2014 Overview of Forest Health Conditions in Southern B.C.

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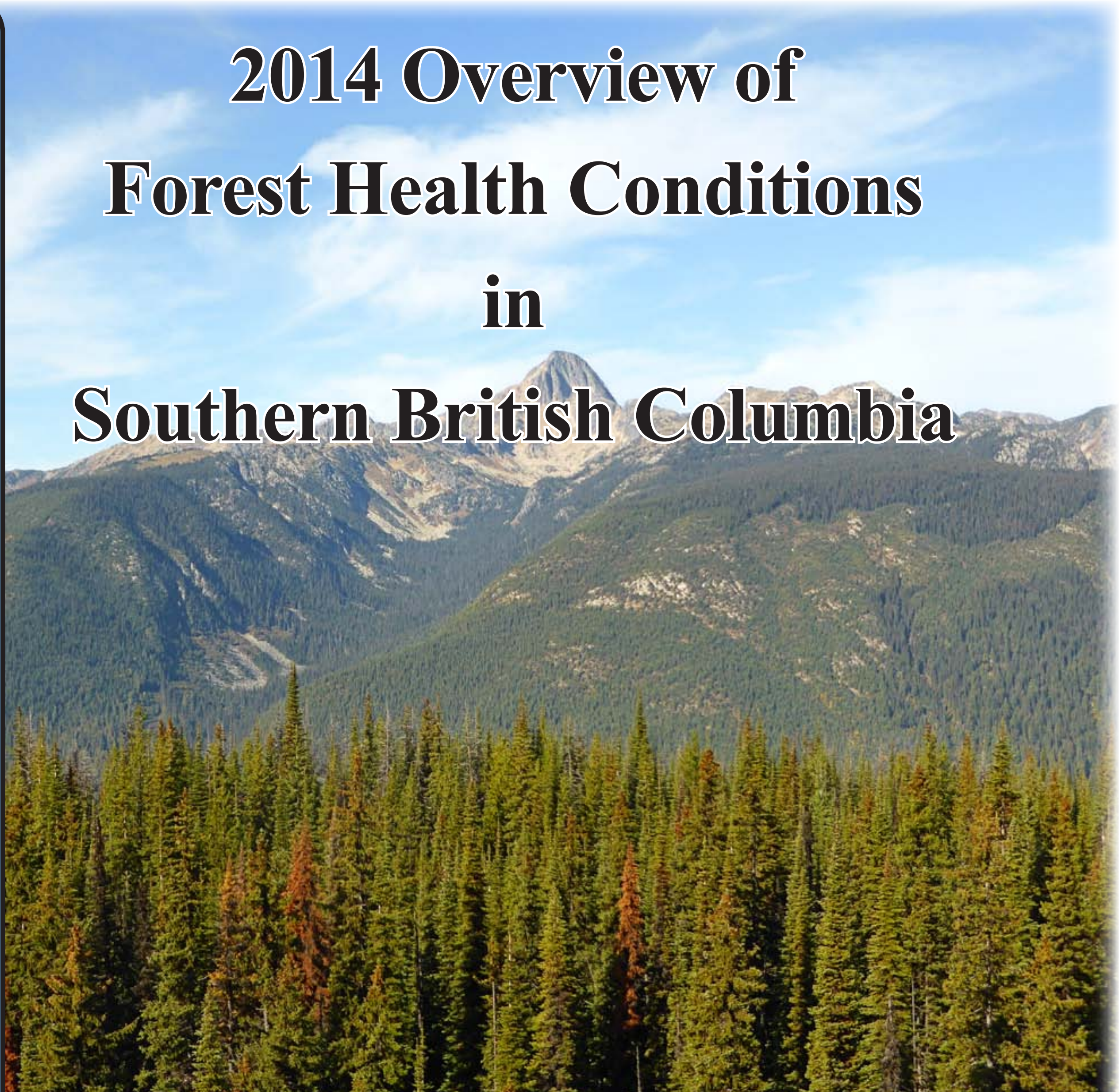

BRITISH COLUMBIA

Ministry of Forests, Lands, and Natural Resource Operations

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Introduction

This report summarizes the results of the 2014 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 and Natural Resource Operations 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://www.for.gov.bc.ca/hfp/health/overview/methods.htm). 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 2014 surveys were completed between July 18th and August 24th, 2014. A total of 304.3 hours of fixed-wing aircraft flying in 56 separate flights were required to complete the surveys, which covered all areas within the Cariboo, Thompson Okanagan, and Kootenay Boundary Natural Resource Regions. This landbase is over 25 million hectares, of which over 15 million hectares are forested land. Flying conditions were variable, with some weather-related delays during the early period of surveying, and delays caused by heavy smoke from extensive wildfires in central and northern B.C.

Defoliating insects were the most common damaging agents, with nearly 540,000 hectares affected. Bark beetles were the most widespread cause of recent tree mortality, affecting nearly 322,000 hectares. An assortment of other disturbances, such as foliar diseases, animal damage, declines, wildfire, windthrow, and other abiotic agents, caused damage on another 79,500 hectares (Table 2).

Table 1. Severity ratings used in the aerial overview surveys. Two main types of severity ratings are used. Bark beetles and other direct mortality-causing agents are rated based on the percentage of recently killed trees in the stand. Defoliators (both insect and disease) are rated based on the severity of foliage loss.

Disturbance Type	Severity Class	Description
Tree Mortality (including bark beetles, abiotic factors, and animal damage)	Trace	< 1% of trees in the polygon recently killed
	Light	1-10% of trees in the polygon recently killed
	Moderate	11-29% of trees in the polygon recently killed
	Severe	30-49% of trees in the polygon recently killed
	Very Severe	50% + of trees in the polygon 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 leaf miner defoliation is rated according to the percentage of trees in the stand that are affected, based on tree mortality classes.
** Decline syndrome severity ratings developed from USDA Sudden Aspen Decline rating criteria.

Table 2. Area summaries for forest health factors mapped during the 2014 aerial overview surveys.

Timber Supply Area and Damaging Agent	Area of Infestation (hectares)					
	Trace	Light	Moderate	Severe	Very Severe	Total
Mountain Pine Beetle						
Arrow	858.7	536.6	22.0	21.6	0.0	1,438.9
Boundary	8,799.9	13,110.7	3,515.0	150.2	0.0	25,575.8
Cranbrook	842.4	525.6	520.5	0.0	0.0	1,888.4
Golden	711.2	1,120.5	424.2	155.8	0.0	2,411.8
Invermere	1,327.7	3,299.2	1,655.4	302.0	0.0	6,584.4
Kamloops	0.0	9.5	0.0	0.0	0.0	9.5
Kootenay Lake	779.6	1,231.2	843.3	286.5	0.0	3,140.6
Lillooet	1,251.1	2,200.8	912.8	50.8	10.3	4,425.9
Merritt	306.5	925.6	21.9	8.9	0.0	1,262.9
Okanagan	1,056.9	2,253.0	97.0	30.9	0.0	3,437.8
Revelstoke	0.0	0.0	124.2	0.0	0.0	124.2
Williams Lake	148.6	1,286.0	68.7	0.0	0.0	1,503.3
Total	**16,082.6**	**26,498.6**	**8,205.2**	**1,006.8**	**10.3**	**51,803.5**
Douglas-fir Beetle						
100 Mile House	426.9	3,084.9	75.7	0.0	0.0	3,587.4
Arrow	129.3	507.8	252.5	84.4	0.0	973.9
Boundary	34.1	15.9	0.0	0.0	0.0	50.0
Cranbrook	0.0	38.1	6.8	0.0	0.0	44.9
Golden	31.8	0.0	0.0	0.0	0.0	31.8
Invermere	125.2	295.4	281.3	0.0	0.0	701.9
Kamloops	0.0	166.6	75.7	27.3	3.5	273.2
Kootenay Lake	74.1	484.1	119.4	0.0	0.0	677.5
Lillooet	0.0	821.1	682.3	184.8	97.5	1,785.6
Merritt	0.0	96.2	96.7	18.4	14.5	225.8
Okanagan	0.0	409.6	291.7	84.3	11.8	797.4
Quesnel	0.0	388.9	119.5	0.0	0.0	508.4
Revelstoke	12.1	42.7	41.3	0.0	0.0	96.1
Williams Lake	181.7	19,257.7	2,582.3	276.4	0.0	22,298.1
Total	**1,015.1**	**25,608.9**	**4,625.1**	**675.6**	**127.2**	**32,052.0**
Spruce Beetle						
100 Mile House	408.9	242.9	0.0	0.0	0.0	651.8
Arrow	8.3	80.2	0.0	0.0	0.0	88.5
Cranbrook	0.0	9.2	0.0	0.0	0.0	9.2
Golden	0.0	0.0	0.0	0.0	0.0	0.0
Invermere	0.0	441.5	2,573.9	1,134.3	0.0	4,149.8
Kamloops	64.0	44.9	57.4	15.4	0.0	181.7
Kootenay Lake	0.0	0.0	0.0	0.0	0.0	0.0
Lillooet	46.0	128.0	564.3	418.0	45.9	1,202.2
Merritt	57.2	221.1	652.2	111.1	0.0	1,041.6
Okanagan	0.0	0.0	16.8	0.0	0.0	16.8
Quesnel	0.0	224.8	13.8	0.0	0.0	238.6
Revelstoke	0.0	58.8	0.0	0.0	0.0	58.8
Williams Lake	54.0	1,045.8	531.4	0.0	0.0	1,631.2
Total	**638.4**	**2,497.2**	**4,409.9**	**1,678.8**	**45.9**	**9,270.3**
Western Balsam Bark Beetle						
100 Mile House	692.0	4,243.7	0.0	0.0	0.0	4,935.7
Arrow	2,172.0	733.4	92.4	0.0	0.0	2,997.8
Boundary	1,095.5	135.6	15.1	0.0	0.0	1,246.3
Cranbrook	920.9	580.2	120.0	8.2	0.0	1,629.3
Golden	1,944.1	3,202.6	465.4	0.0	0.0	5,612.0
Invermere	1,145.7	1,579.8	589.0	0.0	0.0	3,314.6
Kamloops	96,936.4	4,592.8	0.0	0.0	0.0	101,529.2
Kootenay Lake	1,006.8	514.2	0.0	0.0	0.0	1,521.0
Lillooet	11,026.7	213.5	0.0	0.0	0.0	11,240.2
Merritt	11,409.2	0.3	0.0	0.0	0.0	11,409.5
Okanagan	60,201.1	455.9	0.0	0.0	0.0	60,657.0
Quesnel	292.5	1,338.5	0.0	0.0	0.0	1,631.0
Revelstoke	814.6	252.1	0.0	0.0	0.0	1,066.7
Williams Lake	7,796.7	11,374.2	847.8	0.0	0.0	20,018.7
Total	**197,454.2**	**29,216.7**	**2,129.8**	**8.2**	**0.0**	**228,808.9**

Table 2 continued. Area summaries for forest health factors mapped during the 2014 aerial overview surveys.

Timber Supply Area and Damaging Agent	Area of Infestation (hectares)			
	Light	Moderate	Severe	Total
Western Spruce Budworm				
100 Mile House	9,809.2	0.0	0.0	9,809.2
Arrow	0.0	380.0	0.0	380.0
Kamloops	3,668.2	119.6	0.0	3,787.9
Lillooet	52.6	0.0	0.0	52.6
Merritt	186.4	0.0	0.0	186.4
Okanagan	639.8	22.2	0.0	662.0
Quesnel	265.2	0.0	0.0	265.2
Williams Lake	28,626.7	834.9	0.0	29,461.6
Total	**43,248.1**	**1,356.8**	**0.0**	**44,604.9**
Two-Year Cycle Budworm				
100 Mile House	7,328.7	360.3	0.0	7,689.0
Kamloops	29,659.4	414.6	0.0	30,074.0
Quesnel	54,699.2	1,911.4	0.0	56,610.5
Williams Lake	34,574.9	1,370.3	0.0	35,945.2
Total	**126,262.1**	**4,056.6**	**0.0**	**130,318.7**
Pine Needle Sheath Miner				
100 Mile House	340.6	168.1	0.0	508.7
Arrow	0.0	12.0	0.0	12.0
Kamloops	467.1	290.8	0.0	757.8
Quesnel	101.6	210.0	0.0	311.6
Williams Lake	0.0	43.7	0.0	43.7
Total	**909.2**	**724.6**	**0.0**	**1,633.8**
Aspen Serpentine Leaf Miner				
100 Mile House	57,794.3	8,462.3	986.4	67,243.0
Arrow	3,096.4	800.1	220.8	4,117.3
Boundary	58.7	0.0	175.5	234.2
Cranbrook	236.1	285.6	18.8	540.5
Golden	5,574.2	1,589.9	30.3	7,194.4
Invermere	408.8	0.0	0.0	408.8
Kamloops	23,330.6	7,891.9	726.7	31,949.2
Kootenay Lake	4,001.4	489.8	0.0	4,491.2
Merritt	567.5	50.7	12.7	630.9
Okanagan	2,635.6	1,702.2	132.8	4,470.6
Quesnel	22,105.5	9,563.9	789.1	32,458.5
Revelstoke	942.0	709.0	0.0	1,651.0
Williams Lake	42,118.6	30,122.9	2,212.7	74,454.2
Total	**162,869.7**	**61,668.3**	**5,305.7**	**229,843.8**
Birch Leaf Miner				
Arrow	23.1	0.0	0.0	23.1
Golden	23.3	61.1	35.1	119.6
Kamloops	533.4	558.9	0.0	1,092.3
Kootenay Lake	126.8	253.4	39.6	419.8
Okanagan	0.0	214.6	0.0	214.6
Revelstoke	23.9	90.6	0.0	114.5
Total	**730.5**	**1,178.7**	**74.7**	**1,983.9**
Forest Tent Caterpillar				
Kamloops	0.0	94.8	0.0	94.8
Okanagan	382.3	1,181.4	0.0	1,563.8
Quesnel	114,804.2	9,207.0	134.7	124,145.8
Williams Lake	3,146.4	0.0	0.0	3,146.4
Total	**118,332.9**	**10,483.2**	**134.7**	**128,950.8**
Satin Moth				
Kamloops	7.4	30.8	16.8	55.0
Lillooet	0.0	0.0	9.0	9.0
Merritt	31.3	14.0	14.4	59.6
Okanagan	176.8	25.0	119.4	321.2
Total	**215.5**	**69.8**	**159.5**	**444.9**

Table 2 continued. Area summaries for forest health factors mapped during the 2014 aerial overview surveys.

Timber Supply Area	**Area of Infestation (hectares)**					
and Damaging Agent	**Trace**	**Light**	**Moderate**	**Severe**	**Very Severe**	**Total**
Wildfire						
100 Mile House	0.0	0.0	0.0	21.5	0.0	21.5
Arrow	0.0	0.0	0.0	349.3	0.0	349.3
Boundary	0.0	0.0	0.0	6.8	0.0	6.8
Cranbrook	0.0	0.0	0.0	919.7	0.0	919.7
Golden	0.0	0.0	0.0	304.6	0.0	304.6
Invermere	0.0	0.0	0.0	6,171.6	0.0	6,171.6
Kamloops	0.0	0.0	0.0	149.1	110.0	259.1
Kootenay Lake	0.0	0.0	0.0	279.8	0.0	279.8
Lillooet	0.0	0.0	1,437.8	51.6	0.0	1,489.4
Merritt	0.0	0.0	0.0	1,393.1	0.0	1,393.1
Okanagan	0.0	0.0	23.0	1,128.2	121.1	1,272.3
Quesnel	0.0	0.0	0.0	16,222.6	0.0	16,222.6
Revelstoke	0.0	0.0	0.0	87.0	0.0	87.0
Williams Lake	0.0	0.0	6.2	2,530.9	0.0	2,537.0
Total	**0.0**	**0.0**	**1,467.0**	**29,615.8**	**231.1**	**31,313.9**
Post-Wildfire Mortality						
100 Mile House	0.0	1,464.4	94.8	0.0	0.0	1,559.2
Kamloops	0.0	0.0	13.2	0.0	0.0	13.2
Lillooet	0.0	39.6	45.5	0.0	0.0	85.1
Okanagan	0.0	0.0	23.2	0.0	0.0	23.2
Quesnel	0.0	123.4	31.5	58.6	0.0	213.6
Williams Lake	0.0	584.8	1,409.7	989.0	0.0	2,983.5
Total	**0.0**	**2,212.2**	**1,618.0**	**1,047.6**	**0.0**	**4,877.9**
Weather-Related Cedar Damage						
100 Mile House	0.0	2,478.0	253.9	0.0	0.0	2,731.8
Arrow	0.0	559.9	0.0	0.0	0.0	559.9
Golden	13.6	1,091.4	413.4	0.0	0.0	1,518.3
Kamloops	0.0	8,726.3	1,397.0	9.5	0.0	10,132.8
Kootenay Lake	0.0	271.8	0.0	0.0	0.0	271.8
Okanagan	0.0	637.5	6.1	0.0	0.0	643.5
Quesnel	0.0	208.7	1,428.5	47.3	0.0	1,684.5
Revelstoke	0.0	6,424.9	1,225.0	0.0	0.0	7,649.9
Williams Lake	0.0	3,726.3	2,348.6	0.0	0.0	6,074.8
Total	**13.6**	**24,124.8**	**7,072.5**	**56.8**	**0.0**	**31,267.3**
Flooding Damage						
100 Mile House	0.0	0.0	0.0	22.9	0.0	22.9
Arrow	0.0	0.0	0.0	37.8	0.0	37.8
Cranbrook	0.0	0.0	0.0	26.2	0.0	26.2
Golden	0.0	0.0	0.0	68.9	0.0	68.9
Invermere	0.0	0.0	0.0	51.0	0.0	51.0
Okanagan	0.0	0.0	0.0	7.7	0.0	7.7
Quesnel	0.0	0.0	46.0	50.5	0.0	96.6
Williams Lake	0.0	85.3	390.5	800.9	0.0	1,276.7
Total	**0.0**	**85.3**	**436.6**	**1,065.9**	**0.0**	**1,587.8**
Windthrow						
100 Mile House	0.0	0.0	29.3	0.0	0.0	29.3
Arrow	0.0	0.0	0.0	42.0	0.0	42.0
Cranbrook	0.0	0.0	0.0	151.8	0.0	151.8
Invermere	0.0	0.0	0.0	66.3	0.0	66.3
Kootenay Lake	0.0	0.0	0.0	21.5	0.0	21.5
Merritt	39.3	0.0	0.0	0.0	0.0	39.3
Okanagan	0.0	0.0	0.0	0.0	7.1	7.1
Quesnel	0.0	10.8	0.0	5.6	0.0	16.4
Revelstoke	0.0	0.0	0.0	24.4	0.0	24.4
Williams Lake	0.0	0.0	0.0	4.0	0.0	4.0
Total	**39.3**	**10.8**	**29.3**	**315.6**	**7.1**	**402.1**

Southern Interior Overview

Mountain Pine Beetle, *Dendroctonus ponderosae*

Area affected by mountain pine beetle continued on a downward trend in southern B.C. A total of 51,804 hectares were affected, down from 2013 levels of 63,102 hectares (Table 3). Red attacked area decreased significantly in the Merritt and Okanagan Timber Supply Areas (TSAs). Although attack remains widespread across much of the Kootenay Lake, Cranbrook, Invermere, and Arrow TSAs, affected area declined by 25-35%. Area affected in the Boundary TSA increased by 20%, which now accounts for nearly half of all mapped mountain pine beetle attack. Attack remained generally scattered and of a low intensity, with over 80% of the affected stands in southern B.C. having 10% or lower red attack levels.

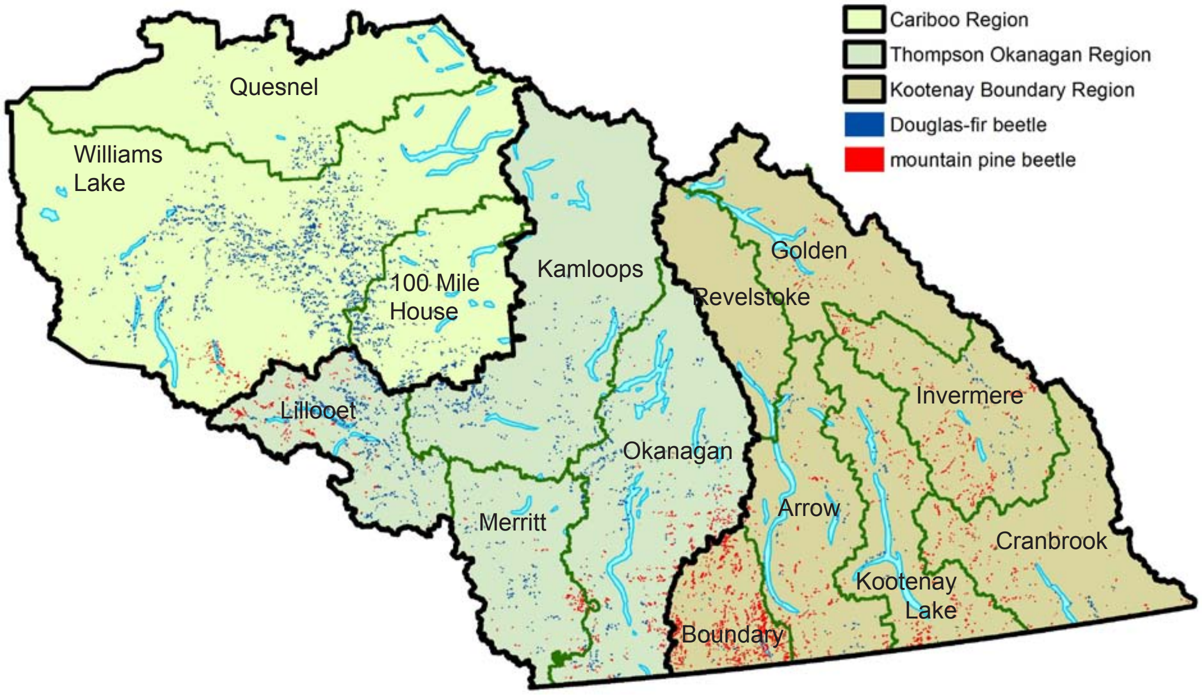


Figure 1. Timber Supply Areas and major bark beetles in the Southern Interior in 2014.

Table 3. Area infested, number of polygons, average polygon size, number of spot infestations, and number of trees killed in spot infestations for mountain pine beetle in the Southern Interior, 2002-2014.

Year	Area Infested (ha)	Number of Polygons	Average Polygon Size (ha)	Number of Spot Infestations	Number of Trees Killed in Spot Infestations
2002	612,054	7,349	83	6,308	56,054
2003	2,525,722	13,133	192	5,270	42,372
2004	4,220,499	41,057	102	4,932	63,410
2005	4,853,830	49,381	96	3,839	35,033
2006	5,125,879	59,971	86	5,672	71,803
2007	5,379,219	59,373	91	5,429	71,409
2008	4,812,045	52,402	67	3,181	39,569
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

Attack in whitebark pine stands continued to increase, with 5,300 hectares affected. Most affected stands were in the Purcell Range, in the Cranbrook, Invermere, and Golden TSAs, with some additional attack mapped near Gold Bridge in the Lillooet TSA. Attack in ponderosa pine and western white pine was restricted to a few small, scattered spots.

The mountain pine beetle management strategy has been upgraded from either salvage or holding action to suppression in 26 Beetle Management Units (BMUs), covering just over two million hectares. Four BMUs covering 275,000 hectares have been changed from holding action to salvage.

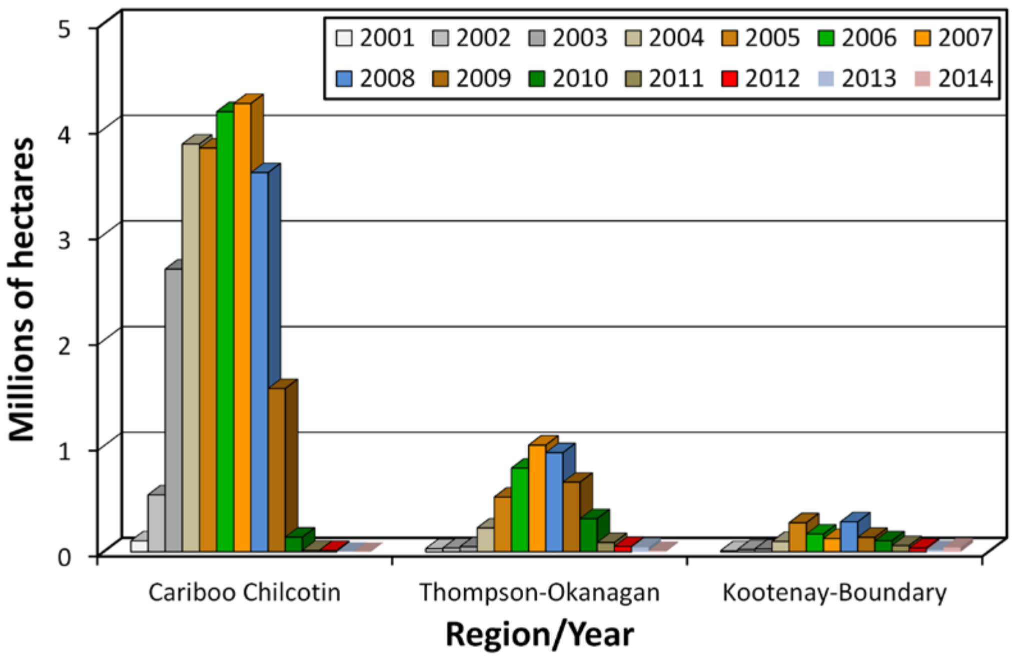


Figure 2. Area affected by mountain pine beetle from 2001 - 2014 in the three Natural Resource Regions of southern B.C.

Whitebark pine killed by mountain pine beetle in the Lillooet TSA.

Douglas-fir Beetle, *Dendroctonus pseudotsugae*

Douglas-fir beetle populations increased in several areas, notably in the Williams Lake and 100 Mile House TSAs, where the total area affected increased more than 10-fold from 2013. Increased attack was also seen in the Quesnel, Lillooet, Merritt, Kamloops, Arrow, Kootenay Lake, and Invermere TSAs. Attack decreased by 80% in the Golden TSA and by 65% in the Cranbrook TSA, while populations remained stable across most of the Okanagan and Boundary TSAs. Detailed helicopter GPS surveying carried out in the Williams Lake TSA during September and October indicated that Douglas-fir beetle red attack levels continued to increase after the aerial overview surveys were completed. Infested area in southern B.C. increased by over five-fold to 32,052 hectares, with the number of spot infestations increasing by nearly two-fold to 3,868 (Table 4).

Table 4. Douglas-fir beetle infestations in the Southern Interior, 2013 - 2014.

Timber Supply Area	**Number of spot infestations**		**Number of trees killed in spot infestations**		**Area affected by polygon infestations (ha)**	
	2013	**2014**	**2013**	**2014**	**2013**	**2014**
100 Mile House	83	394	297	1,948	291	3,587
Arrow	139	77	2,173	625	452	974
Boundary	27	28	492	320	13	50
Cranbrook	62	41	717	280	162	45
Golden	18	14	220	140	191	32
Invermere	66	78	683	955	489	702
Kamloops	247	413	1,555	3,115	236	273
Kootenay Lake	71	48	816	490	220	678
Lillooet	361	626	2,535	5,705	437	1,786
Merritt	108	190	567	1,241	65	226
Okanagan	449	397	2,810	3,165	906	797
Quesnel	23	158	74	1,371	160	508
Revelstoke	20	20	345	245	77	96
Williams Lake	579	1,384	2,914	11,982	2,036	22,298
Total	**2,253**	**3,868**	**16,198**	**31,582**	**5,735**	**32,052**

Western Balsam Bark Beetle, *Dryocoetes confusus*

Area affected by western balsam bark beetle increased by over 56,000 hectares, to 228,810 hectares. The bulk of affected stands continue to be within the Kamloops and Okanagan TSAs, which accounted for over 70% of the mapped area. Attack was scattered but widespread in other TSAs. Attack intensity was typically low in most affected stands, with 85% of all attack classified as trace.

Western balsam bark beetle.

Spruce Beetle, *Dendroctonus rufipennis*

Area affected by spruce beetle fell slightly, to 9,270 hectares. Nearly 45% of the mapped area was in the Invermere TSA, where the infestation in the Palliser River - North White River area continued to expand. Other significant, but more scattered infestations were recorded in the southern portions of the Merritt TSA, the Cayoosh Creek area of the Lillooet TSA, and in the eastern end of the Williams Lake and 100 Mile House TSAs.

Western Spruce Budworm, *Choristoneura occidentalis*

Western spruce budworm populations are declining to pre-outbreak levels throughout most of its historic range in southern B.C. Budworm activity was significantly lower in all Timber Supply Areas in the south in 2014. The total area defoliated declined significantly in 2014 to just 44,605 hectares, a 65% decline from 2013 (Table 5, Figure 3), with most of the affected area only lightly defoliated.

The most notable decrease was observed in the Thompson Okanagan Region, where defoliation declined from 36,498 hectares in 2013 to 4,689 hectares in 2014, an 87% decline. The Lillooet TSA had the lowest area affected, with just 53 hectares mapped, and the Kamloops TSA had the largest area affected, with 3,790 hectares mapped. The most continuous area of defoliation was northwest of Kamloops, in the research and demonstration forest area near Lac du Bois and McQueen Lake. Much of this area was not sprayed in 2014 because of ongoing research trials being conducted in the area. In the Okanagan TSA, most of the active defoliation was west of Okanagan Lake in the Trout Creek and Apex Mountain areas.

In the Cariboo Region, only 39,536 hectares of western spruce budworm defoliation was mapped, down from 90,326 hectares in 2013. The 100 Mile House TSA saw the most significant decline, where the mapped area was down by over 80%, from 50,400 hectares in 2013 to just under 10,000 hectares in 2014. The most continuous populations were found in the Meadow Lake and Canoe Creek areas, with additional patches near Clinton and the east end of Loon Lake. Defoliated area in the Williams Lake TSA only declined by about 10,400 hectares (25%), from 39,880 hectares in 2013 to 29,460 hectares in 2014. The most widespread budworm activity in the TSA was in the Hawks Creek, Flat Rock, Meldrum Creek, Chimney Creek, and Williams Lake areas. The 265 hectares mapped in the Quesnel TSA is an extension of the Hawkes Creek population in the Williams Lake TSA.

In the Kootenay Boundary Region, only 380 hectares of moderate western spruce budworm defoliation was mapped, down from 1,565 hectares in 2013. All of the defoliation was in the Cariboo Creek drainage in the the Arrow TSA, where two patches were mapped in high elevation stands east of a low elevation stand that was defoliated in 2013.

Table 5. Area defoliated by western spruce budworm from 2012 - 2014 in the Southern Interior of B.C.

Resource Region and Timber Supply Area	**Area defoliated (hectares) 2012**	**2013**	**2014**	**Population fluctuation 2013 to 2014**	**Area change from 2012 to 2014 (ha)**
Thompson-Okanagan					
Kamloops TSA	38,376	31,411	3,788	significant decline	-270,087
Lillooet TSA	34,443	1,660	53	significant decline	(down significantly)
Merritt TSA	91,795	1,678	186	significant decline	
Okanagan TSA	110,162	1,764	662	decline	
Total	**274,776**	**36,513**	**4,689**		
Cariboo					
100 Mile House TSA	48,105	50,205	9,809	significant decline	-89,015
Williams Lake TSA	79,617	39,694	29,462	decline	(down significantly)
Quesnel TSA	830	49	265	slight increase	
Total	**128,552**	**89,948**	**39,536**		
Kootenay-Boundary					
Arrow TSA	0	80	380	slight increase	-51,424
Boundary TSA	43,064	1,250	0	decline	(down significantly)
Cranbrook TSA	6,982	172	0	decline	
Revelstoke TSA	1,703	15	0	decline	
Other TSAs	55	0	0	decline	
Total	**51,804**	**1,517**	**380**		
South Area Total	**455,132**	**127,978**	**44,605**		**-410,527**

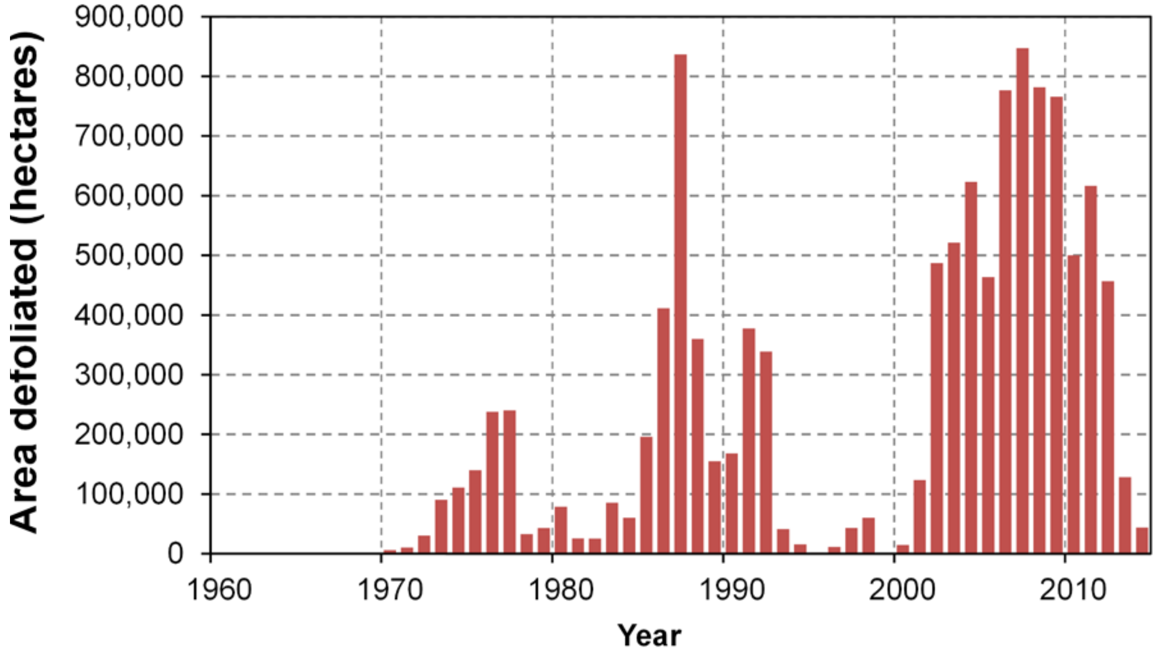


Figure 3. Annual area of western spruce budworm defoliation in British Columbia from 1960 to 2014, as mapped by the aerial overview surveys.

The late May spring dispersal of second instar budworm larvae was well synchronized with host bud softening. An early spring warm spell caused some 2nd instar larvae to disperse early and many of these were not successful in mining needles or buds. However, the remainder of 2nd instar larvae dispersed later in the season and many went straight into the buds rather than mining needles first. Similar to 2013, there was very little variation in larval stages at most sites scheduled for treatment with *B.t.k.*. As noted in the 2013 report, needle mining levels were once again fairly low, significantly lower than was observed in 2011, 2012, and 2013 (Kamloops and Merritt TSAs). The sharp decline in both area and severity of budworm feeding observed throughout most of the southern interior in 2014 was due to the combination of targeted spray programs and a natural decline. Good recovery of trees was observed on sites treated with *B.t.k.* in past years.

Top: fourth instar western spruce budworm larva; Right: shoot damage from early instar budworm feeding.

Reconstruction of Past Outbreak Events

The three graphs in Figure 4 show the relationship between growth reduction (shown as the percent of trees with a reduction in annual incremental growth) and annual defoliation in three general outbreak areas: Kamloops, Merritt, and Okanagan Southeast. Reduced tree ring growth is caused by a number of factors, including defoliation, and each has a distinct signature. Western spruce budworm defoliation will cause reduced annual growth during years of active defoliation and for a number of years following cessation of feeding. Additionally, tree ring records only represent a small spatial area (trees within a plot) compared to a larger area depicted by aerial overview records. However, general outbreak patterns are recognizable and very informative when both criteria are compared. In the Kamloops (Figure 4, upper) and Okanagan Southeast (Figure 4, lower) outbreak areas, the defoliated area was very low between 1996 and 2003, but many trees still showed reduced growth. As a result, when budworm populations increased in the mid-2000's, trees did not have a chance to recover and this growth reduction continued. Depending upon how long southern B.C. sees a decline in budworm activity will determine whether trees are able to recover normal growth patterns or remain at reduced incremental growth.

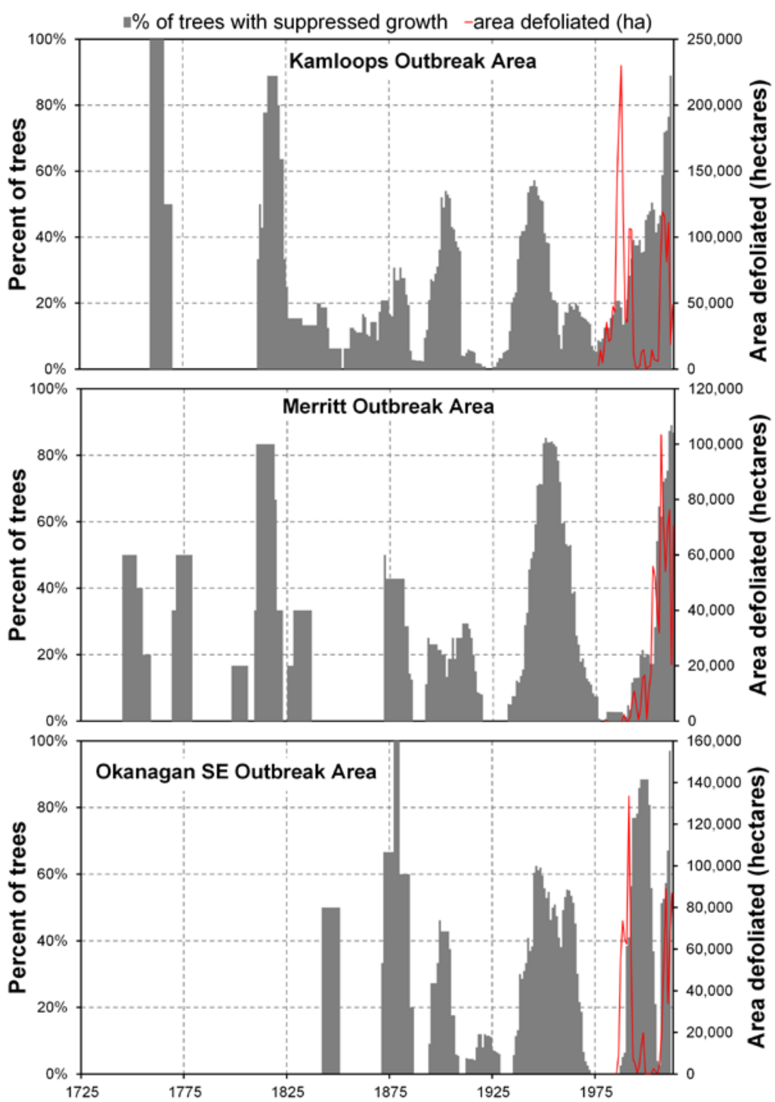


Figure 4. Comparison of annual growth suppression (shown as percent of trees displaying growth suppression) to annual mapped defoliation records (annual hectares defoliated) in three Outbreak Areas.

2014 Western Spruce Budworm Spray Program

A total of 56,737 hectares of high priority Interior Douglas-fir were treated with Foray 48B (*Bacillus thuringiensis* var. *kurstaki*, or *B.t.k.*, P.C.P. No. 24977) between June 18th and July 2nd, 2014, in the Thompson Okanagan and Cariboo Regions (Tables 6 and 7). The spray program required four spray days to complete in the Thompson Okanagan Region (average 5,906 hectares per day) and seven days to complete in the Cariboo Region (average 4,731 hectares per day).

Table 6. Summary of the 2014 western spruce budworm spray program in southern B.C. The table summarizes, by Region, the area sprayed with *B.t.k.*, volume of *B.t.k.* applied, number of spray blocks, number of staging sites and number of days required to complete each spray program.

	Resource Region		
	Thompson Okanagan	Cariboo	Total
Area sprayed (hectares)	23,623	33,114	56,737
Volume *B.t.k.* applied (litres)	56,694	79,474	136,168
Number of spray blocks	16	17	33
Number of staging sites	9	2	11
Number of days to complete	4	7	11

Western Aerial Applications Ltd. conducted the aerial application for the Thompson Okanagan Region. Combinations of two Lama 315B helicopters and two Hiller UH12ET helicopters, each equipped with four Beecomist 361A ultra low volume hydraulic sprayers, were available for the program. Fuel trucks and loading crews were deployed at each staging site as needed, and most spray mornings two staging sites were operating simultaneously. Western Aerial delivered 57 mini-bulk containers (1,000 litres of *B.t.k.* per mini-bulk) to the nine staging sites located in the Kamloops TSA. This worked very efficiently, as the crew could familiarize themselves with the landing and loading sites in advance of treatment dates and ensure the mini-bulks were positioned in the best location at each site.

Two AT-802F Air Tractor fixed-wing aircraft supplied by Conair Aviation completed the aerial application in the Cariboo Region. The project was a collaborative effort between Region and District staff, the Provincial Air Tanker Centre, Conair Aviation, and forest health contractors. The *B.t.k.* was delivered by tanker truck to the Cariboo, where it was transferred to several 2,500 US gallon (9,460 litre) storage tanks located at the Williams Lake and 108 Mile House airports. The Cariboo spray operations were staged from these airports. Spray programs in both Regions were planned and implemented by Regional staff with contractors assisting with population monitoring, weather monitoring, pre- and post-spray assessments, and egg mass sampling.

The cost for the Thompson Okanagan Region spray program was $35.04 per hectare, all-found. This figure was slightly higher than in 2013 ($30 per hectare) due to a smaller area being treated, but still within projected all-found costs of between $30 to $35. The cost for the Cariboo Region spray program was $28.53 per hectare, all-found. The aerial application cost in the Thompson Okanagan was $10.46 per hectare, as compared to $4.82 per hectare in the Cariboo, accounting for most of the all-found cost differences (Table 8).

Table 7. 2014 western spruce budworm spray blocks in the Thompson Okanagan and Cariboo Resource Regions. The table lists, by Region, the geographic area, Timber Supply Area, area sprayed, volume of *B.t.k.* applied and treatment dates.

Region and Geographic Area	Timber Supply Area	Area Sprayed (Hectares)	Litres *B.t.k.* applied	Date Sprayed
Thompson Okanagan				
Black Pines	Kamloops	1,444	3,466	June 18
Cannell Creek	Kamloops	1,480	3,553	June 18
Inskip Lake	Kamloops	1,408	3,380	June 18
O'Connor Lake	Kamloops	871	2,090	June 18
Pinantan Lake	Kamloops	2,482	5,958	June 19
Sullivan Lake South	Kamloops	3,181	7,635	June 19
Sullivan Lake North	Kamloops	2,142	5,141	June 20
Menanteau Lake	Kamloops	1,603	3,847	June 19-20
Homfray Lake	Kamloops	2,204	5,289	June 25
Chartrand Creek	Kamloops	5,694	13,665	June 25
Forge Creek	Kamloops	765	1,836	June 25
Gump Lake	Kamloops	348	836	June 25
Thompson Okanagan Total		**23,623**	**56,694**	**June 18 - 25**
Cariboo				
White Lake	Williams Lake	2,647	6,353	June 23
San Jose	100 Mile House	1,477	3,545	June 23
Big Creek	Williams Lake	2,554	6,130	June 23, 25
Westwick Lakes	Williams Lake	325	780	June 25
Alberta Lake	100 Mile House	931	2,234	June 25
Pipeline Road	100 Mile House	1,083	2,599	June 25, 26
Clink Lake	100 Mile House	5,730	13,752	June 26, 27
Big Lake North	100 Mile House	4,363	10,471	June 26, 27, 30
Alex Lake	100 Mile House	3,322	7,973	June 30
Gaspard Creek	Williams Lake	1,966	4,718	June 30, July 1
Big Lake South	100 Mile House	3,144	7,546	June 30, July 1, 2
Jesmond	100 Mile House	732	1,757	July 1
Gaspard Creek East	Williams Lake	364	874	July 1
Augustine Flat	100 Mile House	356	854	July 1
Fletcher Lake	Williams Lake	3,247	7,793	July 1, 2
Big Bar Lake	100 Mile House	421	1,010	July 2
Stable Creek	100 Mile House	452	1,085	July 2
Cariboo Total		**33,114**	**79,474**	**June 23 - July 2**
2014 Provincial Total		**56,737**	**136,168**	**June 18 - July 2**

Lama 315B helicopter conducting aerial spray operations near Chartrand Creek.

Table 8. Itemized costs of 2014 western spruce budworm spray program in the Thompson Okanagan and Cariboo Regions.

Activity	Expenditure: Thompson Okanagan	Expenditure: Cariboo
B.t.k. purchase	$481,342	$674,734
Planning, advertising, trucking and supplies	$28,154	$33,544
Treatment operations and monitoring (e.g. weather monitoring, spray efficacy sampling)	$21,530	$17,476
Aerial application	$247,000	$159,494
Helicopter support	$3,081	$18,985
Egg mass sampling	$46,600	$40,740
Total cost	$827,708	$944,973
Total hectares treated	23,623	33,117
Approximate cost per hectare	$35.04	$28.53

Spray Monitoring and Efficacy Assessment

Treatment timing was normal for the geographic areas treated. May and June had moderate temperatures, with considerable precipitation in late June. There were no weather delays in the Thompson Okanagan program, however a few spray mornings in the Cariboo were delayed or cut short due to rain. The first areas to be treated in the Thompson Okanagan were near Pinantan Lake, Menanteau Lake, and along the east and west sides of the North Thompson River Valley, between June 18th and 20th. The remainder of the Region's program was west of Kamloops and north of Logan Lake, and was completed on June 25th. Spraying in the Cariboo commenced on June 23rd, with the last areas being completed on July 2nd (Table 7).

Timing of the spray is critical to obtain optimum foliage protection and maximize insect population reduction. Our aim is to treat blocks when larvae are predominantly 4th or late 3rd instar, when new shoots are elongating, as this will best achieve our goals. Figure 5 compares the abundance of larval instars, at the pre-spray sampling time, averaged over the treatment and control blocks within the Thompson Okanagan and Cariboo Regions. In both Regions, over 80% of all insects were third or fourth instar in treatment blocks at the pre-spray. There was a slightly higher proportion of 4th instar larvae present at the time of the spray in the Thompson Okanagan Region, because treatment had to wait until shoots were starting to expand. Therefore, some insects were more advanced in their development. Shoot elongation, coupled with larval development (instar), is a critical factor used to determine optimum timing of spray application. If trees are sprayed while insects are still feeding in the buds, treatment efficacy is reduced. Continual monitoring of shoot and insect development prior to spraying ensures optimal timing of the spray.

In May and early June, spray blocks and nearby candidate stands are monitored for second instar larval dispersal, levels of bud and needle mining, budflush and shoot elongation. At this time, block boundaries can be adjusted if budworm populations are too low to warrant treatment. Conversely, if adjacent stands have high populations, then areas can be appended. During this pre-spray monitoring phase, sites are selected inside and outside of spray blocks for efficacy assessments (pre- and post-spray larval sampling).

A total of 150 trees, in 10 sprayed areas and 5 unsprayed control areas were sampled for budworm larvae pre- and post-spray (Table 9). Pre-spray samples were collected one day prior to *B.t.k.* application and two post-spray samples were collected at approximately one-week intervals after spraying. Two post-spray samples are usually sufficient to determine spray efficacy. It is often difficult to find comparable control sampling sites since most of the stands with high budworm populations are designated for treatment. Therefore, since the untreated control areas sampled in 2014 did not necessarily have directly comparable budworm populations (e.g. similar elevation, insect density, developmental stage), the calculations of percent mortality and corrected mortality may be misleading. Defoliation level, using the Fettes defoliation scale, was also recorded for each branch sample at each of the larval sampling times.

Table 9. Results of the pre- and post-spray assessment of western spruce budworm in the Thompson Okanagan and Cariboo Chilcotin Regions, showing the number of live budworm larvae per square metre of foliage, the total percent mortality, and Abbott's corrected mortality, at the pre-spray and each post-spray assessment.

	Pre-spray	**First Post-spray**			**Second Post-spray**		
Block	**Larvae per m^2**	**Larvae per m^2**	**Mortality (%)**	**Corrected Mortality (%)**	**Larvae per m^2**	**Mortality (%)**	**Corrected Mortality (%)**
Thompson Okanagan							
Black Pines *B.t.k.*	394.2	253.2	24.6		79.0	74.5	
Isobel Lake *B.t.k.*	335.2	70.1	76.7		87.3	71.4	
O'Connor Lake *B.t.k.*	293.0	193.7	30.2		156.1	42.6	
Sullivan Lake North *B.t.k.*	187.3	54.1	65.9	57.3	13.3	91.4	85.6
Sullivan Lake control	138.2	87.3	20.1		60.3	39.6	
Sullivan Lake South *B.t.k.*	194.9	96.6	50.6	38.2	90.2	53.9	23.7
Sullivan Lake control	138.2	87.3	20.1		60.3	39.6	
Chartrand Creek North *B.t.k.*	69.6	29.7	43.9	-	2.6	96.7	92.9
Chartrand Creek control	135.5	67.7	48.7		63.5	53.4	
Chartrand Creek South *B.t.k.*	155.1	68.3	58.3	18.7	87.2	46.2	-
Chartrand Creek control	135.5	67.7	48.7		63.5	53.4	
Cariboo							
Block 1 *B.t.k.*	344.4	120.1	65.1	76.4	39.1	88.6	76.2
Block 1 control	126.2	186.8	-48.0		60.2	52.3	
Block 2 *B.t.k.*	249.9	70.7	71.7	51.3	35.6	85.8	65.4
Block 2 control	86.4	50.2	41.9		35.5	58.9	
Block 3 *B.t.k.*	235.7	35.9	84.8	72.1	5.3	97.8	91.6
Block 3 control	122.5	66.9	45.4		32.5	73.5	

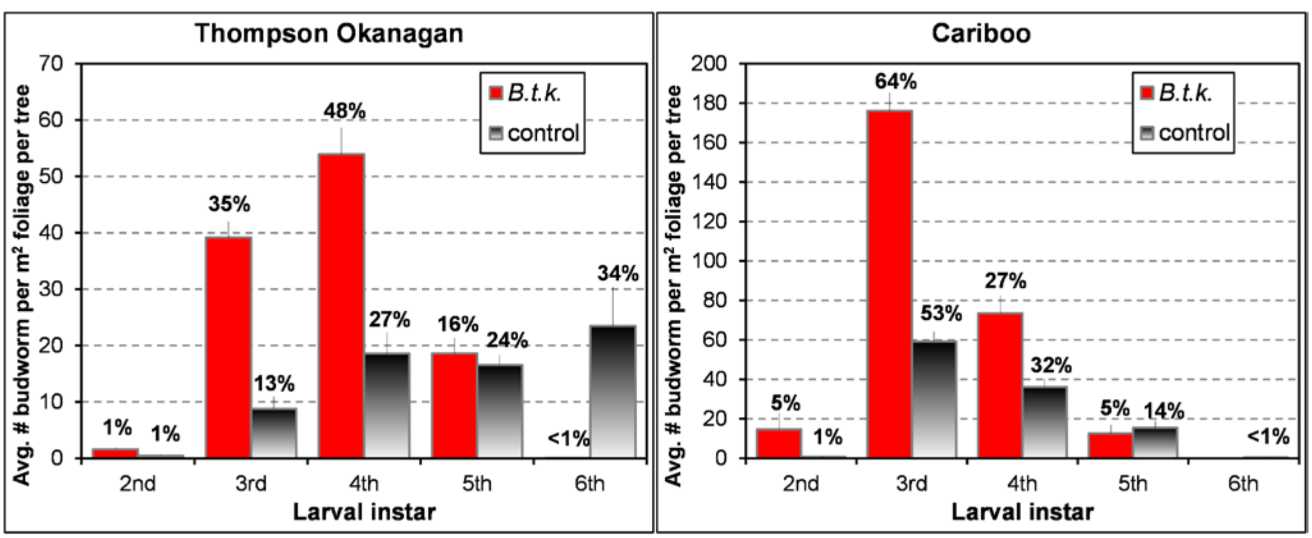


Figure 5. Average number of budworm per square metre of foliage per tree (±Standard Error), for each larval instar stage at the pre-spray sample time in the Thompson Okanagan (left graph) and Cariboo (right graph) Regions. Percentages show the proportion of larvae falling into each larval instar category.

The graph in Figure 6 shows overall abundance of budworm larvae at each sampling date, and shows the population trends by Region within the treated and control sites. What is clearly evident is the more significant and immediate decline in larval numbers in the treated blocks compared to the control blocks. Natural mortality was higher than in past years and was particularly noticeable in the Thompson Okanagan, thereby influencing the corrected mortality calculation (Table 9). By the second post-spray assessment in both the Thompson Okanagan and Cariboo Chilcotin Regions, larval abundance was similar in all sites, ranging from five to eleven insects per two-branch sample.

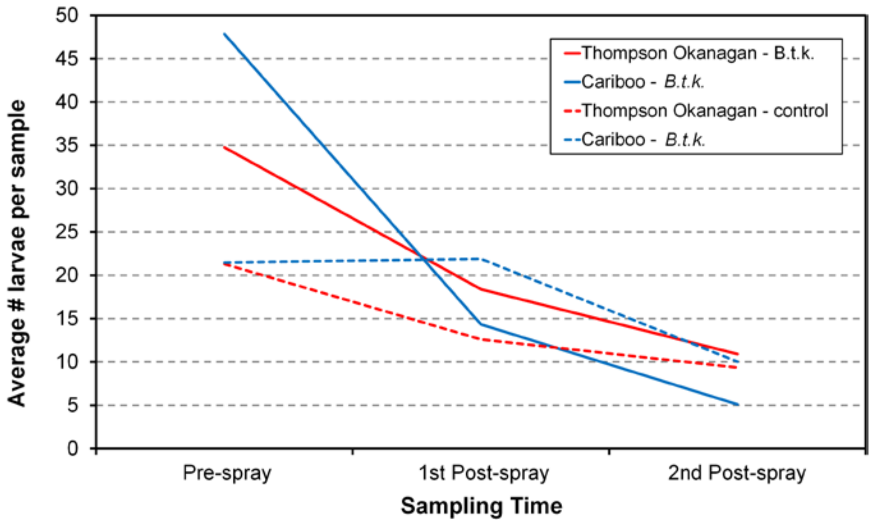


Figure 6. Total number of live western spruce budworm larvae counted at each sampling time in the Thompson Okanagan and Cariboo Regions. The total number of larvae collected during pre- and post-spray sampling was averaged per tree (10 trees per site) over all sites in each Region, keeping treated sampling sites and control sampling sites separate.

The extensive and targeted spray program over the past few years, coupled with the natural decline of the outbreak in both Regions, has resulted in the lowest levels of western spruce budworm defoliation recorded since the late 1990's. From 1993 through 2000, the annual hectares defoliated in B.C. ranged from under 2,000 hectares to just over 60,000 hectares. For fourteen years, 2001-2014, the budworm has been in outbreak over thousands of hectares (Figure 3).

The last three outbreak periods in B.C. each lasted longer than the previous: 1973-1977 (5 years); 1985-1992 (8 years); and, 2001-2014 (14 years) (Figure 3). In comparison, the "refresh" periods between outbreaks remained relatively static, at seven to eight years. It appears that we are entering another "refresh" period, where areas of defoliation fluctuate between a few thousand to fifty or sixty thousand hectares annually in the province. The decision to treat or monitor is in part based upon the spatial proximity of defoliated areas and the point in the outbreak cycle. For example, if most of the defoliation in a given year was mapped in one area, then there would be a greater biological imperative to spray than if it was spread over a wide area. Monitoring will continue on an annual basis to detect any incipient population fluctuations.

Western Spruce Budworm Eggmass Sampling Results

A total of 391 sites in the southern interior and south coast areas were surveyed for western spruce budworm egg masses in the fall of 2014 (Table 10). The density of egg masses at each site sampled, expressed as the number of new egg masses per 10 square metres of foliage, gives an indication of potential budworm populations in the upcoming year and resultant expected defoliation (see table at right).

Number of new egg masses per 10 m^2 foliage	Predicted defoliation
0	Nil
1 – 50	Light
51 – 150	Moderate
Over 150	Severe

The level of predicted defoliation by western spruce budworm is down significantly in all areas. No sites sampled predicted severe defoliation for 2015, and only 24 sites (6% of sites) predicted moderate levels of defoliation, and this is primarily in the Cariboo. 146 sites (37 % of sites) had no egg masses (defoliation prediction is nil) (Table 10). This is the lowest level of western spruce budworm activity since 1995-1996.

Table 10. Results of the fall 2014 western spruce budworm egg mass sampling in southern B.C. showing the average number of new egg masses per 10 square metres of foliage and the number of sites falling into each defoliation prediction category for 2015. Results are averaged by Resource District for each Region.

Region and District	Number of sites	Average # egg masses per 10 m^2 foliage	Number of sites in each category: Nil	Light	Moderate
Thompson Okanagan Region					
Cascades	53	3.3	34	19	0
Thompson Rivers	111	8.2	60	48	3
Okanagan Shuswap	32	4.3	19	13	0
Region total/average	**196**	**6.3**	**113 (58%)**	**80 (41%)**	**3 (2%)**
Cariboo Region					
Central Cariboo	93	27.4	11	71	11
100 Mile House	73	27.0	6	57	10
Quesnel	8	7.5	3	5	0
Region total/average	**174**	**26.3**	**20 (11%)**	**133 (76%)**	**21 (12%)**
South Coast Region					
Chilliwack	21	1.9	13	8	0
Region total/average	**21**	**1.9**	**13 (62%)**	**8 (38%)**	**0**
Total/average - all Regions	**391**	**14.9**	**146 (37%)**	**221 (57%)**	**24 (6%)**

Thompson Okanagan Region

Egg mass sampling sites were distributed throughout the geographic outbreak areas of the Thompson Okanagan Region so that a comprehensive picture could be obtained. Over half of the 196 sites surveyed for eggmasses predict "nil" defoliation in 2015. Eighty sites (41%) predict light defoliation and only three sites (2%) predict moderate defoliation (Table 10). This is a sharp decline from the 2013 sampling results and defoliation predictions, when only 6% of sites predicted "nil" for 2014. Of particular note, all sites sampled within the Isobel Lake, O'Connor Lake and Black Pines spray blocks on the west side of the North Thompson River had nil or light defoliation prediction results, whereas sites outside but nearby the blocks had moderate defoliation predictions. These areas are within a long-term research area and were therefore excluded from treatment in 2014. None of the areas sampled have budworm populations that warrant spray treatment in 2015 (Figure 7).

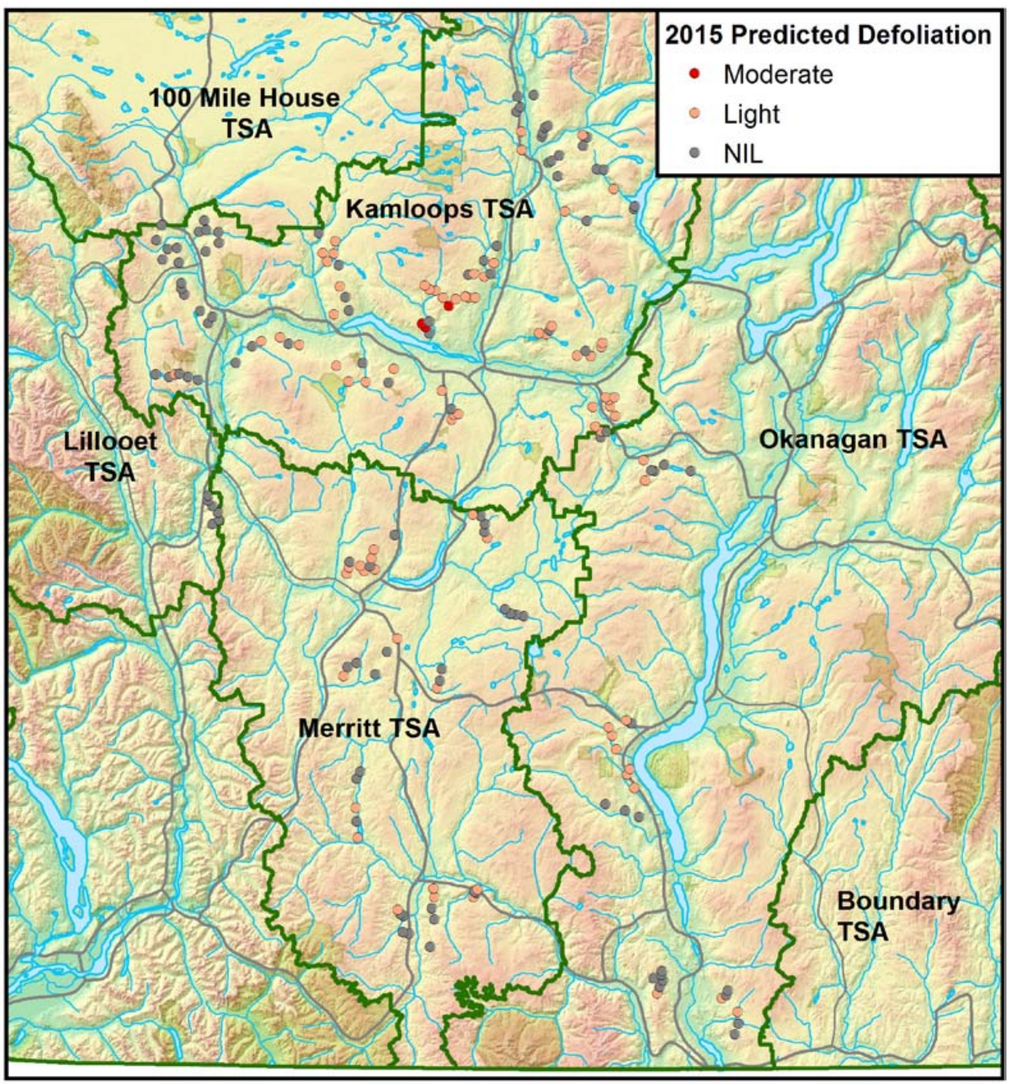


Figure 7. Map showing the location and results of western spruce budworm eggmass sampling in the Thompson Okanagan Region.

Cariboo Region

The proportion of sites sampled in 2014 predicting light or moderate defoliation was relatively unchanged from 2013. Seventy-six percent of sites sampled (133 sites) predict light defoliation in 2015, and 12% of sites (21 sites) predict moderate defoliation. Only 11 % of sites (20 sites) predict "nil" defoliation. The average number of egg masses per 10 square metres of foliage, averaged over all sites in the Cariboo Region, was down slightly from 28.3 in 2013, to 26.3 in 2014 (Table 10). The geographic areas being considered for *B.t.k.* treatment in 2015 are located near Loon Lake, west of Lac La Hache and to the north and south of the 2014 Williams Lake spray block (Figure 8). These sites will be monitored in the spring to determine if a spray is warranted. The Cariboo Region budworm population seems to be following the same trajectory as that observed to the south in the Thompson Okanagan Region, perhaps with a one year time-lag.

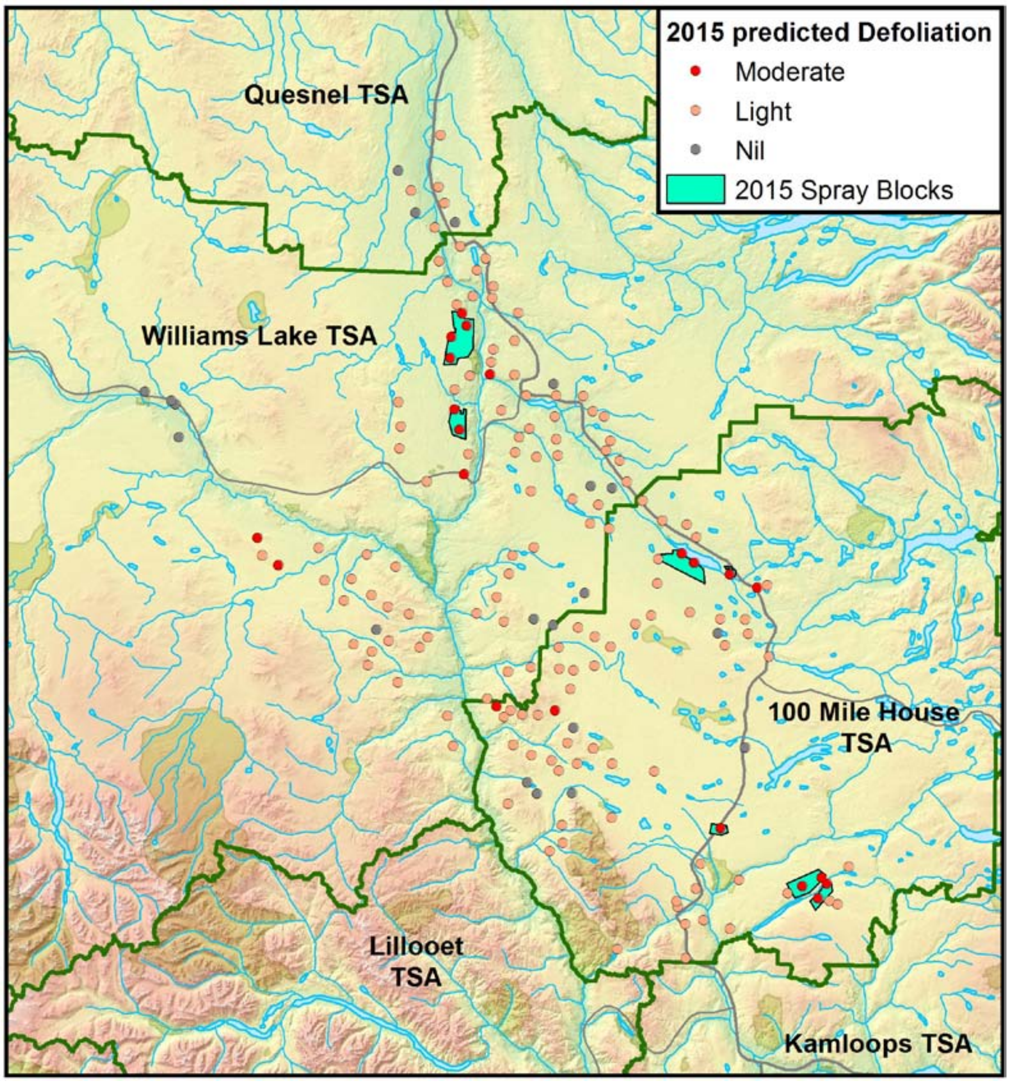


Figure 8. Map showing the location and results of western spruce budworm eggmass sampling, and proposed 2015 spray blocks, in the Cariboo Region.

Monitoring Activities - Defoliator Permanent Monitoring Sites

There is an array of permanent sampling sites throughout the Thompson Okanagan, Cariboo and Kootenay Boundary Regions to monitor the diversity (species richness), incidence, and population fluctuations of defoliating insects. The monitoring methods used include trapping for moths (typically 6-trap clusters at each site) and/or tree beatings for larvae (usually three trees per site). Many of these sites were formerly monitored by the Forest Insect and Disease Survey (FIDS) Unit of Forestry Canada, while other sites are new installations. Monitoring sites are strategically located within historic outbreak areas, or in other areas of special interest. The primary defoliators monitored annually at these sites include:

a) Douglas fir tussock moth, *Orgyia pseudotsugata*;
b) Western hemlock looper, *Lambdina fiscellaria lugubrosa*;
c) Western spruce budworm, *Choristoneura occidentalis*; and,
d) Western false hemlock looper, *Nepytia freemani*

Given the possibility of range expansion, influenced by changing climate and host condition, additional sites were added to the defoliator monitoring network. In 2007, thirteen three-tree beating sites, formerly monitored by FIDS, were re-established in the East Kootenays to monitor the incidence of western false hemlock looper (*Nepytia freemani*) and western spruce budworm (*Choristoneura occidentalis*) (Figure 9). The East Kootenays have a limited history of visible defoliation by these defoliators, but given our changing climate and Douglas-fir encroachment throughout the Rocky Mountain Trench, conditions may become more favorable for both western spruce budworm and western false hemlock looper, and we may see more extensive outbreaks in the future.

Western spruce budworm was not found at any of the thirteen sites in 2014, and no defoliation was noted. Defoliator diversity was very low overall in 2014, with only one western false hemlock looper, one *Eupithecia annulata*, and one *Zeiraphera improbana* recorded. The results of the 2014 monitoring for Douglas-fir tussock moth andwestern hemlock looper are discussed in the following sections of this report.

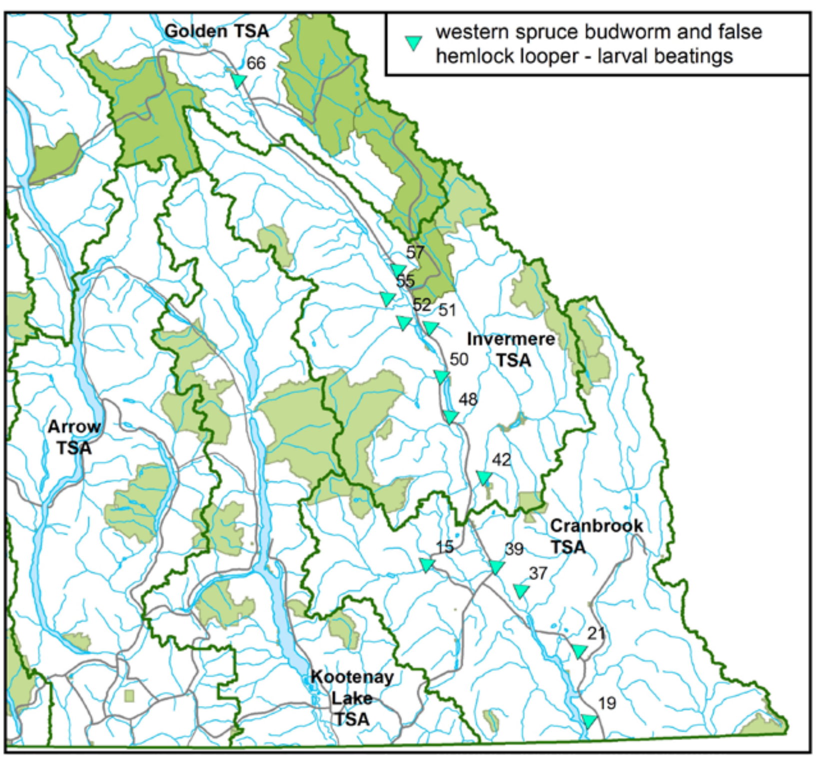


Figure 9. Location of East Kootenay western spruce budworm and false hemlock looper three-tree beating permanent sampling sites.

Douglas-fir Tussock Moth, *Orgyia pseudotsugata*

For the second year in a row, no Douglas-fir tussock moth defoliation was detected during the aerial overview surveys. Ground checks revealed no evidence of tussock moth defoliation and very few larvae were found in ground surveys or three-tree beatings.

A total of 68 permanent sampling sites (PSSs) were monitored for Douglas-fir tussock moth larval and moth populations, using six-trap clusters and three-tree beatings (Figure 10, Table 11). Three sites in the Similkameen historical outbreak area were discontinued due to poor site quality, and one new site was established in the Okanagan historical outbreak area to more fully cover that geographic area.

Overall, only fifty-three percent of the PSSs had positive trap catches. Seven sites in West Kamloops, Boundary and the Cariboo had no moth catches; three sites in Kamloops had zero moths; and, four sites in each of the Okanagan and Similkameen had zero moth catches. Although at endemic levels, the highest moth catches were at the Heffley Creek and Monte Creek PSSs in the Kamloops outbreak area. An informal survey was conducted at the Heffley Creek site, but only a few larvae were found, significantly fewer than was observed in 2013. The Big Bar South PSS had the highest moth catches in the Cariboo, at 3.6 moths per trap, down from 16.7 moths per trap in 2013. All other sites in the Cariboo were at endemic levels (Table 11).

Figure 11 illustrates the collapse of the tussock moth population across all outbreak areas, with the Similkameen being the first to decline, in part due to the virus spray in 2009 in and around Stemwinder Provincial Park. Populations may start to build again as early as 2017-2019 in some locations.

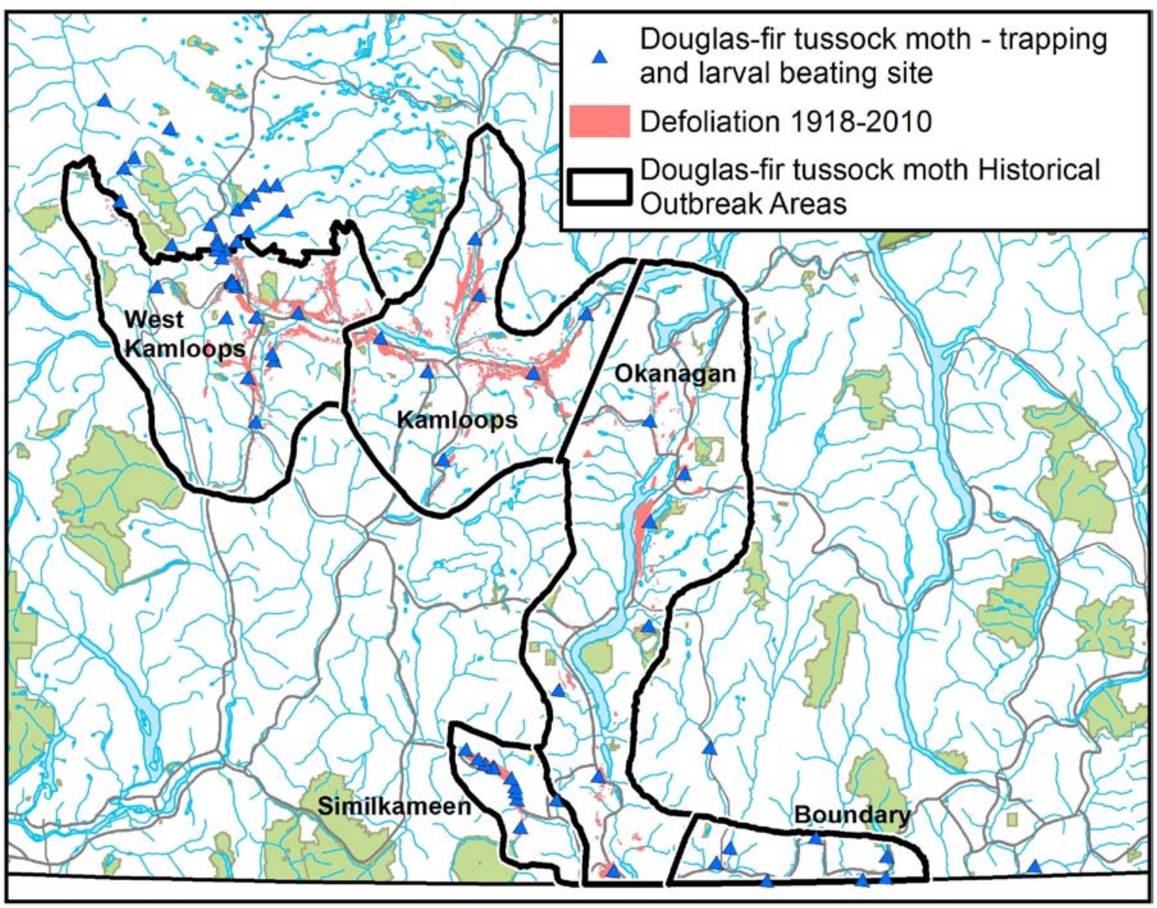


Figure 10. Douglas-fir tussock moth permanent sampling sites, historical outbreak areas, and areas of defoliation from 1918-2010.

Table 11. Average number of Douglas-fir tussock moths caught per 6-trap cluster in the Thompson Okanagan, Kootenay Boundary and Cariboo Regions. Traps are located at permanent trapping sites where there is a history of tussock moth outbreaks or where there is the potential for range expansion.

		Average moth catch per trap				
Site	**Location**	**2010**	**2011**	**2012**	**2013**	**2014**
Kamloops						
1	McLure	25.6	40.5	29.0	7.2	0.2
2	Heffley Creek	2.0	3.3	33.4	27.7	8.3
3	Inks Lake	1.0	6.2	6.0	6.3	0.0
4	Six Mile	48.8	19.2	29.0	5.3	0.2
9	Stump Lake	22.7	79.8	0.7	0.3	0.0
10	Monte Creek	21.7	54.5	59.2	18.2	11.7
11	Chase	0.0	1.8	8.6	0.3	0.0
	Average of sites	**17.4**	**29.3**	**23.7**	**9.3**	**2.9**
West Kamloops						
5	Battle Creek	46.5	2.5	0.0	0.2	0.0
6	Barnes Lake	24.3	37.5	4.7	0.5	0.0
7	Carquille/Veasy Lake	38.2	54.5	16.0	27.7	5.0
8	Pavilion	7.8	82.5	3.2	0.7	0.2
21	Spences Bridge	59.3	68.5	56.0	4.0	0.0
22	Veasy Lake FSR (2.8 km)	27.8	68.0	16.2	16.8	3.0
23	Veasy Lake FSR (4.2 km)	5.6	43.3	3.3	9.3	0.2
24	Veasy Lake FSR (3.5 km)	6.8	76.3	14.5	29.3	1.2
25	Highway 99	11.0	23.0	7.4	4.0	0.2
26	Venables Valley	24.3	39.7	11.5	1.2	0.0
27	Maiden Creek	3.5	8.0	3.5	0.7	0.0
28	Highway 99	3.0	9.3	7.2	3.8	0.5
29	Cornwall 79	28.8	49.5	1.2	0.7	0.8
30	Cornwall 80	2.0	6.0	0.2	0.8	0.0
31	Barnes Lake	7.7	9.8	0.8	1.2	0.0
	Average of sites	**19.8**	**38.6**	**9.7**	**6.7**	**0.7**
Okanagan						
12	Yankee Flats	3.0	32.0	42.7	-	0.7
13	Vernon	22.0	35.2	38.2	2.0	0.0
14	Winfield/Wood Lake	34.0	14.7	6.8	0.0	0.2
15	Kelowna/June Springs	46.8	0.7	0.0	0.0	0.0
16	Summerland	0.0	8.5	0.5	0.0	0.0
17	Kaleden	2.9	3.7	0.3	0.0	0.3
18	Blue Lake	0.0	0.5	0.5	0.0	0.2
45	Glenmore (new site in 2014)					0.0
	Average of sites	**15.5**	**13.6**	**12.7**	**0.3**	**0.2**
Similkameen						
19	Stemwinder Park	0.0	0.0	0.3	0.2	0.7
32	Olalla	5.7	3.7	2.0	0.0	1.2
33	Red Bridge Recreation Site	0.3	0.0	0.0	0.0	0.7
36	Lawrence Ranch	0.0	0.8	0.7	0.0	0.2
38	Highway 3 - Bradshaw Creek	0.0	3.2	0.3	2.0	2.5
39	Highway 3 - Winters Creek	0.0	1.2	0.8	0.2	0.8
40	Highway 3 Nickelplate Road	0.0	6.2	0.0	0.4	0.0
41	Stemwinder FSR	0.0	3.0	0.0	0.3	0.0
42	Old Hedley Road	0.0	0.4	0.0	0.0	0.0
43	Pickard Creek Recreation Site	0.3	2.5	1.0	0.2	0.3
44	Old Hedley Road	5.7	0.7	0.8	0.0	0.0
	Average of sites	**1.1**	**2.0**	**0.5**	**0.3**	**0.6**
Boundary (Average of 9 sites)		**2.0**	**73.0**	**1.0**	**0.6**	**0.2**
Cariboo (30 sites in 2013; 18 sites in 2014)*		**1.7**	**1.6**	**1.4**	**3.6**	**1.6**

* Average of 58 sites in 2008-2012

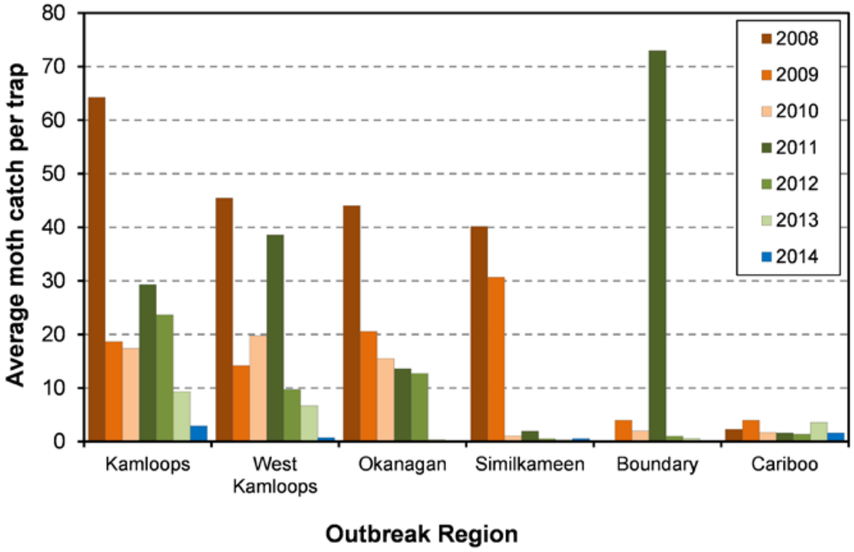


Figure 11. Average number of Douglas-fir tussock moths caught per trap per site, averaged for each Outbreak Region, in southern B.C. from 2008 to 2014.

In late June to early July, three-tree beatings were conducted to monitor larval populations at 38 of the 50 PSSs in the Thompson Okanagan Region and Boundary area. No July three-tree beatings were conducted in the Cariboo. No Douglas-fir tussock moth larvae were collected at any of the PSSs, except for one larva at the Heffley Creek site. This downward trend mirrors the trapping results of 2014. Defoliator diversity in the three-tree beatings was down from previous years, with only 15 different species recorded. The most common and abundant defoliator across all sites was the western spruce budworm, with 285 larvae found at 20 sites, but budworm abundance was also down significantly. The highest larval budworm counts were at the Summerland, Old Heffley Road, Inks Lake, Eholt, Johnson Creek, and Wallace Road PSSs.

Western Hemlock Looper, *Lambdina fiscellaria lugubrosa*

No defoliation by western hemlock looper was recorded in the 2014 aerial overview surveys (Figure 13). The next population increase and possible outbreak is expected to occur between 2019 and 2021.

Western hemlock looper and associated forest defoliators are monitored annually at several permanent sample sites throughout the Thompson Okanagan and Kootenay Boundary Regions. There are 16 sites in the Thompson Okanagan Region, where both three-tree beatings and six-trap cluster monitoring are conducted. There are 25 sites in the Revelstoke - Columbia area in the Kootenay Boundary Region, all of which have three-tree beatings, and eleven of which also have six-trap cluster monitoring (Figure 12).

Three-tree beatings were conducted in mid-July to monitor larval populations. Traps were placed concurrently with the larval sampling and collected in late September to early October after moth flight was complete.

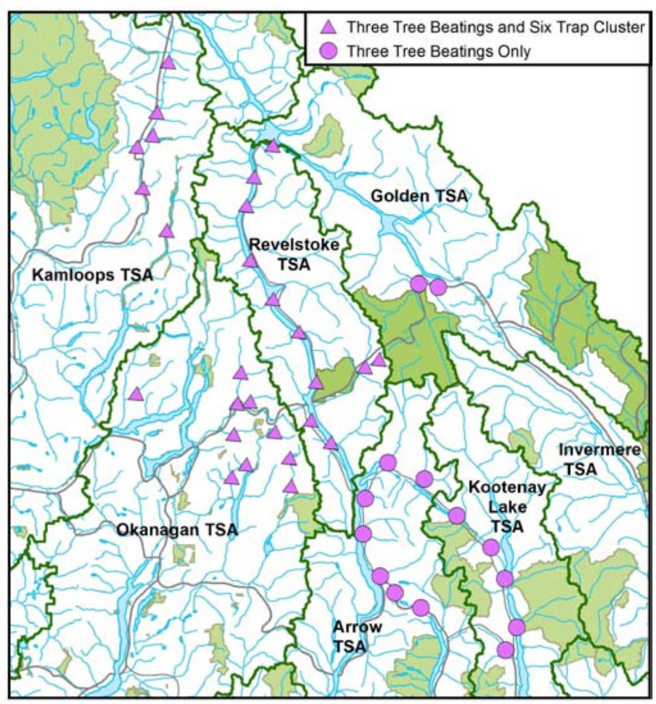


Figure 12. Location of western hemlock looper six-trap clusters and three-tree beating permanent sampling sites in southern B.C.

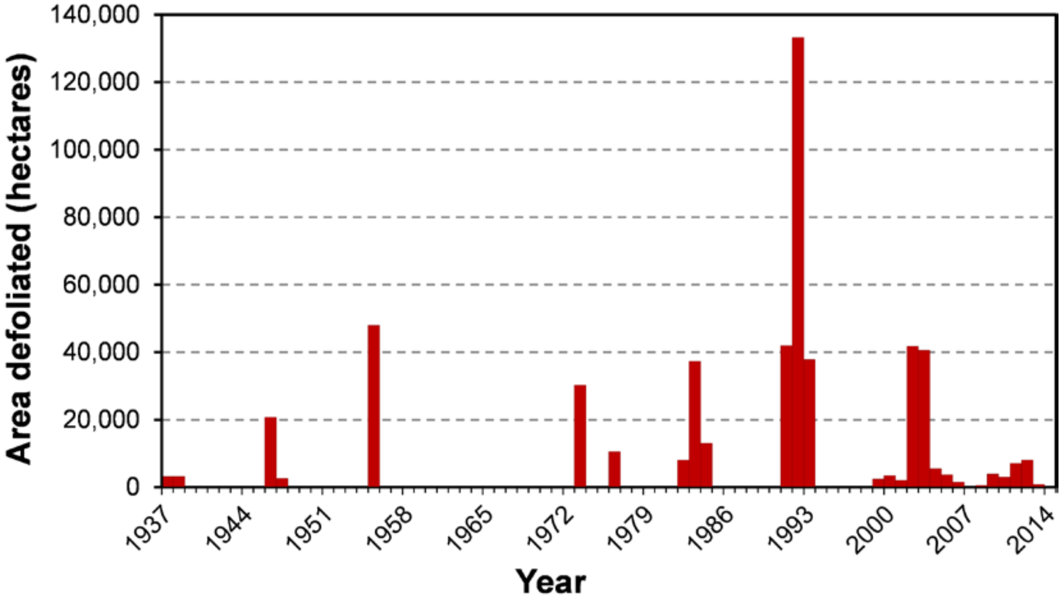


Figure 13. Area defoliated by western hemlock looper in the southern interior of B.C., 1937-2014.

Both trap catches (Figure 14) and larval counts (Figure 15) continued to decline in 2014. The highest trap catch was at the Noisy Creek site, with an average of 106 moths per trap, down from 117 in 2013, and 450 in 2012. Areas with the lowest trap catches (average less than 10 moths per trap) included sites in the North Thompson Valley, Adams River/Tumtum Lake, Bigmouth Creek, Carnes Creek, and Kinbasket Lake.

Only three of the 41 three-tree beating sites were positive for western hemlock looper larvae. Overall larval diversity and abundance was low again in 2014 (Figure 15).

Population trends in all three categories - moth trapping, larval sampling, and mapped defoliation, indicate western hemlock looper has returned to endemic levels in all areas. This last cycle was minimal in terms of area damaged and tree mortality when compared to past outbreaks, such as the 1991-1993 or 2002-2006 outbreaks, when extensive areas were severely damaged. This could potentially indicate that the next outbreak cycle in nine to ten years may be more extensive and severe.

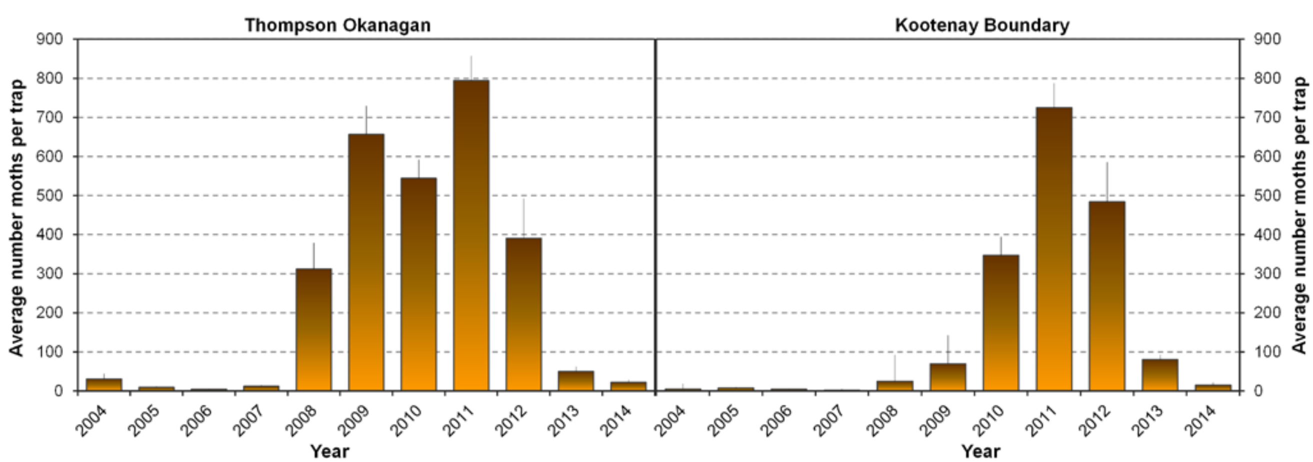


Figure 14. Annual average (± standard error) western hemlock looper moth catches in 6-trap clusters (2004-2014) in the Thompson Okanagan Region (16 sites, left graph) and Kootenay Boundary Region (11 sites, right graph).

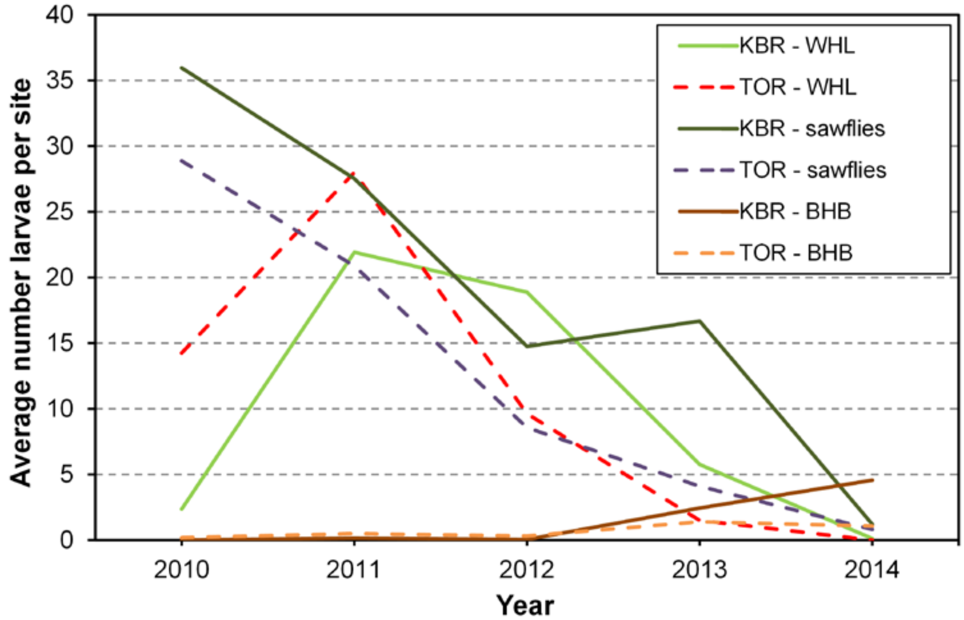


Figure 15. Results of three-tree beatings at permanent sample sites in the Thompson Okanagan Region (TOR) and Kootenay Boundary Region (KBR), showing the average number of larvae per site from 2010 to 2014 of western hemlock looper (WHL), blackheaded budworm (BHB) and sawflies (sawflies).

Two-Year Cycle Budworm, *Choristoneura biennis*

Defoliation increased in 2014 due to this being the “on” year in the feeding cycle of this insect. Damage was mapped on just over 130,000 hectares, which is more than double the area mapped in 2012, the last “on” year. Affected stands were located throughout the eastern portions of the Quesnel, Williams Lake, and 100 Mile House TSAs, and in the northern parts of the Kamloops TSA. Most defoliation was classified as light, which may be due partially to a cool spring, and therefore delayed feeding.

Pine Needle Sheath Miner, *Zellaria haimbachi*

Pine needle sheathminer defoliated 47 separate immature lodgepole pine stands in the Kamloops, 100 Mile House, Quesnel, Williams Lake, and Arrow TSAs. A total of 1,634 hectares of light to moderate defoliation was mapped. While most of the affected stands have only been defoliated for one year, a few areas north of Kamloops have been defoliated for three to four consecutive years. Some stands that have experienced more than three years of defoliation were not detected in the aerial overview survey, because the new foliar growth was so reduced that the new feeding was extremely hard to detect except from the ground. Populations in the Okanagan appear to have collapsed, with no new defoliation detected.

Outbreaks of pine needle sheath miner are cyclical, like many other defoliators, and occur at intervals of 15 to 20 years and in distinct geographic locations. Little is known of the impact caused to trees from one or multiple years of defoliation by this insect. From preliminary observations in currently affected stands, impact to height growth could be significant after two years of attack. Impacts will be quite variable within and between stands due to the spatially diverse pattern of defoliation and may range from reduced height growth to minor volume loss. In the current outbreak, relatively few stands have been affected, largely due to the spatial discreteness of young pine regeneration. However, in 15 to 20 years’ time when we expect another outbreak, there will be significant young lodgepole pine across the landscape due to the harvest of mountain pine beetle killed forests. The increased abundance of host, closer proximity of stands, climate change effects and enhanced silviculture could present optimum conditions for the next outbreak.

Pine needle sheath miner. Left: first year of defoliation on a young lodgepole pine; Right: affected shoot showing webbing and a pupa.

Aspen Serpentine Leaf Miner, *Phyllocnistis populiella*

Aspen serpentine leaf miner damage increased significantly for the third consecutive year, from 114,500 hectares in 2013, to 229,845 hectares in 2014. Defoliation was widespread across the Quesnel, Williams Lake, 100 Mile House, and northern Kamloops TSAs, but more scattered in other areas.

Forest Tent Caterpillar, *Malacosoma disstria*

The large forest tent caterpillar outbreak around Quesnel expanded substantially, and now covers just over 124,000 hectares. Additional smaller infestations in the Williams Lake, Okanagan and Kamloops TSAs increased the total area affected to 128,950 hectares.

Birch Leaf Miner, *Fenusa pusilla*

Several small, scattered pockets of birch leaf miner damage were mapped in the Kamloops, Okanagan, Golden, Revelstoke, Arrow, and Kootenay Lake TSAs. Total affected area was 1,985 hectares, with over 60% of the defoliation classified as moderate to severe.

Satin Moth, *Leucoma salicis*

Satin moth defoliation was up, from 234 hectares in 2013, to 445 hectares in 2014. Most of the affected stands were in the Okanagan, with some additional small, scattered pockets in the Kamloops, Lillooet, and Merritt TSAs. Just over half of the mapped damage was classified as moderate to severe.

Gypsy Moth, *Lymantria dispar*

The Ministry of Forests, Lands, and Natural Resource Operations, the Canadian Food Inspection Agency, and the Canadian Forestry Service cooperatively monitor for occurrence of European gypsy moth at many sites throughout the southern interior. In 2013, a single moth was caught in a monitoring trap near McLeese Lake. A delimiting grid of additional traps was deployed in the area in 2014 but no additional moths were caught; another delimiting grid will be deployed in 2015. In 2012, a single moth was captured in a monitoring trap near Kaslo. Delimiting grids were deployed in the area in 2013 and 2014, but no further moths were caught. The population in this location is assumed to have died out. A single moth was captured near Trail in 2014; a delimiting grid of traps will be used to monitor populations in 2015 and 2016.

Male gypsy moth caught in trap. Surrey, B.C., 2014.

Larch Needle Blight, *Hypodermella laricis*

Larch needle blight damage was limited to several small, scattered pockets, mostly in the Kootenay Boundary Region. Total area affected was down to 1,070 hectares.

Pine Needle Diseases

Several lodgepole pine plantations exhibited symptoms of needle disease damage. Ground checks helped to verify the causal agents. Pine needle cast (*Lophodermella concolor*), occasionally mixed with the secondary pathogen *Hendersonia pinicola*, caused light damage to 440 hectares in the Merritt and Okanagan TSAs. Red band needle blight (*Dothistroma septosporum*) infection, also occasionally mixed with *Hendersonia pinicola*, damaged 534 hectares in the Okanagan and Kamloops TSAs.

Bear Damage

Bear damage was observed on 4,125 hectares in 2014, down from 4,970 hectares in 2013. Affected stands were mostly immature lodgepole pine plantations and damage consisted of tree mortality and top kill. Most of the damage was in the Lussier River and Palliser River drainages in the Invermere TSA, along the east arm of Quesnel Lake in the Williams Lake TSA, and in scattered pockets in the West Kootenays, Kinbasket Lake, Golden, and south Okanagan areas.

Wildfire

New wildfire activity was relatively low again in 2014, with 31,314 hectares burned. Nearly half of the area burned was within a single large fire near Euchiniko Lakes in the Quesnel TSA. Post-wildfire mortality, caused by Douglas-fir beetle and other secondary insects, bark scorching, crown and root damage, can persist for several years in and near burned areas. Ongoing tree mortality was mapped on 4,880 hectares this year. Most of this damage was in and around the Itcha Ilgachuz (2010), Meldrum Creek (2010), Dog Creek (2010), Chilko Lake (2009), and Edge Hills (2009) wildfire areas.

Wildfire damage in a high-elevation forest.

Flooding

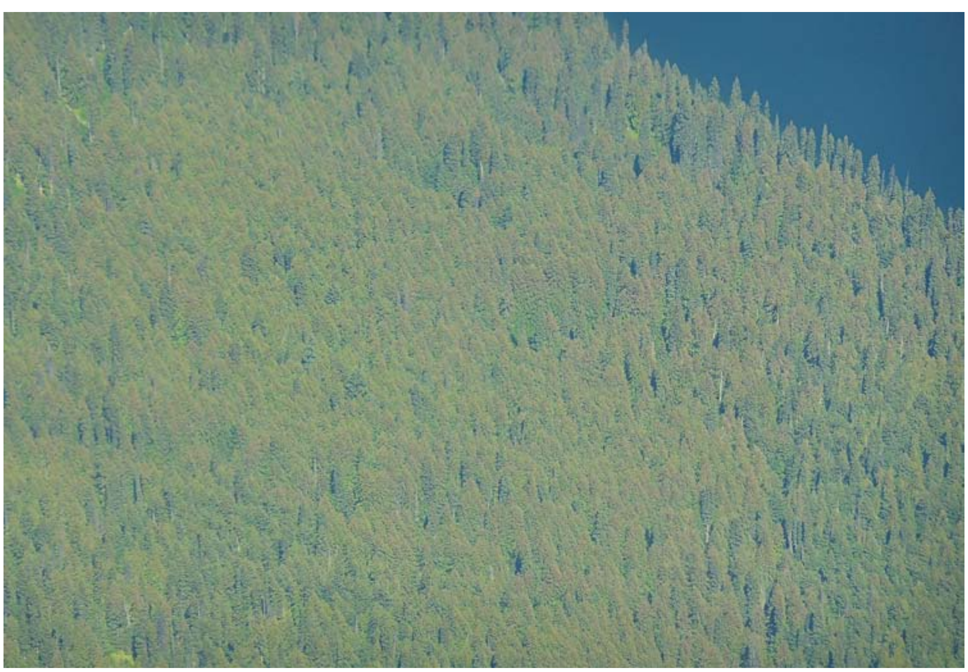
Numerous small patches of lodgepole pine, mostly in the West Chilcotin, were killed by flooding damage due to raised water tables caused by previous mountain pine beetle - caused stand mortality. Additional scattered patches of flooding damage, mainly caused by high water during spring runoff, were seen in other areas of the Region. Total area affected was 1,590 hectares.

Aspen Decline

The area affected by aspen decline symptoms fell, from 1,950 hectares in 2013, to 1,530 hectares in 2014. Many stands previously affected have re-foliated and are now either unaffected or only lightly affected. There was minimal additional tree mortality in 2014.

Weather-Related Cedar Damage

Western red cedar exhibited unusual foliar discolouration and loss in many stands across the northern Selkirk, northern Monashee, and Cariboo Ranges. Although the symptoms were similar to those often caused by summer drought, drought conditions typically cause damage to younger trees, and other more drought-susceptible species such as western hemlock first; however western red cedar was the only tree species affected in these stands, and mature, open-grown trees tended to be the most heavily damaged. The symptoms were not shared by younger trees growing in plantations nearby, nor were they affected by aspect. Foliage thinning, loss, and discolouration were most apparent in the upper and outer crowns, unlike typical cedar flagging which tends to affect the inner crown and older foliage. The exact cause of this damage is not known, but most likely resulted from a combination of weather conditions creating stress on the trees. If these symptoms persist in 2015, more thorough ground checking will be required. In total, 31,270 hectares were affected although damage levels below the threshold visible during aerial surveys were likely more widespread.



Western red cedar near Murtle Lake exhibiting discoloured foliage and thin tops.

A Conifer Mealy Bug, *Puto Cupressi*

Puto cupressi (Colem.) is a mealy bug that has occasionally been observed infesting conifers in southern B.C. The Canadian Forest Service Forest Insect and Disease Survey noted populations in the early to late 1960's in the Asp Creek drainage northwest of Princeton. During this same time period other infestations were recorded in the old Penticton Forest District near Beaconsfield Mountain, Upper Keromeos Creek, upper Shatford Creek, and along Apex Mountain Road. The heaviest infestation, which affected subalpine fir and lodgepole pine, was at 1,675 metres, at kilometre 11 of the Apex Mountain Road. The understory was quite heavily deformed at this location, but overall growth deformities were scarce.

On September 26, 2014, a ground check was conducted in a stand of subalpine fir on Mount Kobau, northwest of Osoyoos. There is an ongoing, active infestation of *Puto cupressi* on most of the subalpine fir and some Douglas-fir near the top of Mt. Kobau Road, from the radio tower north to Testalinden Lake. The site is slightly over 1,800 meters elevation, primarily in the IDFdk1a with patches in the ESSFxc1. The mealy bug occurred in high numbers on subalpine fir, causing severe deformity, and even mortality, to both overstory and understory trees. Very active populations were observed at Testalinden Lake. There was some western balsam bark beetle attack in the area, but this seemed to be secondary to the mealy bug. *Puto cupressi* was also found at the top of Apex Mountain Road on subalpine fir, but was not causing any observable growth problems.

Clockwise from left: deformed Abies on Mount Kobau; active infestation of Puto cupressi; gouting on understory trees; severe gouting on branches of mature Abies.

Other Damage

Several other damaging agents were recorded during the aerial surveys, including 1,100 hectares of cottonwood leaf rust, 1,040 hectares of landslide and avalanche damage, 400 hectares of windthrow, 120 hectares of drought damage, 110 hectares of hail damage, 60 hectares of western blackheaded budworm, and a few small pockets of aspen and poplar shoot blight (*Venturia macularis*). Lodgepole needleminer (*Coleotechnites* spp.) feeding was observed from the ground in the vicinity of Vermilion Pass, along both sides of Highway 93 extending from Kootenay National Park across the B.C. - Alberta border into Banff National Park. Damage was moderate and covered approximately 465 hectares, but was not readily visible during aerial surveys due to hazy conditions.

Thompson Okanagan Region Summary

The Thompson Okanagan portion of the aerial overview surveys was carried out between July 18th and July 29th, 2014. Fifty hours of flight time over nine survey days were required to complete the entire landbase of the Region. Conditions were variable during the early parts of the survey, with a few delays and many flight re-routings due to wildfire smoke and low cloud ceilings. All surveys were conducted by Kevin Buxton (Ministry of Forests, Lands, and Natural Resource Operations) and Janice Hodge (JCH Forest Pest Management) and utilized a Cessna 210 operated by AC Airways, Langley, B.C.

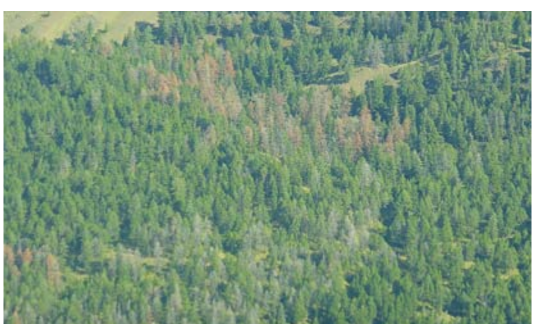
Kamloops TSA

Bark Beetles

Western balsam bark beetle infestations continued to be widespread across the northern two-thirds of the TSA, especially in the Wells Gray Park, Trophy Mountain, Raft River, Mad River, Dunn Peak, and Adams Lake areas. Overall area affected was up by over 40%, to 101,530 hectares.

Spruce beetle populations have continued to decline, with a nearly 90% drop in mapped attack, to 182 hectares. The infestations in the Cahilty Creek and upper Wentworth Creek area have largely run their course, having consumed most of the available mature host material. A few scattered, new infestations were seen in the upper Hat Creek area near the Kamloops - Lillooet TSA boundary, but the affected area was minor.

Spruce beetle near Tsintsunko Lake.



Douglas-fir beetle spot infestation near Criss Creek, Kamloops TSA.

Douglas-fir beetle population trends are variable across the TSA. Overall, the number of spot infestations increased by nearly 70% to 413, while the area in larger patches increased slightly to 273 hectares. A significant increase in the number of small, scattered spot infestations was seen in the Deadman River, Battle Creek, Scottie Creek, lower Hat Creek, and Walhachin areas. In other areas such as Louis Creek, Adams Lake, Barriere River, Paul Lake, Campbell Range, and Duck Range, attack centres remained widespread but did not show any significant increase. In the Isobel Lake - Pass Lake area, populations appear to be declining due to a combination of natural mortality agents coupled with an aggressive trap tree and harvesting program.

Mountain pine beetle remained nearly nonexistent in the TSA, with only 10 hectares of new red attack mapped along the east side of Adams Lake. The mountain pine beetle management strategy has been changed from salvage to suppression in 25 of the TSA's 30 Beetle Management Units, which cover nearly two million hectares, or 70% of the TSA's land base.

Defoliators

Western spruce budworm declined sharply due to two consecutive years of aerial spray programs, combined with natural population declines. Affected area was down to 3,790 hectares, most of which was classified as light. The majority of active defoliation was in and around Wheeler Mountain, Opax Mountain, McQueen Lake, and Daily Creek. Egg mass sampling caried out during the fall of 2014 indicate that in most areas of the TSA, budworm populations will continue at very low levels in 2015. A few pockets of moderate defoliation are expected to occur near the eastern end of Red Plateau and near McQueen Lake.

2014 was an "on" year in the feeding cycle of **two-year cycle budworm**. Defoliation was detected on 30,075 hectares, which is an increase of nearly 50% from 2012 levels. Most of the affected stands were in the Dunn Peak, Spahats Creek, Mad River, Raft River, Wells Gray Park, and TFL #18 areas.

New areas of **pine needle sheath miner** defoliation were observed in several scattered lodgepole pine plantations near Eileen Lake, Johnson Lake, Dunn Peak, Raft River, Hole In The Wall Forest Service Road, and Otter Creek. This insect continued to moderately defoliate several pine plantations near Jamieson Creek. Area defoliated increased to a total of 760 hectares.

Aspen serpentine leaf miner remained the most widespread damaging agent of deciduous trees, with 31,950 hectares affected. **Birch leaf miner** caused light to moderate defoliation of 1,092 hectares of paper birch in the Fadear Creek and Bush Creek areas. **Forest tent caterpillar** damage declined to just 95 hectares near North Barriere Lake, and **satin moth** moderately to severely defoliated 55 hectares of aspen in several small patches near Adams Lake and Logan Lake.

Other Damage

Aspen decline symptoms were observed in several small patches in the Hat Creek, Oregon Jack, and Cornwall Creek areas. No new tree mortality occurred, and damage was rated light to moderate.

Dothistroma needle blight damage to lodgepole pine plantations was mapped on 140 hectares near Blue River, TumTum Lake, and Vavenby. Most stands were only lightly affected. **Cottonwood leaf rust** lightly to moderately damaged 252 hectares in the upper Adams River, Clearwater, Raft River, and Chu Chua areas.

Weather-related cedar damage (see page 29 for a description) was mapped on 10,133 hectares. The most heavily affected stands were in the Murtle Lake, Azure Lake, Angus Horne Lake, and upper Clearwater River areas, while stands around Blue River, and the upper Adams River were less affected.

Other damaging agents recorded during the aerial surveys were 260 hectares of **wildfire**, 13 hectares of **post-wildfire mortality** north of Whitecroft, 23 hectares of **drought** damage to Douglas-fir near Scottie Creek, and 4 new **avalanche tracks** that killed 60 hectares of spruce-subalpine fir forest.

Western red cedar discolouration near Angus Horne Lake, Wells Gray Park, Kamloops TSA.

Birch leaf miner damage near Adams Lake, Kamloops TSA.

Merritt TSA

Bark Beetles

Mountain pine beetle infestations declined by 65%, from 3,515 hectares in 2013, to 1,263 hectares in 2014. An additional 615 trees were killed in 84 small spot infestations. Almost all of the new attack was in the McNulty and upper Red Creek areas. The mountain pine beetle strategy for the McNulty Beetle Management Unit, which covers just over 40,000 hectares, was moved from holding action to suppression based partially on the results of the aerial surveys.

The area infested by **spruce beetle** increased slightly, to 1,042 hectares in 2014. The new attack tended to be in small, moderate to severely affected patches, the number of which has increased significantly, from 27 separate patches in 2013, to 60 in 2014. Most of the affected stands were in the southeast corner of the TSA, near the Pasayten River, Placer Creek, Smith Creek, and Willis Creek.

Following a widespread, scattered single-tree blowdown event in April of 2013, **Douglas-fir beetle** attack levels have increased across the TSA. The area of red attack patches more than doubled to 226 hectares, and the number of small spot infestations increased by more than 75% to 190. Most of the additional attack was around Chapperon Lake, the upper Nicola River, Otter Creek, Allison Creek, and Prospect Creek.

Western balsam bark beetle caused trace mortality on 11,410 hectares, mostly in high elevation stands along the western boundary of the TSA.

Spruce beetle attack in the Pasayten River drainage near Manning Park, Merritt TSA.

Defoliators

Western spruce budworm damage was limited to 186 hectares, in small patches of defoliation near Kane Valley, south of Logan Lake, and east of Princeton near Wolfe Creek. Egg mass sampling carried out during the fall of 2014 indicated that budworm populations will remain low in the TSA in 2015.

Other defoliators included 630 hectares of **aspen serpentine leaf miner** and 60 hectares of **satin moth**.

Satin moth defoliation near Princeton, Merritt TSA.

Other Damage

Pine needle cast infections were again visible in lodgepole pine plantations near Stemwinder Mountain, Larcan Creek, and Sunday Summit. A total of 392 hectares were affected, and almost all areas were classified as light. Many trembling aspen stands appear to be recovering from **aspen decline** syndrome. The area affected has declined from 1,580 hectares in 2013, to 800 hectares in 2014. As well, the severity of symptoms has lessened, with less than 160 hectares exhibiting bare tops and/or new tree mortality.

Other damaging agents recorded during the aerial surveys were 1,395 hectares of **wildfire**, 45 hectares of light **bear** damage to a lodgepole pine plantation near Pothole Creek, and 40 hectares of trace **windthrow** damage to Douglas-fir east of Peter Hope Lake.

Lillooet TSA

Bark Beetles

Mountain pine beetle was active across much of the western portions of the TSA. Total affected area was down slightly to 4,425 hectares, although the proportion of this area classified as moderate and severe increased to over 25%. The most significant areas of red attack were at Cadwallader Creek and the upper Bridge River. Scattered mortality continued in whitebark pine stands, in the Relay Creek, Slim Creek, upper Bridge River, Hurley River, Cayoosh Creek, and Stein River areas, where nearly 650 hectares were affected.

Mountain pine beetle, Cadwallader Creek, Lillooet TSA.

Douglas-fir beetle infestations continued to expand. The area affected was up over four-fold to 1,786 hectares in 174 separate patches. An additional 5,700 trees were killed in 625 small spot infestations. Increased levels of attack were seen in almost all Douglas-fir stands in the TSA, especially in the Carpenter Lake valley, the Yalakom River valley, the French Bar - Watson Bar area, Cayoosh Creek, Seton Lake, and the Stein River valley.

Douglas-fir beetle infestation near Watson Bar Creek, Lillooet TSA.

New **spruce beetle** activity was mapped throughout the Cayoosh Creek valley and side drainages, especially Blowdown Creek, Gott Creek, and Phair Creek. New infestations were also seen in the headwaters of Relay Creek and Paradise Creek, near the Lillooet - Williams Lake TSA boundary. Total area affected was just over 1,200 hectares, 80% of which suffered moderate to severe mortality.

Area affected by **western balsam bark beetle** increased by over four-fold, to 11,240 hectares. Although mortality rates remained at trace levels in nearly all areas, infestations were scattered across most of the high elevation stands in the TSA.

Other Damage

Defoliator activity was very low in 2014. The only mapped activity was one 53 hectare patch of light **western spruce budworm** just south of Gold Bridge, and one nine-hectare patch of **satin moth** near Laluwissin Lake.

Other damaging agents mapped during the overview surveys were 54 hectares of **aspen decline** near Pavilion, nine hectares of **bear** damage, 1,490 hectares of **wildfire** damage, 85 hectares of **post-wildfire mortality** east of Tyaughton Lake, and 6 hectares of **drought** damage.

Spruce beetle infestation in upper Cayoosh Creek, Lillooet TSA.

Okanagan TSA

Bark Beetles

Mountain pine beetle populations continued to decline, with total affected area down by 70% for the second year in a row, to just 3,440 hectares. The number of spot infestations also fell by 70%, to 160. Attack intensity was low in most affected stands, with over 95% classifed as trace to light. Extensive susceptible pine remains in the south and southeast portion of the TSA, and the potential exists for infestations to persist for several more years. The mountain pine beetle management strategies for four beetle management units, covering nearly 275,000 hectares of the TSA landbase, were changed from holding action to salvage in the fall of 2014.

Douglas-fir beetle infestation levels declined slightly. Both the total area affected in patches and the number of small spot infestations were down by 10%, to 800 hectares, and 400 spots, respectively. Attack rates increased around the Salmon River, Westwold, Ashnola River, and Apex Mountain areas, but decreased in other areas near Anstey Arm, Skimikin, Mabel Lake, and Cherryville. District staff are currently coordinating ground surveys and significant levels of green attack have been found, especially on TFL #49.

Douglas-fir beetle spot infestation near Snehumption Creek, Okanagan TSA.

Western balsam bark beetle populations remain active throughout the high elevation areas of the TSA. In 2014, a total of 60,660 hectares of trace attack were mapped. The most widespread attack was seen at Humamilt Lake, Pukeashun Mountain, Lichen Mountain, Hunters Range, Fly Hills, Silver Star Mountain, Greystokes Plateau, Winnifred Creek, Tahaetkun Mountain, Big White, Headwater Lakes, and Brent Mountain.

Spruce beetle activity was limited to two small patches totalling 17 hectares, in upper Young Creek.

Defoliators

Western spruce budworm populations remained low, with visible defoliation limited to 660 hectares near Summerland. Egg mass sampling was carried out in the fall of 2014, and indicates that populations will likely remain low in 2015.

Aspen serpentine leaf miner damage declined from 8,130 hectares in 2013, to 4,470 hectares in 2014. Affected stands were scattered around Scotch Creek, Reinecker Creek, Chase Creek, Pinaus Lake, Sugar Lake, and Monashee Creek. **Forest tent caterpillar** damage was also down, from 3,390 hectares in 2013, to 1,560 hectares in 2014; most of the defoliation was at Ross Creek and Hunters Creek. **Satin moth** defoliation expanded to 320 hectares. Small patches of defoliation were observed in several locations near the Ashnola River, Cawston, Vaseux Creek, Mission Creek, Darke Lake, Bear Creek, and Fly Hills. Light to moderate **birch leaf miner** defoliation was mapped on 215 hectares near Skimikin Lake.

Other Damage

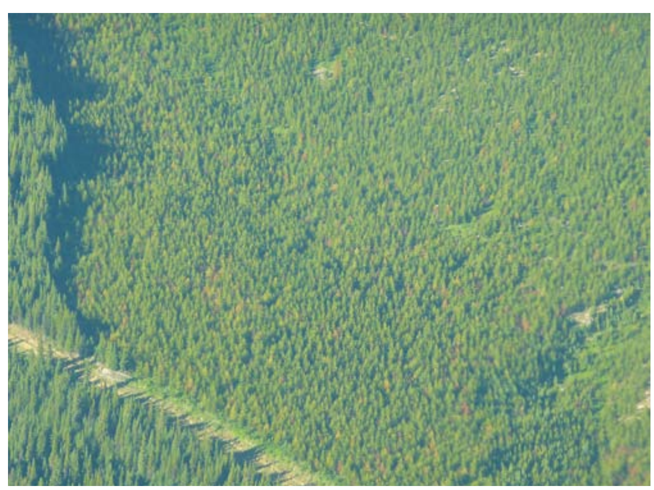
Dothistroma needle blight damage was observed in several lodgepole pine plantations near Sugar Lake, Cherry Creek, Hidden Lake, Cavanaugh Creek, Greenbush Lake, and Creighton Creek. A total of 395 hectares were affected. The stands in the upper Cherry Creek drainage have been affected for the third year in a row and many trees have suffered significant foliage loss. **Cottonwood leaf rust** damaged 845 hectares of cottonwood stands along the Shuswap River between Cherryville and Mabel Lake, and near Wap Creek, Malakwa, Seymour Arm, Humamilt Lake, and Scotch Creek. A single lodgepole pine plantation in the Seymour River valley near Tsuius Mountain was defoliated by a combination of **pine needle cast** and ***Hendersonia pinicola***, a secondary pathogen that often accompanies or follows pine needle cast infestions. However, damage levels were light. For the second year in a row, a small, 7-hectare western larch plantation at Kwikoit Creek was infected with **larch needle blight**.

A trembling aspen stand severely defoliated by satin moth near Mount Kobau, Okanagan TSA.

Weather-related cedar damage (see page 29 for a description) was observed at Myoff Creek, Anstey River, Kwikoit Lake, Humamilt Lake, and the upper Seymour River. Area affected was 645 hectares.

Other damaging agents observed in the TSA included 177 hectares of **bear damage** in lodgepole pine plantations, 24 hectares of **aspen decline**, 1,272 hectares of **wildfire**, 23 hectares of **post-wildfire mortality**, and small areas of **flooding damage** (8 hectares) and **windthrow** (7 hectares). District staff completed Stand Development Monitoring surveys in ten young stands in 2014.

Western gall rust on a young lodgepole pine, Okanagan TSA..



Bear feeding damage in a lodgepole pine plantation near Ideal Lake, Okanagan TSA.

Cariboo Region Summary

The Cariboo portion of the aerial overview surveys required 149.8 hours of flight time, with 29 separate flights between July 22nd and August 9th. Of this, approximately 9 survey days and 60 hours of flight time were spent surveying adjoining areas within the West Coast, South Coast, Omineca, and Skeena Resource Regions. Conditions were mixed, with significant smoke, and overcast, wet weather encountered in the eastern portions of the Williams Lake and 100 Mile House TSAs. The surveys covered the entire landbase of the Cariboo Chilcotin Resource Region. All surveys were conducted by Joe Cortese, Bob Erickson, Don Wright, and Mel Dodge. Aircraft were chartered from Lawrence Air, Cariboo Air, and Lakes District Air and used Cessna 182 and 185 aircraft.

Quesnel TSA

Bark Beetles

The area affected by **western balsam bark beetle** continued to decline, from nearly 20,000 hectares in 2012, to just 1,630 hectares in 2014. **Douglas-fir beetle** populations increased significantly, especially in the Narcosli Creek, Marguerite, Alexandria, and Nazko areas. Just over 500 hectares in 23 separate patches were mapped, and the number of spot infestations increased to almost 160. **Spruce beetle** populations remained low, with 240 hectares of light attack mapped in Bowron Lake Park, Sovereign Creek, and Landslide Creek. No mountain pine beetle was mapped within the TSA.

Defoliators

Two-year cycle budworm defoliation remained widespread across much of TFL #52 and surrounding areas. A total of 56,610 hectares were mapped, with nearly all of the damage classified as light. **Forest tent caterpillar** populations increased dramatically, with nearly 125,000 hectares of defoliation mapped in the Quesnel River, Cottonwood, and Blackwater Mountain areas. **Aspen serpentine leaf miner** damage increased to 32,460 hectares. Affected stands were typically mixed aspen-conifer and were scattered across most of the TSA. **Pine needle sheath miner** defoliation was detected in six separate lodgepole pine plantations near Gibraltar Mine, Deserters Creek, Cottonwood Canyon, and Kruger Lake; total area affected was 312 hectares. **Western spruce budworm** populations were low, with only 265 hectares of light defoliation. Based on eggmass sampling results, populations will remain low in 2015.

Other Damage

Weather-related cedar damage was mapped on 1,685 hectares in Bowron Lake Provincial Park. Several areas sustained substantial damage and some topkill and/or tree mortality may occur. This damage was of an unknown, but probably weather-related cause.

Other damage recorded by the aerial surveys included 16,220 hectares of **wildfire**, 215 hectares of **post-wildfire mortality**, 97 hectares of **flooding** damage, 16 hectares of **windthrow,** and 2 new **avalanche paths**.

Western red cedar exhibiting thinning, discoloured foliage along the edge of Isaac Lake, Bowron Lake Provincial Park, Quesnel TSA.

Williams Lake TSA

Bark Beetles

Douglas-fir beetle red attack levels expanded more than 10-fold, to 22,300 hectares in patches and nearly 1,400 spot infestations. This expansion was anticipated, after ground surveys in 2013 indicated extremely high levels of green attack. The large wildfires of 2009 and 2010 provided abundant host material in the form of fire-damaged Douglas-fir. Beetles were attracted to this susceptible host material and as a result, populations built up to high levels in these stands. By 2013, the damaged trees were no longer suitable habitat for beetles, with attack quickly spreading into neighbouring, undamaged Douglas-fir stands. Extensive red attack was mapped throughout the Fraser River and Chilcotin River corridors, as well as along the Taseko, Chilko, Chilanko, and Homathko valleys.

The area affected by **western balsam bark beetle** remained static, at just over 20,000 hectares. Infestations appear to be declining slightly in the Cariboo Mountains. In the Chilcotin-Coast Mountains, infestations are increasing, although most attack remains in small, very scattered pockets. Infestation intensity increased slightly, with 60% of affected stands sustaining more than 1% red attack.

Spruce beetle has continued to decline overall, from 18,000 hectares in 2012, to just 1,630 hectares in 2014. Only one-third of the affected stands were rated as moderately attacked, with the remainder rated as lightly attacked. Most attack was confined to the eastern edge of the TSA, around Quesnel Lake, Niagara Creek, and the MacKay River. Small new infestations were also detected in the upper Churn Creek - Fish Lakes area; as a result, the spruce beetle management strategy for the Upper Churn BMU was changed from monitor to suppression.

Mountain pine beetle remained active in several small, widely scattered pockets around Taseko Lake, Yohetta Valley, Big Creek, and Dash Creek. The total area affected was just over 1,500 hectares, most of which was classified as lightly attacked.

Defoliators

Western spruce budworm damage declined sharply in all areas to the south of Riske Creek, and expanded slightly in the areas around Williams Lake, Soda Creek, and Meldrum Creek. A total of 29,460 hectares were defoliated, which is the lowest level in several years. Eggmass sampling results indicate that populations will remain low in most areas in 2015, with some isolated areas of moderate defoliation around Meldrum Creek, Soda Creek, and south of Hanceville.

The area affected by **two-year cycle budworm** more than doubled, to the highest level in over a decade. 35,945 hectares of defoliation were mapped, although nearly all of it was classified as light. Most of the affected stands were in the Keithley Creek, Quesnel Lake, Mackay River, and Bosk Lake areas.

Aspen serpentine leaf miner populations continued to expand. Defoliation was recorded on nearly 75,000 hectares, with over 40% of the affected area classified as moderate or severe. The most widespread damage was around Horsefly, Horsefly River, Beaver Creek, and Big Lake. Many smaller, scattered pockets of damage were mapped throughout the north and south Chilcotin.

Just under 3,150 hectares of light **forest tent caterpillar** defoliation was mapped in the Beavermouth area. No tree mortality is expected.

A single **European gypsy moth** was caught in a monitoring trap near McLeese Lake in 2013. A delimiting grid was deployed in the area in 2014 to monitor populations; however, no additional moths were caught. A delimiting grid will again be deployed in 2015.

European gypsy moth egg masses, Surrey, B.C..

Other minor defoliating insects included 60 hectares of light defoliation by **blackheaded budworm** at Nude Creek (a tributary of the Homathko River), and 44 hectares of moderate defoliation by **pine needle sheath miner** in a lodgepole pine plantation near Skelton Lake.

Other Damage

Weather-related cedar damage (see page 29 for a description) was mapped on 6,075 hectares. The damage was scattered throughout valley bottoms in the Cariboo Mountains, but was particularly widespread in the Niagara Creek and Isaiah Creek valleys.

Tree mortality due to **bear feeding** was mapped on 1,735 hectares. The most extensive damage was in the Killdog Creek, Bouldery Creek, and Spanish Lake areas.

A variety of other abiotic damage was observed during the aerial surveys. Moderate to severe **post-wildfire mortality** in Douglas-fir and lodgepole pine was observed on 2,985 hectares. The damage occurred within and around areas that were damaged by wildfires in 2010, near Dog Creek, Meldrum Creek, Riske Creek, Chilko Lake, and Itcha Ilgachuz Park. New **wildfire** activity damaged 2,540 hectares. **Flooding** damage, mainly due to raised water tables post-mountain pine beetle, was again widespread across the west Chilcotin; total area affected was 775 hectares. The tailings pond breach at the Mount Polley Mine killed an additional 500 hectares of mixed forest.

Scattered whole-tree mortality, initially suspected to be animal feeding damage from porcupine or bear, was detected in a few sites covering 90 hectares near Tatla Lake. A site visit by FLNRO specialists Bill Chapman (soil scientist) and David Rusch (forest pathologist) revealed **drought stress** to be the cause. The mortality occurred on rocky outcrops with thin soils and steep north facing aspects. The symptoms disappeared in the depressions at the toe of these slopes revealing a lack of moisture as the cause. The damage primarily occurred in mid-aged lodgepole pine, but some older Douglas-fir was also affected.

Other minor abiotic damage included 110 hectares of **aspen decline** syndrome, four hectares of **windthrow**, and five new **avalanche** tracks.

Drought damaged stands near Tatla Lake, Williams Lake TSA.

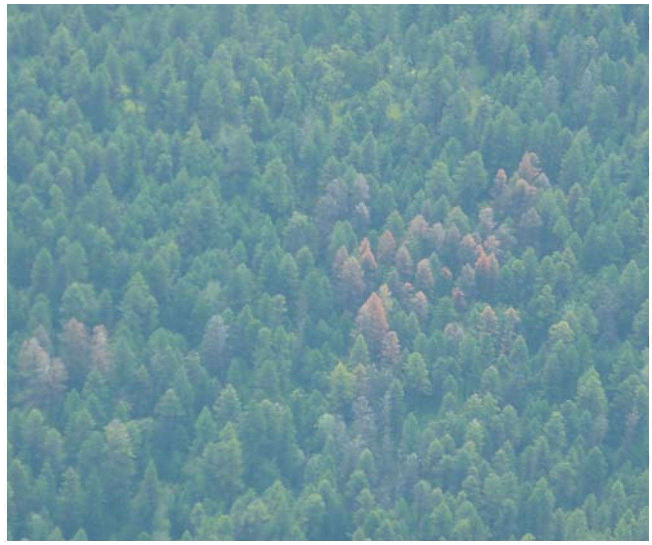
100 Mile House TSA

Bark Beetles

Douglas-fir beetle populations expanded significantly in 2014. The total area affected was up over 12-fold to 3,590 hectares. The number of spot infestations was also up, from 83 in 2013, to 395 in 2014. Significant red attack was seen throughout the Loon Lake, Clinton, Kelly Lake, Jesmond, Canoe Creek, Dog Creek, and Lac La Hache areas.

Spruce beetle attack remained at a relatively low level, at 650 hectares of trace and light mortality. The affected stands were scattered around Spanish Creek, Hendrix Creek, and Timothy Lake Road.

Western balsam bark beetle activity remained confined to the northeast portion of the TSA, in and around Spanish Creek and Windy Mountain. Area affected and attack intensity both increased, with most of the 4,935 hectares experiencing greater than 1% red attack.

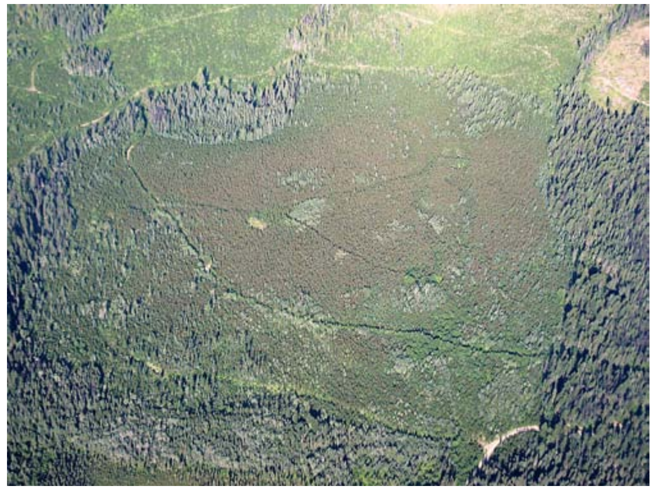


Douglas-fir beetle near Deadman River, along the 100 Mile House TSA - Kamloops TSA border.

Trap trees attacked by target bark beetle, Douglas-fir beetle (left inset) and secondary beetle, Douglas-fir pole beetle (right inset)

Defoliators

Western spruce budworm damage declined sharply, from over 50,000 hectares in 2013, to 9,810 hectares in 2014. This is a result of natural population decline combined with several years of aerial spraying in the most heavily impacted stands. Egg mass sampling results indicate that budworm populations may increase around Lac La Hache and Loon Lake, while remaining relatively low elsewhere.



Pine needle sheath miner defoliation in a lodgepole pine plantation near Beddingfield Lake, 100 Mile House TSA

Two-year cycle budworm damage was at the highest level in several years. Nearly 7,700 hectares were defoliated near Hendrix Lake, Boss Creek, and Windy Mountain, although most of the damage was light.

Pine needle sheath miner populations were present at outbreak levels in 12 separate lodgepole pine plantations around Timothy Lake and Canim Lake. The total area affected was 510 hectares. Defoliation was rated as light to moderate, and damage to date is limited to some height and incremental growth loss.

Aspen serpentine leaf miner was widespread across most areas of the TSA. A total of 67,245 hectares were affected, although most damage was rated as light due to aspen being a minor component of many mixed stands.

Other Damage

Weather-related cedar damage (see page 29 for a description) was mapped on 2,730 hectares. The damage was located along valley bottoms near Pendleton Lakes, Crooked Lake, Deception Creek, and Hendrix Creek.

Hail damage to Douglas-fir near Exeter, 100 Mile House TSA.

Post-wildfire mortality, due to a combination of Douglas-fir beetle, secondary beetles, and bole and root damage, continued to kill Douglas-fir in and around the 2009 Edge Hills wildfire area. 1,560 hectares were affected.

Other animal and abiotic-caused damage included 200 hectares of light **bear feeding** damage to lodgepole pine plantations near Deception Creek and Spanish Creek, 220 hectares of **aspen decline syndrome**, 110 hectares of **hail damage** to a mixed forest near Exeter, 30 hectares of **windthrow**, and 23 hectares of **flooding damage**.

Kootenay Boundary Region Summary

The Kootenay-Boundary portion of the surveys required 104.5 hours over 18 days of flying, between July 26th and August 24th. Weather conditions and visibility were generally good, with thunderstorm activity and smoke causing some delays. Surveys covered the entire landbase of the Arrow, Boundary, Kootenay Lake, Cranbrook, Invermere, Revelstoke, and Golden Timber Supply Areas. The surveyors were Neil Emery, Greg Jewitt, and Adam O'Grady of Nazca Consulting Ltd. and used a Cessna 337 Skymaster operated by Babin Air.

Arrow TSA

Bark Beetles

Mountain pine beetle attack continued to occur in small, scattered pockets across the southern portion of the TSA. Total area affected was 1,440 hectares, most of which was classified as trace or light. An additional 240 spot infestations were mapped. The area affected by **Douglas-fir beetle** continued to increase, from 452 hectares in 2013, to 975 hectares in 2014. The number of spot infestations increased to 77. Most additional tree mortality was on TFL #23, near Galena Bay. Infestations near Slocan Lake and the Pend D'Oreille River were relatively static. **Western balsam bark beetle** attack increased but was still relatively scattered, with trace and light attack mapped on 3,000 hectares. **Spruce beetle** populations remained low, with a few small patches totalling 90 hectares near Whatshan Peak and St. Leon Creek, and several spot infestations in South Fostall Creek, Plant Creek, and Nemo Creek.

Mountain pine beetle mixed with western balsam bark beetle, Arrow TSA.

Other Damage

Two patches of moderate **western spruce budworm** defoliation were mapped in upper Caribou Creek, east of Burton. The total area was 380 hectares. During ground surveys, a few small patches of defoliation were observed just west of Needles, along the edges of Highway 6; however, the area affected was very small and was not visible during the aerial surveys.

Pine needle sheathminer moderately defoliated twelve hectares of young lodgepole pine east of Trail.

Aspen serpentine leaf miner damage was mapped on 4,117 hectares. Most of the defoliation was in the Barnes Creek, New Denver, and Incomappleux River areas. A single 23 hectare patch of **birch leaf miner** was recorded just north of Salmo.

Other damaging agents mapped during the aerial surveys included 86 hectares of **larch needle blight** near Slocan and Mosquito Creek, 560 hectares of **weather-related cedar damage** (see page 29), 324 hectares of **bear feeding damage** in lodgepole pine plantations, 349 hectares of **wildfire**, 42 hectares of **windthrow,** 38 hectares of **flooding damage**, and 20 new **avalanche paths** that damaged 145 hectares of mixed balsam-spruce stands.

Boundary TSA

Bark Beetles

Area affected by **mountain pine beetle** increased by 20%, to 25,575 hectares, or nearly half of all the area mapped in southern B.C. Another 5,480 trees were killed in 552 spot infestations. Red attack was widespread across most areas of the TSA. Reduced attack rates were seen in the upper Granby and Kettle River valleys, while increases were seen around Christina Lake and Grand Forks.

Western balsam bark beetle attack levels remained relatively static, at 1,245 hectares. **Douglas-fir beetle** populations remained low, with only three patches totalling 50 hectares, and 28 spot infestations.

Scattered mountain pine beetle north of Conkle Lake, Boundary TSA.

Other Damage

Defoliator activity was limited to 234 hectares of **aspen serpentine leaf miner** in Gladstone Park. No western spruce budworm defoliation was recorded by the aerial surveys, although trace levels of defoliation were observed during larval sampling at permanent sampling sites located along Highways 3 and 33.

The only other damaging agent detected during the aerial surveys was **bear feeding damage** in four lodgepole pine plantations, covering 67 hectares.

Kootenay Lake TSA

Bark Beetles

Mountain pine beetle attack rates continued to decline. Total area affected in 2014 was just 3,140 hectares, over 65% of which was classified as trace or light. The number of spot infestations was also down, from 375 in 2013, to 217 in 2014. While detailed bark beetle surveys in the southeast portion of the TSA (near Hawkins Creek, Kid Creek, and Moyie River) showed a significant increase in red attack levels, only low levels of green attack have been found during ground surveys. Many newly killed trees appear dead as a result of *Ips* engraver beetles, armillaria root disease, and other factors.

Douglas-fir beetle populations increased around Argenta, the West Arm of Kootenay Lake, and Midge Creek. The area affected was up from 220 hectares in 11 separate patches in 2013, to 680 hectares in 22 separate patches in 2014. The number of spot spot infestations was down, from 71 in 2013, to 48 in 2014.

Western balsam bark beetle attack levels increased, from 465 hectares in 2013, to 1,520 hectares in 2014. Most of the affected stands were scattered across high elevation areas on the west side of Kootenay Lake, from Goat Range Park south to West Arm Park.

Other Damage

Aspen serpentine leaf miner damage continued to increase, with affected area up from 2,020 hectares in 2013, to 4,500 hectares in 2014. Most of the affected stands were scattered around Nelson, West Arm, Riondel, Kaslo Creek, and Meadow Creek. **Birch leaf miner** defoliated 420 hectares of paper birch in the upper Duncan River valley, and near Whitewater Ski Resort.

In 2012, a single **European gypsy moth** was caught in a pheromone trap near Kaslo. Delimiting grids of additional traps were deployed in the area in 2013 and 2014, but no further moths were trapped. It is assumed the gypsy moth was not able to become established.

Larch needle blight infection levels were at the lowest level in several years, with just 315 hectares of light damage.

Several other damaging agents were mapped during the aerial surveys, including 270 hectares of **weather-related cedar damage** (see page 29), 240 hectares of **bear damage** to lodgepole pine plantations, 280 hectares of **wildfire**, 48 hectares of **avalanche** damage, and 22 hectares of **windthrow**.

Cranbrook TSA

Bark Beetles

Mountain pine beetle populations continued to decline, although at a slower rate than the previous two years. Red attack area was down 25% to 1,890 hectares. The number of spot infestations was down by 40%, from 292 to 173. Nearly one-third of the attack (535 hectares and 20 spot infestations) occurred in whitebark pine stands. Most of the remaining attack was around Cranbrook, Moyie, Redding Creek, St. Mary River, and Matthew Creek.

Douglas-fir beetle populations remained low in most areas of the TSA. Most of the red attack was mapped near Grasmere, between the Wigwam River and the U.S. border. Forty-one spot infestations and three patches covering 45 hectares were mapped.

Although **western balsam bark beetle** populations continued to increase, attack remained very scattered in small patches. Just under 1,630 hectares of trace and light attack were mapped, mainly in the Bull River, Elk River, Redding Creek, and St. Mary River areas.

Spruce beetle was limited to a single nine-hectare patch near Snowshoe Lake in the upper Wigwam River, and two spot infestations near Plumbob Mountain and Sparwood.

Other Damage

No **western spruce budworm** defoliation was detected in 2014. Light and moderate **aspen serpentine leaf miner** defoliation was mapped on 541 hectares near St. Marys River, Moyie, Flathead, and the upper Elk River. **Larch needle blight** activity remained low, at just 225 hectares.

Other damage detected by the aerial surveys included 300 hectares of **bear feeding damage** to lodgepole pine plantations, 920 hectares of **wildfire**, 150 hectares of **windthrow**, 26 hectares of **flooding**, and 69 separate **avalanche** paths that damaged 390 hectares of mixed spruce-subalpine fir stands.

INVERMERE TSA

Bark Beetles

Overall area affected by **mountain pine beetle** was down from 9,950 hectares in 2013, to 6,585 hectares in 2014. Attack in lodgepole pine has declined by over 50%, from 7,950 hectares in 2013, to 3,720 hectares in 2014. At the same time, attack in whitebark pine has increased to 2,865 hectares, over 40% of the red attack. Most of the affected lodgepole pine stands were in the Skookumchuck River, Findlay Creek, Dutch Creek, and Toby Creek drainages. Some localized increases were seen in the Palliser River area. Most of the infested whitebark pine stands were in the northwest part of the TSA, in the Spillimacheen River, Bobbie Burns Creek, and Francis Creek areas.

Mountain pine beetle near McMurdo Creek, Invermere TSA.

The **spruce beetle** infestation in the Palliser River - North White River area continued to expand, with affected area nearly doubling to 4,150 hectares. Attack rates were high, with nearly 90% of the infested stands suffering moderate to severe mortality.

Douglas-fir beetle activity increased, with 34 separate patches totalling 700 hectares, and an additional 78 spot infestations that killed an additional 955 trees. Most of the new attack was in the lower Lussier River valley, the lower White River valley, and in Kootenay National Park.

Western balsam bark beetle attack declined slightly, from 4,050 hectares in 2013, to 3,315 hectares in 2014. Most of the infestations were small, and widely scattered across the TSA. At the same time, infestation intensity increased, with 65% of the affected area classified as light or moderate, up from 10% in 2013.

Other Damage

Defoliator activity was limited to 410 hectares of light **aspen serpentine leaf miner** damage. **Larch needle blight** infection was mapped on 300 hectares in Diorite Creek.

Bear feeding damage in lodgepole pine plantations was widespread in the Lussier River, White River, and Fenwick Creek areas. Thirty-one separate plantations were affected, with an area totalling just over 800 hectares.

Other damaging agents included 6,170 hectares of **wildfire**, 66 hectares of **windthrow**, 50 hectares of **flooding**, and 19 new or expanded **avalanche** paths that damaged 165 hectares of spruce-subalpine fir forest.

Damage to young lodgepole pine from bear feeding. Upper photo: scattered mortality due to bear feeding, North White River, Invermere TSA. Lower photo: damage to the bole of a young lodgepole pine, Grave Creek, Invermere TSA.

Golden TSA

Bark Beetles

Area infested by **mountain pine beetle** declined by 20%, to 2,410 hectares. Attack in lodgepole pine declined by over half, from 2,890 hectares in 2014, to 1,316 hectares in 2014. At the same time, attack in high-elevation whitebark pine stands expanded, to almost 1,100 hectares.

Western balsam bark beetle expanded over two-fold, from 2,630 hectares in 2013 to 5,610 hectares in 2014. Most of the affected stands were scattered across the southern half of the TSA.

Both **Douglas-fir beetle** and **spruce beetle** populations remained low, with just one patch of 32 hectares and 14 spot infestations of Douglas-fir beetle, and three spot infestations of spruce beetle.

Other Damage

Aspen serpentine leaf miner damage expanded in the Rocky Mountain Trench between Golden and Bush Arm. Total area affected was 7,195 hectares. **Birch leaf miner** defoliation was recorded on 120 hectares in Bluewater Creek. **Lodgepole needleminer** (*Coleotechnites* spp.) feeding was observed from the ground in the vicinity of Vermilion Pass, along both sides of Highway 93 extending from Kootenay National Park across the B.C. - Alberta border into Banff National Park. Damage was moderate but was not readily visible during aerial surveys due to hazy conditions. The area affected was approximately 465 hectares.

Lodgepole needleminer damage near Vermilion Pass, Golden TSA.

Weather-related cedar damage (see page 29 for a description) was observed in the Cummins River, Molson Creek, upper Wood River, and upper Bush River areas. A total of 1,520 hectares were affected.

Other damaging agents mapped during the surveys were 142 hectares of **larch needle blight** in Kootenay National Park, 215 hectares of **bear damage** scattered along the east side of the Rocky Mountain Trench, 305 hectares of **wildfire damage**, 70 hectares of severe **flooding damage**, and 100 hectares of **avalanche damage**.

Revelstoke TSA

Bark Beetles

Activity levels for most bark beetles remained low in 2014. **Mountain pine beetle** attack was limited to 125 hectares, **Douglas-fir beetle** to 95 hectares plus 20 spot infestations, and **spruce beetle** to 60 hectares. **Western balsam bark beetle** was the exception, with affected area up from 235 hectares in 2013, to 1,067 hectares in 2014.

Other Damage

Defoliator activity was limited to 1,650 hectares of light and moderate **aspen serpentine leaf miner** southeast of Revelstoke, and 115 hectares of **birch leaf miner** in the upper Goldstream River valley.

Weather-related cedar damage (see page 29) was widespread in the northern portion of the TSA. In many stands, the level of foliage loss was high, and some top kill and tree mortality may result. The total area affected was 7,650 hectares. The cause of this damage is unknown, but is probably weather or climate related.

Other damaging agents were 2,535 hectares of **wildfire**, 24 hectares of **windthrow** at La Forme Creek, 10 hectares of **bear damage** to a lodgepole pine plantation east of Mica Dam, and three new **avalanche paths** that damaged 40 hectares of spruce-subalpine fir forests.

Weather-related western red cedar damage near Kinbasket Lake, Revelstoke TSA. Left: aerial view of damage signature; Right: closeup of damage to individual tree crown.

Forest Health - Special Projects

Dryocoetes Confusus Attack in the Thompson Okanagan Region

Lorraine Maclauchlan, Forest Entomologist, Thompson Okanagan Region

Infestations of western balsam bark beetle, *Dryocoetes confusus* Swaine (Coleoptera: Scolytidae), have been reported since comprehensive forest pest surveys began in the 1930's (Garbutt 1992). However, because of the remoteness of some of these forests aerial survey coverage was often limited and sporadic, and thus estimates of past mortality and unrecoverable volume are unreliable. With the uncertainty around B.C.'s mid-term timber supply largely caused by losses incurred from the mountain pine beetle, it is even more imperative to have reliable estimates of volume, losses and rates of mortality in these high elevation forests.

D. confusus selectively kills subalpine fir, *Abies lasiocarpa* (Hook.) Nutt., at low levels each year over a large host range, but will occasionally reach outbreak populations. Cumulative mortality may be significant in chronically infested stands, but western balsam bark beetle appears less aggressive than other tree-killing bark beetles during outbreaks (Stock 1991, Unger and Stewart 1992). Until the past 10-15 years, only larger, more intense areas of red attack were mapped in the annual aerial overview surveys, and some of the more remote drainages were not flown, thus under reporting the extent of tree mortality. In more recent years, aerial survey coverage has approached 100% of the landbase, and in 2008 a new severity category of "trace" (less than 1% red attack) was incorporated into the survey methodology to better capture low level, but pervasive attack. Over time, this improved annual mapping will provide much needed data to better understand the impacts of *D. confusus* in these subalpine forests. However, more detailed stand impacts are needed in the short term to improve mortality and loss estimates.

Three long-term projects are contributing to the understanding and elucidation of the impact, attack dynamics and biology of *D. confusus* in southern B.C.:

1. Eleven permanent sample plots located in subalpine-fir dominated stands throughout the Thompson Okanagan Region. Each one-hectare plot has all trees numbered, stem mapped, and assessed for pest incidence and damage. These plots have been assessed at regular intervals and have provided temporal and spatial data of *D. confusus* activity and impact in these stands.

2. *D. confusus* is the predominant mortality factor in subalpine fir forests and is clearly visible from the air when conducting aerial surveys. Subalpine fir is easily distinguished from other conifers by their long, narrow crown of stiff branches and remains visible for many years following death. Detailed aerial surveys using rotary wing aircraft were conducted in 1996-1997 and again in 2014 to determine the relative amounts of live and dead subalpine fir in high elevation ecosystems.

3. Developmental requirements of *D. confusus* were determined in the field and laboratory (1998-2000 and 2014), to determine the degree-day requirements of this insect and whether the larval and/or adult stage needs a cold period to complete physiological development (facultative or obligatory diapause). *D. confusus* currently displays a two year life cycle, overwintering first as a late instar larva and then again as a new adult. Given climate change, it is important to know if either or both of these overwintering periods are necessary and if the insect could complete its development in one year rather than two. This would have serious implications on future outbreaks. To determine if new adults require a cold period prior to emerging, first year attack (larvae) and second year attack (pupae-adults) are currently bearing reared at 24ºC, both with and without a cold period. Rearing will be complete in the spring of 2015.

Western Balsam Bark Beetle Time-Series Impact Assessment

Methods

Methodology and results from the 1996-1997 aerial surveys are summarized in Maclauchlan (1998). In 1996, the Forest Service Inventory (BCMOF 1995) was used as the first level of stratification for the survey:

- Forest District, Timber Supply Area , mapsheet and polygon number;
- Forest cover polygons with leading subalpine fir (>50% by basal area);
- biogeoclimatic zone, subzone and variant (BEC classification);
- age class (age class 5 and up (1996); age class 6 and up (1997)); and
- polygon area (five hectares and greater).

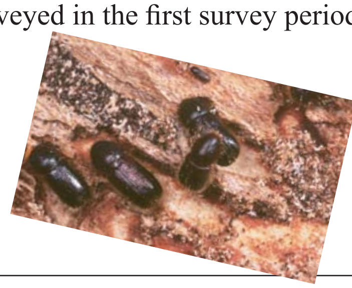
The data were sorted by BEC and age class, and weighted according to the area (hectares) contained within each stratum. Sampling was then divided accordingly. Polygons of less than five hectares were not selected for aerial surveying due to flying costs and the difficulty of locating them accurately in the air.

Aerial surveys were conducted using helicopters, with three personnel in the helicopter. One person sat in the front locating polygons and determining survey lines, while two surveyors sat in the back on opposite sides of the helicopter observing and collecting survey data. Surveyors looked down using a narrow line of sight just outside the landing skid of the helicopter as a reference for their survey line (Figure 1). Only mature, dominant canopy subalpine fir was recorded, by category, as: live (green foliage); red (bright red foliage, indicating attack in the prior calendar year); or, grey (dull red to no foliage, indicating the tree had been dead more than 2 years) (Figure 1). As the survey was being conducted, the helicopter flew low and slow, approximately 30 metres above the tree canopy and at a ground speed of approximately 40 kilometres per hour, dependent upon wind and local terrain conditions.

A subset of the first (1996-97) survey flight lines were re-flown in the 2014 surveys. The 2014 methodology was identical to that used in 1996-1997, except for streamlining of map construction and navigation. Survey-specific information added to the maps used in the survey included the outlines of the forest cover polygons surveyed in 1996-1997, location of the original 1996-1997 aerial survey lines, and the 1:20,000 British Columbia Geographic System (BCGS) mapsheet grid (Figure 2). The georeferenced .pdf files were transferred to a GPS-enabled Samsung Note 3 Android smartphone. Using the combination of paper maps and smartphone loaded with the PDF Maps application (Avenza Systems), the navigator could very accurately direct the pilot along the original 1996-1997 survey lines.

Results and Discussion

By 2014, portions of the polygons surveyed in 1996-1997 could not be re-surveyed due to harvesting, wildfire activity, inclement weather, or time constraints. In 1996 and 1997, a total of 807 polygons on 134 mapsheets were surveyed over 36 days and in 2014, a total of 503 polygons on 114 mapsheets were surveyed over 18 days. The 1995 forest cover inventory (BCMOF 1995) identified just over 372,000 hectares of leading subalpine fir over the age of 100 years in the Thompson Okanagan Region. Approximately 68,448 hectares were surveyed in the 1996-1997, and 51,346 hectares in 2014. The area harvested after the 1996-1997 surveys accounted for less than 9% (5,875 ha) of the total area surveyed in the first survey period.



Most surveys were conducted in the Engelmann Spruce – Subalpine Fir (ESSF) biogeoclimatic zone, where the majority of subalpine fir occurs, although *Dryocoetes* attack was recorded in all ecosystems surveyed. In the 1996-97 assessment, average subalpine fir mortality, by ecosystem, ranged from just under 10 % to over 17 % (Table 1). In the 2014 assessment, average percent mortality of subalpine fir increased in all ecosystems and age classes surveyed (Table 1). The majority of surveys (469 surveys) were conducted in the ESSF zone where the average mortality of subalpine fir was just over 31 percent. When comparing subzones within the ESSF, the ESSFxc subzone sustained the highest level of annual attack, at 1.6 percent annually.

Table 1. Percent subalpine fir mortality, grouped by BEC (biogeoclimatic zone), showing: number of polygons surveyed in both survey times (N in 2014); average (± S.E.), maximum and minimum mortality in the first (1996-1997) and second (2014) survey time; and, average (±S.E.) annual % mortality. BEC zone codes are: AT=alpine tundra; ESSF=Engelmann Spruce-Subalpine Fir; ICH = Interior Cedar-Hemlock; MS = Montane Spruce; SBS = Sub Boreal Spruce.

	N	1996-1997 % mortality			2014 % mortality			Annual % mortality
BEC	(2014)	Avg. ± S.E.[a]	Max.	Min.	Avg. ± S.E.[a]	Max.	Min.	(Avg. ± S.E.)
AT	22	9.9 ± 1.5ab	26.5	0.0	26.8 ± 2.3a	56.4	0.3	1.0 ± 0.1
ESSF	469	17.4 ± 0.4c	55.7	0.0	31.5 ± 0.6a	70.0	0.4	0.8 ± 0.04
ICH	4	11.2 ± 4.6bc	30.7	0.0	20.9 ± 8.2a	40.4	3.0	0.5 ± 0.4
MS	6	15.5 ± 3.9bc	47.4	1.9	38.8 ± 5.3a	54.9	25.5	1.4 ± 0.2
SBS	2	10.7 ± 0.5bc	13.9	0.0	28.5 ± 15.0a	43.6	13.5	1.1 ± 0.9

[a] *Means followed by the same letter are not significantly different (P<0.01; Scheffé test).*

This aerial survey was very accurate in assessing the number of dead standing subalpine fir in stands. However, when trees are killed by the western balsam bark beetle, they start to decay and fall down. Data from several long-term research plots revealed an annual fall-down rate of western balsam bark beetle-killed trees of 0.7 % in the ESSFwc and ESSFmw, and 1.1 % in the ESSFxc. Therefore, the mortality caused by *D. confusus* in these forests is even higher than accounted for in this study.

For a complete summary of this project please contact Lorraine Maclauchlan.

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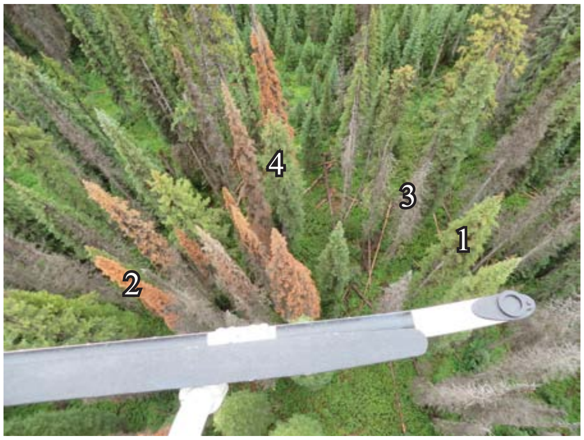
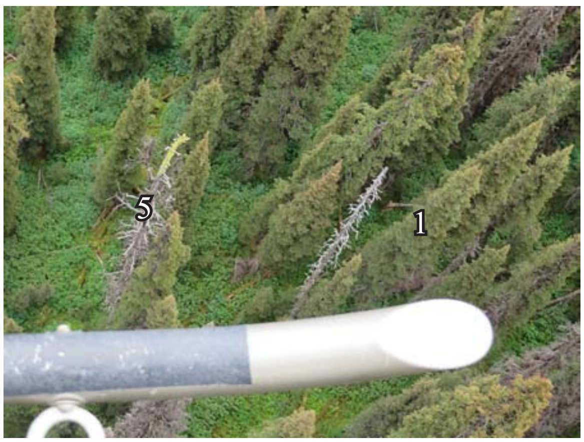


A. High component of red and grey subalpine fir, with scattered spruce.

B. High component of grey subalpine fir, some live subalpine fir, and large, live spruce in centre.



C. High component of live subalpine fir, with some live and dead spruce.

D. Mix of live and dead subalpine fir, and large spruce.

Figure 1. Examples of surveyor view from helicopter: 1 = green subalpine fir; 2 = red subalpine fir; 3 = grey subalpine fir; 4 = live spruce; and, 5 = dead spruce.

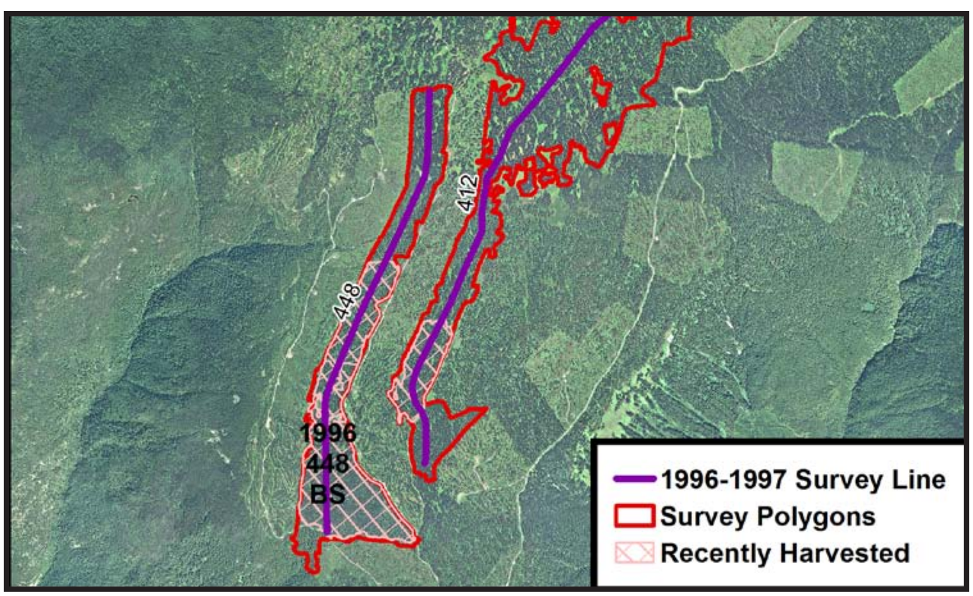


Figure 2. Example of map used in aerial surveys showing the outline of two polygons that were surveyed in 1996 (448 and 412), the flight path and areas within the polygon that have been harvested since 1996.

Pests of Young Pine – Okanagan Falls Plot

Introduction

Extensive mortality of mature lodgepole pine due to mountain pine beetle over the past 15 years, and subsequent salvage harvest, has produced an extensive inventory of young, relatively even-aged lodgepole pine across the B.C. landscape. Numerous insects and diseases affect lodgepole pine throughout its life, from seedling to maturity. Some of these pests cause mortality, and others affect growth and form. Over the next 20 to 50 years, the B.C. landscape will be dominated by young, regenerating lodgepole pine, in pure stands and in species mixtures. It is imperative to understand the risks and impacts from pests. As the effects of climate change become more pronounced, regeneration will become increasingly vulnerable and we could potentially see new and elevated occurrences of pest damage. Evaluation of pest activity in existing young pine may give us an insight into potential problems and impacts in the future.

A number of permanent sample plots (PSPs) have been established throughout the southern interior of B.C. to monitor pest impact, outbreak dynamics and tree response to pest damage over time. Over the past 25 years these plots have been monitored and re-assessed for new pest damage, defect formation, mortality and general tree growth and response. These plots were originally established to study the impact and attack dynamics of the lodgepole terminal weevil, *Pissodes terminalis* Hopping, however all pests were recorded and monitored. Damaging agents commonly found in young lodgepole pine stands in the southern interior of B.C. include Comandra blister rust (*Cronartium comandrae*), western gall rust (*Endocronartium harknessi*), and various animal and abiotic damage that can severely affect lodgepole pine.

Young lodgepole pine killed by a western gall rust stem gall; right: fork caused by lodgepole terminal weevil attack.

2014 re-assessment

In 2014, the OK-1 PSP was re-assessed. This PSP is located on the 200 Road outside of Okanagan Falls, B.C., on Tree Farm License 15. The OK-1 PSP statistics are listed below:

- Biogeoclimatic ecosystem classification: IDFdm1
- Plot size: 0.22 hectares
- Average age (2014): 38 years

A small research plot was originally established in 1985, and then expanded to 0.22 hectares and over 600 trees in 1987. 645 of the trees are lodgepole pine 645, with 13 spruce and 3 western larch. At establishment all trees were alive, and average age was 11 years in 1987. By 2014, the average age of lodgepole pine was 38 years, 30% were dead, and 6.4% were missing and presumed dead. Over 76% of the pine had some pest incidence recorded in one or more of the assessment years (Figure 1). The most prevalent pests were terminal weevil, animal damage (typically squirrel feeding), and Comandra blister rust, each affecting over 30% of pine in the plot (Table 1).

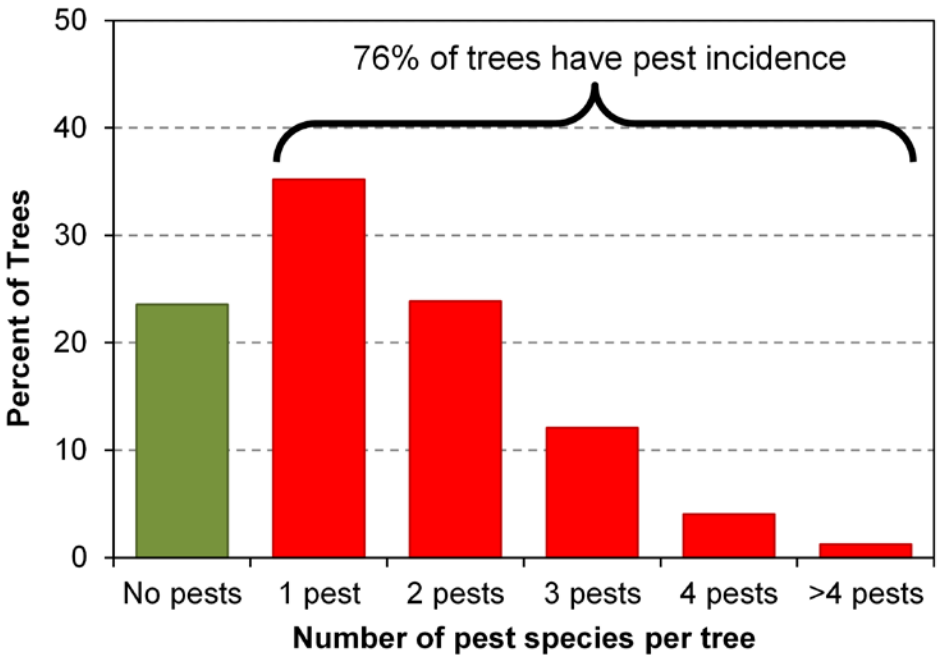


Figure 1. Percent of lodgepole pine not affected by pests, or affected by one or more pests, in the Okanagan Falls-1 plot.

Table 1. List of the most prevalent damaging agents in the Okanagan Falls-1 plot and the percent of pine affected by each pest.

Pest	% pine
Lodgepole pine terminal weevil	38
Animal damage (squirrel)	35
Comandra blister rust	32
Suppressed	23
Western gall rust	19
Wind fall	10
Stalactiform blister rust	5

The terminal weevil affected 38% of the pine in the plot, but many trees suffered multiple attacks. Each time a leader is killed by this insect, the tree compensates by having one of the subtending laterals take over apical dominance. If a stand is more open-grown (low density), with ample inter-tree spacing, laterals may not immediately assume a vertical orientation, causing a defect in the stem to form. Each attack by the weevil was followed over the years to determine what, if any, defect resulted from the weevil attack, and if these defects changed over time. By the final 2014 assessment, 54% percent of trees attacked by *P. terminalis* had a major defect on the bole (crook, fork, or staghead) (Figure 2).

The occurrence and severity of other pests were also tracked and some interesting trends were seen. Most Comandra blister rust infections on branches were dead by the 2014 assessment, but those occurring on the stem had usually killed the host tree (Figure 3).

For a full report on this project please contact Lorraine Maclauchlan.

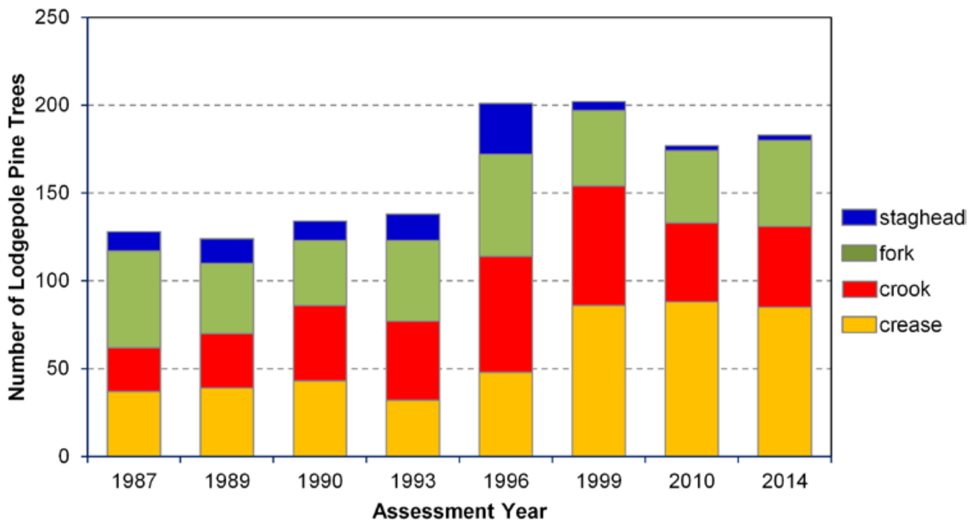


Figure 2. The number of lodgepole pine trees with defects resulting from attack by *Pissodes terminalis* and the frequency of resultant defect in each assessment year: crease=no impact; crook=stem offset at point of attack; fork=two stems arising from point of attack; and, staghead=multiple stems arising from point of attack. Only the most severe defect on a tree was counted.

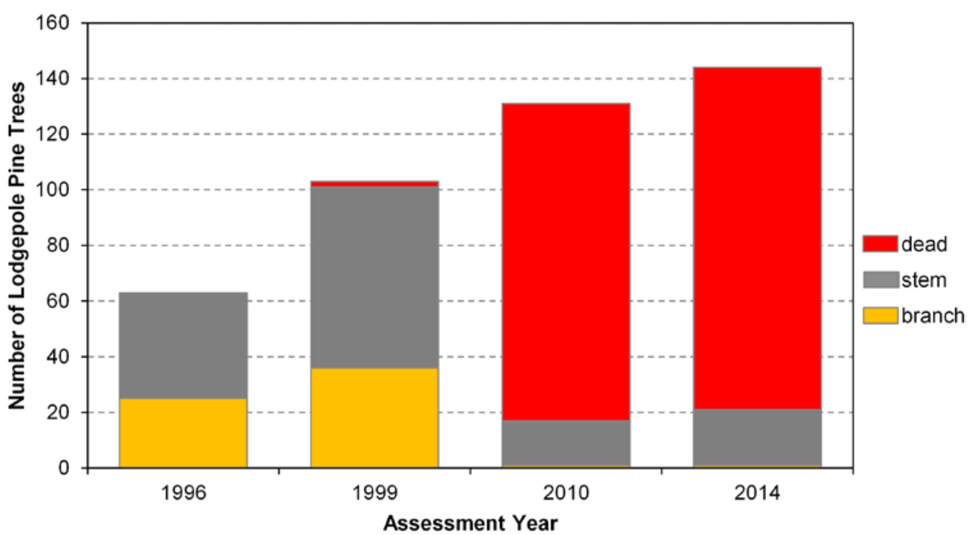


Figure 3. The number of lodgepole pine in the Okanagan Falls-1 plot infected with Comandra blister rust in each assessment year, showing: number of pine with branch infections; number of pine with stem infections; and number of pine killed.

Staghead defect caused by lodgepole terminal weevil attack.

Other pests of young lodgepole pine. Left: western gall rust stem gall; right: squirrel feeding on a stalactiform blister rust canker.

Field Trip: Density Issues in the South Okanagan

On May 26, 2014, a field trip was jointly organized by Walt Klenner, Lorraine Maclauchlan, other MFLNRO specialists, and Weyerhaeuser Canada to view various examples of density issues in the South Okanagan. Other participants included staff from Weyerhaeuser Canada, J.S. Thrower and other contractors. The tour focused on density and forest health issues in young and intermediate age stands of lodgepole pine, Douglas-fir and western larch.

Stops and discussions included:

1. Thinning trials conducted in the late 1980's in suppressed, high density regenerated lodgepole pine along the 201 Road. Thinning was done by running a mower through the dense suppressed pine when it was about 10-12 years of age. The strips in treated stands compared to control areas did not show drastic differences in total volume after ±30 years but there was some difference in individual tree size and volume due to edge effects. Trees along the edge of strips had larger diameters due to more available light, less competition, and potentially more available water and nutrients.

2. Spacing trial in lodgepole pine established in the early 1990's by L. Maclauchlan, at 28 km on the 200 Road on TFL #15.

3. Permanent sample plot in lodgepole pine established in 1985 by L. Maclauchlan, at 17 km on the 200 Road (OK Falls Plot #1).

4. Dense Douglas-fir and western larch regeneration in a wildfire area, and options to reduce density.

30 years post-mechanical spacing (mowing) of lodgepole pine.

Unspaced control area.

Herbicide thinning strips in lodgepole pine-Douglas-fir-larch mixture.

Dense Douglas-fir regeneration after wildfire.

Is Western White Pine More Resistant to Armillaria Root Disease Than Other Conifers?

Michael Murray, Forest Pathologist, Kootenay-Boundary Region

Western white pine has remarkable properties for promoting healthy forests and economies. It is fast-growing on a good variety of soil conditions and elevations. White pine provides large seeds for wildlife, yet is resistant to deer browsing. Achieving heights of over 200 feet (60 metres), its straight-boled graceful stature is considered by many as the most attractive conifer in British Columbia. White pine was historically a dominant tree in the Kootenays before over-harvesting and white pine blister rust invasion. By the late 1900s, very few old trees remained. Despite the availability of disease-resistant planting stock, relatively few are planted.

The loss of white pine has been accompanied by a shift to Douglas-fir and lodgepole pine domination. These species are prone to a greater variety of forest health agents than white pine. This shift has reduced productivity by approximately 50% per acre (Fins and others, 2001). In the Kootenays, a primary agent contributing to plantation tree mortality is Armillaria root disease, where 30% or more cumulative infection occurs.

Is white pine more resistant to Armillaria than its competitors? This question was posed about 30 years ago leading to a handful of research trials being established to address this question. Three of these trials (Busk, Marl, and Smallwood, Table 1) were installed by the Canadian Forest Service in 1987. Results from an additional three trials (all unrelated, Table 2) are also available. Findings from the six trials indicate that white pine is typically less prone to Armillaria infection than Douglas-fir and lodgepole pine. Only a single trial indicated greater impacts to white pine. These new results suggest that planting white pine will usually yield better survival than Douglas-fir and lodgepole pine on sites prone to Armillaria.

Fins, L. and others. 2001. Return of the giants: restoring white pine ecosystems by breeding and aggressive planting of blister rust-resistant white pines. Station Bulletin 72. University of Idaho. 21 p.

Table 1. Percent Armillaria Root Disease on DEAD trees (2014). Plantations established 1987 (27 yrs old)

Species	Busk	Marl	Smallwood
White Pine	**2.5**	**13.9**	**18.4**
Douglas-fir	-	5.0	25.0
Lodgepole Pine	5.0	-	-
Both Species	2.8	13.1	18.9

Table 2. Percent Armillaria Root Disease on LIVING and DEAD trees (2013). Vlem Creek surveyed in 2003.

Species	**Columbia West** Planted 1987	**McPhee** Planted 2004	**Vlem Creek** Planted 1984
White Pine	**4.0**	**5.4**	**2.0**
Douglas-fir	4.3	5.6	10.3
Lodgepole Pine	6.7		
Cedar	0	1.8	
Larch	3.4		
Species Combined	3.4	3.8	5.6

New Field Trials Established to Screen Blister Rust Resistance in Whitebark Pine

Michael Murray, Forest Pathologist, Kootenay-Boundary Region

As whitebark pine continues to decline in numbers, a new effort has begun to address an old forest health challenge….the non-native white pine blister rust disease. By identifying rare rust-resistant parent trees, we can protect them and collect seeds, thus promoting the planting of hardy offspring that are likely to survive the non-native pathogen. The development of disease resistance in western white pine has proven a successful model for whitebark pine in the United States. Thus, the approach in British Columbia is very similar.

Beginning in 2011, a search for healthy disease-free trees was conducted throughout the Kootenays. Forty trees were identified for seed collection. Progeny were reared at Kalamalka Research Centre's nursery (FLNRO) until this past summer when nearly 4,500 seedlings were planted in research trials. The planted seedlings are tagged according to their respective parents. Survivorship will be monitored over the next five or more years. Those seedlings that thrive will indicate a natural resistance to disease. Thus, the original parent trees will be targeted for future seed collection.

A crew plants 1,000 seedlings near the lookout on Idaho Peak.

Three field trial sites were chosen based on good accessibility and high blister rust hazard. Seedlings were planted along transects at 1 and 2 meter intervals based on available space. Idaho Peak is a maintained recreation area with interpretive signs, benches, and a decommissioned fire lookout. The Sale Mountain trial is adjacent to a BC Hydro communications facility. Puddingburn Mountain supports a Nav Canada facility next to this trial. An additional two trials were established in Glacier National Park, where Parks Canada oversaw planting of about 500 seedlings at two remote locations known locally as Grizzly and Prairie Hills. These semi-treed sites had experienced recent wildfire. Seedlings will be assessed annually during the following five years (2015-2019) for health and survivorship.

Field Trial	General Location	Number of Seedlings
Idaho Peak	New Denver – Silverton	1,000
Sale Mountain	Revelstoke	1,000
Puddingburn Mountain	Kimberley	2,000
Grizzly Hills	Glacier National Park	250
Prairie Hills	Glacier National Park	250

Forest Pathology Publications

Murray, M.P. 2014. A Canadian-based blister rust inoculation trial for whitebark pine. In: Chadwick, K. Compiled Proceedings of the 61st Annual Western International Forest Disease Work Conference; 2013 October 6-11; Waterton Lakes National Park, Alberta. p. 35-38.

Young Pine PSPs Show Effects of Elytroderma Severity on Lodgepole Pine Height and Diameter Growth

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

Three young pine permanent sample plots (PSPs) were remeasured in 2014 by Entopath Management Ltd (Table 1). The trees were rated for *Elytroderma deformans* (DFE) foliage disease using a 6 point Hawksworth scale with stunting used in place of dwarf mistletoe brooms.

Trees with ratings of 5 or 6 had significant reductions in height growth compared to healthy trees. PSP 8 also showed significant height reduction for trees with a severity rating of 4 (21% reduction compared to healthy trees). For the 3 sites, trees with severity ratings of 5 had 16-27% less height growth compared to healthy trees and trees with severity rating of 6 had 32-62% less height growth than healthy trees (Figure 1, left).

Diameter at breast height (DBH) compared to healthy trees was only significantly lower for the most severely infected trees (tree class 6). The graph of DBH as a function of *Elytroderma* severity class (Figure 1, right) showed an increasing trend in DBH at lower severity ratings compared to healthy trees. However, the differences in DBH were only significantly higher than the healthy trees for PSP 8 severity rating 1, 2, and 3. One possible explanation for the higher DBHs is that stem swellings caused by *Elytroderma* stem infections may result in larger stem diameters compared to healthy trees for trees in the lower severity classes.

Table1. Summary of *Elytroderma* permanent sample plots.

PSP Number	Biogeoclimatic Zone	Stand Age	Density (stems/ha)	Infection Rate (%)	Mean severity of DFE infected trees	Percent of trees in severity class 5 & 6
5	IDFdk4	30	6,840	89	3.7	44
8	IDFdk3	30	2,550	54	1.5	12
11	IDFdk3	39	5,280	91	4.1	55

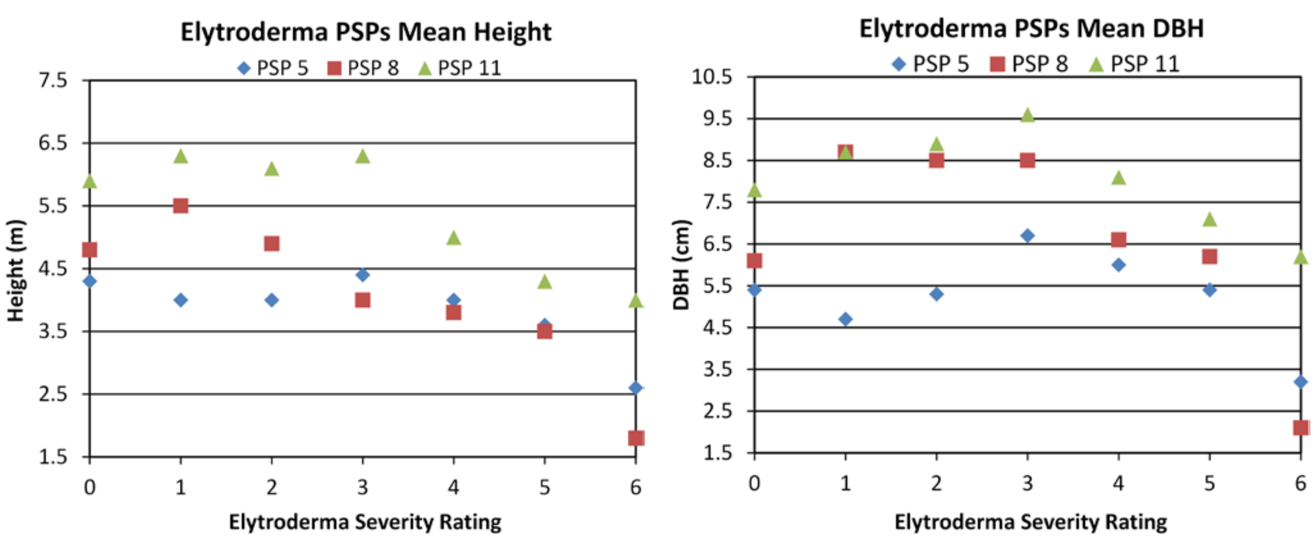


Figure 1. Height (left graph) and diameter (right graph) as a function of *Elytroderma* Hawksworth Severity Class for 3 permanent sample plots (PSPs).

BALSAM WOOLLY ADELGID, *ADELGES PICEAE*

Background

The balsam woolly adelgid, *Adelges piceae* (Ratzeburg) (BWA), was introduced from Europe around 1900 and is now distributed throughout eastern and western North America. It attacks all true firs, *Abies* species, including subalpine, balsam and Fraser fir (Salom and Day 2010). Subalpine fir, *Abies lasiocarpa*, is the most readily damaged of the B.C. species. Widespread damage and mortality on this host has been found in high elevation stands in Idaho. Amabilis fir, *A. amabilis*, is the second most affected host and heavy mortality has occurred at certain sites on the B.C. mainland. Grand fir, *A. grandis*, is the least susceptible to damage but can suffer appreciable deformation and mortality (Turnquist and Harris 1993).

Balsam woolly adelgid is found in the southwest portion of the province with the Coastal and Cascade Mountains acting as natural barriers to movement north. Provincial Balsam Woolly Adelgid Regulations were established to protect the highly susceptible *A. lasiocarpa* in the B.C. interior, and slow the spread of BWA (http://www.agf.gov.bc.ca/cropprot/balsamwa.htm). The quarantine zone restricts the movement and growing of *Abies* spp. from within the zone to outside the zone. The quarantine restricts the movement of *Abies* spp. within the province, the US, and from the rest of Canada.

Damage

The balsam woolly adelgid is considered a serious pest of forest, seed production, landscape, and Christmas trees. It generally concentrates either on the outer portions of tree crowns or on the main stem and large branches. Stem infestations are usually more serious, causing greater levels of damage and mortality. Abnormal drooping of the current shoots and gouting of the outer twigs characterize crown infestations. The crown becomes increasingly thin and dieback may occur. Persistent crown infestation can kill a tree over a number of years (Salom and Day 2010). Stem attacks are characterized by the conspicuous presence of white woolly masses that, under heavy attack, give the lower bole a whitewashed appearance. The wood responds to adelgid feeding in an "allergic" manner that causes swelling of the sapwood, and results in gouting of the twigs and increased heartwood formation in the sapwood, called "rotholz" or "redwood." This abnormal growth of sapwood tissue inhibits water flow within the tree.


Balsam woolly adelgid on subalpine fir bark, Rossland, B.C.

Adult balsam woolly adelgids are very small (<2 mm long) aphid-like, wingless, oval, purplish black insects, covered with white, woolly, wax threads (Turnquist and Harris 1993). The female (no male adelgids) may lay as many as 100 eggs in a cluster about her body. These hatch into tiny, first-stage nymphs or "crawlers". The crawler selects a feeding location on thin bark, branch nodes, leaf or cone buds, and inserts its tube-like mouthparts and remains at this location for the remainder of its life. It becomes a black, flattened, resting form with a characteristic pattern of white wax exudations along the midline, and in a fringe around its body (Turnquist and Harris 1993). This is the overwintering form. Feeding begins after several weeks, or after overwintering. After three months, it becomes an adult and begins laying eggs. Eggs, young crawlers and adults are present from as early as February in coastal areas until October. There are two to four generations each year. At low population levels, detection is very difficult and requires microscopic examination of branch nodes.

The Issue

Adelges piceae is spreading outside the established quarantine zone. In 2009, BWA was reported in the Cascades Forest District (within the North Cascade Mountain Range). In 2012, BWA was detected in the Rossland area, north of the Idaho border, which is outside the current quarantine zone. This prompted a ground survey to confirm the identification as *A. piceae* and to determine the extent and severity of infestation. Data from this survey may lead to amendment of the quarantine zone in B.C. Adelgid samples were placed in non-denatured 95% EtOH and sent to Agriculture and Agri-Food Canada, Ottawa for positive identification.

In February 2015, a Christmas-tree grower in Kelowna brought in samples of Fraser fir with branch gouting to the Kalamalka Research Station, Vernon, B.C. The trees were planted in the Christmas tree farm about seven years ago and were obtained from the Sorrento Tree Nursery. The adelgids on the trees looked like *Adelges piceae* so they have been sent to Agriculture and Agri-Food Canada, Ottawa for positive identification.

Photographs of Fraser fir infested with adelgids, Kelowna B.C.
Left: gouting on Fraser fir branches; and Right: adelgid "crawlers" on Fraser fir buds.
Photographs by Ward Strong, Kalamalka Research Station, Vernon, B.C.

2014 Results

BWA is more widespread and is at higher densities than was first anticipated in the Rossland and Red Mountain area of southern B.C. White woolly flocculence was not very evident on the branches of infested trees, however, it was evident on the bark of the stem and in some areas it was very dense (see photo on page 60). The adelgid was found on *A. grandis* and *A. lasiocarpa*.

BWA was found at the following locations (Figure 1):

- Red Mountain
- south side of Granite Mountain. The trees on which BWA was found were mostly symptomless, but some had minor gouting, deformity and a decline in health.
- north of Red Mountain ski village – BWA widespread northward until the forest becomes undisturbed mature hemlock and cedar. Patches with high density populations of BWA on the stem bark were found.
- Black Jack cross country ski trails – widespread and a number of large patches with high densities of BWA on the stem bark.
- Monte Christo Mountain - BWA readily found on the stem bark.

All samples sent from the Rossland area for identification were positively confirmed as *Adelges piceae*. The samples from Kelowna are still being processed. Thanks to the following scientists for the processing and identification of samples:

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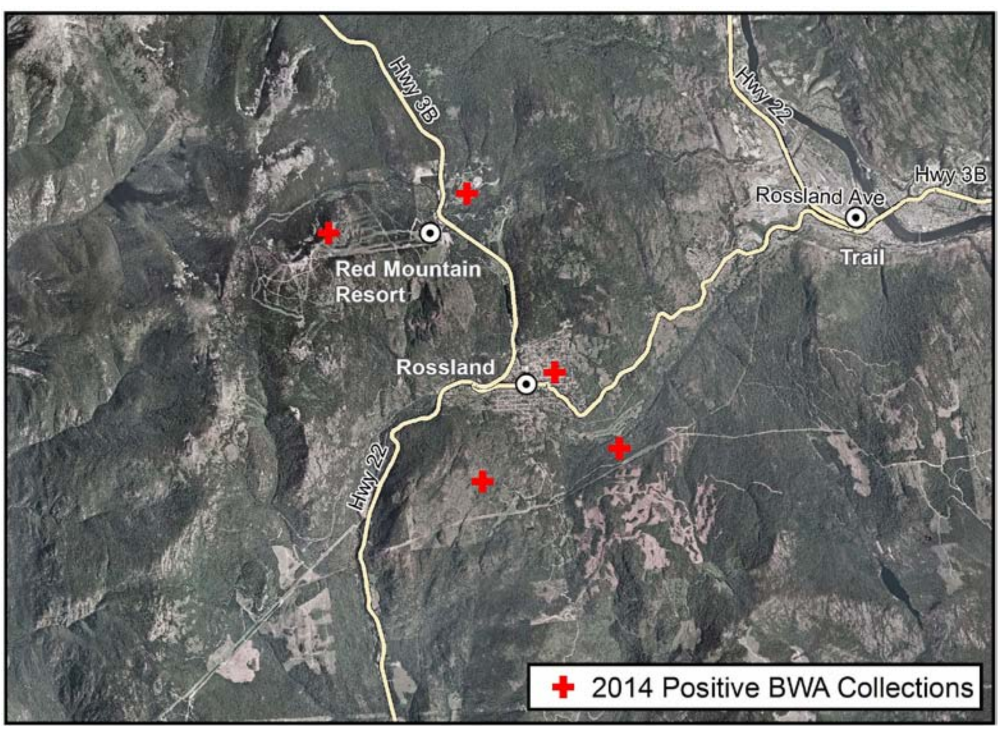

Figure 1. Map showing locations of positive balsam woolly adelgid collections in 2014.

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This report is available in PDF format at http://www.for.gov.bc.ca/rsi/ForestHealth/Overview.htm