110
Lillooet	0	58	70	51	9	188
Merritt	0	156	145	102	4	407
Okanagan	168	927	931	237	24	2,288
Total	**51,082**	**19,953**	**8,984**	**2,050**	**120**	**82,190**
Spruce beetle						
Quesnel	1,793	337	0	0	0	2,130
Williams Lake	3,386	3,391	1,645	49	0	8,472
Arrow	58	235	118	17	0	428
Cranbrook	142	254	1,041	2,273	235	3,945
Golden	271	310	1,111	129	0	1,822
Invermere	18	1,613	1,835	214	379	4,059
Kootenay Lake	41	111	311	647	0	1,110
Revelstoke	123	27	27	0	0	177
Kamloops	0	2,425	1,967	622	0	5,013
Lillooet	681	500	1,247	682	12	3,122
Okanagan	114	0	0	0	0	114
Total	**6,625**	**9,205**	**9,301**	**4,635**	**626**	**30,391**
Mountain pine beetle						
Quesnel	0	60	0	0	0	60
Williams Lake	15,301	20,413	6,172	688	0	42,575
Arrow	574	290	172	0	0	1,036
Boundary	641	209	42	0	0	892
Cranbrook	500	630	184	0	0	1,313
Golden	218	129	220	45	186	797
Invermere	968	1,552	2,958	517	17	6,012
Kootenay Lake	719	1,474	1,189	127	0	3,509
Revelstoke	47	67	148	0	0	262
Lillooet	697	4,016	1,876	159	0	6,747
Okanagan	2	44	0	0	0	46
Total	**19,667**	**28,884**	**12,960**	**1,536**	**203**	**63,249**

Timber Supply Area	Area of infestation (hectares)					
and Damaging Agent	Trace	Light	Moderate	Severe	Very Severe	Total
Western balsam bark beetle						
100 Mile House	3,876	31	85	0	0	3,993
Quesnel	53,876	1,070	0	0	0	54,946
Williams Lake	64,949	5,430	658	47	0	71,084
Arrow	6,273	885	0	0	0	7,158
Boundary	1,678	0	0	0	0	1,678
Cranbrook	4,833	3,052	1,023	0	0	8,908
Golden	3,765	5,956	1,314	6	0	11,042
Invermere	7,872	5,583	1,991	60	0	15,506
Kootenay Lake	6,579	1,870	64	0	0	8,513
Revelstoke	4,317	1,019	14	0	0	5,351
Kamloops	51,826	5,367	36	200	0	57,429
Lillooet	14,839	742	27	89	0	15,697
Merritt	7,439	70	0	49	0	7,557
Okanagan	41,949	351	0	63	0	42,362
Total	**274,072**	**31,424**	**5,215**	**514**	**0**	**311,225**
Western spruce budworm						
100 Mile House	0	934	126	0	0	1,059
Williams Lake	0	9,517	786	4,582	0	14,885
Boundary	0	67	0	0	0	67
Kootenay Lake	0	0	10	3	0	13
Kamloops	0	3,543	752	0	0	4,296
Lillooet	0	745	105	0	0	850
Merritt	0	2,736	209	0	0	2,945
Total	**0**	**17,542**	**1,988**	**4,585**	**0**	**24,115**
Two-year cycle budworm						
100 Mile House	0	250	0	0	0	250
Quesnel	0	1,897	0	0	0	1,897
Williams Lake	0	402	0	0	0	402
Kamloops	0	884	37	0	0	922
Total	**0**	**3,434**	**37**	**0**	**0**	**3,471**
Douglas-fir tussock moth						
Williams Lake TSA	0	0	0	1,662	0	1,662
Kamloops TSA	0	0	4	0	0	4
Merritt TSA	0	0	0	14	0	14
Okanagan TSA	0	211	642	175	0	1,028
Total	**0**	**211**	**646**	**1,851**	**0**	**2,708**
Western hemlock looper						
Arrow	0	373	61	114	0	548
Invermere	0	8	0	0	0	8
Kootenay Lake	0	202	83	14	0	298
Revelstoke	0	157	63	0	0	220
Total	**0**	**740**	**207**	**128**	**0**	**1,074**

Timber Supply Area	Area of infestation (hectares)					
and Damaging Agent	**Trace**	**Light**	**Moderate**	**Severe**	**Very Severe**	**Total**
Aspen serpentine leafminer						
100 Mile House	0	34,967	35,402	10,630	0	80,999
Quesnel	0	16,124	54,965	18,597	0	89,687
Williams Lake	0	40,809	33,362	14,987	0	89,157
Arrow	0	5,857	6,398	0	0	12,255
Boundary	0	454	0	0	0	454
Cranbrook	0	922	428	0	0	1,350
Golden	0	727	703	73	0	1,503
Invermere	0	707	768	0	0	1,476
Kootenay Lake	0	4,042	2,007	0	0	6,050
Revelstoke	0	1,405	1,444	0	0	2,849
Kamloops	0	17,518	10,140	1,741	0	29,399
Merritt	0	0	5	13	0	18
Okanagan	0	2,655	1,626	553	0	4,833
Total	**0**	**126,188**	**147,248**	**46,594**	**0**	**320,030**
Birch leafminers (*Fenusa pusilla, Profenusa thomsoni, Lyonetia prunifoliella*)						
Arrow	0	359	341	0	0	701
Cranbrook	0	8	18	9	0	35
Golden	0	0	84	6	0	90
Kootenay Lake	0	575	212	0	0	788
Revelstoke	0	0	23	0	0	23
Kamloops	0	671	481	114	0	1,267
Okanagan	0	6	52	0	0	58
Total	**0**	**1,619**	**1,213**	**129**	**0**	**2,961**
Drought - general, foliage loss						
Kamloops	0	902	1,525	240	0	2,666
Okanagan	0	47	118	0	0	165
Total	**0**	**949**	**1,643**	**240**	**0**	**2,831**
Drought - mortality						
100 Mile House	0	0	171	5	0	176
Williams Lake	49	585	250	48	0	932
Arrow	0	106	89	9	0	205
Boundary	11	2,746	2,117	0	0	4,874
Cranbrook	36	340	258	46	0	680
Golden	0	14	8	0	0	22
Invermere	0	635	208	31	0	875
Kootenay Lake	0	255	41	0	0	296
Kamloops	0	0	7	1	0	8
Merritt	0	4	20	0	0	24
Okanagan	10	488	234	58	0	790
Total	**106**	**5,174**	**3,403**	**198**	**0**	**8,881**

Timber Supply Area and Damaging Agent	Area of infestation (hectares)					
	Trace	**Light**	**Moderate**	**Severe**	**Very Severe**	**Total**
Post-burn mortality						
100 Mile House	17	5,554	3,137	4,492	0	13,200
Quesnel	0	7,798	5,436	2,943	47	16,223
Williams Lake	21	5,276	5,005	17,385	9,546	37,233
Arrow	0	0	131	0	0	131
Boundary	0	0	110	185	0	295
Cranbrook	0	107	1,100	487	0	1,694
Golden	0	54	562	151	0	766
Invermere	0	198	1,157	1,063	0	2,418
Kootenay Lake	0	25	304	16	0	344
Revelstoke	0	12	0	0	0	12
Kamloops	0	707	277	50	15	1,048
Merritt	0	0	107	0	0	107
Okanagan	0	36	187	90	0	312
Total	**38**	**19,768**	**17,512**	**26,860**	**9,607**	**73,785**
Larch Needle Blight						
Arrow	23	31	22	17	0	93
Boundary	0	25	0	0	0	25
Cranbrook	0	1,147	644	0	0	1,790
Golden	0	24	0	0	0	24
Kootenay Lake	0	81	88	20	0	189
Total	**23**	**1,308**	**754**	**36**	**0**	**2,122**

Mountain pine beetle attack, Lillooet TSA

Southern Interior Overview

Mountain Pine Beetle, *Dendroctonus ponderosae*

The area affected by mountain pine beetle increased by 26,068 hectares, to 63,249 hectares (Tables 2 and 3; Figures 1 and 2). Most of this increase was due to the continuing expansion of infestations in the Williams Lake TSA. A 40% increase in spot infestations throughout the south were noted in 2019 compared to 2018 (Table 3). The Arrow and Cranbrook TSAs saw significant expansion and Boundary TSA had modest increases in new attack mapped. The area affected in the Lillooet and Invermere TSAs declined significantly. There is still very little mountain pine beetle being mapped in the Okanagan TSA, but ground reconnaissance indicates a building population in some locations. Over seventy-five percent of all attack was trace to light.

Many of the higher elevation infestations occurred in whitebark pine or mixed species stands.

Table 3. Area infested, number of polygons, average polygon size, number of spot infestations, and number of trees killed in spot infestations by mountain pine beetle in the southern interior, 2009-2019.

Year	Area Infested (ha)	Number of Polygons	Average Polygon Size (ha)	Number of Spot Infestations	Number of Trees Killed in Spot Infestations
2009	2,342,129	23,493	100	5,745	73,994
2010	558,118	15,127	37	6,573	89,747
2011	161,012	5,999	27	4,526	56,835
2012	109,181	3,484	20	3,515	45,574
2013	63,102	1,707	40	2,905	29,670
2014	51,804	1,350	38	2,062	17,995
2015	40,045	1,180	21	1,615	15,635
2016	54,925	1,413	39	1,410	15,050
2017	25,979	717	36	860	7,960
2018	37,181	981	38	868	7,7654
2019	63,249	925	68	1,415	11,771

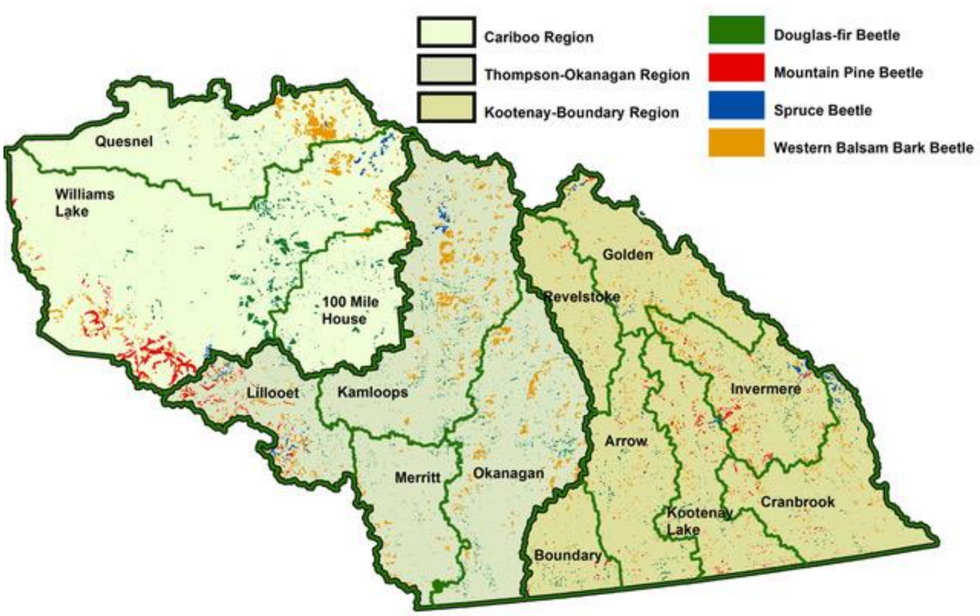


Figure 1. Timber Supply Areas and bark beetle infestations in the southern interior of B.C. in 2019.

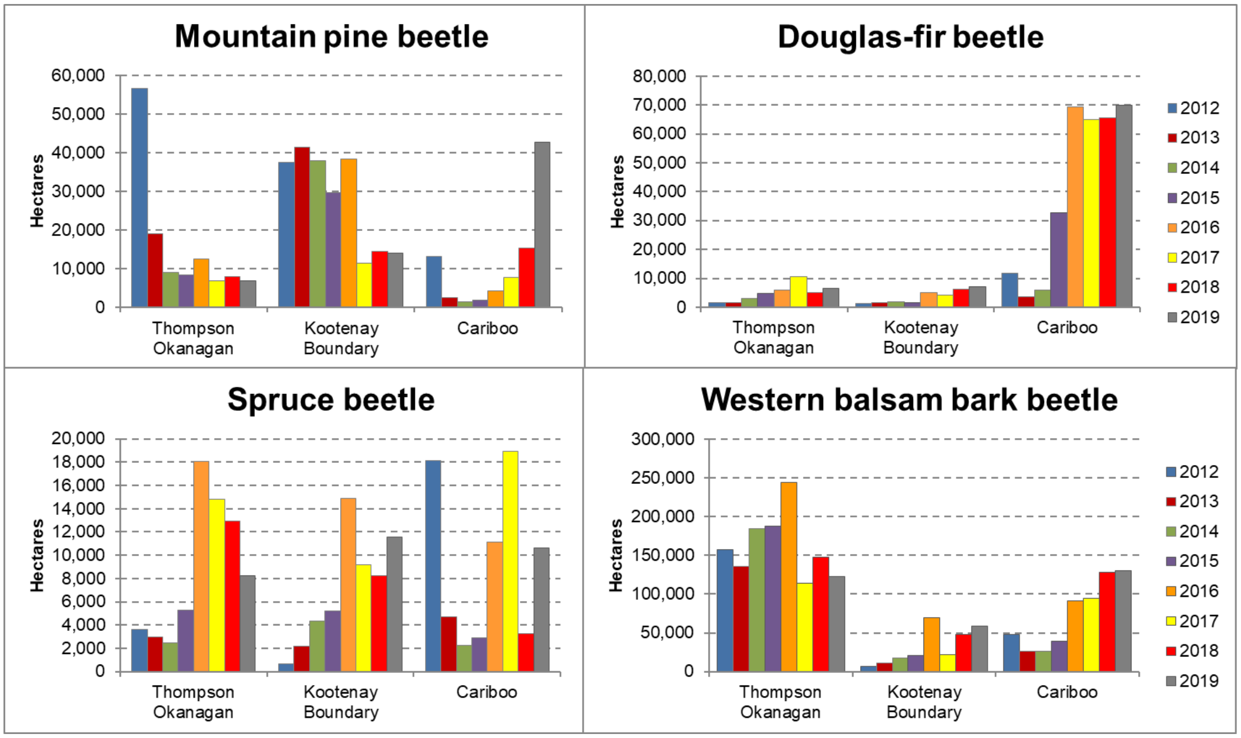


Figure 2. Area affected by major bark beetles in the southern interior of B.C. (Cariboo, Kootenay Boundary and Thompson Okanagan Regions) from 2012-2019.

DOUGLAS-FIR BEETLE, *DENDROCTONUS PSEUDOTSUGAE*

Douglas-fir beetle remained widespread across many areas of southern B.C., especially in the Cariboo Region, where 84% of the total area of Douglas-fir beetle attack was mapped. The most significant increased activity was seen in the 100 Mile House, Williams Lake and Kamloops TSAs where larger patches of infestation were recorded (Table 4). Boundary, Kootenay Lake and Okanagan TSAs also saw increased Douglas-fir beetle activity, while infested area declined in Lillooet, Merritt, Quesnel and Revelstoke TSAs. In the remaining 7 TSAs, the level of Douglas-fir beetle infestation did not vary greatly from 2018. The increased activity in the 100 Mile House, Williams Lake and Kamloops TSAs is due to the increase in available host material in and around the recent wild fires of 2017 and 2018.

Cryptoporus volvatus on fire scorched and Douglas-fir beetle attacked trees

Douglas-fir beetle galleries and larvae

Table 4. Douglas-fir beetle infestations in the southern interior of B.C., 2018-2019.

Timber Supply Area	Spot Infestations Number 2018	Spot Infestations Number 2019	Spot Infestations Trees 2018	Spot Infestations Trees 2019	Patch Infestations Number 2018	Patch Infestations Number 2019	Patch Infestations Area (ha) 2018	Patch Infestations Area (ha) 2019
100 Mile House	405	429	2,661	2,780	94	119	6,417	12,272
Quesnel	427	400	4,038	3,872	171	34	10,389	2,582
Williams Lake	1,163	758	10,921	6,516	512	299	50,254	54,541
Arrow	365	272	5,341	3,328	138	118	2,556	2,324
Boundary	140	101	1,895	1,172	16	59	473	1,101
Cranbrook	171	200	1,565	2,255	33	34	659	526
Golden	28	24	350	383	11	8	71	174
Invermere	160	268	2,642	3,770	93	82	1,390	1,443
Kootenay Lake	223	184	3,168	2,064	41	60	642	977
Revelstoke	50	30	549	357	37	23	524	258
Kamloops	1,001	917	7,795	7,048	268	349	1,976	3,110
Lillooet	278	314	1,999	2,325	90	30	565	188
Merritt	288	326	2,275	2,258	62	54	581	407
Okanagan	879	950	7,810	7,803	278	262	1,974	2,288
Total	**5,578**	**5,173**	**53,009**	**45,931**	**1,844**	**1,531**	**78,471**	**82,190**

SPRUCE BEETLE, *DENDROCTONUS RUFIPENNIS*

The area affected by spruce beetle increased, from 24,493 hectares in 2018, to 30,391 hectares in 2019 (Table 2; Figure 2). The most notable increases were observed in the Quesnel, Williams Lake and Cranbrook TSAs. Attack intensity declined throughout most of the Thompson Okanagan Region, particularly in the Kamloops and Lillooet TSAs. Infestations of note continued in: Wells Gray Park; Quesnel Lake area; Cardtable Mountain; Dil-Dil Plateau; Tyaughton Creek; along the Duffey Lake corridor in Van Horlick Creek, Gott Creek and Cottonwood Creek; Hamill Creek; and, Mount Aosta to Mount Abruzzi.

WESTERN BALSAM BARK BEETLE, *DRYOCOETES CONFUSUS*

The total area of western balsam bark beetle mapped in 2019 decreased slightly to 311,225 hectares affected, compared to 322,859 hectares affected in 2018. However, eight of fourteen TSAs saw an increase in attack over 2018 levels, including Lillooet, Williams Lake, Arrow, Kootenay Lake and Cranbrook TSAs. The most significant decreases were seen in the Kamloops and Okanagan TSAs even though these two TSAs still saw some of the highest attack levels in the southern interior at 57,429 and 42,362 hectares, respectively. The Quesnel, Williams Lake, Kamloops and Okanagan TSAs had the most affected area, ranging from 42,362 hectares in the Okanagan TSA to just over 71,000 hectares in the Williams Lake TSA (Table 2; Figure 2). Eight TSAs saw slight to moderate increases in area affected.

WESTERN PINE BEETLE, *DENDROCTONUS BREVICOMIS*

Western pine beetle activity remained low in 2019 and was only mapped in the Arrow (41 hectares) and Kootenay Lake TSAs (10 hectares).

Western balsam bark beetle attack near Raft River, Kamloops TSA

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.

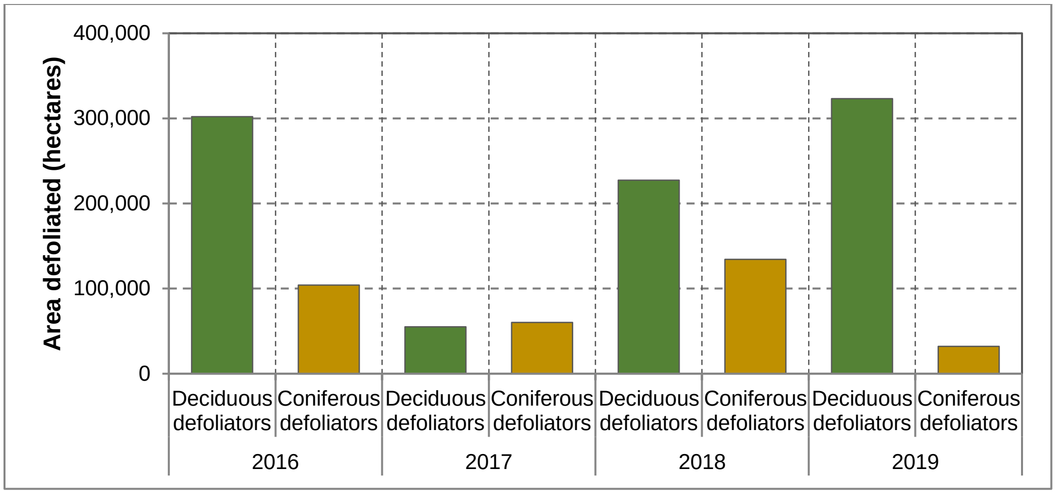


Figure 3. Area of deciduous and coniferous defoliation in the southern interior of B.C., 2016-2019.

In 2019, there was a 6,460 hectare decrease in the overall area impacted by insect defoliators of deciduous and coniferous forests in the southern interior of B.C. (Figure 3). However, defoliation of deciduous forests increased by 95,803 hectares from 2018 to 2019. Three species of deciduous defoliators were observed, with the aspen serpentine leafminer (*Phyllocnistis populiella*) being the most prevalent, affecting almost 320,030 hectares. Aspen serpentine leafminer defoliation in the three Cariboo Region TSAs increased by 84,187 hectares, or 48 percent, from 2018 to 2019. Five species of coniferous defoliators were recorded, with western spruce budworm (*Choristoneura freeman*) being the most widespread, with 24,102 hectares affected over the southern interior.

Birch leafminer damage was mapped on 2,961 hectares in 2019 compared to 4,403 hectares in 2018. Most of the increase was observed at the north end of the Kamloops TSA (Clearwater-Avola) and in the Arrow and Kootenay Lake TSAs. These defoliators continued to affect areas in the North Thompson valley; between New Denver and Kaslo; along the Salmo Creston Pass; and around St. Mary's Lake west of Kimberly. Typically, the damage was found in mixed age stands, often containing hemlock, Douglas-fir, cedar, lodgepole pine, white pine, with birch, aspen and cottonwood throughout.

Areas with foliar discoloration of birch were ground checked in various locations in the Kamloops and Okanagan TSAs including Vavenby Mountain; Avola Mountain FSR; Birch Island, Lost Creek Road; Fadear Creek FSR; Scotch Creek; Skimikin; Foghorn Mountain FSR; and Martin Creek. During ground checks, pupal hammocks were found on the underside of lower birch leaves. Most birch displayed blotchy leaf mining and discolouration, especially in the upper crowns. We observed ejected frass accumulated on the underside of the leaves, caught up in webbing.

Wide scale birch leaf "browning" and mining were noted from May through June, in the Kootenay Boundary and Thompson Okanagan Regions in the south, and Omineca Region in the north, throughout the range of paper birch, *Betula papyrifera*. Larval collections were made in mid-June through the beginning of July from thirteen sites (nine in the Thompson Okanagan; three in the Kootenay Boundary; and one in the Omineca) and genomic DNA sequencing was conducted by Jeanne Robert, Omineca Region. The DNA sequencing confirmed the pest species to be *Lyonetia prunifoliella*, (Lepidoptera: Lyonetiidae) for all 13 sites. This damage was previously thought to be a complex of birch leafminers (*Fenusa pusilla* and *Profenusa thomsoni*), (Hymenoptera: Tenthredinidae), but we now know that at least some of the damage is caused by *Lyonetia prunifoliella*.



Lyonetia prunifoliella *in pupal hammocks (left and centre) and foliar damage (right)*

Moderate patches of defoliation by the **aspen leaf roller** (*Pseudexentera oregonana*) (46,581 hectares) and some **satin moth** (*Leucoma salicis*) (200 hectares) were observed throughout the survey area.

Defoliation of coniferous forests decreased by 76%, to 32,107 hectares affected in 2019 largely due to the **two-year cycle budworm** (*Choristoneura biennis*) being in its "off" year. The total area mapped for this insect was 3,471 hectares, with the majority located in the Quesnel and Kamloops TSAs and small areas mapped in the Williams Lake and 100 Mile House TSAs.

Western spruce budworm (*Choristoneura freemani*) levels remained unchanged from 2018 in the southern interior, at 24,115 hectares. The static growth is in large part due to this year's targeted spray program in the Cariboo Region that covered most of the affected area. However, populations are increasing throughout the budworm's range, with new pockets found in the Cariboo and Thompson Okanagan Regions. The 100 Mile House TSA saw a four-fold decline in mapped defoliation and there was only a modest increase in defoliation mapped in the Williams Lake TSA. Much of the mapped defoliation in the Cariboo was located within spray blocks where the damage had occurred prior to treatment. Therefore, we expect a further decline in budworm populations in these areas. Western spruce budworm activity increased in the Kamloops, Merritt, and Lillooet TSAs in the Thompson Okanagan Region, particularly in the Criss Creek, Mamit Lake and Nicola Lake areas. Very little defoliation was mapped in the Kootenay Boundary Region in 2019.

The Quesnel TSA was the only area with **pine needle sheathminer** (*Zellaria haimbachi*) activity in 2019. The total area defoliated by this insect was 751 hectares as compared to 3,497 hectares in 2018.

Pine needle sheathminer damage in the Cariboo

Western spruce budworm defoliation

Western Spruce Budworm, *Choristoneura freemani*

Western spruce budworm defoliation of Douglas-fir was mapped in seven TSAs in the south area in 2019. The total area defoliated was 24,115 hectares, an increase of 1,481 hectares from 2018. The most notable increases were observed in the Williams Lake and Kamloops TSAs (Table 2). Three TSAs saw a decrease in budworm defoliation in 2019: 100 Mile House, Boundary and Kootenay Lake. Western spruce budworm populations in the Kootenay Boundary Region remain low in both the Boundary and Kootenay Lake TSAs in 2019, with only 67 and 13 hectares defoliated, respectively.

Although budworm populations are increasing in parts of the south area, the area affected remains low compared to levels reached at the height of the last outbreak. Western hemlock looper was observed in many of the stands where budworm was active in the Thompson Okanagan Region. The combination of these two defoliators added to the severity of defoliation mapped and will likely cause higher levels of defoliation in 2020 in many interior Douglas-fir stands. The abundance of hemlock looper in interior Douglas-fir stands coincides with marked increases in trap catches of hemlock looper in interior hemlock stands (see western hemlock looper section).

The Cariboo Region sprayed 16,786 hectares of priority areas with Foray 48B (*Bacillus thuringiensis* var. *kurstaki*; P.C.P. No. 24977) in June 2019 (Figure 4; Table 5). This targeted spray program held the western spruce budworm spread to a minimum in the Williams Lake TSA.

Seven blocks (Table 5) were treated over a six-day period with *B.t.k.* at 2.4 litres per hectare between June 16th and June 21st, 2019. Western Aerial Applications Ltd. conducted the aerial applications using one 315B Lama helicopter and one Hiller UH12ET helicopter, each equipped with four Beecomist 361A ultra low volume hydraulic sprayers. The spray operations were conducted from four staging sites where the *B.t.k.*, mobile fuel trucks and loading crews were positioned. The spray program was planned and implemented by Cariboo Region and District staff, and co-op students, with support from Thompson Okanagan Region and Victoria staff.

Defoliation in Criss Creek, Kamloops TSA

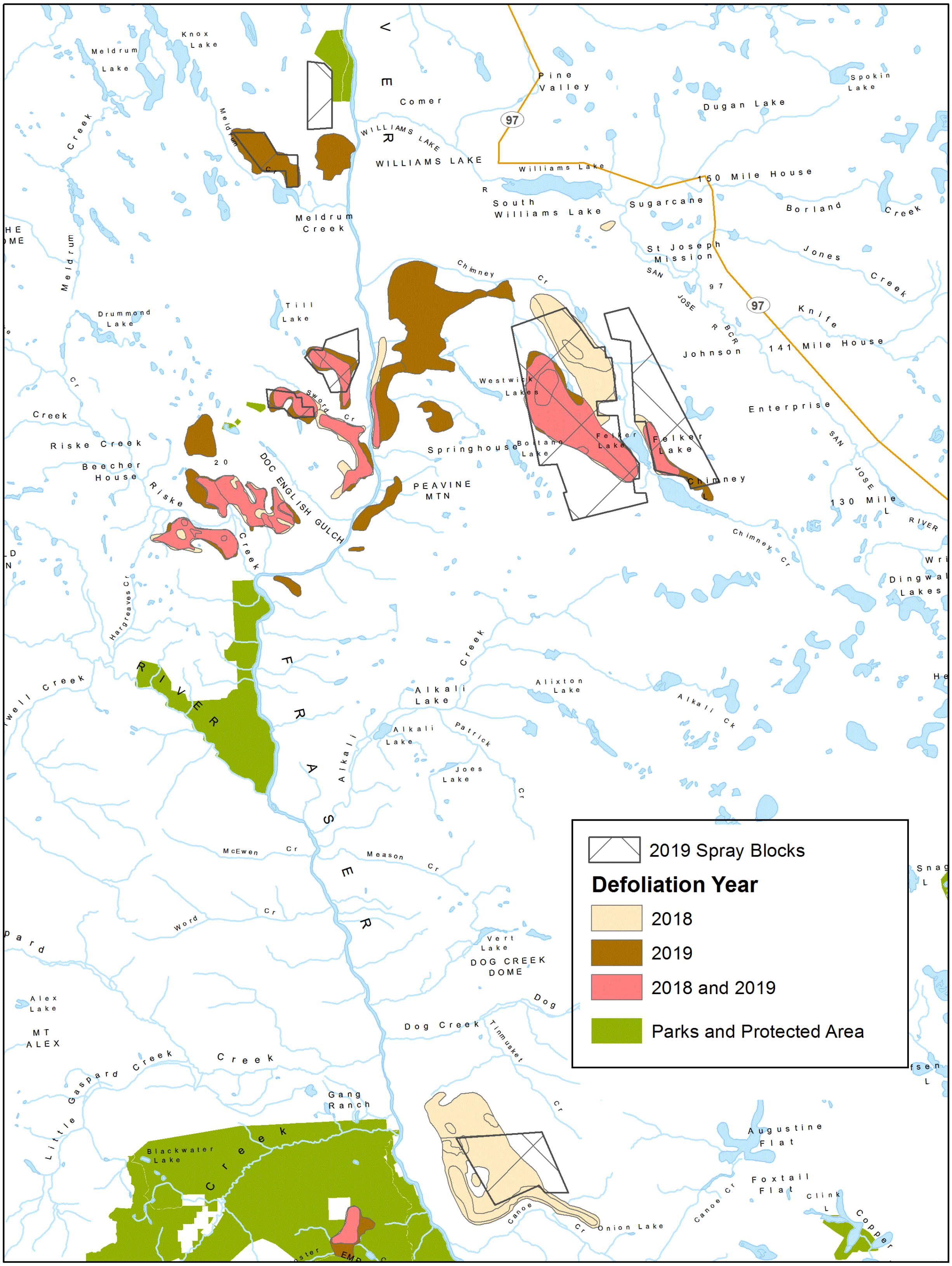
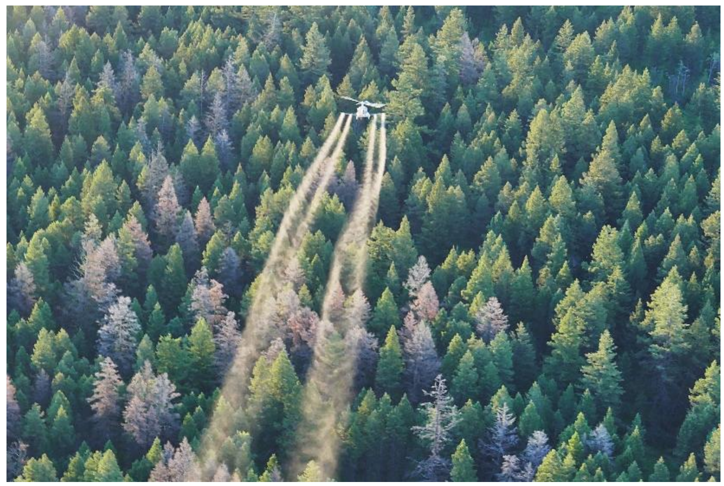


Figure 4. Map showing 2019 spray blocks and 2018 and 2019 defoliation in the Cariboo Region.

Table 5. 2019 western spruce budworm spray blocks in the Cariboo region showing the treated area, litres of *B.t.k.* applied and date sprayed.

Spray Blocks	Block size (ha)	Litres *B.t.k.*	Date sprayed
1. Meldrum Creek West	770	1,850	June 16
2. Meldrum Creek East - White Lake	788	1,890	June 16
3. Riske Creek North - Till Lake	1,050	2,520	June 16
4. Riske Creek South - Lower Meldrum	444	1,065	June 16-17
5. Felker Lake West - Colpitt	7,900	19,220	June 16-18 & 20-21
6. Felker Lake East - Felker	3,334	8,000	June 17-21
7. Canoe Creek	2,500	6,000	June 21
Total	**16,786**	**40,545**	

Lama leaving staging site



Spray swath over spray block and Douglas-fir beetle mortality

Efficacy assessment

Pre- and post-spray larval sampling was done in select locations to determine larval density and effect of *B.t.k.* treatment. Pre-spray sampling was done the day before treatment and then at weekly intervals post-spray until all the budworm larvae had pupated or were dead. Due to most high budworm population areas receiving treatment, larval density was generally much higher in the spray blocks sampled than within the control areas (Table 6). Larval density ranged from 120 to more than 300 larvae per m^2 foliage in the pre-spray sampling, comparable to numbers seen in 2012, which recorded some of the highest levels of budworm observed in the south. The majority of larvae were 3rd or 4th instar, except for the Meldrum block, where about 30 percent were in the 5th instar (Figure 5). Therefore, there was visible defoliation in most blocks at the time of treatment (Figure 4). However, budworms in the Canoe Creek block were the least advanced and minimal defoliation was evident at the time of treatment. Populations declined in both treated and control areas, but the decline was rapid and significant in treated blocks. Mortality from the *B.t.k.* treatment was most pronounced in the Canoe Creek area where larval densities were reduced from over 232 to just 20 larvae per m^2 foliage (Table 6). Natural mortality was high in the control areas, but the treatment blocks had higher populations and the *B.t.k.* spray brought larval density down to below what was recorded in the control sites.

Abbott's corrected mortality compares the mortality caused by *B.t.k.* (percent mortality) to the natural percent mortality observed in untreated control areas (Table 6). Percent mortality and Abbott's corrected mortality are calculated as follows:

$$\% \text{ Mortality} = \frac{\text{(pre-spray density of live insects) - (post-spray density of live insects)} \times 100}{\text{(pre-spray density of live insects)}}$$

$$\text{Abbott's corrected mortality (\%)} = \frac{\text{(treated \% mortality) - (untreated \% mortality)} \times 100}{100 - \text{(untreated \% mortality)}}$$

Table 6. Results of pre- and post-spray larval sampling at several sites in the Cariboo 2019 spray program.

	Larval density (# larvae per m^2 foliage)			% mortality			
				Uncorrected		Corrected	
Sample location	Pre-spray	1st post	2nd post	1st post	2nd post	1st post	2nd post
Meldrum spray	175.9	10.9	2.6	93.8	98.5	48.2	63.0
Meldrum control	119.7	14.3	4.7	88.0	96.0		
Colpitt spray	234.3	36.7		84.3	100.0	33.4	
Colpitt control (same as Felker control)	153.3	36.0		76.5			
Felker spray	302.2	20.5	15.1	93.2	95.0	71.2	62.6
Felker control	153.3	36.0	20.4	76.5	86.7		
Canoe spray	232.3	20.0		91.4		71.2	
Canoe control	174.1	65.4		62.4			

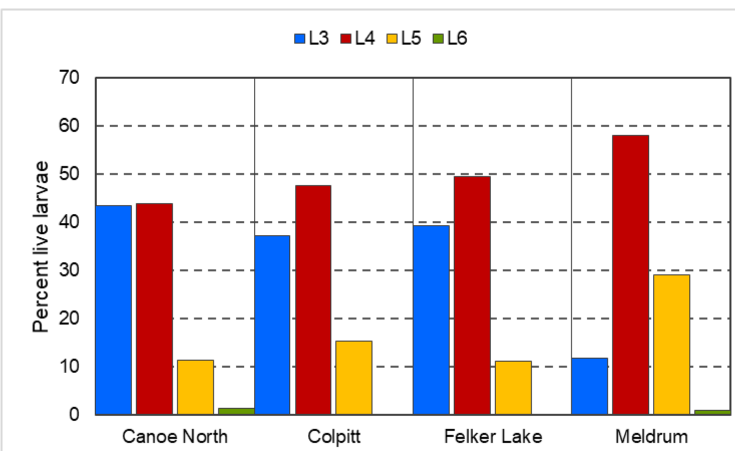


Figure 5. Distribution of larval instars within four spray blocks collected at the pre-spray sample time.

Cariboo spray crew

Conducting efficacy assessment for budworm spray

Budworm and coneworm (Dioryctria) larvae

Defoliation predictions for 2020

232 sites were sampled throughout the south area for western spruce budworm egg masses (Table 7). Egg mass sampling provides an estimate of the defoliation expected in 2020 based upon the density of egg masses found. Well over half the sites sampled (69%) predicted no defoliation in 2020 and 27% had predictions of light defoliation. No sites predicted severe defoliation, with only a few expecting moderate levels (Table 7). In the Thompson Okanagan Region, the key areas where budworm populations increased and defoliation is expected in 2020 are in the Kamloops and Merritt TSAs, near Criss Creek, Mamit Lake and northwest of Nicola Lake.

Egg mass surveys in the Kootenay Boundary Region are conducted annually in high priority stands that have a history of defoliation. Eighteen sites were sampled, all in the Boundary TSA. Half the samples yielded no egg masses (9 of 18 sites). Eight sites fell into the light category (Table 7) and one site yielded an average of 67 egg masses per $10m^2$ of foliage. The highest egg mass counts were all located southwest of Rock Creek, off the Bridesville Road. No spray program is planned for 2020 in the Kootenay Boundary Region.

Ninety-one sites in the Cariboo Region were sampled for egg masses in the fall of 2019. Most sites (67 of 91) had no egg masses. Results for twenty-two sites predicted light defoliation and two sites predicted moderate defoliation in 2020. Moderate defoliation is predicted in sites located along Place Lake Road and English Road in the Central Cariboo TSA. Approximately 15,000 hectares are proposed for *B.t.k.* treatment in 2020.

Left to Right: budworm larva; moths mating; new eggmass; and, hatched eggmass.

Table 7. Results of the fall 2019 western spruce budworm egg mass sampling in the south area. Number of sites indicating nil, light, moderate, severe defoliation in 2020 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; Light = 1-50 egg masses; Moderate = 51-150 egg masses; Severe >150 egg masses.

	2020 predicted defoliation (No. sites)				Total	No. egg masses	
Region and TSA	Nil	Light	Moderate	Severe	# sites	Avg.	Max.
Cariboo							
100 Mile House	27	9	0	0	36	3.1	25
Williams Lake	40	13	2	0	55	4.3	69
Total	**67**	**22**	**2**	**0**	**91**	**3.8**	**69**
Kootenay Boundary							
Boundary	**9**	**8**	**1**	**0**	**18**	**13.6**	**67**
Thompson Okanagan							
Kamloops	30	19	1	0	50	8.3	53
Merritt	15	12	5	0	32	26.2	150
Lillooet	27	2	0	0	29	1.0	24
Okanagan	12	0	0	0	12	0.0	0
Total	**84**	**33**	**6**	**0**	**123**	**10.4**	**150**
Total for South Area	**160**	**63**	**9**	**0**	**232**		

The 2019 spray program marked the first spray program for western spruce budworm since 2015 (Figure 6). Due to the continuing expansion of budworm throughout the south in 2019, we are proposing additional treatments in 2020 in the Cariboo and Thompson Okanagan Regions, totalling approximately 23,000 hectares (8,000 hectares in the Kamloops and Merritt TSAs; 15,000 hectares in the Williams Lake TSA).

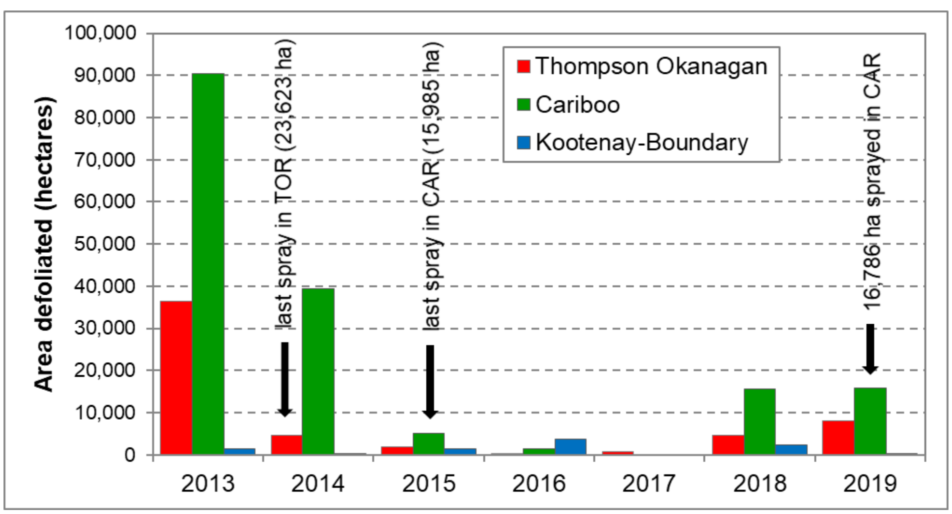


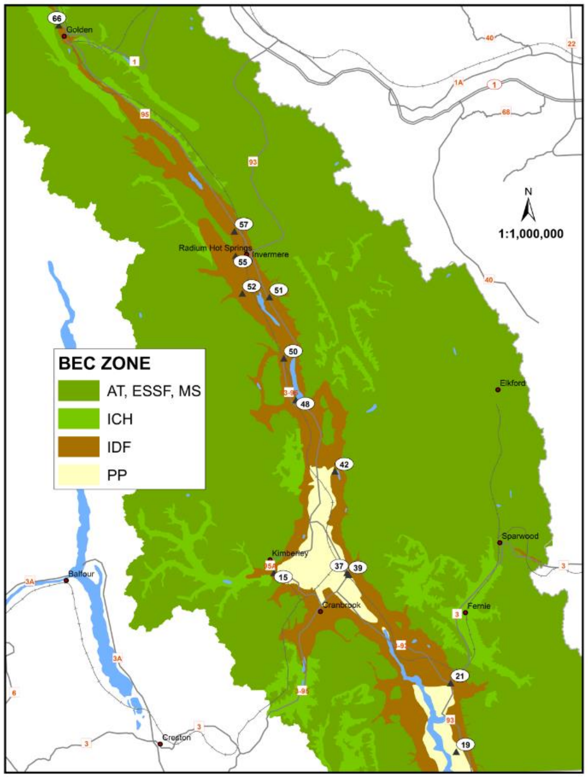
Figure 6. Hectares of western spruce budworm defoliation in the southern interior (2013-2019), showing the years of *B.t.k.* treatments in the Thompson Okanagan (TOR) and Cariboo (CAR) Regions.

In 2007, thirteen permanent sample plots formerly monitored by the Forest Insect and Disease Survey Unit of Forestry Canada were re-established in the East Kootenays to monitor the incidence of western false hemlock looper, *Nepytia freemani*, and western spruce budworm, *Choristoneura freemani.* The East Kootenays do not have a history of visible defoliation by western spruce budworm. It is possible however, that given climate change and Douglas-fir encroachment throughout the Rocky Mountain Trench, that conditions may become favorable to the expansion of western spruce budworm populations.

Assemblage of defoliating insects found when larval sampling

Western spruce budworm populations continue to remain low in the East Kootenays with only one budworm larva found near Edgewater (#57 - Figure 7). Conifer sawflies were the most common defoliator noted, found at eight of 13 sites, followed by false hemlock looper and green striped forest looper both found at five sites. Defoliator diversity was down slightly from 2018.

Tree beating – a method of sampling for defoliators



Western hemlock looper moth and larva

Figure 7. East Kootenay permanent sample plot distribution in the Rocky Mountain Trench.

DOUGLAS-FIR TUSSOCK MOTH, *ORGYIA PSEUDOTSUGATA*

The Douglas-fir tussock moth has begun its next outbreak cycle in the southern interior, with numerous single-tree epizootics and patches of defoliation noted in 2019 (Figure 8). A total of 2,708 hectares of light to severe defoliation was mapped in the Thompson Okanagan and Cariboo Regions (Table 2) and some single-tree epizootics were observed in the Kootenay Boundary Region. The 1,662 hectares mapped in the Cariboo Region represent a new area for tussock moth and the most northerly occurrence of tree and stand defoliation ever to be recorded for this insect. The tussock moth has most likely been at very low levels throughout low elevation IDF stands in the south. However, changing climatic conditions have allowed this insect to reach outbreak levels in geographic locations where in the past it could not.

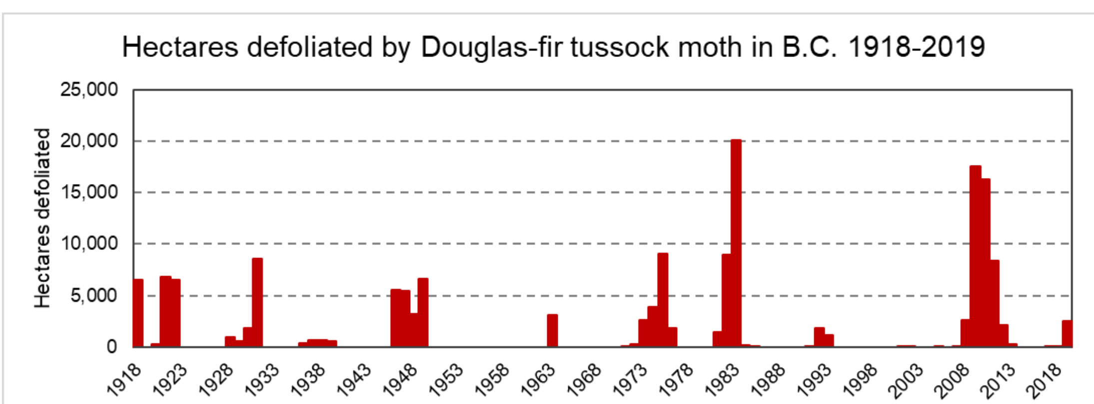


Figure 8. Douglas-fir tussock moth defoliation in British Columbia 1918-2019.

The most extensive and severe defoliation in the Thompson Okanagan Region was located east of Osoyoos and near Oliver in the Okanagan TSA (1,028 hectares) (Table 2). Defoliation was also mapped near Vernon, Kelowna, Kamloops, and along the Similkameen River, near Stemwinder Provincial Park. Sampling conducted near the end of larval feeding showed the presence of NPV (virus) in the Stemwinder and McKinney Road (east of Oliver) populations, indicating a possible population collapse. Elsewhere defoliation was noted near Ellison Provincial Park south of Vernon, and on the west side of the east arm of Okanagan Lake. New areas of defoliation are expected in 2020. A private landowner near Heffley Creek, northeast of Kamloops, treated 342 hectares on the Seven O Ranch with *B.t.k.* to control a population of tussock moth on their property.

Douglas-fir tussock moth defoliation near Dog Creek and on Anarchist Mountain

Douglas-fir tussock moth defoliation was mapped for the first time in the Cariboo Region south of Alkali Lake and Dog Creek (Figure 9). Approximately 1,662 hectares of severe defoliation were mapped, and many trees were killed within this defoliated area. Ground checks found numerous new egg masses along the outer edges of the main defoliated area and beyond. A spray program using *B.t.k.* is proposed for 2020.

Five Douglas-fir tussock moth Outbreak Areas were delineated in 2011 after the last major outbreak in the province. The original Outbreak Areas are: WK=West Kamloops; KA=Kamloops; OK=Okanagan; SIM=Similkameen; and, KT=Kootenay; (Figure 9). Outbreak Areas were delineated by analysing past outbreaks (mapped defoliation) (1918-2011), elevation and drainages (topography), host range and ecosystem. These Outbreak Areas have unique outbreak periodicity and amplitude. However, with the occurrence of Douglas-fir tussock moth in the Cariboo the Outbreak Areas have been updated to reflect this new, expanded range (Figure 9).

Early instar Douglas-fir tussock moth

Late instar Douglas-fir tussock moth

Douglas-fir tussock moth infected with virus

Female Douglas-fir tussock moth laying eggs

Annual monitoring with six-trap clusters

The last Douglas-fir tussock moth outbreak collapsed in 2012. From 2012 through 2015, trap catches declined to very low levels until 2016, when a slight increase in the average number of male moths caught was observed in all Outbreak Areas (Figure 10; Table 8). Outbreak periodicity 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 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 next summer.

The Blue Lake trap site is in the Okanagan Outbreak Area and was the closest to the mapped 2019 defoliation. The trap-catch numbers in 2018 and 2019, 34.4 and 18.3 moths per trap, respectively, indicated that defoliation was imminent. There were also small pockets of defoliation near the Wood Lake and Glenmore trapping sites in the Okanagan. Numerous trap sites in the Kamloops Outbreak Area show increasing moths caught and we may see more than just single tree defoliation events in 2020 (e.g. McLure, Six Mile, Monte Creek, Haywood-Farmer and Buse Lake). The 2018 trap catches in the Similkameen Outbreak Area accurately predicted defoliation throughout the Similkameen River valley. The defoliation was very concentrated in the valley bottom in narrow strips. Most of the outbreak occurred on private land, Indian Reserve land and parks. Three sites each in the Similkameen and West Kamloops Outbreak Areas had over 25 moths per trap in 2019 (Olalla, Hwy. 3 Bradshaw Creek, Stemwinder; Barnes Lake, Veasy Lake, Hwy. 99) (Table 8). In the West Kamloops Outbreak Area (Figure 10) defoliation can be expected along Hwy. 99 corridor near Veasy Lake, Pavilion Lake and Crown Lake, as well as in the Barnes Lake area off Hwy. 97C (Figure 10) next season.

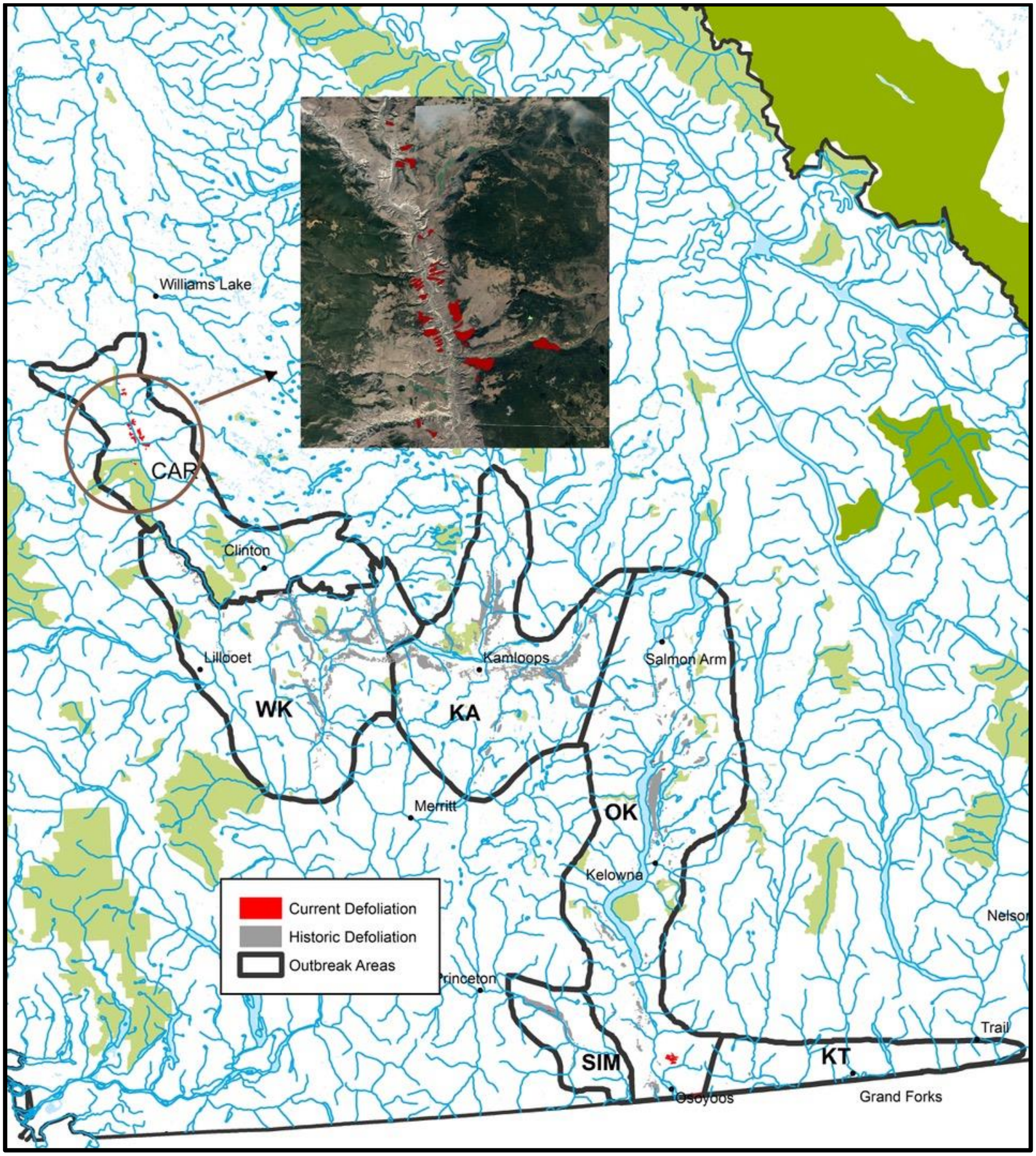
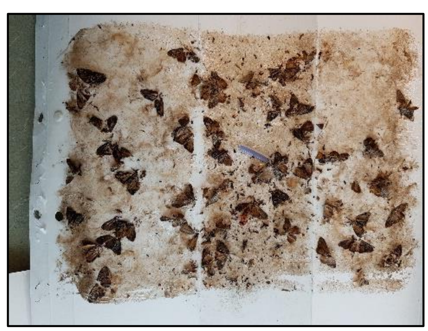


Figure 9. Map showing areas of current (2019) and historic (1908-2018) Douglas-fir tussock moth defoliation and the delineation of Outbreak Areas. Inset shows the 2019 mapped defoliation in the Cariboo overlaid on satellite imagery. Outbreak Areas are: WK=West Kamloops; KA=Kamloops; OK=Okanagan; SIM=Similkameen; KT=Kootenay; and, CAR=Cariboo.

Table 8. Average number of Douglas-fir tussock moths caught per 6-trap cluster in the Thompson Okanagan and Cariboo Regions (2013-2019). Lures from three suppliers (Scotts (Solida), ChemTica (WestGreen Global Technologies), and Synergy Semiochemicals) were compared in 2016-2019.

		Average moth catch per site						
		Scotts lures			Average of three lures			
Site	**Location**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Kamloops (KA)								
1	McLure	7.2	0.2	0.5	5.5	8.9	10.9	21.2
2	Heffley Creek	27.7	8.3	9.5	26.6	26.8	32.4	18.6
3	Inks Lake	6.3	0	0	0.1	0.1	0	0.2
4	Six Mile	5.3	0.2	0.3	3.4	3.8	9.9	23.1
9	Stump Lake	0.3	0	0	0	0.3	0.1	1.3
10	Monte Creek	18.2	11.7	2.3	3.8	6.4	7.8	20.1
11	Chase	0.3	0.0	0.0	1.7	0.3	3.4	5.9
48	Haywood-Farmer		new 2018				9.6	20.3
49	Buse Lake		new 2018				5.4	14.1
	Average of sites	**9.3**	**2.9**	**1.8**	**5.9**	**6.7**	**8.8**	**13.7**
Okanagan (OK)								
12	Yankee Flats	-	0.7	0.2	3.2	0.5	2.3	1.2
13	Vernon	2	0	0		1.4	5.3	0.4
14	Wood Lake	0	0.2	0.3	7.6	17.0	41.3	17.0
15	June Springs	0	0	0	0.5	1.1	2.0	2.7
16	Summerland	0	0.0	0	0.7	0.9	0.3	1.6
17	Kaleden	0	0.3	0.2	4.9	6.2	4.4	7.5
18	Blue Lake	0	0.2	0.3	11.5	17.3	34.4	18.3
45	Glenmore		0	0	5.3	9.0	25.4	20.1
	Average of sites	**0.3**	**0.2**	**0.1**	**4.8**	**7.1**	**14.4**	**8.6**
Similkameen (SIM)								
19	Stemwinder Park	0.2	0.7	0.2	8.6	8.2	29.8	-
32	Olalla	0	1.2	4.3	21.2	21.6	40.4	29.1
33	Red Bridge	0	0.7	1.7	8.8	7.4	9.3	9.4
36	Hwy 3 Lawrence Ranch	0	0.2	2.2	10.7	11.2	30.4	-
38	Hwy 3 Bradshaw Creek	2	2.5	3.6	17.7	10.3	29.2	36.8
39	Hwy 3 Winters Creek	0.2	0.8	1.3	7.6	7.6	27.7	17.4
40	Hwy 3 Nickelplate Road	0.4	0	0	8.8	9.7	31.3	18.7
41	Stemwinder	0.3	0	0	11.4		34.2	26.5
42	11.8 km Old Hedley Rd	0	0	0	0.3	0.4	2.0	3.8
43	Pickard Creek Rec Site	0.2	0.3	0.5	5.5	6.8	31.6	14.5
44	5.7 km Old Hedley Rd	0	0	0	3.9	4.3	20.4	7.6
	Average of sites	**0.3**	**0.6**	**1.3**	**9.5**	**8.8**	**26.0**	**18.2**

Milk carton trap



Douglas-fir tussock moths in trap

		Average moth catch per site						
		Scotts lures			Average of three lures			
Site	**Location**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
West Kamloops (WK)								
5	Battle Creek	0.2	0	0	0.3	0.7	0.9	no access
6	Barnes Lake	0.5	0	0	2.5	9.9	7.7	25.4
7	Carquille/Veasy Lake	27.7	5	8.3	10.9	burnt	burnt	discontinued
8	Pavilion	0.7	0.2	0	1.6	7.7	7.1	20.7
21	Spences Bridge	4	0	0.3	2.5	7.3	8.6	9.4
22	Veasy Lake	16.8	3	10	9.7	burnt	1.7	13.7
23	Veasy Lake	9.3	0.2	0	5.8	burnt	3.1	
24	Veasy Lake	29.3	1.2	12.3	6.2	burnt	6.7	25.0
25	Hwy 99	4	0.2	0.5	8.7	burnt	burnt	discontinued
26	Venables Valley	1.2	0	0	0.0	1.4	0.2	4.6
27	Maiden Creek	0.7	0	0	0.2	1.0	1.6	6.6
28	Hwy. 99	3.8	0.5	0.3	2.2	6.1	9.2	28.6
29	Cornwall 79	0.7	0.8	0.3	1.1	burnt	burnt	burnt
30	Cornwall 80	0.8	0	0	0.7	burnt	burnt	burnt
31	Barnes Lake	1.2	0	0	0.6	2.1	0.8	9.1
46	Barnes Lake Road.		new 2018				2.2	11.2
47	Stinking Lake		new 2018				0.3	6.8
	Average of sites	**6.7**	**0.7**	**2.1**	**3.5**	**4.5**	**3.8**	**14.6**
Boundary (KT) (8 sites in 2019)		**0.6**	**0.2**	**0.2**	**0.6**	**1.3**	**2.3**	**5.0**
Cariboo (CAR) (16 sites in 2019)		**3.6**	**1.6**	**0.1**	**1.6**	**2.4**	**1.8**	**5.0**

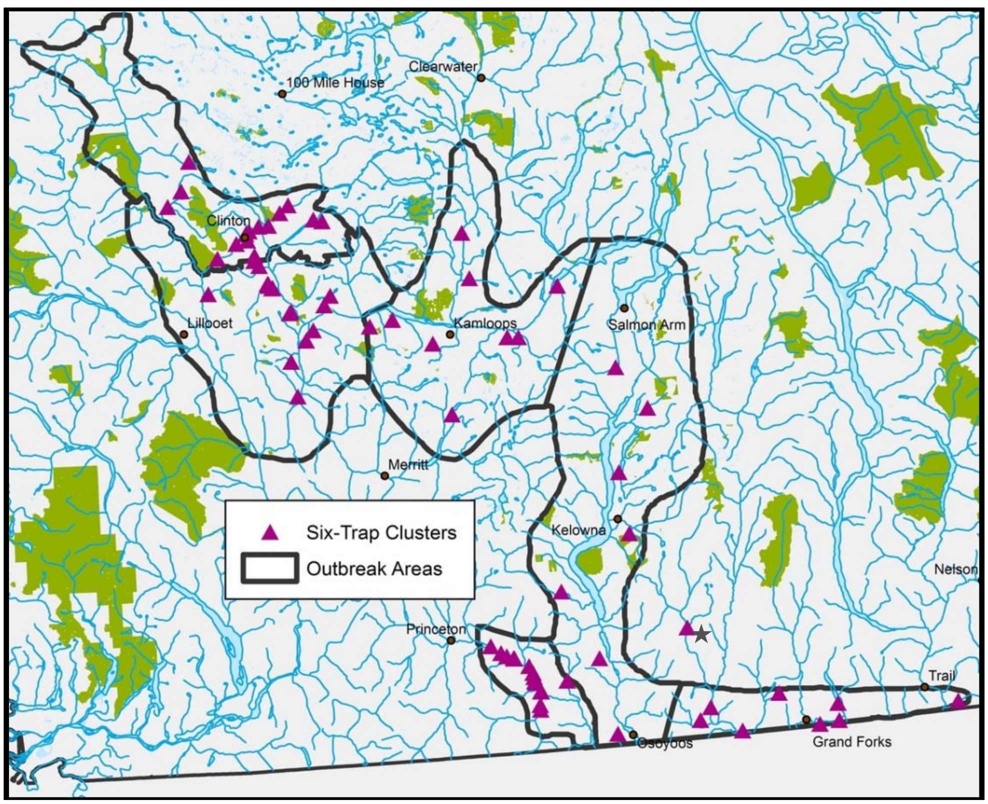


Figure 10. Location of Douglas-fir tussock moth 6-trap clusters throughout the southern interior.

Douglas-fir tussock moth lures from three companies have been established in 6-trap clusters at each trapping site since 2016 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 will no longer produce the same lure after 2019. All lures have a loading of 5µg pheromone but the Synergy lure is slightly longer which should even out the release rate, reducing the initial pheromone burst and ultimately make the lure last longer in the field (David Wakarchuk, personal communication). In 2019, three lines (one line per company) of 6 traps each were set at each trapping site in the Thompson Okanagan (37 sites) and Cariboo (16 sites) Regions. The Kootenay Boundary Region had eight trapping sites and used only the WestGreen Global Technologies (ChemTica) lure. The ChemTica and Synergy average trap catches were comparable at all sites as well as the City of Kamloops, in the four Outbreak Areas within the Thompson Okanagan (Figure 11). The ChemTica and Synergy lures caught significantly more moths than the Scotts lure.

Six traps per lure were placed at each trapping site in the Cariboo Region. The Synergy lures caught an average of over 10 moths per trap (Table 9) in four of the sixteen trap sites. At the Big Bar South trapping site, all lures caught over 20 moths per trap and the average was 28.3 moths per trap across all lure types (Table 9).

Table 9. Average number of Douglas-fir tussock moths caught in 6-trap clusters in the Cariboo Region using three lure types produced by Synergy Semiochemicals, ChemTica (WestGreen Global Technologies), and Scotts (Solida).

		Average trap catch (6 trap cluster)			**Avg. of 3 lure**
Site No.	**Location**	**Synergy**	**ChemTica**	**Solida**	**types**
3	Liden Road	4.8	1.5	3.0	3.1
4	Bonaparte River	4.5	2.7	0.7	2.6
5	Bonaparte River	11.0	6.0	6.8	7.9
7	North of Clinton	7.2	7.0	1.2	5.1
11	Loon Lake East end	4.0	1.8	0.8	2.2
17	Hwy./South District Boundary	12.0	3.8	4.4	6.7
20	South of Clinton	7.0	6.7	7.0	6.9
25a	Kelly Lake Road	6.8	2.0	1.0	3.3
25	Kelly Lake	4.8	3.3	1.0	3.1
34	Alkali Lakes	1.7	0.7	0.7	1.0
42	Fifty-one Creek	5.5	3.5	0.0	3.0
50	Bonaparte River	1.0	1.0	0.3	0.8
53	Big Bar North	10.3	7.7	2.7	6.9
54	Big Bar South	43.6	20.2	21.2	28.3
57	Meadow Lake	2.3	1.3	0.5	1.4
60	Brigade Creek	3.8	2.3	0.8	2.3
	Average	**8.15**	**4.47**	**3.25**	**5.29**

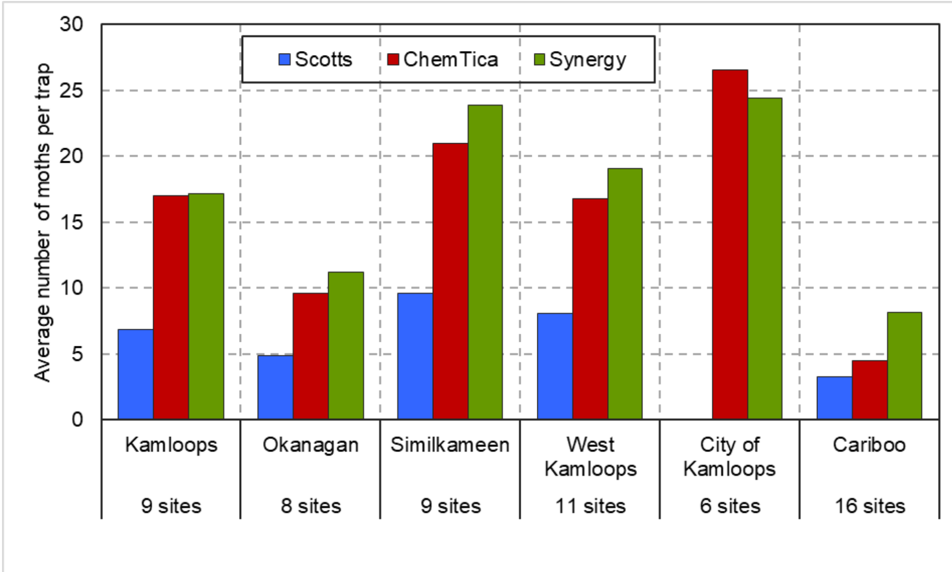


Figure 11. Average number of Douglas-fir tussock moths caught per 6-trap cluster, by lure producer, averaged within an Outbreak Area.

Eight permanent trapping sites are monitored in the Kootenay Outbreak Area (Boundary) and two sites caught over 10 moths per trap in 2019 (Wallace Road and Kettle Provincial Park) (Figure 12). Overall, an average of 5 moths per 6-trap cluster were caught in 2019, an increase from 2018, indicating defoliation may occur in the next few years.

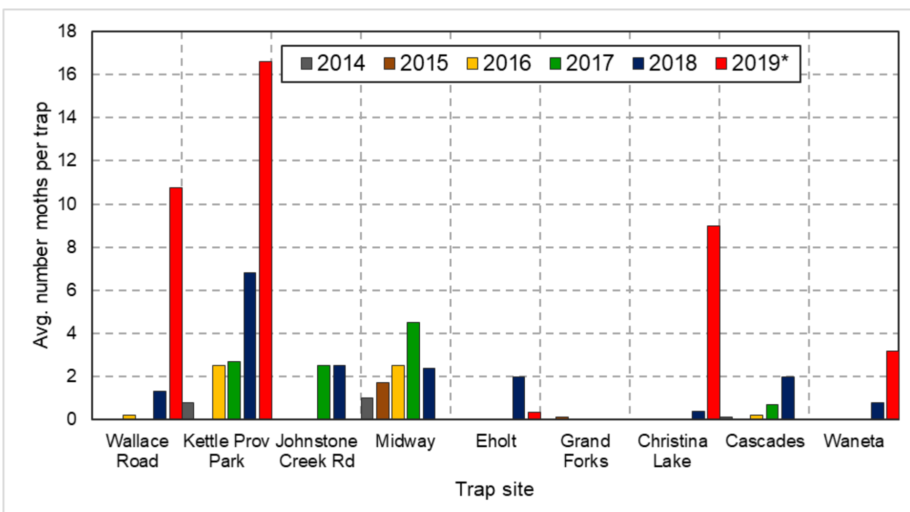


Figure 12. Average number of Douglas-fir tussock moths caught per 6-trap cluster at permanent trapping sites in the Kootenay Boundary Region (2014-2019).

Three-tree beatings

Three-tree beating is a procedure for sampling defoliating forest insect larvae, which involves beating the foliage and collecting the fallen insects on a tarpaulin. Three-tree beating provides temporal and spatial information on the richness and diversity of defoliating insects. The three-tree beatings in the Thompson

Okanagan Region were conducted between June 19 and 22, 2019, and between June 30 and July 1, 2019, in the West Kootenay Boundary area.

In the Thompson Okanagan Region, there were five positive sites, similar to 2018 (Table 10), with an average of 9.2 larvae/positive site, an increase from 2.7 in 2018. All other sites sampled were negative. Two of the positive sites were in the Okanagan Outbreak Area, two in the Similkameen Outbreak Area, and one in the Kamloops Outbreak Area. Defoliation was observed near the Heffley Creek site and in the Similkameen, near Stemwinder Forest Service Road. New areas of defoliation were also noted within 300 meters of the Nickelplate/Apex, Blue Lake, and Lake Country sites.

Douglas-fir tussock moth was the most common defoliator with only six other defoliator species recorded, including western false hemlock looper at five sites (McLure, Six Mile, Vernon, Spences Bridge, Red Bridge).

In the Kootenay Outbreak Area, no Douglas-fir tussock moth larvae were found at any of the 9 sites (Table 10). However, like 2018, defoliation of blue spruce was noted in Rock Creek, east to Greenwood, and in Midway; all on private property. Western spruce budworm was present at one site, Johnstone Creek Road (68 larvae recorded), down from five sites in 2017. At the Johnstone Creek Road site, light defoliation was observed on mature trees and moderate defoliation on understorey trees. This site historically has budworm present.

There was a lower diversity and total number of defoliators than in 2018; nine species in 2019 compared to 11 species in 2018, and a total of 81 larvae in 2019 compared to 149 larvae in 2018. This lower diversity and number are likely due to the cooler and wetter early summer of 2019.

Table 10. Dominant insects recorded in three-tree beatings in the Kootenay Boundary (9 sites) and Thompson Okanagan (35 sites) Regions. The total number of insects and number of sites where insects were found is recorded.

Region	Douglas-fir tussock moth (*Orgyia pseudotsugata*)	Western spruce budworm (*Choristoneura freemani*)	Western hemlock looper (*Lambdina fiscellaria lugubrosa*)	Western False Hemlock Looper (*Nepytia freemani*)	Sawflies (*Anoplonyx laricivorus*)	Green-striped forest looper (*Melanolophia imitata*)
Kootenay Boundary						
Total insects	0	36	28	1	2	7
No. sites	0	1	4	1	1	5
Thompson Okanagan						
Total insects	46	6	1	12	8	3
No. sites	5	2	1	5	6	2

WESTERN HEMLOCK LOOPER *LAMBDINA FISCELLARIA LUGUBROSA*

In 2019, defoliation by western hemlock looper was mapped on 1,074 hectares in four TSAs within the Kootenay Boundary Region (Table 2) for the first time in five consecutive years of no visible defoliation in the southern interior. Most defoliation was mapped in the Arrow TSA on 548 hectares, followed by Kootenay Lake and Revelstoke TSAs at 298 and 220 hectares respectively. Most of the defoliation was light, but there were patches of severe defoliation in the Arrow and Kootenay Lake TSAs near Marsh Adams Creek, Giegerich Creek, along the Duncan River, Kuskanax Creek, Bremner Creek and Beatrice Lake.

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 13). Three-tree beatings and moth trapping were done at all 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 of the sites. 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. Traps were collected between September 25 and October 5, 2019. There are permanent sample sites in the Cariboo Region, but no sampling was conducted in 2019.

The average number of western hemlock looper moths caught per trap is trending upward (Table 11, Figure 14) from a 5-year period of minimal catches between 2013 and 2017. Average trap catches per site increased at 12 sites in the Thompson Okanagan and 8 sites in the Kootenay Boundary (Table 11). Sites with the highest average moth catch per trap in 2019 include: Greenbush Lake (515 moths); Shuswap River (422 moths); and, Murtle Lake (316 moths) in the Thompson Okanagan and Begbie Creek (658 moths); Kinbasket Lake (518 moths); and Pitt Creek Recreation Site (342 moths) in the Kootenay Boundary (Table 11). Additional defoliation could be visible at several sites in 2020 in both hemlock-dominated and interior Douglas-fir-dominated stands. Notable defoliation has occurred in 2018 and 2019 near Baker Lake in Washington State to the south.

Western hemlock looper larva, pupa and moth

Table 11. Average number of western hemlock looper moths caught per six-trap cluster in the Thompson Okanagan and Kootenay Boundary Regions, 2012-2019.

Site #	Location	Average moth catch per trap							
		2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Thompson Okanagan Region									
1	Serpentine River	26	3	2	6	1	9	18	38
2	Thunder River	79	6	7	34	2	34	146	107
3	Mud Lake	52	4	1	13	1	14	294	120
4	Murtle Lake	88	8	3	25	3	51	134	316
5	Finn Creek	35	5	2	13	0	14	43	237
7	Scotch Creek	705	44	11	20	4	34	311	222
8	Yard Creek	-	175	33	141	17	72	29	145
9	Crazy Creek	410	30	21	41	2	32	143	146
10	Perry River North	197	59	29	58	10	-	302	197
11	Three Valley Gap	240	53	21	50	8	55	234	291
12	Perry River South	410	70	29	33	8	30	156	233
13	Kingfisher Creek	732	80	43	55	27	50	241	211
14	Noisy Creek	450	117	106	107	12	47	128	178
15	Shuswap River	411	46	26	49	6	49	161	422
16	Greenbush Lake	1,530	83	20	23	11	81	140	515
17	Adams River/Tum Tum	501	12	8	41	0	39	84	119
	Average of sites	**391**	**50**	**22**	**44**	**7**	**41**	**160**	**219**
Kootenay-Boundary Region									
66	Sutherland Falls	222	40	21	2	1	-	72	235
72	Tangier FSR	390	110	23	19	1	19	98	56
73	Martha Creek	281	105	31	3	3	23	86	33
74	Goldstream River	597	137	23	2	3	42	55	257
75	Downie Creek	743	86	24	9	9	9	35	246
76	Bigmouth Creek	645	38	2	2	1	26	25	88
78	Carnes Creek	518	66	7	5	3	15	8	257
83	Begbie Creek	557	171	23	11	0	50	97	658
84	Pitt Creek Rec. Site	865	13	6	4	2	50	60	342
85	Kinbasket Lake	304	83	4	9	2	20	145	518
87	Jumping Creek	201	36	4	3	5	41	68	NA
	Average of sites	**484**	**80**	**15**	**6**	**3**	**29**	**68**	**269**

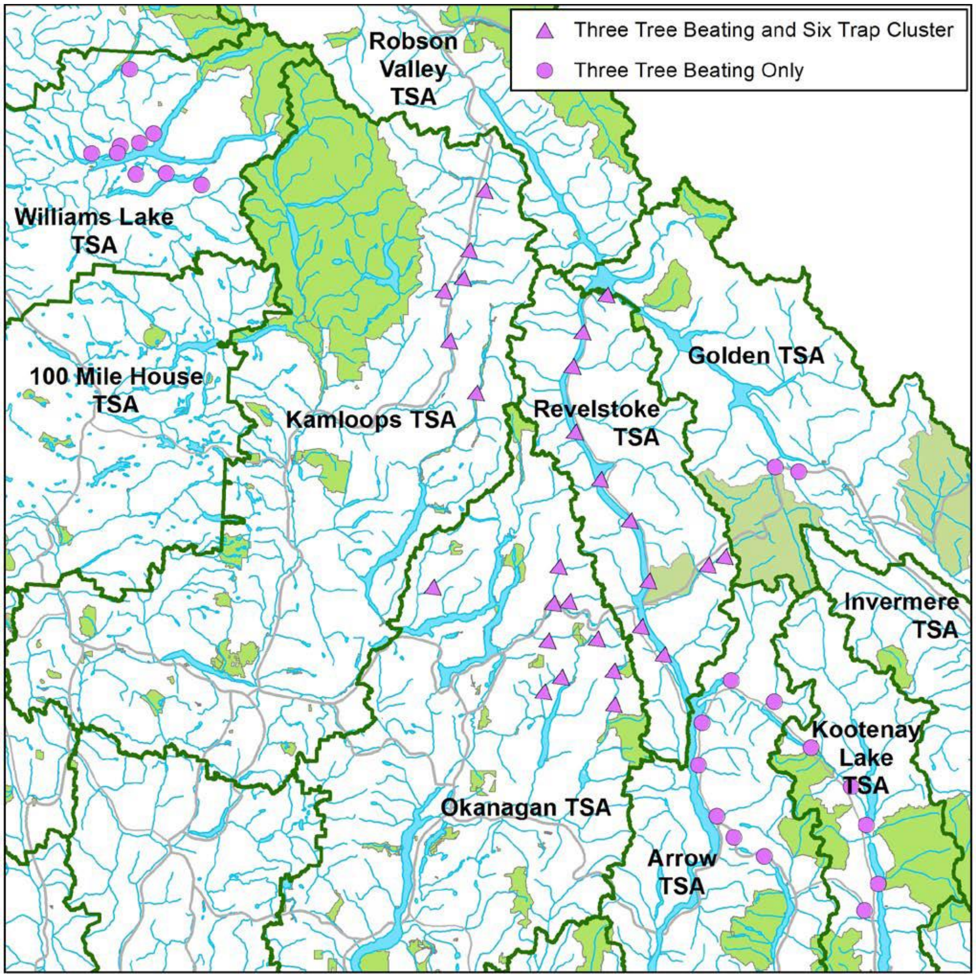


Figure 13. Locations of western hemlock looper permanent sampling sites in southern British Columbia.

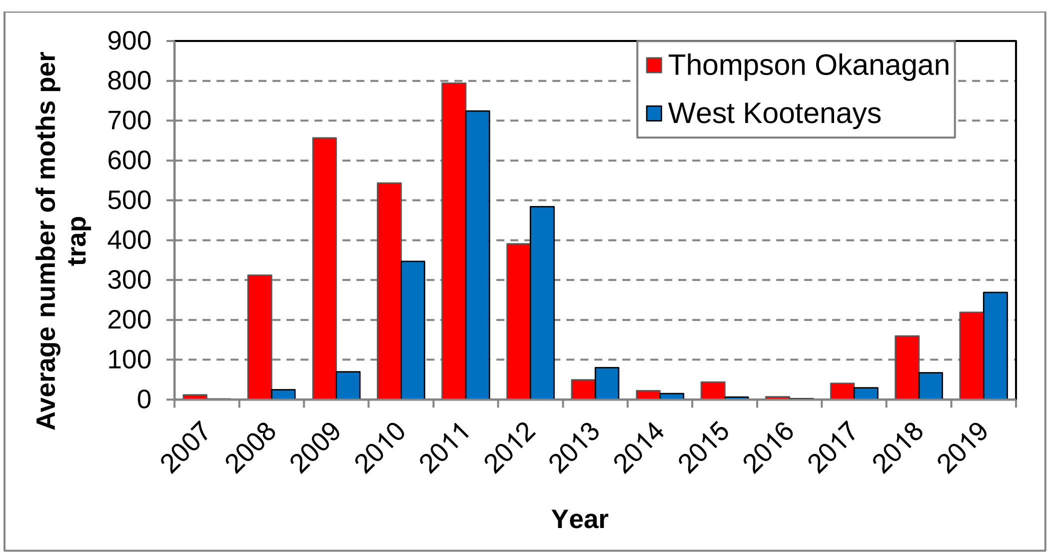


Figure 14. Average annual western hemlock looper trap catch in the Thompson Okanagan and West Kootenays, 2007-2019.

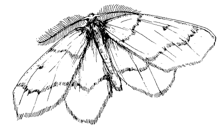
For the second consecutive year, defoliator activity increased throughout the Thompson Okanagan and Kootenay Boundary Regions, with larvae found in 15 of 16 sites and 24 of 25 sites, respectively (Table 12) in the three-tree beatings. The most dominant insects found were the western hemlock looper, filament bearer (*Nematocampa resistaria*) and hemlock sawflies (*Neodiprion sp.*). Both the abundance and richness of defoliator species found in 2019 increased over that of 2018.

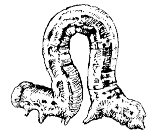
In the Thompson Okanagan, western hemlock looper larvae were found in 94% of sites visited in 2019, up from 75% of sites in 2018. The highest counts were at Mud Lake, Crazy Creek and Three Valley Gap. In the Kootenay Boundary Region, western hemlock looper larvae were found in 92% of the sites, up from 52% in 2018. Bigmouth Creek had the highest count at nine larvae, followed by Gerrard and Box Lake with eight larvae each. Box Lake had the highest defoliator activity with six different species - leading to trace to light defoliation, with the dominant defoliator being saddleback looper (*Ectropis crepuscularia*). Sawfly numbers were high in the Kootenay Boundary Region (Table 12) with the highest level recorded at Keen Creek, between New Denver and Kaslo.

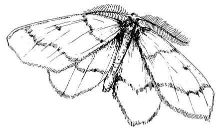
Table 12. Results from the 2019 three-tree beatings at permanent sample sites located in areas of historic western hemlock looper defoliation in the Thompson Okanagan and Kootenay Boundary Regions. The table shows the total number of specimens of the dominant insect species collected.

Site No.	Region and Geographic Location	Western Hemlock Looper (*Lambdina fiscellaria lugubrosa*)	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*
Thompson Okanagan Region									
1	Serpentine-Lemprière								
2	Thunder River		2				1	2	1
3	Mud Lake	8	3				3		
4	Murtle Lake Road								
5	Finn Creek	4		1			1	1	
7	Scotch Creek	2		1					
8	Yard Creek Road	2							
9	Crazy Creek Road	9		1					1
10	Perry River North	5				2	1		
11	Three Valley Gap/Wap Creek	8	2	2					1
12	Perry River South/Eagle River	6		2					
13	Kingfisher Creek Road	4					1		
14	Noisy Creek/Kingfisher Creek	1	3		3		3	32	1
15	Shuswap River	4	1					1	
16	Greenbush Lake	1				2			
17	Adams River/Tum-Tum		2	2			1	6	
	Total insects	**54**	**13**	**9**	**3**	**4**	**11**	**42**	**4**

Site No.	Region and Geographic Location	Western Hemlock Looper (*Lambdina fiscellaria lugubrosa*)	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*
Kootenay Boundary Region									
30	Keen Creek	6	60	2			4	3	
38	Hills	6		4	6		4		
58	Halfway River	4			1				
61	Box Lake	8	77	3	2		40	25	
62	Kuskanax Creek	3		5					
65	Shelter Bay Ferry	2							
66	Sutherland Falls	2							
69	Quartz Creek	1	6	1					
70	Gerrard	8	27					1	
71	Trout Lake	5							
72	Tangier FSR	6	12					3	
73	Martha Creek	4	3		1				
74	Goldstream River	2	3						
75	Downie Creek	3	10						
76	Bigmouth Creek	9	2						
78	Carnes Creek	0							
79	Lardeau FSR	7		3					
80	Meadow Creek	2							
81	Schroeder Creek	2	15						
82	Beaton	3		1	1				
83	Begbie Creek	2		1			1	13	
84	Pitt Creek Rec Site	6	35						
85	Kinbasket Lake	4	38						
86	Beaver River	0	42						
87	Jumping Creek	5	9					1	
	Total insects	**100**	**339**	**20**	**11**	**0**	**49**	**46**	**0**





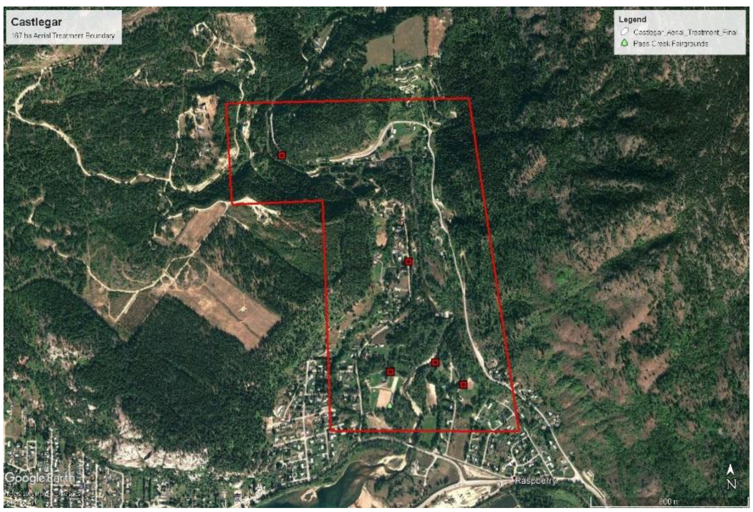


GYPSY MOTH, *LYMANTRIA DISPAR*

The Ministry of Forests, Lands, Natural Resource Operations and Rural Development, the Canadian Food Inspection Agency (CFIA), and the Canadian Forestry Service cooperatively monitor for occurrence of European gypsy moth at many sites throughout the southern interior. In 2018, three moths were trapped at a site near Castlegar. A delimiting grid of additional traps (43 traps per square mile) was deployed in 2019 in the area of interest in and around Castlegar. One trap caught 9 moths, while four other traps caught single moths, for a total of 13 moths. In late October, the Regional Entomologist and CFIA personnel ground surveyed the area within a 500 meter radius of "positive traps", but no egg masses were found.

Gypsy moth in trap

A spray program using *B.t.k.* is planned for 167 hectares in May-June to eradicate Gypsy moth from the area. An Open House was held in Castlegar on January 23, 2020 to inform the public.

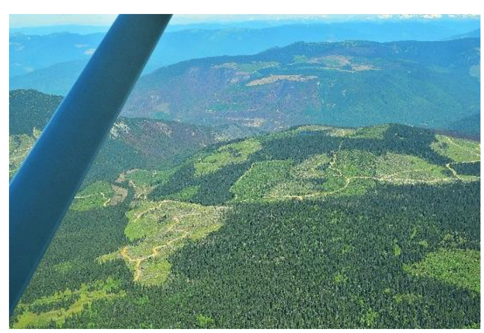


Proposed aerial spray for gypsy moth in Castlegar. Red dots show traps where moths were caught.

Babita Bains, Marnie Duthie-Holt, Tim Ebata and Dean Christianson at Castlegar Gypsy moth Open House.

THOMPSON OKANAGAN REGION SUMMARY

The Thompson Okanagan portion of the aerial overview surveys was carried out between July 15th and July 26th, 2019. The surveys were completed in 47.4 hours, over 8 flight days. Conditions and visibility were good. All surveys were conducted by Kevin Buxton (Ministry of Forests, Lands, Natural Resource Operations and Rural Development – now retired) and Janice Hodge (JCH Forest Pest Management), and utilized a Cessna 210 operated by AC Airways of Langley, B.C.



Over Elephant Hill Fire, Kamloops TSA

KAMLOOPS TSA

Bark Beetles

Douglas-fir beetle attack was mapped on 3,110 hectares, up from 1,976 hectares in 2018. The most substantial and extensive attack occurred in the north portion of the TSA from Clearwater to Vavenby and many of the side drainages such as Raft and Otter Rivers. Many patches were also mapped along the Barriere River, Saskum Lake, East Barriere Lake and Lemieux Creek. Populations expanded in the Heffley – Louis Creek area and on the west side of the Thompson River near McQueen Lake. Small pockets of attack were observed around the perimeter of the 2017 Elephant Hill Fire (EHF) in the Deadman River-Mowich Lake area. It is anticipated that Douglas-fir beetle attack will intensify around the fire perimeter as beetles fly out of the fire-affected area into green stands. Douglas-fir beetle attack was difficult to differentiate from post-fire mortality within the EHF perimeter. Scattered patches and spots were mapped in the southeast of the TSA between Campbell Lake and Meadow Lake.

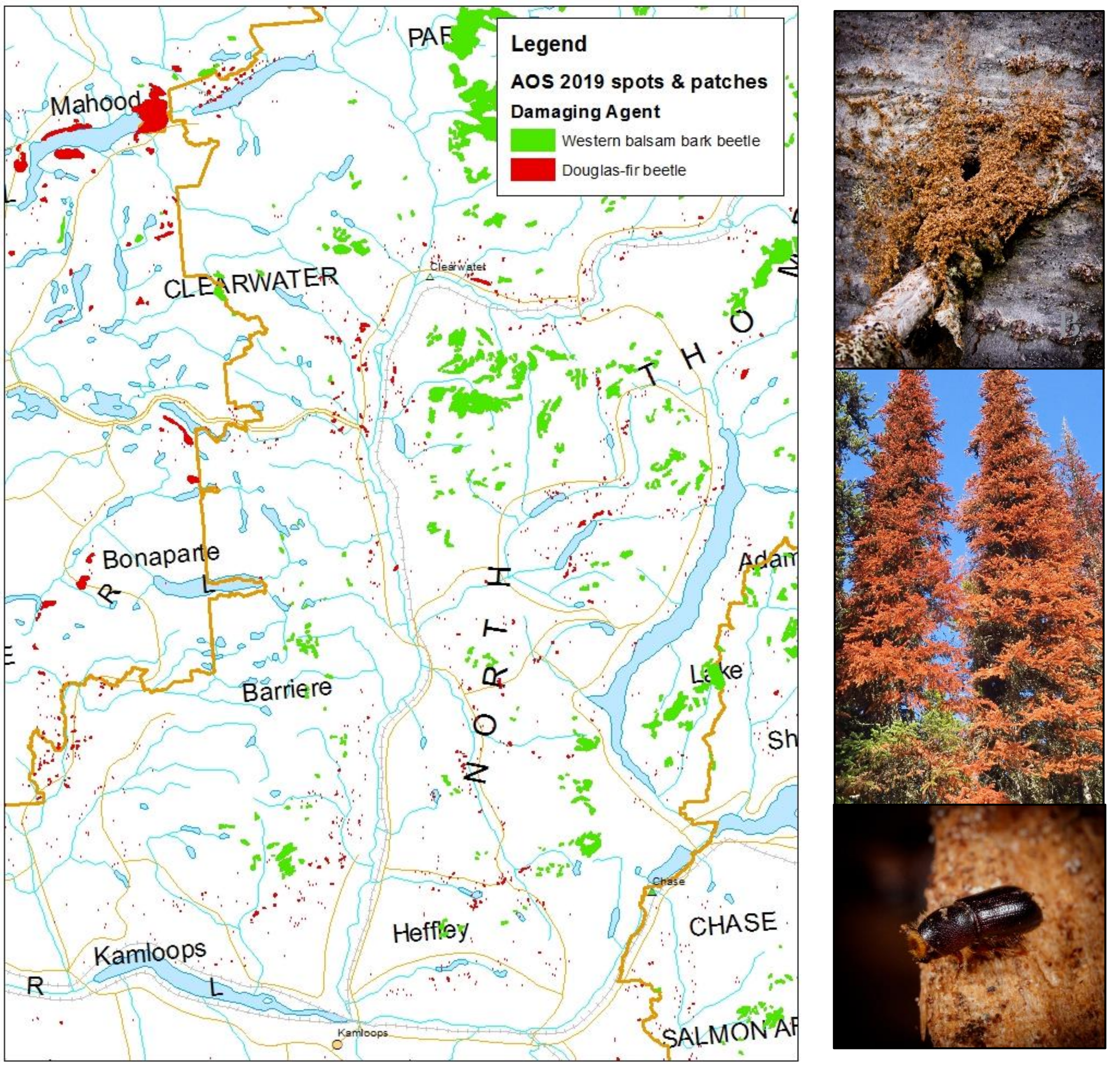


Figure 14. Spots and patches of Douglas-fir beetle and patches of western balsam bark beetle mapped in 2019 in the north section of the Kamloops TSA.

Western balsam bark beetle attack was mostly at trace levels over 57,429 hectares, a 17% decline in area from 2018 and closer to the area mapped in 2017. The infestations were in most high elevation subalpine fir stands north of Kamloops, throughout Wells Gray Park, Raft Mountain, Trophy Mountain, Battle Mountain, and Dunn Peak areas. The area affected by **spruce beetle** fell from 6,917 hectares to 5,013 hectares. The active spruce beetle area is within Wells Gray Park around Kilpill Lake, Anderson Lake and McDougall Lake. Infestations appear to be spotting northward. No spruce beetle was mapped south of the Park.

No **mountain pine beetle** was observed.

Defoliators

Western spruce budworm defoliation almost doubled to cover 4,296 hectares. The most noticeable expansion was in the Criss Creek and Tranquille River areas where many understory trees were severely defoliated. The population near Robbins Range seems to be declining. Egg mass sampling indicates continued light defoliation in 19 of 50 sites sampled in the Kamloops TSA. 4,174 hectares are scheduled for *B.t.k.* treatment in the Criss Creek area in 2020.

Light defoliation by **two-year cycle budworm** was mapped on 922 hectares, down significantly from 2018 because this is the “off” year in their cycle. Patches of defoliation were mapped southwest of Clearwater Lake, in the Grizzly Mountains near Clearwater Peak and south of Monticola Lake.

Only 4 hectares of **Douglas-fir tussock moth** defoliation were mapped near Heffley Creek. For the second year, the Seven O Ranch sprayed over 300 hectares with *B.t.k.* to control the tussock moth, which has presumably influenced the population decline. Single tree defoliation events were observed at numerous spots in Barnhartvale, North Kamloops and Vinsula. Additional defoliation is anticipated in 2020.

The **aspen serpentine leafminer** defoliation increased about 9,000 hectares in the TSA to cover 29,399 hectares throughout Wells Gray Park and south near Niskonlith.

Birch leafminer damage declined to 1,267 hectares. Populations persisted in the upper North Thompson around Albreda, Vavenby and Birch Island, and near Fadear Creek in the south (see defoliator section). **Satin moth** damage was limited to 47 hectares in three patches near Blue Earth Creek, Chartrand Creek and Dardanelles Lake. Five hectares of **balsam woolly adelgid** mortality was mapped at Sun Peaks Mountain Resort.

Diseases and Other Damage

Dothistroma needle blight was detected between Finn Creek and Adams River on 24 hectares. **White pine blister rust** caused spotty mortality along the Adams River from Sunset Creek to Oliver Creek. The other notable disturbance in the Kamloops TSA was **cedar flagging** that was mapped over 19,233 hectares throughout the North Thompson Valley, Blue River and Wells Gray Park. **Post-burn mortality** (1,048 hectares) was observed on the southern and western perimeter of the EHF in a number of young pine stands. Very little **drought mortality** was mapped (8 hectares) and 2,666 hectares of **foliar discoloration** from drought were observed near Kilpill Mountain and Blue River. 353 hectares of **burn**; 74 hectares of **aspen decline** near McLean Lake; plus, minor **flooding**, **frost kill** to buds and **windthrow**.

Cedar flagging

Aspen serpentine leafminer damage

MERRITT TSA

Bark Beetles

Bark beetle activity declined across the Merritt TSA with only two bark beetle species mapped. **Douglas-fir beetle** infestations were mapped on 54 patches and 326 spots for a total of 407 hectares infested. The most active infestations were in the northeast of the TSA from Glimpse Lake to Chapperon Creek. **Western balsam bark beetle** covered 7,557 hectares, down from 9,306 hectares in 2018, mostly trace attack along the western boundary of the TSA in the Cascades Range and between Finnegan Creek and Arcat Creek in the east.

Defoliators and Other Damage

Western spruce budworm defoliation increased substantially in 2019 covering 2,945 hectares. The most expansion was seen northwest of Nicola Lake, near Mammit Lake and Danish Creek and in the Asp Creek and Wolfe Creek areas near Princeton. 3,830 hectares are proposed for spray with *B.t.k.* in 2020 near Danish Creek and northwest Nicola Lake. 2019 marked the first year **Douglas-fir tussock moth** defoliation was mapped since the last outbreak in Merritt TSA. Severe defoliation was mapped on 14 hectares along the Similkameen River in Stemwinder Provincial Park and numerous private campgrounds and properties in the area. Ground assessments found evidence of NPV (nuclear polyhedrosis virus) in populations in the Park. Some private land owners had sprayed their property so there were no larvae to assess. Small patches of **satin moth** and **aspen serpentine leafminer** were noted on 70 and 18 hectares, respectively. One 29-hectare patch of **balsam woolly adelgid** damage was mapped in Britton Creek.

Douglas-fir tussock moth defoliation above Similkameen River, Merritt TSA

200 hectares of **wildfire damage** was mapped and 107 hectares of **post-burn mortality.** **Aspen decline** was detected in 13 patches near Quilchena Creek, Midday Creek, Howarth Creek and Murray Lake. **Bud kill** affected 3 hectares, while 24 hectares of **drought mortality** were recorded.

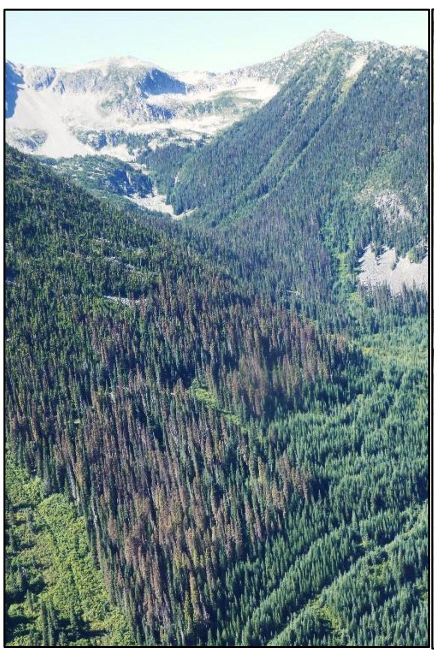
LILLOOET TSA

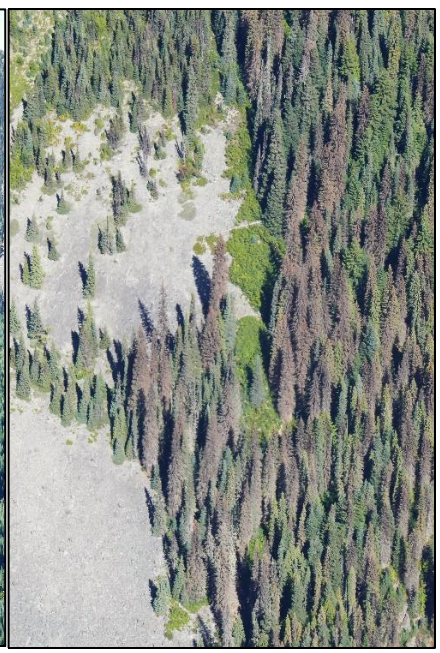
Bark Beetles

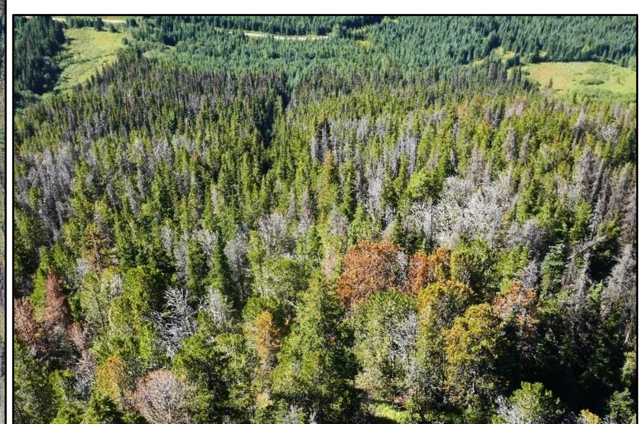
Douglas-fir beetle populations continued to decline, to just 188 hectares in 2019. **Mountain pine beetle** attack declined from 7,891 hectares in 2018 to 6,747 hectares, although it was still very active throughout the TSA in both lodgepole pine and whitebark pine. Populations were active in the Bridge River and Slim Creek drainages in the north and near Downton Creek and Cadwallader Creek in the south.

The area infested by **spruce beetle** declined by almost 50 percent to 3,122 hectares in 196 patches. Populations were still active along the south side of Duffey Lake, Cottonwood Creek, Van Horlick Creek and Gott Creek. Patches of attack were also mapped in the Tyaughton Creek area. Much of the mature spruce in these drainages is now dead.

The area affected by **western balsam bark beetle** increased by 3,869 hectares since 2018 to 15,697 hectares of primarily trace attack. 377 patches occurred throughout high elevation sites in the TSA, particularly in the Tyaughton Creek to Eldorado Mountain area.







Spruce beetle damage (left and centre) and mountain pine beetle killed whitebark pine (right), Lillooet TSA

OKANAGAN TSA

Bark Beetles

Douglas-fir beetle infestations increased slightly in 2019, to 950 spots and 262 patches on 2,288 hectares. Attack is widespread and scattered throughout the TSA, particularly in the Lumby and Cherryville area.



Douglas-fir beetle galleries and attack near Cherryville, Okanagan TSA

The area affected by **western balsam bark beetle** declined somewhat to 42,362 hectares of mostly trace attack. This year-to-year fluctuation reflects to some degree the two-year life cycle of the beetle. Most high elevation subalpine fir sites had pockets of attack including Winnifred Creek, Coalgoat Creek to Buck Mountain, Sicamous Creek, Pukeashun Mountain, and Big White to Damfino Creek. **Spruce beetle** was detected in one patch (114 hectares) on Mount Mabel and **mountain pine beetle** infestations were mapped on 46 hectares in the south of the TSA.

Defoliators

Defoliator population and diversity has fluctuated year to year in the Okanagan, with a mix of light to severe defoliation by **Douglas-fir tussock moth** mapped over 1,028 hectares in the south portion of the TSA, between Oliver and Osoyoos, near McKinney Road and Anarchist Mountain. Many single tree occurrences were observed in ground reconnaissance near the Kelowna Airport, Silver Star Mountain Road and at the intersection of Hwy. 1 and the Chase-Falkland Road. These populations are expected to expand in 2020 (see Defoliator section). **Aspen serpentine leafminer** damage was mapped on 4,833 hectares, an increase from 661 hectares mapped in 2018. Both **birch leafminer** and **satin moth** damage declined to 58 hectares and 74 hectares, respectively.


Douglas-fir tussock moth defoliation, Anarchist Mountain, and female laying eggs

Foliar and root diseases and stem rusts

Disease damage remained relatively unchanged from 2018 with: **Dothistroma needle blight** (166 hectares); **cottonwood leaf rust** (*Melampsora occidentalis*) (139 hectares); **laminated root rot** (126 hectares); and, **white pine blister rust** (13 hectares).

Other Damage

Cedar flagging was mapped over 2,372 hectares in the ICH and transition IDF sites in the north and northeast of the TSA. **Wildfire damaged** 3,564 hectares and **post-burn mortality** was mapped on 312 hectares. Damage from **drought** decreased to 790 hectares of mortality and 165 hectares of foliar damage. Young pine stands north of McLean Creek and between Johnson Creek and Penticton Creek were most affected. 73 hectares of other abiotic damage were mapped.

Drought damage to young pine, Okanagan TSA

CARIBOO REGION SUMMARY

The Cariboo portion of the aerial surveys was completed between June 23rd and September 5th. The Cariboo Region was flown in two sections (divided north-south) by two different contractor teams. The lead surveyor on the south portion of the flights was Barbara Zimonick, with Karen Baleshta as second seat. The surveyors for the north portion of the flights were from Industrial Forest Services Ltd., Prince George B.C. A total of 94.7 hours over 20 days, were expended to cover the Region. Aircraft were supplied by Cariboo Air and Guardian Air. Cessna 182s were the primary aircraft used for the surveys.

Most forest pathogens are not detected in the Aerial Overview Survey other than foliar disease and mortality associated with disease-climate interactions. Forest pathogens are not cyclical in nature, but are often influenced by climate, both moisture and drought. Throughout the Cariboo, there is a high rate of drought mortality associated with root disease, particularly in the Interior Cedar Hemlock (ICH) biogeoclimatic zone. Drought mortality is not an expected event in the ICH. However, with high levels of root disease present throughout this ecosystem, mortality rates increase if there is drought.

100 MILE HOUSE TSA

Bark Beetles

The area affected by **Douglas-fir beetle** almost doubled from 6,417 hectares in 2018 to 12,272 hectares in 2019. A total of 119 patches were mapped, with an additional 429 spot infestations killing approximately 2,780 trees. Attack was widespread in the Canim to Mahood Lake area in the northeast of the TSA, south of Green Lake, in the Bonaparte River drainage and along the Fraser River and Big Bar Creek area. Much of this expansion can be attributed to the wildfires over the past two years and the build-up of beetles in fire-stressed trees. **Western balsam bark beetle** declined in area affected by about 27 percent to 3,993 hectares in 2019 mostly in the Spanish Creek area, bounded on the northeast edge of the TSA and Big Timothy Mountain to the north. No **mountain pine beetle** or **spruce beetle** activity was recorded in the TSA.

Defoliators and Foliar Diseases

Western spruce budworm defoliated patches of Douglas-fir between 100 Mile House and Lac la Hache near 108 Mile Lake, resulting in 1,059 hectares of mapped defoliation, a 76% decline from 2018. Seventy-five percent of the 36 sites sampled for egg masses resulted in "nil", with only nine sites predicting light defoliation in 2020, many along the 2400 Road. **Two-year cycle budworm** is in its "off" year and only a small patch of light defoliation (250 hectares) was mapped near Windy Creek on the far eastern edge of the TSA. **Aspen serpentine leafminer** damage continued to be widespread in a central west-to-east swath across the TSA, affecting 80,999 hectares – a 21 percent increase from 2018. No other insect defoliator activity or foliar disease damage was observed during the survey.

Other Damage

Twenty-one hectares of **aspen decline** was noted near Sulphurous Lake and twenty-six patches of **cedar decline** were mapped over 2,971 hectares near Deception Mountain and Ruth Redfern Creek area. **Post-burn mortality** was observed in patches from Clinton to south of Green Lake and along the Loon Lake corridor and Bonaparte River. A mix of light to severe intensity was mapped on 13,200 hectares. Two patches of **drought mortality** were mapped between Big Lake and Tad Lake (176 hectares). **Flooding** was recorded on sixteen hectares south of Trurans Lake on Fiftyseven Creek.

QUESNEL TSA

Bark Beetles

The area affected by **Douglas-fir beetle** saw a seventy-five percent reduction from 2018 with 2,582 hectares mapped over thirty-four patches and 400 spots killing approximately 3,872 trees. Infestations were scattered west in Quesnel View, north of the intersection of the Fraser and Cottonwood Rivers. The area affected by **western balsam bark beetle** remained relatively unchanged from 2018, with 138 patches and 169 spot infestations for a total of 54,946 hectares of mostly trace and light attack. Most of the affected stands are in a north-south swath in the Barkerville Mountain-Wells area and Bowron Lake Park. **Spruce beetle** infestations saw a 4-fold increase in 2019 after a significant decline in 2018, most likely due to the two-year life cycle of the beetle. Affected area was mostly trace to light mortality over 23 patches and 37 spot infestations near Matthew Creek, Mount Patchett and west of Bradley Creek, totaling 2,130 hectares. **Mountain pine beetle** was limited to nine spot infestations and one 60-hectare patch in the far west of the TSA near Tilgatgo Lake.

Other Damage

2019 was an "off" year for **two-year cycle budworm**, with only six patches of light defoliation mapped near Dragon Lake, Barkerville Mountain, Hardscrabble Mountain and Mount Anderson (1,897 hectares). **Pine needle sheathminer** defoliation declined from 1,800 hectares in 2018 to 751 hectares in 2019 on 12 lodgepole pine plantations near Pelican Lake, Boot Lake and Mervin Creek. **Aspen serpentine leafminer** damage was mapped on 89,687 hectares in 2019, an increase of 44 percent over 2018. Most defoliation was mapped as moderate. Aspen serpentine leafminer was detected almost everywhere the host was found.

Post-burn mortality was mapped on 16,223 hectares throughout the western half of the TSA in and around the 2017-2018 wildfires. **Fire mortality** was mapped on only 177 hectares. **Cedar decline** was mapped on 4,804 hectares in the Bowron Lake Park area in the east of the TSA. Some **foliar damage** was mapped affecting young pine north of Granite Mountain (118 hectares).

WILLIAMS LAKE TSA

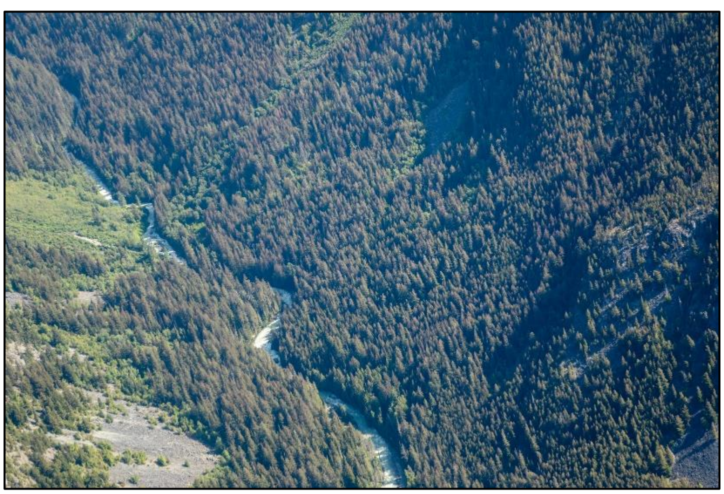
Bark Beetles

Douglas-fir beetle populations increased again in 2019 to 54,541 hectares over 299 patches and 758 spot infestations (approximately 6,516 trees). The average patch size increased from 98 hectares in 2018 to 182 hectares in 2019. The most concentrated attack was north and south of Williams Lake and along the Fraser River corridor; south along Soda Creek and the Empire Valley to the border with 100 Mile House TSA. Scattered attack was mapped in the far west and east of the TSA. **Spruce beetle** attack saw a three-fold increase in area affected in 2019 (8,472 hectares) primarily mapped as trace or light. Most of the 71 patch and 37 spot infestations were recorded along the north arm of Quesnel Lake to Mitchell Lake and near Welcome Mountain.

Mountain pine beetle infestations continued to expand in 2019, mapped on 42,575 hectares, almost triple the number of hectares mapped in 2018. Attack was mostly trace to light, in 130 patch and 90 spot infestations. Attack continued to expand in the Tatlayoko Lake - Chilko Lake - Taseko Lake area, with smaller patches east of Anahim Lake. **Western balsam bark beetle** was widespread throughout high elevation sites in the Tatlayoko Lake - Chilko Lake - Taseko Lake area in the southeast of the TSA, and from Likely to Clearwater Lake and Quesnel Lake in the northeast. 64,949 hectares of the total 71,084 hectares mapped in 2019 was trace. This was a slight increase in activity from 2018.

Defoliators and Other Damage

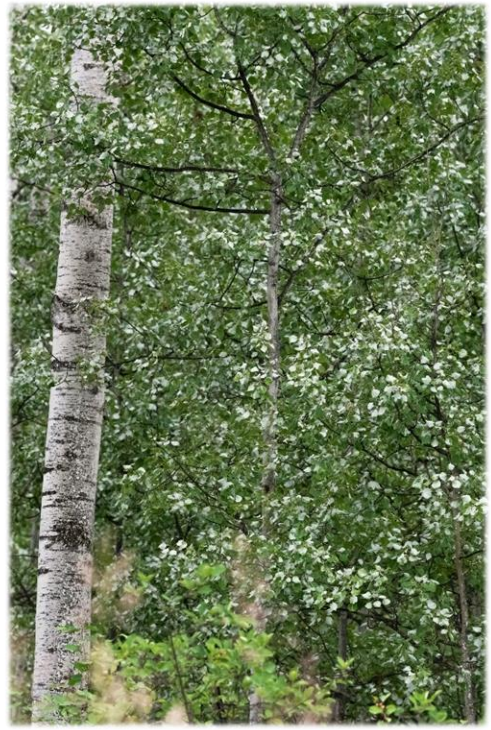
Western spruce budworm defoliation was mapped on 14,885 hectares, 9,517 hectares of which were designated light attack, a slight decrease from 2018. Much of this mapped defoliation occurred within blocks that were sprayed with *B.t.k.* to control the budworm. Because of high budworm populations in the areas that were sprayed, some feeding occurred prior to treatment and was therefore visible as light defoliation during the Aerial Overview Survey. Populations were located primarily in the central portion of the TSA near Meldrum Creek, Riske Creek, south of Chimney Creek and Felker Lake. A total of 16,786 hectares were sprayed with *B.t.k.* between June 16-21, 2019 (see Defoliator section for details). New areas of defoliation were mapped along the Fraser River east of Meldrum Creek, south of Chimney Creek and near Peavine Mountain. Eggmass sampling indicated that some sites will see light or moderate defoliation in 2020 (Table 7, Defoliator section). Of the 55 sites sampled, 13 sites predict light defoliation and two predict moderate. The Region and District's proactive management of defoliators will continue to treat small, new infestations with 10,000 hectares planned for treatment with *B.t.k.* in 2020.



Western spruce budworm defoliation (left) and Douglas-fir tussock moth defoliation (right), Williams Lake TSA

Douglas-fir tussock moth was the most notable defoliator detected in the Williams Lake TSA in 2019. This is the most northerly record of tussock moth defoliation ever and all of the damage fell into the severe category, with many trees killed. 1,662 hectares were defoliated from Dog Creek north along both sides of the Fraser River (Figure 9, Defoliator section) and two small patches south of the Gang Ranch.

Ground surveys conducted in the fall of 2019 indicate that the population has expanded significantly from these defoliated patches and therefore a 12,000-hectare control program (applying 4 litres per hectare, twice) is proposed for 2020. **Two-year cycle budworm** was in year one of its two-year cycle ("off" year). Only 402 hectares of light defoliation were mapped in six patches near Niagara Creek. The area affected by **aspen serpentine leafminer** increased by 31 percent from 2018 affecting 89,157 hectares. 47 percent of the defoliation was classified as light and 37 percent as moderate. Aspen was infested in a large swath from Soda Creek to Miocene, Horsefly River and Black Creek. To the west, large areas were mapped near Vedan Lake in the Nemaiah Valley.



Post-burn mortality was extensive and widespread throughout areas burned in the 2017-2018 wildfires, totaling 37,233 hectares. **Drought mortality** was mapped on 932 hectares, up slightly from 2018, in the Meason Creek and Patrick Creek area. **Cedar flagging** very prevalent throughout the ICH in the Likely – Quesnel Lake – Horsefly Lake area with 35,320 hectares mapped. Other abiotic damage included 205 hectares of **aspen decline**, 700 hectares of **flooding** and 18 hectares of **fire.**

KOOTENAY BOUNDARY REGION SUMMARY

The Kootenay Boundary Region aerial surveys were completed between July 21st and August 29th and required 107.5 hours of flight time over 19 days. Weather conditions were generally good with mainly clear weather and occasional rain delays. All surveys were conducted by Neil Emery and Adam O'Grady of Nazca Consulting Ltd., using a Cessna 337 Skymaster operated by Babin Air.

SELKIRK SOUTH: ARROW, BOUNDARY, AND KOOTENAY LAKE TSAS

Bark Beetles

Douglas-fir beetle infestations increased marginally throughout the Kootenay Boundary Region with population increases in the Boundary and Kootenay Lake TSAs: 1,101 hectares and 977 hectares, respectively. Scattered attack was mapped in the West Kettle to Grand Forks area; along the west arm of Kootenay Lake; and south of Fruitvale. Populations in the Arrow TSA remained relatively static at 2,324 hectares affected. Much of the increased activity can be related to the drought and wildfire events in the past couple of years.

The area affected by **mountain pine beetle** increased in the Arrow TSA to 1,036 hectares and remained relatively static in the Boundary and Kootenay Lake TSAs at 892 hectares and 3,509 hectares respectively. Most attack was mapped as trace or light. Infestations were recorded on the east side of Kootenay Lake including Campbell Creek north of Riondel, Fry Creek, Hamill Creek and the east side of Duncan Lake up Glacier Creek. Scattered attack was also mapped along the USA border in Moyie River, Kid Creek and Hawkins Creek. Mountain pine beetle mortality occurred in both lodgepole pine and whitebark pine stands.

Cumulatively, the area affected by **western balsam bark beetle** in the three TSAs increased from 12,576 hectares to 17,349 hectares. Most infestations were mapped as trace and were scattered through high elevation sites in the Selkirk and Purcell Mountains, Twelve Mile Creek and Fortynine Creek. **Spruce beetle** populations increased to 5,483 hectares in the three TSAs, with the outbreaks continuing near Hamill Creek and Summit Lake.

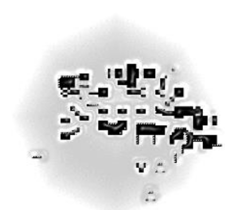
Western pine beetle activity was limited to 41 hectares in three small infestations.

Western pine beetle galleries and adult.

Defoliators and Foliar Diseases

Defoliation by **western spruce budworm** declined to only 80 hectares, with the majority seen northwest of Brides Creek. **Aspen serpentine leafminer** remained fairly static (18,759 hectares over 3 TSAs) with a decline in the Arrow TSA and slight increases in the Boundary and Kootenay Lakes TSAs. Affected areas included stands near Warfield and Nelson along the Kootenay River and Apex Creek. **Western hemlock looper** seems to be building across the southern interior of B.C. with defoliation mapped in the Arrow (548 hectares) and Kootenay Lake (298 hectares) TSAs. Defoliation was observed near Kuskanax Creek, Bremner Creek, Marsh Adams Creek and Giegerich Creek. Foliar diseases affected 494 hectares with: **Dothistroma needle blight** (156 hectares); **larch needle blight** (*Hypodermella laricis*) (307 hectares); **birch leafminer** (1,489 hectares); and, 31 hectares unidentified.

Birch leafminer damage near Creston, Arrow TSA



Other Damage

8,606 hectares of various abiotic damage types were detected in 2019. **Drought mortality** was mapped on 5,374 hectares, mostly in the West Kettle area of the Boundary TSA. **Cedar flagging** was detected on 1,788 hectares, with the largest areas along Kuskanax Creek and Howser Creek. **Post-burn mortality** was observed on 770 hectares, in all three TSAs.

SELKIRK NORTH: GOLDEN AND REVELSTOKE TSAS

Bark Beetles

Mountain pine beetle attack declined for the second year in a row, with 1,059 hectares recorded in 2019 compared to 1,335 hectares in 2018. The more aggressive infestations were in Bigmouth Creek, east and west of Beaver River, Yoho and Glacier National Parks, Valenciennes River and the upper end of the Blaeberry River.

In Revelstoke and Golden TSAs, **spruce beetle** infestations declined to 1,999 hectares in 2019. Populations were mapped in upper Tangier River, Mountain Creek, Casualty Creek, Illecillewaet River, Lane Creek, Wood River and Cirque Creek. The area affected by **western balsam bark beetle** was up by 16 percent (increase of 2,304 hectares over the two TSAs), to 16,392 hectares. Most infestations were trace to light severity across most high elevation areas. Some of the largest patches were mapped in the Moonraker Peak and Canyon Creek areas.

Spruce beetle infestation in Glacier National Park

Douglas-fir beetle declined to 431 hectares affected, with 31 patch infestations and 54 spot infestations mapped. Most infestations were in the southern portion of the Revelstoke TSA near Arrowhead on Beaton Arm of the Upper Arrow Lake, Akolkolex Creek and Mulvehill Creek.

Defoliators and Other Damage

Aspen serpentine leafminer affected 4,351 hectares; **birch leafminer** defoliated 113 hectares; and, **western hemlock looper** was mapped on 220 hectares near La Forme Creek and from Canyon Hot Springs up the Tangier River. This could indicate the first year of a hemlock looper outbreak cycle.

Other damage was mapped over 11,873 hectares and included **cedar flagging** (10,929 hectares), which was widespread throughout both TSAs, 779 hectares **post-burn mortality,** 24 hectares larch needle blight, 28 hectares **wildfire** damage, 22 hectares **drought mortality**, 33 hectares **flood** damage, 20 hectares **slide** damage and 38 hectares of unidentified abiotic damage.

Cranbrook and Invermere TSAs

Bark Beetles

Mountain pine beetle infestations declined from 8,302 hectares in 2018 to 7,325 hectares mapped in 2019, with most infestations in the Invermere TSA where 212 patch infestations of 281 spot infestations were recorded. The heaviest attack was mapped in the Jumbo Creek to Toby Creek area, Dutch Creek, and Buhl Creek to Skookumchuck Creek.

The area affected by **Douglas-fir beetle** did not change very much from 2018, with 1,969 hectares affected in 116 patches and 468 spots. Many of the infestations are along the Kootenay River from Radium Hot Springs in the north to Lussier River in the south.

There was just under a 40 percent increase in **spruce beetle** activity in the two TSAs, with 8,004 hectares mapped in 2019 compared to 5,771 hectares in 2018. Most infestations were in the northeast, along the B.C. - Alberta border, near Mount Queen Mary, Palliser River, Mount Abruzzi and Mount Acosta.

The area affected by **western balsam bark beetle** remained relatively unchanged from 2018 (21,458 hectares) with 24,414 hectares mapped in 2019. The most severe infestations were mapped in the northwest portion of Invermere TSA, Spillimacheen Mountain to Bugaboo Creek, Bull River to Brule Creek, and north of Mount Kuleski.

Other Damage

Black army cutworm (*Actebia fennica*) was monitored using pheromone traps, on three fires in the Cranbrook TSA in 2019 (Table 13). One trap at the Meachan site exceeded the 350-moth threshold at 406 moths, representing a moderate threat for defoliation. All other trap catches were under the threshold, meaning there is a low risk of defoliation occurring in 2020.

Table 13. Results from the 2019 black army cutworm moth trapping in the Cranbrook TSA (average number moths per trap ± standard deviation).

Location	Average number moths per trap (± S.D.)	Number traps per site
Meachan	218 ± 116	6
Lost Dog	93 ± 78	6
Wickman	70 ± 63	4

Black army cutworm moths in trap

Insect defoliator activity was limited to 2,869 hectares comprised of **aspen serpentine leafminer** (2,826 hectares) (Kootenay Crossing, Wilmer), 35 hectares of **birch leafminer** and **western hemlock looper** (8 hectares). **Larch needle blight** was detected on 1,790 hectares in the Bull River area northeast of Fort Steele.

Post-burn mortality (4,112 hectares) and **drought mortality** (1,555 hectares) were the main abiotic disturbances in 2019. **Cedar flagging** affected 625 hectares near Albert River, White Creek and the St. Marie River. Other abiotic damage included 98 hectares of **wildfire damage**, 21 hectares **aspen decline**, 35 hectares **flood** damage, 6 hectares **slide** damage and 216 hectares **windthrow**.

FOREST HEALTH SPECIAL PROJECTS

Dwarf Mistletoe Sanitation Trial Update

David Rusch, Forest Pathologist, Cariboo and Thompson Okanagan Regions

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

In 2017, the Gaspard Creek site was burned in a fire and all the trees were burned. In 2018, an additional site was added at Sky Ranch Road, south of Fletcher Lake (SBPSxc). This site was assessed prior to sanitation for dwarf mistletoe severity, *Elytroderma* severity, and percent circumference scarred. This site was planted and reassessed in 2019 and a third site was assessed prior to sanitation near Little Gaspard Creek (IDFdk4) in the same year. The Little Gaspard Creek site will be reassessed following planting in 2020, bringing the total number of sites with post-sanitation measurements to three. All 3 sites are BCTS Forest For Tomorrow blocks.

Results & Discussion:

The number of sanitized trees for each site by height class is shown in Fig. 1 and the percent dwarf mistletoe incidence of sanitized trees at each of the three sites is shown in Fig. 2. Tables 1-3 show stocking levels, incidence and mean severity of dwarf mistletoe, *Elytroderma*, scarred trees, and mean height pooled by treatment. Pre-sanitation (Table 1), post-sanitation prior to planting (Table 2) and post-sanitation after planting (Table 3) values were calculated separately. Severities are not indicated in Table 3 because planting did not affect the mean severity of affected trees. Because *Elytroderma* and scarring were not assessed prior to sanitation, there is no pre-sanitation data available for *Elytroderma* and scarring on the Gaspard Creek Site. Planting density varied from 1,300 to 1,750 stems per hectare.

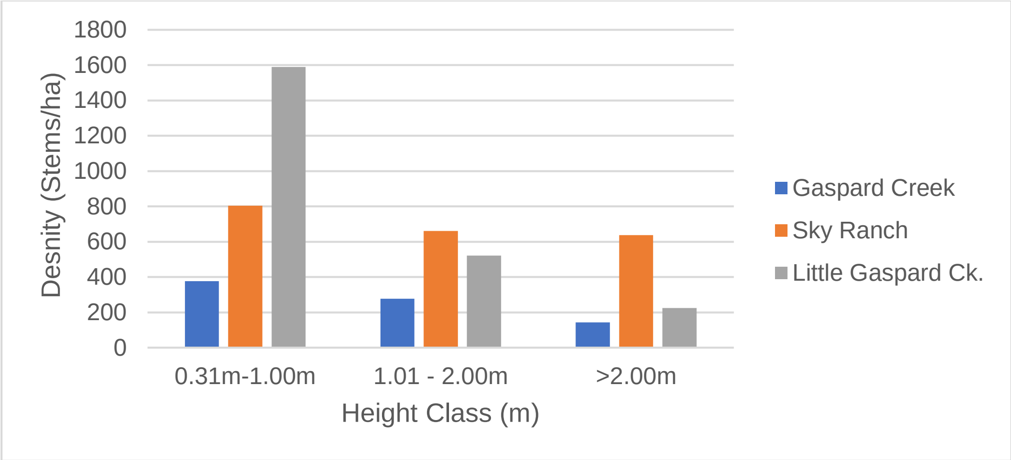


Figure.1 Sanitized trees by site and height class

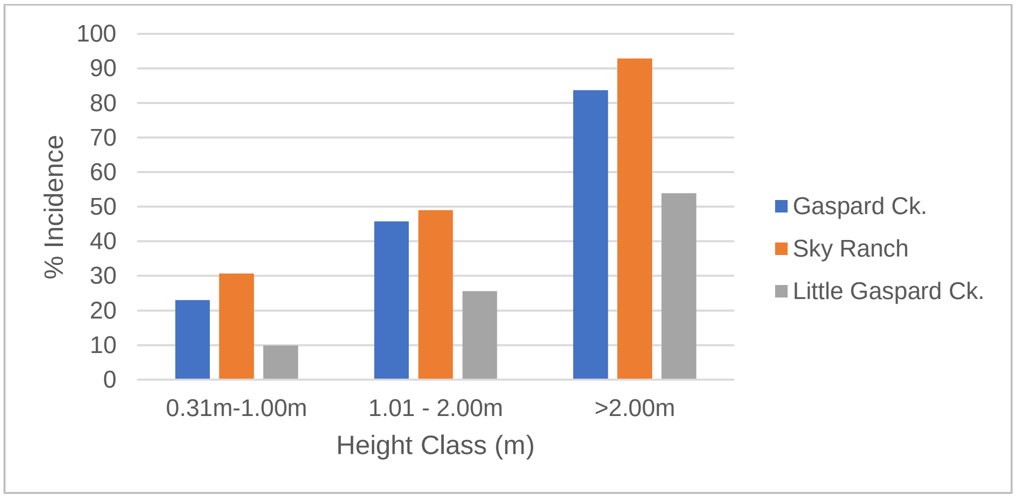


Figure 2. Dwarf Mistletoe Incidence of sanitized trees by site and height class.

Table 1. Pre-sanitation 0.05 ha plot data (plots pooled by treatment).

Site	Treatment	Stocking 0.05 ha plot (stems/ha)	Dwarf Mistletoe Incidence (%)	Mean Hawksworth Dwarf mistletoe severity of infected trees	Elytroderma Incidence 0.05 ha plot (%)	Mean Hawksworth Elytroderma Severity of infected trees	Incidence of scarred trees (%)	Mean % circumference damaged on scarred trees	Mean tree height (m)
Gaspard Creek	0.3 m	3013	21.2	2.3	No data	No data	No data	No data	0.82
	1 m	2107	13.6	2.2	No data	No data	No data	No data	0.73
	2 m	2653	15.3	2.9	No data	No data	No data	No data	0.59
	Control	4520	10.6	2.4	No data	No data	No data	No data	0.70
Sky Ranch	0.3 m	3373	42.9	3.2	22.3	3.4	7.9	26.1	1.58
	1 m	3520	37.1	2.8	16.7	3.2	7.4	31.7	1.39
	2 m	3253	42.6	3.1	19.1	3.4	18.0	22.6	1.26
	Control	5107	16.7	2.7	8.2	3.4	13.1	27.8	0.62

Table 2. Post-sanitation prior to planting 0.05 ha plot data (plots pooled by treatment).

Site	Treatment	Stocking (stems/ha)	Dwarf Mistletoe Incidence (%)	Mean Hawksworth Dwarf mistletoe severity of infected trees	Elytroderma Incidence (%)	Mean Hawksworth Elytroderma Severity of infected trees	Incidence of scarred trees inner (%)	Mean % circumference damaged on scarred trees	Mean Height (m)
Gaspard Creek	0.3 m	1767	5.3	1.6	4.5	4.2	2.3	28.3	0.26
	1 m	1707	6.3	1.6	15.2	4.1	7	29.7	0.45
	2 m	2547	12.3	2.8	7.1	4.5	2.6	19	0.48
	Control	4520	10.6	2.4	13.1	3.7	3.7	39.6	0.70
Sky Ranch	0.3 m	953	8.4	2.3	2.8	3.3	3.5	38	0.26
	1 m	2353	13.6	2.0	4.2	3.3	3.4	36.7	0.41
	2 m	2607	29.9	2.8	10.5	3.2	15.3	23.8	0.75
	Control	5107	16.7	2.7	8.2	3.4	13.1	29.2	0.62

Table 3. Post-sanitation after planting 0.05 ha plot (plots pooled by treatment).

Site	Treatment	Total Pl Stocking (stems/ha)	Planted Pl stocking (stems /ha)	Dwarf Mistletoe Incidence (%)	Elytroderma Incidence (%)	Incidence of scarred trees (%)	Mean tree height (m)
Gaspard Creek	0.3 m	3073	1307	3.0	2.6	1.3	0.23
	1 m	3060	1353	3.5	8.5	3.9	0.34
	2 m	4100	1553	7.6	4.4	1.6	0.36
	Control	5993	1473	8.0	9.9	2.8	0.57
Sky Ranch	0.3 m	2473	1520	3.2	1.1	1.3	0.23
	1 m	4073	1720	7.9	2.5	2	0.33
	2 m	4360	1753	17.9	6.3	9.2	0.54
	Control	6553	1447	13.0	6.4	10.2	0.52

Both the Gaspard Creek and the Sky Ranch Road sites had similar tree densities prior to sanitation, but the Sky Ranch road site had a higher dwarf mistletoe incidence, lower *Elytroderma* incidence, and larger mean residual tree height. Based on the pre-sanitation data, the Little Gaspard Creek site appears to have the highest density and the lowest incidence of dwarf mistletoe of the three sites. As expected, sanitation reduced the incidence of dwarf mistletoe, *Elytroderma*, and scarring caused by logging. It also reduced the severity of dwarf mistletoe but had little or no effect on mean *Elytroderma* severity or mean percent circumference scarred of scarred trees, suggesting that mean *Elytroderma* severity and mean percent circumference scarred are not related to tree height between 0.3-2m.

Tables 4 and 5 show the stocking of affected trees pre- and post- sanitation and the percent reduction in dwarf mistletoe, *Elytroderma*, and scarring as a result of the sanitation treatments. A high percentage of affected trees in the 0.3m treatment at both sites were trees that should have been removed during the sanitation treatment (Table 6). This points out the difficulty in cutting down to a 0.3m sanitation height and emphasizes the importance of careful monitoring of sanitation crews when using a sanitation height of 0.3m to get the maximum possible benefit from the treatment.

Analysis of the Gaspard Creek site data indicated similar levels of stocking across treatments pre-sanitation. The probability of dwarf mistletoe infection was strongly correlated with tree height, with infected trees being twice as tall on average as healthy trees regardless of treatment. The correlation between height and probability of dwarf mistletoe infection is probably a result of tree target size, the length of time the tree was exposed to overhead seed sources, and the fact that it takes on average four years from infection for dwarf mistletoe plants to appear. Skidder damage was strongly related to plot distance from the road and whether a skid trail passed through the plot. The control treatment had the best moose screening, but retention of non-lodgepole pine trees (Douglas-fir and aspen) was almost as important in providing moose screening. There was no significant difference in dwarf mistletoe incidence between the 0.3m and 1m treatment and between the 2m and control treatment, but there were significant differences between the 0.3m and 1m treatments and the 2m and control treatments. This was likely a result of the high variability between plots in residual density, mean height, and dwarf mistletoe levels. No statistical analysis has been done yet for the Sky Ranch Road site.

Table 4. Estimated reductions in dwarf mistletoe and *Elytroderma* from sanitation.

Site	Treatment	Dwarf Mistletoe Sanitized 0.1 ha plot (stems/ha) A	Dwarf Mistletoe Post-sanitation 0.1 ha plot (stems/ha) B	Estimated Dwarf mistletoe reduction (%) A/(A+B)x100%	Elytroderma Sanitized (stems/ha) 0.05 ha plot C	Elytroderma Post-sanitation (stems/ha) 0.05 ha plot D	Estimated Elytroderma reduction (%) C/(C+D)x100%
Gaspard Creek	0.3 m	370	60	86	No data	80	No data
	1 m	193	134	59	No data	260	No data
	2 m	83	323	20	No data	180	No data
	Control	0	403	0	0	593	0
Sky Ranch	0.3 m	1247	64	95	700	27	96
	1 m	813	303	73	480	100	83
	2 m	537	790	40	307	273	53
	Control	0	870	0	0	420	0

Table 5. Estimated reductions in scarred trees from sanitation.

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

Table 6. Density (stems/ha) of affected trees over the sanitation height that were left after sanitation treatments based on pooled plot data. The percentage of all affected trees over the sanitation height is given in brackets.

Site	Treat.	Lodgepole Pine dwarf Mistletoe in 0.1 ha plot (stems/ha)	Elytroderma in 0.05 ha plot (stems/ha)	Scarring in 0.05 ha plot (stems ha)
Gaspard Creek	0.3 m	50 (83)	27 (33)	33 (83)
	1 m	17 (13)	20 (8)	13 (11)
	2 m	3 (1)	0	0
Sky Ranch	0.3 m	47 (89)	27 (100)	80 (50)
	1 m	20 (4)	7 (7)	67 (6)
	2 m	33 (7)	40 (15)	25 (10)

Limber pine health

Michael Murray, Forest Pathologist, Kootenay Boundary Region

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

Limber pine is not commercially harvested in B.C., however it is impacted by mining operations, highway and road developments. Limber pine is similar to whitebark pine (*P. albicaulis*) because its large seeds are a valuable food source for bears, small mammals and birds.

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

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

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

Michael Murray, Forest Pathologist, Kootenay Boundary Region

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

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

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

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

Table 1. Targets determined at the Whitebark/Limber Seed Orchard Workshop, Revelstoke 2019.

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

Re-assessment of western balsam bark beetle permanent sample plots

Lorraine Maclauchlan, Forest Entomologist, Thompson Okanagan Region

Background

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

Ten permanent sample plots, each one hectare in size, were established from 1998-2002, with a final plot established in 2012. Plots are located in the ESSF biogeoclimatic zone within the ESSFwc (6 plots), ESSFmw (2 plots), and ESSFxc (3 plots) subzones (Figure 1, Table 1).

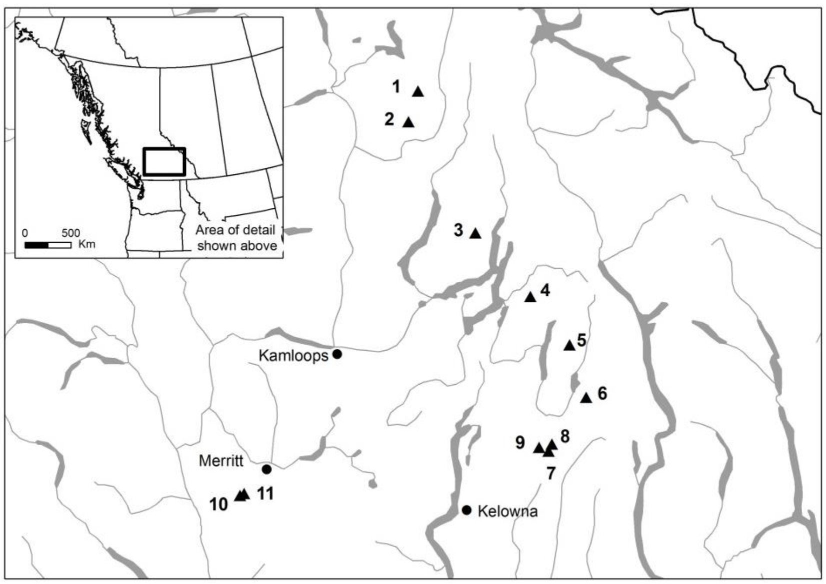


Figure 1. Location of eleven western balsam bark beetle monitoring plots in the Thompson Okanagan Region.

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

Table 1. List of eleven western balsam bark beetle permanent sample plots noting: biogeoclimatic classification (BEC); year of plot establishment; number of subalpine fir (Bl) at establishment (dead and alive), number of live Bl, and the number of all species at establishment.

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

Aerial view of a young subalpine fir forest (lower half of photograph) bordered by an older forest (upper half of photograph) with significant IBB attack (red and grey trees).

Methods

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

- tree status (live, dead, down)
- IBB attack status, crown colour and condition (see Tree Codes, Table 2)

- dbh (cm) of all live trees and Tree Code 1 and 2 trees (Table 2)
- height of a subsample of live trees in each plot (±40 trees)
- other pest incidence or damage evident on trees

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

Table 2. Description of tree codes used to describe plot tree status (live or dead), the stage of decline (foliar fade), and standing or down. Codes 1-6 and 10 are all dead due to IBB. Codes 7 and 11 are unknown or affected by other pests.

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

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

Preliminary results

Six of the eleven plots were assessed in 2019 (Table 3). The remaining five plots will be completed in 2020. The percent mortality of subalpine fir in 2019 ranged from 26.6% at Spius Creek-2 to 58% and 61% at the Sicamous and Martin Creek plots, respectively. The Sicamous Creek plot has been monitored for twenty-one years (Table 3; Figure 2), going from 365 live subalpine fir per hectare to 152 live subalpine fir per hectare in this time. Mortality from IBB peaked around 2013 and many of the IBB-killed trees have since fallen. In the Sicamous plot, there are now fewer live trees than standing dead and down (Figure 2).

Mortality has increased in all plots and across all BECs since plots were established, at varying rates. Plots in the ESSFxc were last assessed in 2013 and had significant rates of mortality (Figure 3). Plots in the ESSFwc and ESSFmw generally had intermediate rates of mortality. However, the ESSFwc, there was geographic variation and some plots had very high mortality. The ESSFwc is the most predominant ESSF subzone in the Thompson Okanagan Region.

Table 3. Comparison of total number of live subalpine fir at plot establishment and at the last assessment. The Martin plot was partially logged (165 trees logged) so the mortality was adjusted to reflect this.

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

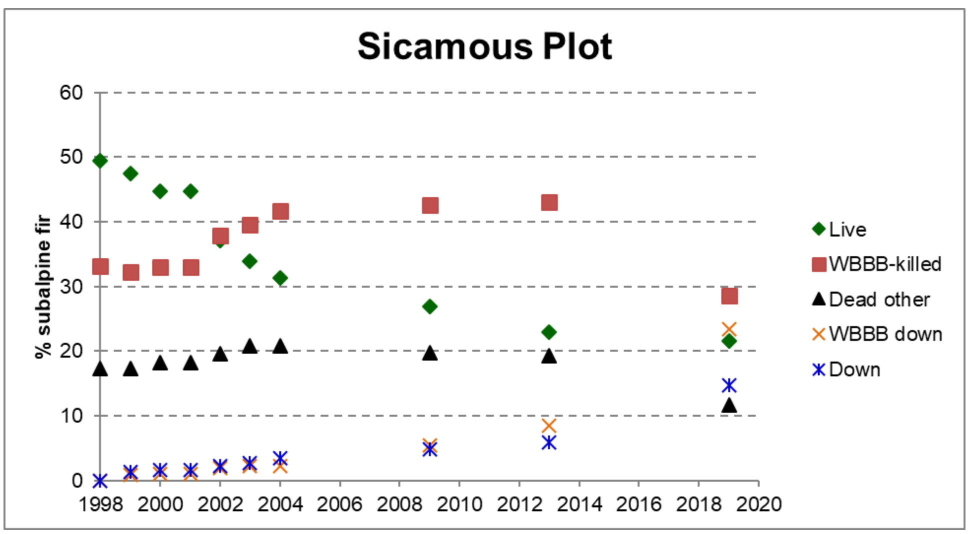


Figure 2. Mortality and fall down over time in the Sicamous Plot, 1998-2019.

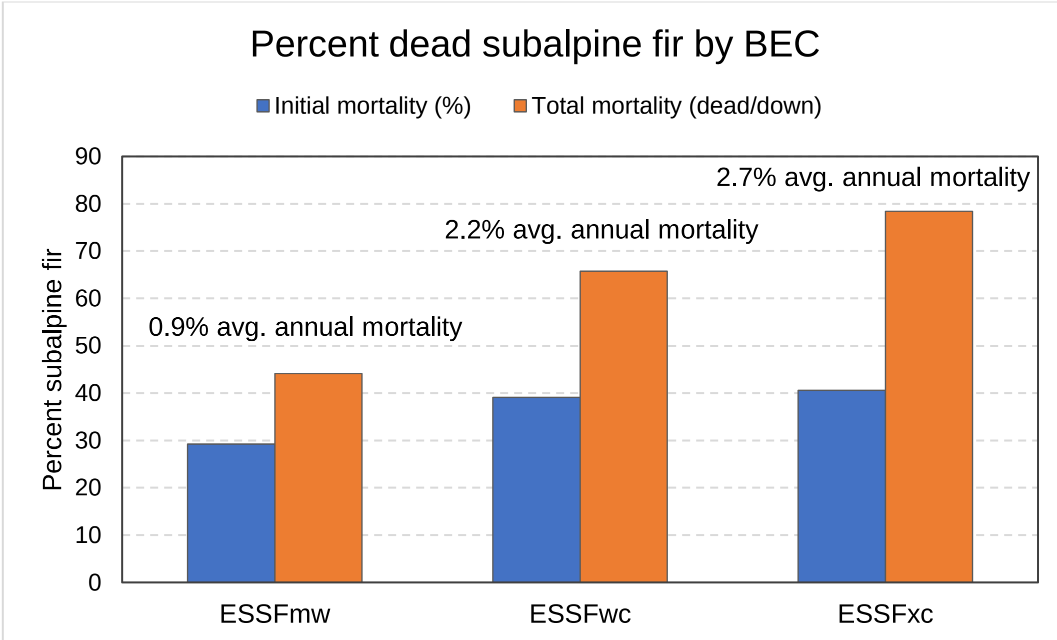


Figure 3. Percent dead subalpine fir (standing dead and down), by BEC, at establishment and at the most recent assessment. Six plots were assessed in 2019 and the other five plots were last assessed in 2011 or 2013.

The basal area (square meters) per hectare of subalpine fir in the plots has declined in two of the BECs (ESSFmw and ESSFwc) and has increased very slightly in the very dry, cold ESSFxc the past twenty-one years. In the Sicamous plot, the decline in live subalpine fir basal area is drastic (Figure 4); since establishment in 1998, there has been a 10.3 m^2 per hectare decrease in subalpine fir basal area. As of 2019, most of the original subalpine fir basal area of this plot is dead or down, with IBB being the dominant damaging agent.

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

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

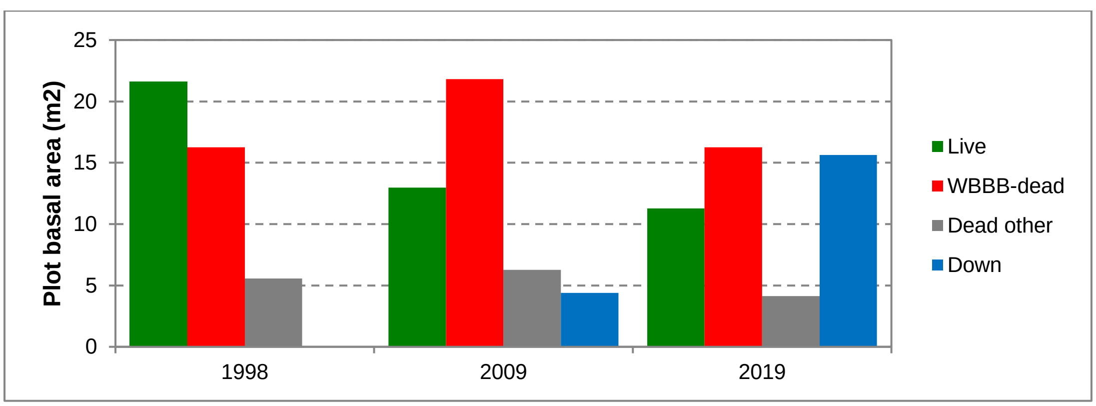
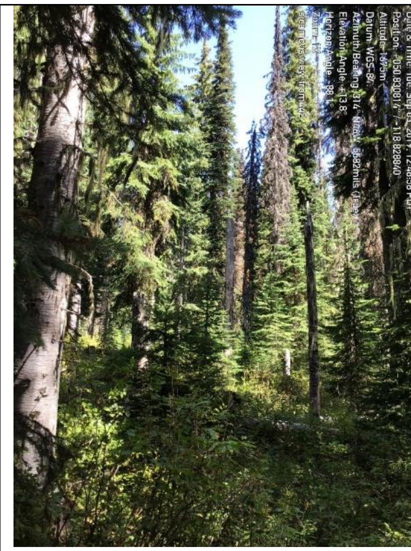


Figure 4. Basal area in the Sicamous Creek plot (square meters) of live, dead and down subalpine fir from 1998 to 2019.

Subalpine fir regeneration is present in some of the larger gaps created by dying trees in the Sicamous Plot

Plot tree showing past IBB attack

Rosie in Spius-1 plot



Sicamous Creek plot

Balsam bark weevil pupa

Balsam bark weevil galleries: Spius-1 plot

IBB female in gallery with eggs

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

Lorraine Maclauchlan, Forest Entomologist, Thompson Okanagan Region

Background

Changing climate, pest activity and fire are affecting forest health, value and productivity across a wide range of forested landscapes. Lodgepole pine, *Pinus contorta* ssp. *latifolia*, is the dominant species in most dry, cold forests of western North America forming pure successional stands or co-dominant mixtures (Klinka et al. 2000). The forests of British Columbia (B.C.) cover an area of just over 60 million hectares (https://www.for.gov.bc.ca/hfd/pubs/docs/mr/mr113/forests.htm) and lodgepole pine is ubiquitous, growing throughout the interior of the province. Numerous pests affect lodgepole pine throughout its rotation, with the key natural disturbance agent of mature lodgepole pine being the mountain pine beetle, *Dendroctonus ponderosae* Hopk. (Coleoptera: Scolytidae) (Safranyik and Carroll 2006; Westfall and Ebata 2017) and fire (Kurz et al. 2008). Mountain pine beetle (MPB) populations periodically erupt killing thousands of hectares of mature, or nearly mature pine trees (Safranyik and Carroll 2006; Maclauchlan et al. 2015). At least four large-scale outbreaks of mountain pine beetle have occurred in western Canada in the past 120 years, as documented in forest survey records or detected as growth releases in tree rings (Alfaro et al. 2004; Taylor et al. 2006; Westfall and Ebata 2017). Alfaro et al. (2004) identified three large outbreaks through tree ring analysis: 1890's, 1940's and the 1980's with many smaller, more localized outbreaks occurring between these major events. The most recent MPB outbreak in B.C. began in the late 1990's, peaking in 2007 at 10 million hectares affected (Westfall and Ebata 2017). By 2008, the beetle had affected almost 14 million hectares of pine forests, an area 10 times larger than any previously recorded outbreak (Safranyik et al. 2010). Since that time, the area affected has declined rapidly to pre-outbreak levels with only 119,089 hectares affected in 2017 (Westfall and Ebata 2018). In addition to extensive timber losses, MPB epidemics may increase fuel loading, which can lead to more severe wildfires, alter successional trajectories and a myriad of other resource values. Gray (2013) found that as the dead overstory of unsalvaged, MPB-impacted stands decayed and fell, both the hazard and risk to wildfire were high. Many of the stands, which burned in the 2017 wildfires, were killed by MPB more than a decade ago. These stands are now falling down and creating massive amounts of ground fuel.

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

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


Young lodgepole pine in Okanagan (left) and Kamloops TSAs (right) showing damage from 2017 drought

Objectives

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

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

Methods

All stand data from the1996-2000 surveys have been collated into a standardized database. The 2019 surveys were conducted in three TSAs (Timber Supply Area) (Okanagan, Kamloops, and Merritt) and two TFLs (Tree Farm Licenses) (TFL 49 located in the North Okanagan; and TFL 59 located in the South Okanagan). The VRI (Vegetation Resource Inventory) data were used to identify candidate stands for survey in 2019. A SPI was conducted in 2019 to collect stand, tree and pest information and to ensure the data could then be compared to the various surveys and installations done from 1996-2000. The SPI is a continuous series of 50 to 100 meter long plots. Plots can vary in width from 1 meter to 5 meters depending on age, size and density of the stand (tree size, species mix, layers). Plot widths were selected so that approximately 50 trees were assessed in each 50-meter strip plot. Every tree greater than 1 meter in height within the plot boundary was examined and tallied, by species, for pest occurrence and severity. If there was a significant number of trees less than 1 meter high (ingress) in a stand, these trees were counted and assessed in a sub-plot (plot width x 10 meters). All SPI plots were located a minimum of 25 meters from the stand edge, roads and unnatural openings.

Information from each SPI plot included:

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

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

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

Preliminary Results

70 SPI surveys were conducted in 2019 in three TSAs and two TFLs within four BECs and were compared to 248 surveys conducted between 1996 and 2000 (Table 1). In 1996-2000 there were often multiple surveys done per opening (stand), particularly in the two TFLs, whereas in 2019 only one SPI was done per opening.

Table 1. Number of plots, by TSA and biogeoclimatic zone (BEC), assessed in 2019 and 1996-2000.

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

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

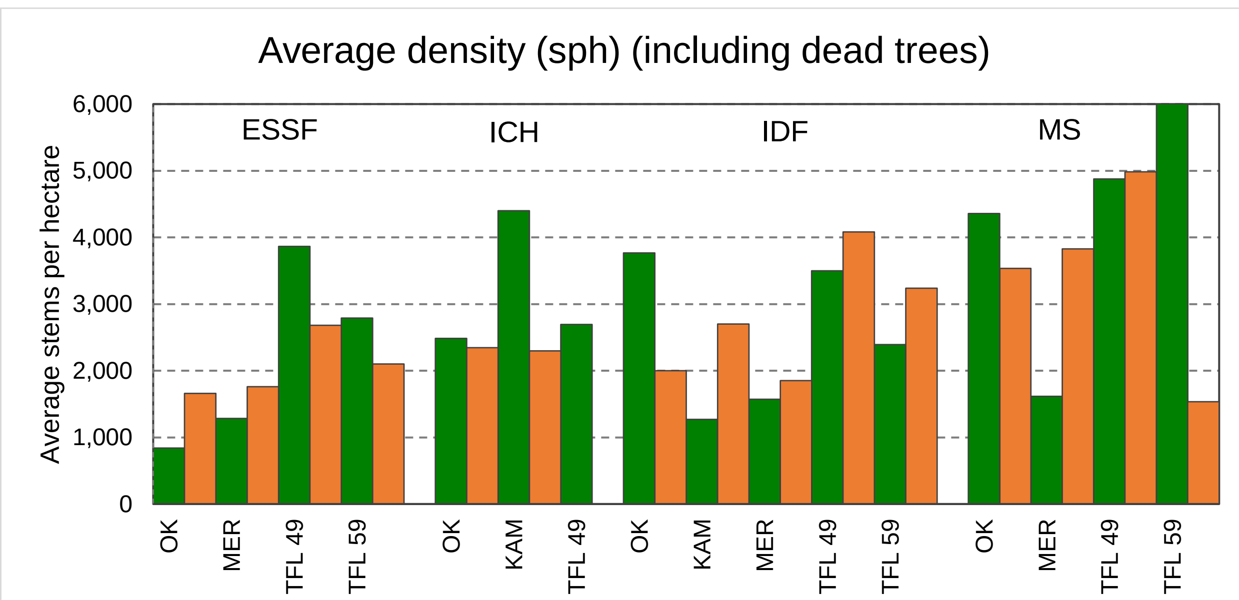


Figure 1. Average density (stems per hectare, including dead trees) by BEC in surveys conducted in 1996-2000 (green bars) and 2019 (orange bars), by TSA and TFL.

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

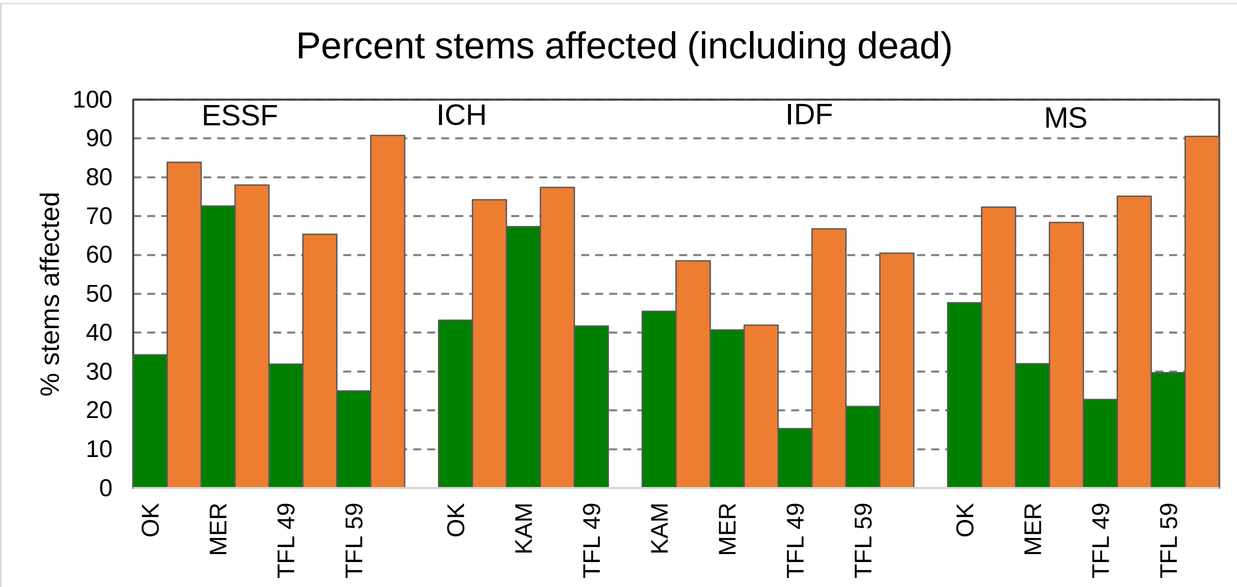


Figure 2. Percent stems affected (lower graph) in surveys conducted in 1996-2000 (green bars) and 2019 (orange bars), by TSA and TFL.

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

Some of the most common damaging agents found in these surveys (Table 2) are compared between the two sampling times in Figure 3. The thirteen most common damaging agents are listed in Table 2 and Figure 3. Of these, only three declined in stands from 1996-2000 to 2019: lodgepole pine dwarf mistletoe, pitch nodule moth and Warren's root collar weevil. There are now guidelines for harvesting stands with dwarf mistletoe so our result shows these eradication efforts have been successful. The other two pests are very site specific. All other pests increased in incidence between these two survey times. Western gall rust and lodgepole pine terminal weevil had the most notable increases in stems affected from 1996-2000 to 2019 (Figure 3). Comandra blister rust had moderate levels of infection in 2019, at nine percent stems infected compared to only 1.5% stems infected in the first survey time.

Table 2. Pest codes for common damaging agents found in young lodgepole pine surveys.

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

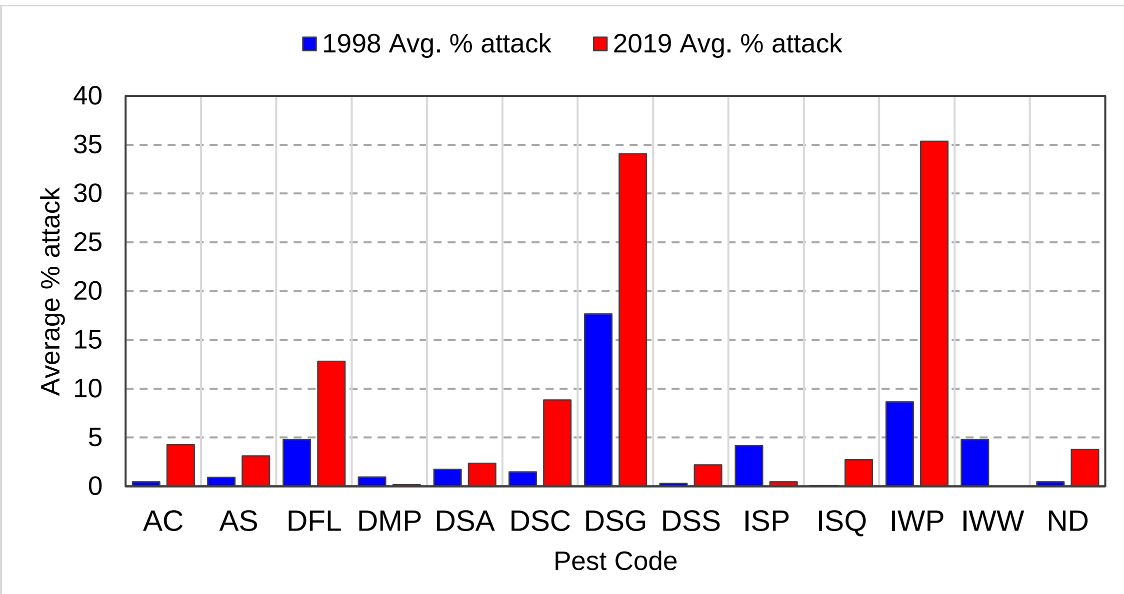


Figure 3. Average attack levels of major pests found in the 1996-2000 and 2019 surveys.

The average percent lodgepole pine infected by western gall rust, lodgepole pine terminal weevil and comandra blister rust were compared among the three TSAs and two TFLs at each survey time (Figure 4). In 1996-2000 surveys, western gall rust levels were below five percent stems infected on both TFLs, whereas in 2019, levels were over 35 percent stems infected (Figure 4). In the first survey, comandra blister rust was found at very low infection levels in Merritt, TFL 49 and TFL 59 (less than one percent), but by 2019 trees of the same age and in the same location and BEC had noticeably higher rates of infection (3-20 percent). The Kamloops and Okanagan TSAs had moderate levels of comandra infection at both survey times, although it was higher in 2019. There were up to seven-fold increases in the incidence of terminal weevil attack between the two survey times. Other studies show that lodgepole pine growing in more open scenarios have higher levels of weevil attack and more severe stem defects due to attacks (Maclauchlan and Borden 1996; Buxton and Maclauchlan 2015).

Lodgepole pine terminal weevil attack (top) and weevil (bottom)

Comandra blister rust

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

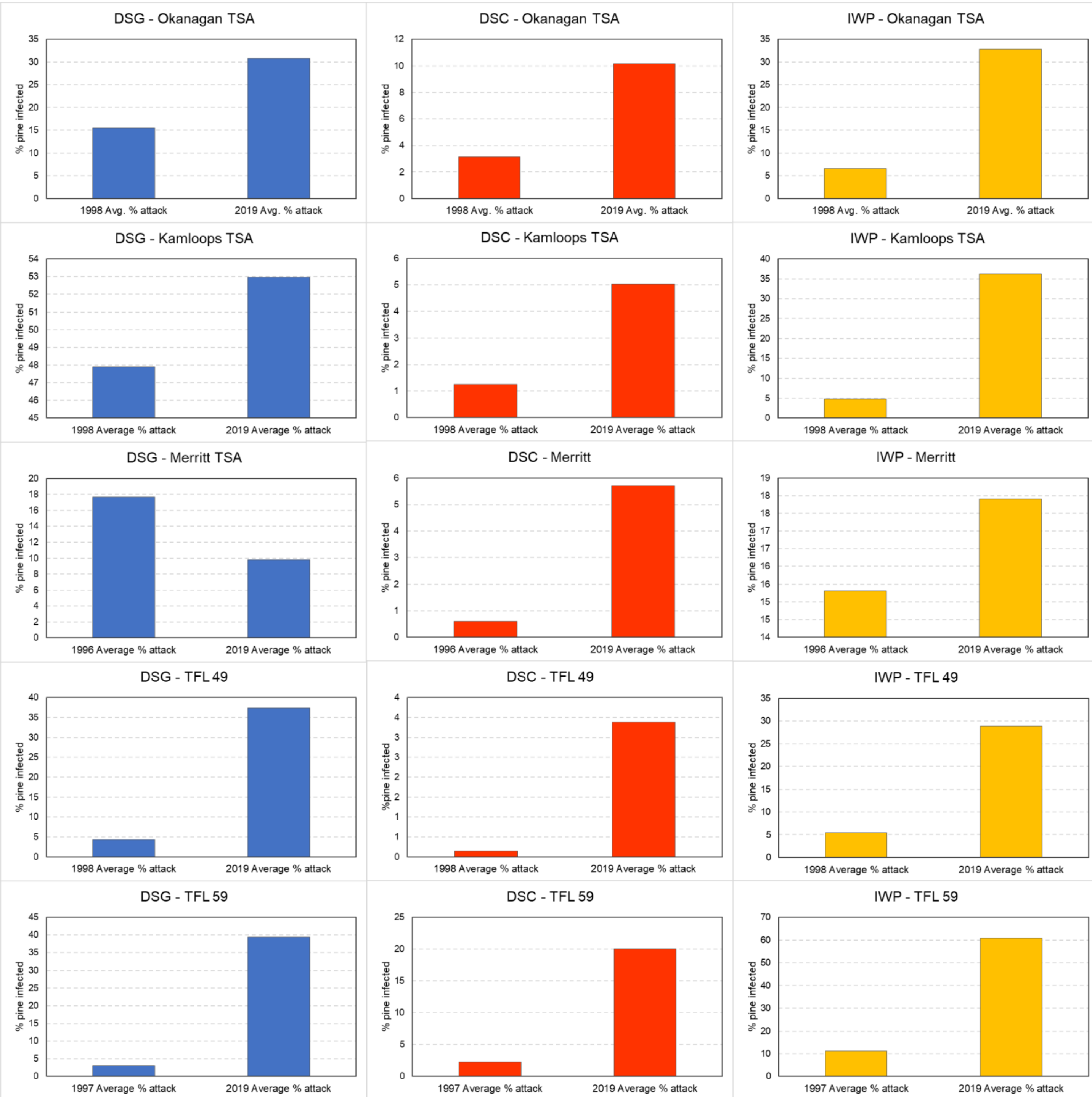


Figure 4. Comparison between survey years of the average percent attack of three major pests (DSG, DSC and IWP) separated by TSA and TFL.

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Forest Health Images

Field tour of drought affected stands

David Rusch – mistletoe stop on Forest Health field trip

Forest health staff discussing post-burn issues

Thompson Rivers District staff

Western spruce budworm defoliation

Debra Wytrykush – field training

Gall on fir

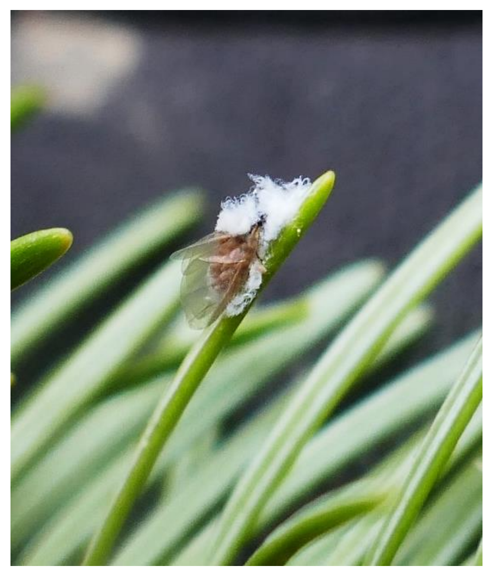
Spray helicopter at dawn

Heather MacLennan (retired) finding IBD

Surveying for Gypsy moth eggmasses near Castlegar

Cicada

Douglas-fir tussock moth cocoon



Adelgid on pine

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