2013 Overview of Forest Health Conditions in Southern British Columbia

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Introduction

This report summarizes the results of the 2013 Aerial Overview Surveys and 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. Forest Service, Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) 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). Table 1 describes damage severity ratings used in the surveys.

The 2013 surveys were completed between July 15th and August 19th, 2013. A total of 288.4 hours of fixed-wing aircraft flying in 57 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 totals greatet than 25 million hectares, of which over 15 million hectares are forested land. Flying conditions were generally good, with a few delays caused by excessive wildfire smoke and poor weather.

Defoliating insects were the most common damaging agents, with nearly 285,000 hectares affected. Bark beetles were the most widespread cause of recent tree mortality, affecting just over 250,000 hectares. An assortment of other disturbances, such as foliar diseases, animal damage, declines, wildfire, windthrow, and other abiotic agents, caused damage on another 32,275 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 2013 aerial overview surveys.

Timber Supply Area and Damaging Agent	Trace	Light	Moderate	Severe	Very Severe	Total
	Area of Infestation (hectares)					
Mountain Pine Beetle						
100 Mile House			*spot infestations only*			0
Arrow	438.4	293.9	96.2	5.3	0.0	833.8
Boundary	7,981.9	9,627.5	3,165.6	477.6	0.0	21,252.6
Cranbrook	1,456.4	814.8	166.3	70.4	0.0	2,507.9
Golden	1,572.9	1,120.9	366.9	8.7	0.0	3,069.3
Invermere	4,668.8	3,643.0	1,375.8	261.6	0.0	9,949.1
Kamloops	58.2	8.4	0.0	0.0	0.0	66.7
Kootenay Lake	1,424.3	1,593.4	605.9	127.1	0.0	3,750.7
Lillooet	1,494.1	2,936.1	421.1	0.0	0.0	4,851.3
Merritt	2,133.1	1,345.0	38.3	0.0	0.0	3,516.5
Okanagan	1,200.2	8,810.0	571.6	6.0	0.0	10,587.8
Quesnel			*spot infestations only*			0
Revelstoke	18.8	0.0	132.1	0.0	0.0	150.9
Williams Lake	1,898.1	621.4	46.0	0.0	0.0	2,565.5
Total	**24,345.3**	**30,814.4**	**6,985.8**	**956.7**	**0.0**	**63,102.2**
Douglas-fir Beetle						
100 Mile House	157.2	122.2	7.0	4.5	0.0	290.9
Arrow	128.1	158.5	89.7	75.4	0.0	451.7
Boundary	0.0	12.5	0.0	0.0	0.0	12.5
Cranbrook	56.4	89.7	0.0	15.5	0.0	161.6
Golden	164.3	0.0	26.8	0.0	0.0	191.1
Invermere	6.2	308.8	174.5	0.0	0.0	489.4
Kamloops	0.0	78.6	82.2	75.6	0.0	236.4
Kootenay Lake	0.0	213.6	6.5	0.0	0.0	220.1
Lillooet	0.0	233.7	185.7	17.3	0.0	436.7
Merritt	0.0	45.9	5.3	14.1	0.0	65.3
Okanagan	0.0	590.0	285.5	30.7	0.0	906.2
Quesnel	43.2	109.0	7.2	0.0	0.0	159.5
Revelstoke	7.6	41.8	27.7	0.0	0.0	77.1
Williams Lake	876.2	939.1	209.4	11.7	0.0	2,036.4
Total	**1,439.2**	**2,943.4**	**1,107.7**	**244.7**	**0.0**	**5,735.0**
Spruce Beetle						
100 Mile House	139.6	147.1	129.5	0.0	0.0	416.2
Golden	11.7	0.0	51.6	0.0	0.0	63.3
Invermere	37.5	124.2	1,762.2	205.9	0.0	2,129.7
Kamloops	0.0	1,124.7	370.3	6.2	0.0	1,501.2
Lillooet	0.0	84.0	206.0	0.0	0.0	289.9
Merritt	0.0	346.6	501.2	18.2	0.0	866.0
Okanagan	0.0	118.6	230.8	0.0	0.0	349.4
Quesnel	132.4	37.8	0.0	0.0	0.0	170.2
Williams Lake	380.4	2,303.8	991.5	421.8	0.0	4,097.5
Total	**701.7**	**4,286.7**	**4,243.1**	**652.1**	**0.0**	**9,883.5**
Western Balsam Bark Beetle						
100 Mile House	1,802.4	112.5	0.0	0.0	0.0	1,914.8
Arrow	1,398.7	103.8	12.5	0.0	0.0	1,515.0
Boundary	1,032.9	0.0	0.0	0.0	0.0	1,032.9
Cranbrook	935.4	403.3	0.0	0.0	0.0	1,338.7
Golden	2,072.5	505.3	52.9	0.0	0.0	2,630.7
Invermere	3,607.6	438.5	5.0	0.0	0.0	4,051.0
Kamloops	71,417.3	365.6	0.0	0.0	0.0	71,782.9
Kootenay Lake	444.2	21.9	0.0	0.0	0.0	466.1
Lillooet	2,538.6	86.8	0.0	0.0	0.0	2,625.4
Merritt	10,309.6	42.2	0.0	0.0	0.0	10,351.8
Okanagan	50,771.3	0.0	0.0	0.0	0.0	50,771.3
Quesnel	4,005.4	937.4	0.0	0.0	0.0	4,942.8
Revelstoke	233.1	0.0	0.0	0.0	0.0	233.1
Williams Lake	13,813.3	5,218.3	0.0	0.0	0.0	19,031.6
Total	**164,382.3**	**8,235.6**	**70.4**	**0.0**	**0.0**	**172,688.3**

Table 2 continued. Area summaries for forest health factors mapped during the 2013 aerial overview surveys.

Timber Supply Area	**Area of Infestation (hectares)**				
and Damaging Agent	**Light**	**Moderate**	**Severe**	**Grey**	**Total**
Western Spruce Budworm					
100 Mile House	47,260.8	2,839.6	104.3	0.0	50,204.7
Arrow	0.0	79.9	0.0	0.0	79.9
Boundary	521.5	728.8	0.0	0.0	1,250.3
Cranbrook	172.4	0.0	0.0	0.0	172.4
Kamloops	27,874.8	3,536.6	0.0	0.0	31,411.3
Lillooet	1,660.4	0.0	0.0	0.0	1,660.4
Merritt	1,678.4	0.0	0.0	0.0	1,678.4
Okanagan	1,764.3	0.0	0.0	0.0	1,764.3
Quesnel	48.6	0.0	0.0	0.0	48.6
Revelstoke	14.9	0.0	0.0	0.0	14.9
Williams Lake	39,219.2	474.5	0.0	0.0	39,693.7
Total	**120,215.3**	**7,659.3**	**104.3**	**0.0**	**127,978.9**
Two-Year Cycle Budworm					
100 Mile House	771.4	0.0	0.0	0.0	771.4
Kamloops	1,134.5	0.0	0.0	0.0	1,134.5
Quesnel	54,091.4	158.7	0.0	0.0	54,250.1
Williams Lake	16,801.5	0.0	0.0	0.0	16,801.5
Total	**72,798.8**	**158.7**	**0.0**	**0.0**	**72,957.5**
Western Hemlock Looper					
Arrow	0.0	25.1	81.7	0.0	106.9
Golden	0.0	104.6	45.4	0.0	150.0
Kootenay Lake	0.0	63.5	19.2	0.0	82.7
Okanagan	0.0	0.0	0.0	84.4	84.4
Revelstoke	0.0	481.2	21.1	0.0	502.3
Williams Lake	0.0	0.0	0.0	1,093.7	1,093.7
Total	**0.0**	**674.4**	**167.4**	**1,178.2**	**841.9**
Pine Needle Sheath Miner					
Kamloops	68.0	90.9	0.0	0.0	158.9
Lillooet	39.7	0.0	0.0	0.0	39.7
Okanagan	82.8	0.0	0.0	0.0	82.8
Total	**190.5**	**90.9**	**0.0**	**0.0**	**281.4**
Aspen Serpentine Leaf Miner					
100 Mile House	6,432.7	2,472.5	0.0	0.0	8,905.1
Arrow	1,104.5	1,025.9	0.0	0.0	2,130.4
Cranbrook	416.5	636.1	0.0	0.0	1,052.6
Golden	2,408.6	1,250.9	26.1	0.0	3,685.6
Invermere	177.6	0.0	0.0	0.0	177.6
Kamloops	20,882.9	22,250.8	970.1	0.0	44,103.8
Kootenay Lake	636.4	1,355.5	25.4	0.0	2,017.3
Lillooet	207.5	274.6	23.0	0.0	505.1
Merritt	1,199.9	647.4	201.5	0.0	2,048.8
Okanagan	4,615.6	2,976.2	537.5	0.0	8,129.4
Quesnel	7,794.7	23.6	0.0	0.0	7,818.2
Revelstoke	1,114.0	93.6	0.0	0.0	1,207.6
Williams Lake	31,415.0	1,269.2	0.0	0.0	32,684.2
Total	**78,406.0**	**34,276.0**	**1,783.7**	**0.0**	**114,465.7**
Forest Tent Caterpillar					
Kamloops	786.8	547.0	0.0	0.0	1,333.8
Okanagan	2,113.7	1,276.2	0.0	0.0	3,389.9
Quesnel	16,178.0	1,066.6	5.0	0.0	17,249.7
Williams Lake	85.4	234.4	0.0	0.0	319.7
Total	**19,164.0**	**3,124.2**	**5.0**	**0.0**	**22,293.1**

Table 2 continued. Area summaries for forest health factors mapped during the 2013 aerial overview surveys.

Timber Supply Area	Area of Infestation (hectares)					
and Damaging Agent	**Trace**	**Light**	**Moderate**	**Severe**	**Very Severe**	**Total**
Larch Needle Blight						
Arrow	0.0	656.9	17.6	0.0	0.0	674.5
Boundary	0.0	133.1	0.0	0.0	0.0	133.1
Cranbrook	0.0	2,014.5	539.2	0.0	0.0	2,553.7
Golden	0.0	46.4	25.9	0.0	0.0	72.2
Invermere	0.0	353.0	0.0	0.0	0.0	353.0
Kamloops	0.0	0.0	3.5	0.0	0.0	3.5
Kootenay Lake	0.0	1,825.0	414.8	15.6	0.0	2,255.3
Okanagan	0.0	252.5	5.3	0.0	0.0	257.8
Total	**0.0**	**5,281.4**	**1,006.2**	**15.6**	**0.0**	**6,303.1**
Wildfire						
100 Mile House	0.0	0.0	0.0	47.7	0.0	47.7
Arrow	0.0	0.0	0.0	276.5	0.0	276.5
Boundary	0.0	0.0	0.0	0.6	0.0	0.6
Cranbrook	0.0	0.0	0.0	175.6	0.0	175.6
Golden	0.0	0.0	0.0	92.5	0.0	92.5
Invermere	0.0	0.0	0.0	25.6	0.0	25.6
Kamloops	0.0	0.0	66.5	1,452.3	1,424.8	2,943.6
Kootenay Lake	0.0	0.0	0.0	262.2	0.0	262.2
Lillooet	0.0	0.0	0.0	34.6	0.0	34.6
Merritt	0.0	0.0	0.0	181.7	0.0	181.7
Okanagan	0.0	0.0	0.0	212.2	0.0	212.2
Quesnel	0.0	0.0	0.0	266.0	0.0	266.0
Revelstoke	0.0	0.0	0.0	50.8	0.0	50.8
Williams Lake	0.0	0.0	0.0	2,487.7	0.0	2,487.7
Total	**0.0**	**0.0**	**66.5**	**5,565.9**	**1,424.8**	**7,057.2**
Post-Wildfire Mortality						
100 Mile House	0.0	305.0	37.6	134.7	0.0	477.3
Kamloops	0.0	64.4	0.0	0.0	0.0	64.4
Lillooet	0.0	74.2	25.2	0.0	0.0	99.5
Quesnel	31.6	466.2	495.9	0.0	0.0	993.6
Williams Lake	639.6	2,830.9	825.8	160.8	0.0	4,457.1
Total	**671.1**	**3,740.7**	**1,384.4**	**295.6**	**0.0**	**6,091.8**
Flooding Damage						
100 Mile House	0.0	0.0	0.0	14.5	0.0	14.5
Arrow	0.0	0.0	0.0	14.1	0.0	14.1
Cranbrook	0.0	0.0	0.0	398.5	0.0	398.5
Golden	0.0	0.0	0.0	17.4	0.0	17.4
Invermere	0.0	0.0	0.0	248.2	0.0	248.2
Kamloops	0.0	0.0	0.0	14.5	0.0	14.5
Lillooet	0.0	0.0	0.0	17.6	0.0	17.6
Okanagan	0.0	0.0	6.4	17.3	4.7	28.4
Quesnel	0.0	16.6	95.3	116.7	0.0	228.7
Revelstoke	0.0	0.0	0.0	35.2	0.0	35.2
Williams Lake	0.0	1,552.3	698.3	269.2	0.0	2,519.9
Total	**0.0**	**1,568.9**	**800.1**	**1,163.2**	**4.7**	**3,536.9**
Satin Moth						
100 Mile House	0.0	0.0	8.6	16.9	0.0	25.5
Kamloops	0.0	0.0	20.1	0.0	0.0	20.1
Merritt	0.0	19.0	0.0	0.0	0.0	19.0
Okanagan	0.0	0.0	124.3	44.8	0.0	169.0
Total	**0.0**	**19.0**	**153.0**	**61.7**	**0.0**	**233.7**
Dothistroma Needle Blight						
Kamloops	0.0	58.1	51.8	0.0	0.0	109.9
Okanagan	0.0	203.6	0.0	0.0	0.0	203.6
Total	**0.0**	**261.7**	**51.8**	**0.0**	**0.0**	**313.5**

Southern Interior Overview

Mountain Pine Beetle, *Dendroctonus ponderosae*

Area affected by mountain pine beetle declined to 63,100 hectares in southern B.C., the lowest level since 1999. The most significant reductions were in the central Okanagan, Princeton, and south Chilcotin, where many populations have collapsed. Infestations were still widespread across much of the east Kootenays, Arrow Lakes, east-central Okanagan, and Bridge River areas. Infestations expanded by 50% in the Boundary TSA and 25% in the Invermere TSA, where there are still large areas of uninfested, high hazard pine forests susceptible to attack.

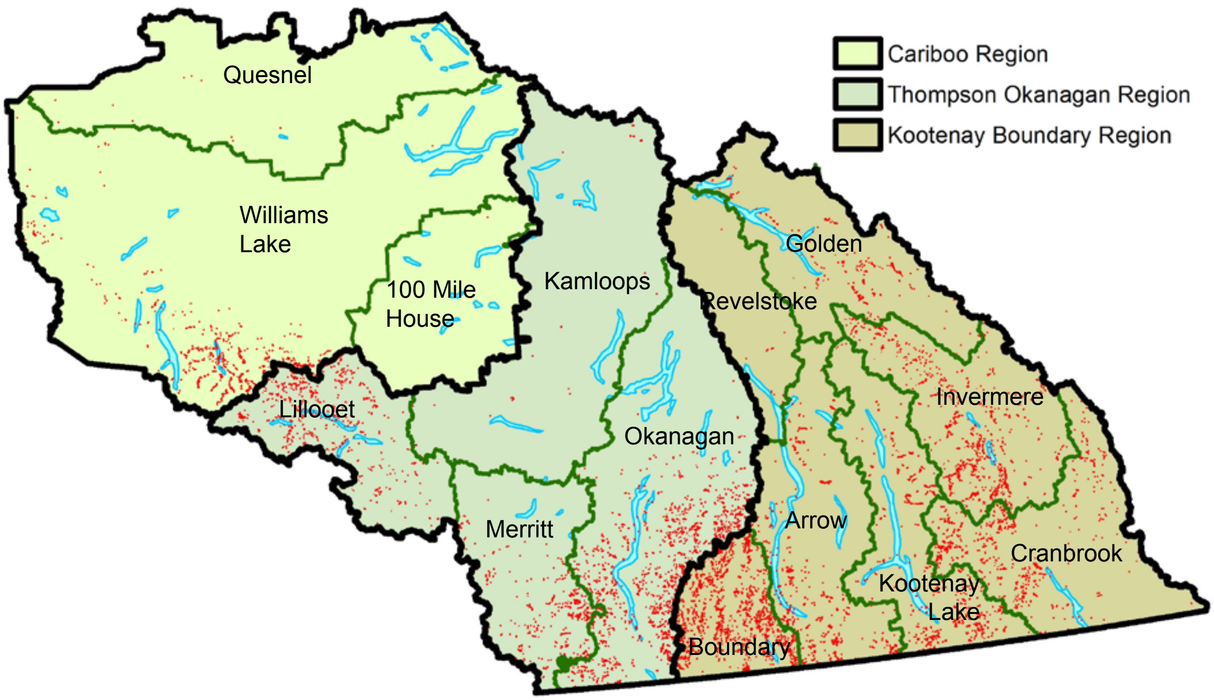


Figure 1. Mountain pine beetle infestations and Timber Supply Areas in the Southern Interior in 2013.

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, 2001-2013.

Year	Area Infested (ha)	Number of Polygons	Average Polygon Size (ha)	Number of Spot Infestations	Number of Trees Killed in Spot Infestations
2001	141,176	4,760	29.7	3,672	37,074
2002	612,054	7,349	83.3	6,308	56,054
2003	2,525,722	13,133	192.4	5,270	42,372
2004	4,220,499	41,057	101.9	4,932	63,410
2005	4,853,830	49,381	95.6	3,839	35,033
2006	5,125,879	59,971	85.5	5,672	71,803
2007	5,379,219	59,373	90.6	5,429	71,409
2008	4,812,045	52,402	67.0	3,181	39,569
2009	2,342,129	23,493	99.7	5,745	73,994
2010	558,118	15,127	36.9	6,573	89,747
2011	161,012	5,999	26.8	4,526	56,835
2012	109,181	3,484	19.5	3,515	45,574
2013	63,102	1,707	40.0	2,905	29,670

Attack intensity remained low in most areas, with 86% of the affected stands categorized as trace to light attack.

Attack in young lodgepole pine stands is now rare, and was mapped on just 33 hectares in the Okanagan. Engraver beetles (*Ips* species) caused scattered mortality on an additional 28 hectares of young lodgepole pine and in the Shuswap and Churn Creek areas.

Infestations increased in whitebark pine stands, from 2,200 hectares in 2012, to 3,282 hectares in 2013. Most of the affected stands were scattered across the Purcell Mountains and around Gold Bridge. Infestations in ponderosa pine have fallen to just 84 hectares.

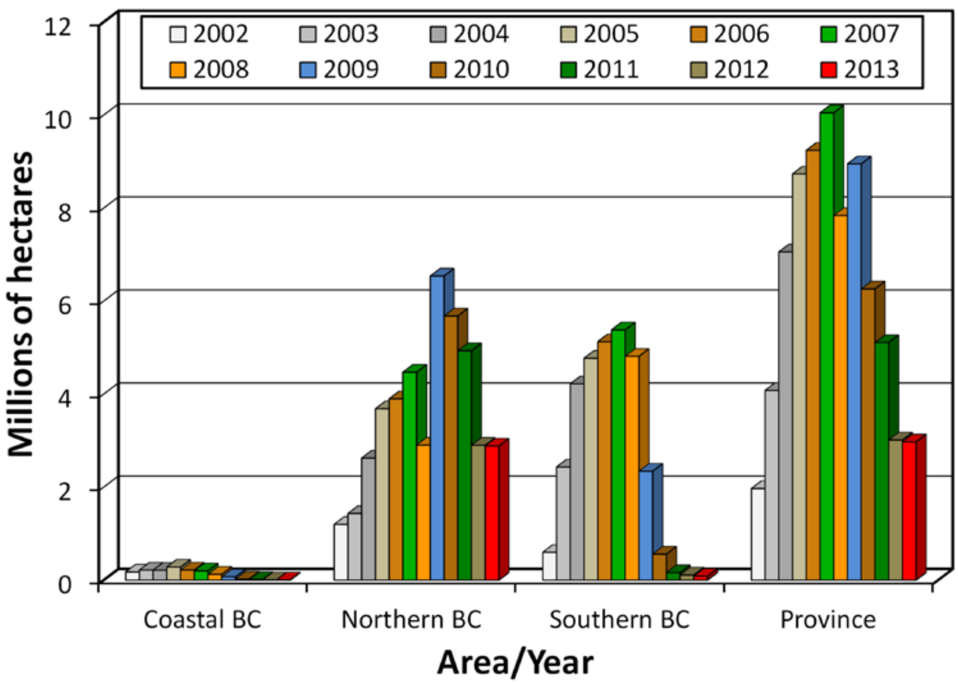


Figure 2. Area affected by mountain pine beetle from 2002 - 2013 in British Columbia, by geographic area.

Lodgepole pine stands killed by mountain pine beetle, Kamloops TSA.

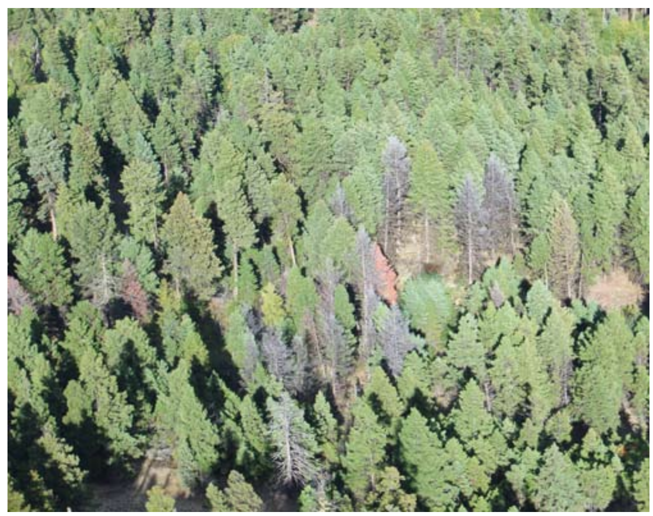
Table 4. Number of spot infestations of Douglas-fir beetle in the Southern Interior in 2013.

Timber Supply Area	Number of spot infestations	Number of trees
Williams Lake	579	2,914
Okanagan	449	2,810
Lillooet	361	2,535
Kamloops	247	1,555
Arrow	139	2,173
Merritt	108	567
100 Mile House	83	297
Kootenay Lake	71	816
Invermere	66	683
Cranbrook	62	717
Boundary	27	492
Quesnel	23	74
Revelstoke	20	345
Golden	18	220
Total	**2,253**	**16,198**

Douglas-fir Beetle, *Dendroctonus pseudotsugae*

Douglas-fir beetle population trends were variable across the survey area. Infestations declined sharply across most of the 100 Mile House and eastern Williams Lake TSAs, while many new, scattered infestations were mapped in the Lillooet, Okanagan, and Arrow TSAs. Attack remains scattered in the Merritt TSA and across much of the east Kootenays and Boundary areas. Due to high levels of blowdown and top breakage in many Douglas-fir stands throughout the southern interior, there may be an increase in Douglas-fir beetle populations over the next two years. Overall infested area fell by more than 50% to 5,735 hectares, however the number of spot infestations remained nearly unchanged at 2,253.

Subalpine fir killed by western balsam bark beetle.



A mix of new and old Douglas-fir beetle attack.

Western Balsam Bark Beetle, *Dryocoetes confusus*

Area affected by western balsam bark beetle declined slightly, from 212,750 hectares in 2012, to 172,688 hectares in 2013. Over 70% of the affected area was within the Kamloops and Okanagan TSAs; however attack remained widespread across most susceptible stands within the survey area. Typically, intensity levels remained tlow, with nearly all attack being classified as trace.

Spruce Beetle, *Dendroctonus rufipennis*

Area affected by spruce beetle declined by over 70%, to 9,880 hectares. Most of this drop was due to the synchronized two-year life cycle of beetle populations in the 100 Mile House and Williams Lake TSAs, which has often resulted in large annual fluctuations in affected area. Infestation status in other TSAs exhibited less fluctuation, while the infestation in the North White River/Fenwick Creek area of the Invermere TSA saw continued expansion.

Western Spruce Budworm, *Choristoneura occidentalis*

The total area defoliated by western spruce budworm in the southern interior declined by 72% in 2013 to 127,980 hectares, a dramatic change from the 455,132 hectares mapped in 2012 (Table 5). In the Cariboo Region, the Williams Lake TSA saw the most significant decline in area defoliated, with active areas mapped from Chimney Lake to Hawkes Creek and Chilcotin Creek. The total area defoliated in 100 Mile House remained static with significant areas being near Big Bar, Meadow Lake and Little Bridge Creek. Defoliation extent and severity also decreased significantly in the Thompson Okanagan Region, particularly in the Merritt and Okanagan TSAs. Populations declined slightly in the Kamloops TSA but there were still many areas of active budworm populations. Key areas of defoliation in 2013 occurred north of Logan Lake to Leighton Lake; north of Kamloops in the Tranquille-Dairy Lake area; between Heffley and Sullivan Lake; and, south of Anderson Creek.

There was a sharp decline in the 2013 defoliation by western spruce budworm in the Kootenay Boundary Region, with 1,502 hectares mapped in 2013 compared to 51,804 hectares in 2012 (Table 5). The majority of active defoliation was in the Boundary TSA (Table 5) west of Arlington Lake, some scattered, small spots near Grand Forks and in the south end of Granby Park near Cochrane Creek.

In the spring there was a small, early dispersal of budworm (2nd instar larvae - L2's) followed by the main L2 dispersal later in May. There was very little variation in larval stage at most sites scheduled for treatment with *B.t.k.* in 2013. Larvae were very well synchronized with bud swell and elongation in 2013 and there remained little variation in instar development at the pre-spray sampling dates. Needle mining levels were significantly lower than observed in 2012. The extent of budworm was much more limited in 2013 but insect density was still high in many sites. A sharp decline in both area and severity of budworm feeding was observed throughout most of the southern interior. The natural cycling of the outbreak coupled with targeted, large control programs have contributed to this population decline. Good recovery of trees was observed in sites treated with *B.t.k.* in 2012 (Fig. 3).

Table 5. Comparison of western spruce budworm defoliation in 2012 and 2013 in the southern interior.

TSA	Area defoliated (hectares) 2012	2013	Area change from 2012 to 2013	Population fluctuation
100 Mile House	48,105	50,205		static
Williams Lake	79,617	39,694	-38,604	down
Quesnel	830	49		down
Kamloops	38,376	31,411		down slightly
Lillooet	34,443	1,660	-238,263	down
Merritt	91,795	1,678	(down	down
Okanagan	110,162	1,764	significantly)	down
Arrow	0	80	-50,232	up slightly
Boundary	43,064	1,250	(down	down
Cranbrook	6,982	172	significantly)	down
Revelstoke	1,703	15		down
South Area Total	**455,077**	**127,978**	**-327,099**	

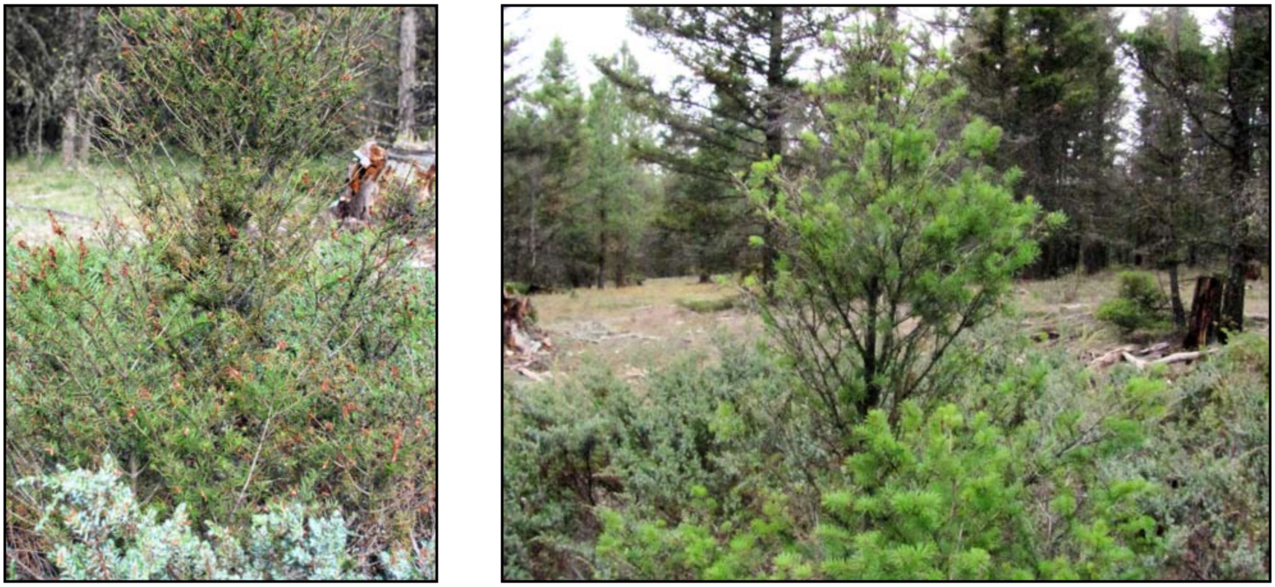


Figure 3. Understory tree in the Kirby Creek 2012 spray block near Merritt, showing 2012 defoliation (left) and 2013 recovery (right).

Based on historic records and trends, western spruce budworm populations are declining in most areas of southern B.C. (Fig. 4). Taking into account the better coverage and quality of mapping over the past few decades, the outbreaks seem to be longer lasting and more widespread when viewed across B.C. as a whole. The 1950's budworm outbreak declined abruptly and populations remained at very low levels until the early 1970's (approximately a 16 year refresh period) when another outbreak was recorded that lasted about 6 years. This was followed by another 6 year refresh period before populations again began increasing in the early 1980's, becoming at the time the largest outbreak on record, lasting about 9 years. After an 8 year refresh period another outbreak began that is only now beginning to wane (2000-2013). Each successive large-scale outbreak period since defoliation mapping began in the early 1900's appears more sustained and expansive than the previous event. For this reason it is important to compare visual accounts (aerial mapping) of defoliation with tree ring growth suppression periods.

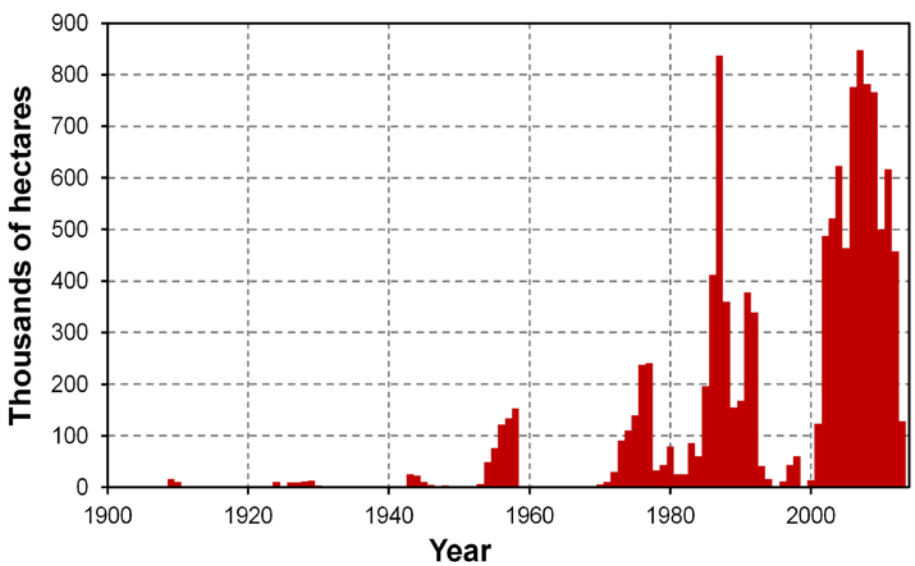
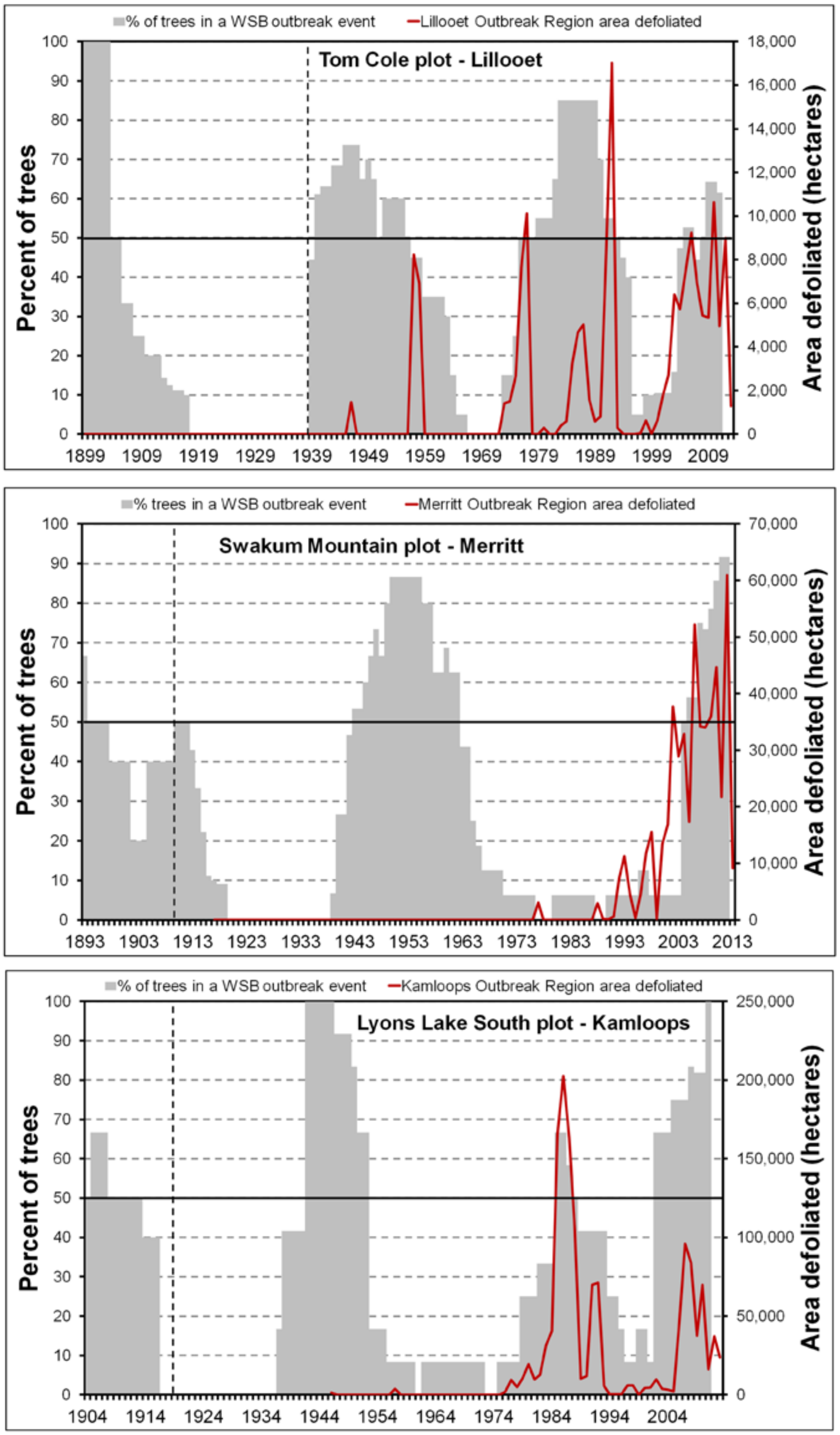


Figure 4. Annual area (hectares) of western spruce budworm defoliation in British Columbia as mapped by the aerial overview survey.

A finer resolution of the budworm outbreak cycles is needed to understand and effectively plan both current and future management of our Douglas-fir forests. A study was conducted using dendrochronological analyses and aerial overview data to reconstruct and compare past outbreak events of western spruce budworm in Douglas-fir-dominated stands in the southern interior of B.C. The objectives of the study were:

- To detect periods of suppression, potentially caused by western spruce budworm defoliation, in cross-dated ring-width series of individual Douglas-fir;
- To identify periods of suppression affecting a large proportion of trees at individual sites, which likely represent past western spruce budworm outbreaks at local to landscape scales; and,
- To compare these periods of growth suppression to aerial overview survey records of defoliation.

Results from this in depth study are now being incorporated into the budworm hazard and risk rating system for the southern interior. Examples of the data are highlighted in Figure 5, showing results from three discrete stands (plots), of the more than 46 stands studied, within three geographic outbreak regions. Each outbreak region has its own unique periodicity of defoliation events as evidenced by both the survey data and tree ring data (Fig. 5). The Lillooet outbreak region has experienced numerous, very regular, often short lived outbreaks which has resulted in reduced growth on affected trees during and after each outbreak event (top graph Fig. 5). The Merritt outbreak region has no *mapped* defoliation-outbreak events prior to the late 1970's (middle graph Fig. 5) yet trees in the Swakum Mountain plot suffered significant growth reduction from 1943 to 1962 (over 50% of trees sampled) even though there were no visual records of defoliation for this time period. If this was an undocumented budworm defoliation period, the refresh period for this stand was over 40 years before another recorded outbreak hit and trees again exhibited reduced incremental growth. The Kamloops outbreak region lies midway between the Merritt and Lillooet outbreak regions in terms of outbreak periodicity and duration (bottom graph Fig. 5). The tree ring data suggest an outbreak event in or around 1942-52, when ring growth decreased significantly (11 year period) and then was followed by approximately a 30 year refresh period. In the early to mid- 1980's an outbreak began in this region and at the Lyons Lake plot, the period of significant growth reduction (1984-87) corresponds exactly to the peak years of this outbreak as mapped in the aerial overview survey. Most, but not all trees in this plot recovered and resumed growth, but again in 2002 through 2010 (cores collected in 2011) over 50% of trees exhibited significant growth reduction which coincides with active budworm defoliation in the region. This represents a much shorter refresh period, only 16 years, and within this time frame there was mapped defoliation in localized areas.



Dashed vertical line = everything to right has sample size of >5 trees
Solid horizontal line = 50% confidence level

Figure 5. Annual hectares affected by western spruce budworm, in three geographic outbreak regions (Top to bottom: Lillooet, Merritt, Kamloops), compared to tree ring data from a plot within the outbreak region (percent trees experiencing budworm event). At least 50% or more of plot trees must show significant growth reduction to classify as an outbreak event.

2013 Western Spruce Budworm Spray Program Operations and Results

Spray Operations

A total of 78,943 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 12 and July 2 in the Thompson Okanagan and Cariboo Regions (Table 6). Treatment timing was normal for the geographic areas treated. June was quite cool and wet. Consequently some spray mornings were cut short due to rain, or delayed a few days.

Table 6. Summary of the 2013 western spruce budworm spray program in southern B.C. The table summarizes, by Region, the area sprayed, volume of *B.t.k.* applied, number of spray blocks, number of staging sites and number of days required to complete each spray program.

	Region		
	Thompson-Okanagan	Cariboo	Total
Area sprayed (hectares)	51,009	27,934	78,943
Volume *B.t.k.* applied (litres)	121,586	67,042	188,628
Number of Blocks	47	11	58
Number of Staging Sites	13	2	15
Number of Days to Complete	9	7	15

The first areas treated were located in the Thompson Rivers and Okanagan Shuswap Districts and were developmentally the earliest and most advanced blocks in the 2013 program (June 12-16, 2013) (Table 7). Budworm larvae in the treatment areas surrounding Gun Lake and Gold Bridge were also well advanced at time of treatment on June 17th (peak 4th with some early 5th instars). However, larvae in the Marshall Lake and Tyaughton Lake blocks were less advanced due to elevation, with primarily 3rd and 4th instars. Very good larval mortality was achieved in both areas. The remaining Cascades District blocks and Cariboo Region blocks were treated in the latter part of June, typical for these locations (June 21-28, 2013) (Table 7). The final blocks treated were in the Surrey Lake area where larval development was much slower due to higher elevation (up to 1,300 metres) and a mix of Douglas-fir and spruce on some sites (July 2, 2013). July 2nd marked a rapid and marked transition from cool temperatures to very hot, dry conditions, which prompted high levels of feeding by the budworm immediately following treatment.

Western Aerial Applications Ltd. conducted the aerial application for the Thompson Okanagan Region. Two Lama 315B helicopters and two Hiller UH12ET helicopters, each equipped with four Beecomist 361A ultra low volume hydraulic sprayers, were deployed 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. In the Thompson Okanagan, a total of 120 bulk containers (1,000 litres of *B.t.k.* per bulk) were delivered to 13 staging sites located in the Cascades, Okanagan Shuswap and Thompson Rivers Districts. The cost per hectare for the Thompson Okanagan 2013 spray program was just under $30 per hectare (all-found). Costs were slightly less than usual due to much of the sampling and monitoring activities being conducted by Regional staff as opposed to co-op students or contractors. The spray program was planned and implemented by Regional staff with key contractors and Victoria staff assisting throughout portions of the program.

The Cariboo Region employed two AT-802F Air Tractors supplied by Conair Aviation to complete their 2013 aerial application of Foray 48B. 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 in sixty-seven 1,000 litre bulk containers which were transferred to 2,500 US gallon storage tanks located at the Williams Lake and 108 Mile airports. All spray operations were staged from these airports.

Table 7. List of 2013 western spruce budworm spray blocks in the Thompson Okanagan and Cariboo Resource Regions. The table lists, by Region, the geographic area, Resource District, area sprayed, volume of *B.t.k.* applied, and treatment dates.

Resource Region and Geographic Area	Resource District*	Area Sprayed (Hectares)	Litres *B.t.k.*	Date Sprayed
Thompson Okanagan				
Onion Road, Westwold	DOS	547	1,313	June 12
Robbins Range, Scuitto Lake, Onion Road	DTR, DOS	9,519	22,845	June 13
Duffy Lake, Indian Gardens	DTR	7,259	17,421	June 14
Bush Lake, Peter Hope Lake	DTR, DCS	7,500	17,999	June 15
Anderson Lake	DTR, DCS	5,610	13,462	June 16
Gun Lake, Marshall Lake	DCS	5,244	12,586	June 17
Kane Valley	DCS	2,329	5,590	June 25
Kane Valley, Lily Lake	DCS	10,270	24,649	June 26
Timber Lake, Surrey Lake	DTR, DCS	2,732	5,722	July 2
Region Total		**51,009**	**121,586**	**June 12 - July2**
Cariboo Region				
Bald Mountain	Central Cariboo	3,353	8,047	June 22, 23, 24
China Lake	100 Mile House	5,060	12,143	June 26, 27
Dog Creek	100 Mile House	1,857	4,456	June 27
Exeter Lake	100 Mile House	1,380	3,312	June 28
Gulatch Lake	Central Cariboo	1,468	3,524	June 28
Little Big Bar	100 Mile House	1,478	3,547	June 27
Mayfield Lake	Central Cariboo	2,105	5,052	June 21
Minton Creek	Chilcotin	3,782	9,077	June 22, 24
Rock Lake	Central Cariboo	693	1,663	June 23
Sting Lake	Central Cariboo	5,935	14,245	June 21, 23, 24, 27, 28
White Lake	100 Mile House	824	1,977	June 27
Region Total		**27,934**	**67,042**	**June 21 - June 28**
Provincial Total		**78,943**	**189,464**	

* DOS = Okananagan Shuswap resource District; DTR = Thompson Rivers Resource District; DCS = Cascades Resource District.

Spraying B.t.k. *for western spruce budworm near Scuitto Lake, Kamloops TSA.*

Operational spray programs began in 1991 after four years of smaller scale, more research oriented programs (Fig. 6). In outbreak years, spray programs must target at least 10% or more of the highest budworm population to effect local population declines. This concept has proven an effective strategy when consistently applied.

The "Southern Interior Area Forest Health Program Pest Management Plan 2013-2017" has been updated and revised to replace the previous version that was in effect 2008-2013. Section 24(2)(g) of the Integrated Pest Management Regulation (IPMR) requires the preparation of a Pest Management Plan (PMP) for insecticide use for the management of native insect pests on more than 50 hectares per year of public land (e.g. provincial Crown land). The Southern Interior Area Forest Health Program Pest Management Plan 2013-2017 can be found on the following web site: *http://www.for.gov.bc.ca/rsi/ForestHealth/index.htm.*

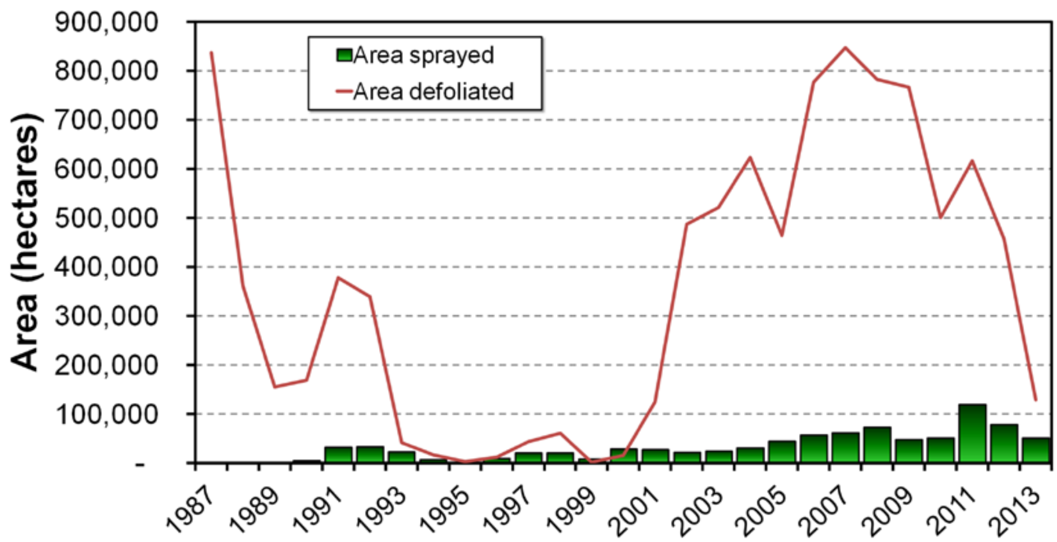


Figure 6. Annual history of spray operations for western spruce budworm compared to hectares of defoliation in the southern interior. In each year the spray occurs in June prior to the defoliation being mapped, in mid- to late-July.

Treatment Efficacy

In May and early June of each year, spray blocks and other candidate stands are monitored for timing of second instar larval dispersal, levels of bud and needle mining and to assess the synchrony of larval development with budflush. At this time, block boundaries can be adjusted where necessary depending on larval abundance and success. 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 190 trees, in 12 sprayed areas (nine in the Thompson Okanagan and three in the Cariboo) and 7 untreated control areas (four in the Thompson Okanagan and three in the Cariboo) were sampled for budworm larvae pre- and post-spray. Pre-spray samples were collected one day prior to *B.t.k.* application and post-spray samples were collected at regular intervals thereafter. Not all of the treated sites in the Thompson Okanagan Region had comparable untreated control areas nearby (e.g. similar elevation, insect density, development stage), therefore fewer unsprayed control areas were sampled and these were used as comparisons for representative treated sites. This also somewhat influenced the calculation of Abbott's corrected mortality in some instances because the control areas were not as similar in initial larval density as ultimately desired. Defoliation to new shoots (Fettes defoliation estimate) was also recorded at each of the larval sampling times.

Timing of spray is critical to obtain optimum foliage protection and maximize population reduction. Our aim is to treat blocks when larvae are predominantly 4th instar or late 3rd instar as this best achieves these goals. Figure 7 compares the abundance of larval instars, at the pre-spray sampling time, averaged over the nine treatment and four control blocks in the Thompson Okanagan Region. In all cases, 4th instars were the most abundant stage followed by 3rd instars. Shoot elongation is another critical factor used to determine optimum timing of spray application, coupled with larval development (instar). Due to the large size of spray blocks with the inherent differences in canopy structure, elevation and aspect, some areas are more or less advanced. Continual monitoring of shoot and insect development prior to spraying ensures optimal timing of the spray. Immediate feeding by budworm larvae following spray is another critical element and is contingent upon weather as well as insect-host development. Warm, dry weather immediately following spray application optimizes larval feeding, and therefore insect mortality, due to ingestion of the *B.t.k.*

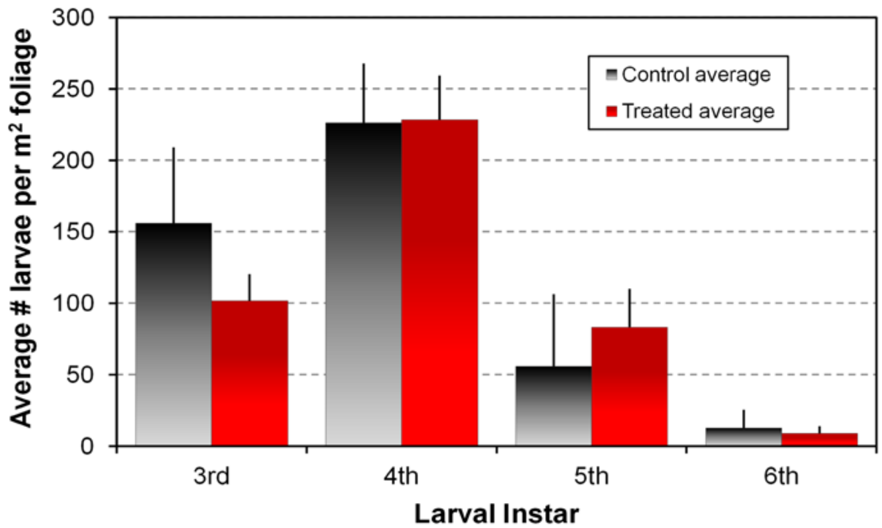


Figure 7. Average number of budworm larvae per square meter of foliage, by instar, at the pre-spray sample time (average ± S.E.) in the Thompson Okanagan Region. Total number of budworm collected at the 4 control and 9 treated sites during the pre-spray sample were averaged by instar. The percent representation of each larval instar in the control and treatment samples is also shown.

Post-spray sampling, which allows for calculation of percent larval mortality, Abbott's corrected mortality, and defoliation assessment, is conducted at 5-7 day intervals until pupae are observed in the samples. Typically, two post-spray samples have been conducted but upon studying results from many years of data, we find there is seldom significant change in calculated efficacy after the first post-spray assessment, when the insecticide applied is *B.t.k.*. When using an insecticide such as NPV (nuclear polyhedrosis virus) that has a different mode of action and takes longer to kill the insect (NPV is used against Douglas-fir tussock moth), multiple post-spray assessments are usually required to determine maximum mortality achieved due to spray treatment. In the future, to continue to streamline our program, we recommend only one post-spray assessment (at least 7 days post-spray). Larval density is standardized to foliar area for comparison across sites and sampling times. Insect density was averaged over all treatment and control sites in each region, and Figure 8 clearly illustrates the dramatic drop in budworm density from the pre-spray to first post-spray in the *B.t.k.*-treated blocks. In the Thompson Okanagan spray blocks, the average larval density (larvae per m^2 foliage) declined from 316 to 97 in the time period between spray and the first assessment. There was little change in budworm abundance at the second post-spray assessment (94 larvae per m^2 foliage) (Fig. 8). Similarly, in the Cariboo spray blocks, the average larval density declined from 264 to 41 in the time period between spray and the first assessment. There was little change in budworm abundance at the second or third post-spray assessment (34 and 27 larvae per m^2 foliage, respectively) (Fig. 8). This supports the intent to reduce efficacy assessments to two sample times: pre-spray and one post-spray. Budworm density also declined, but less precipitously, in the control sites.

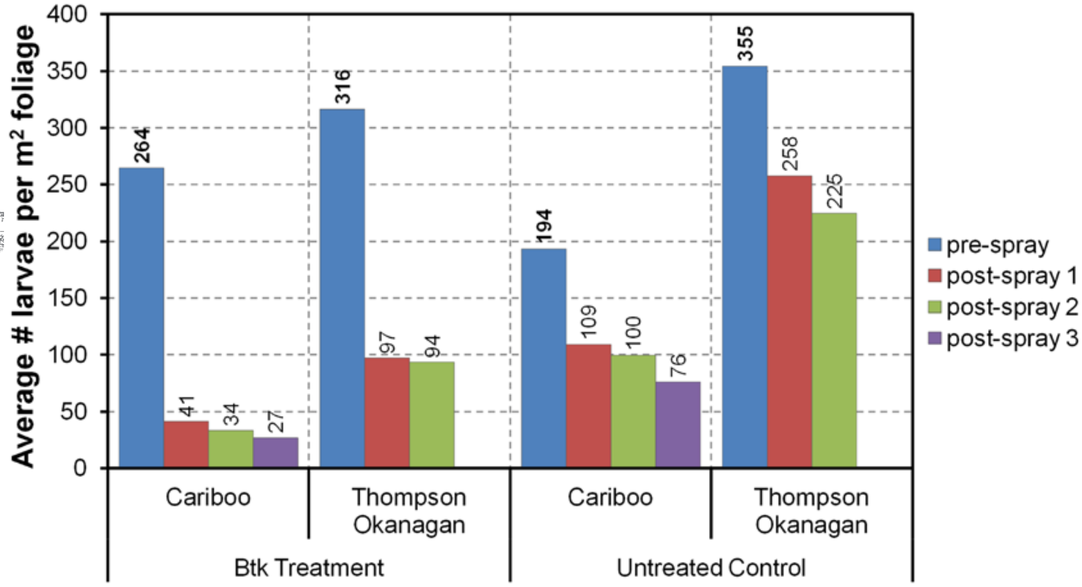


Figure 8. Comparison of budworm larval density (all instars) at the pre-spray and post-spray sampling times in the Thompson Okanagan and Cariboo Regions treated and unsprayed control areas.

The percent mortality in the Thompson Okanagan spray blocks (note: only a selection of sites within the total area sprayed were sampled) ranged from 53.2% to 76.0%, in the Robbins Range 1d and Scuito Lake 2 blocks, respectively, with an average mortality of 65.7% at the first post-spray. This compares to an average of 26% mortality in the corresponding control areas at the 1st post-spray. Abbott's corrected mortality was on average lower at 52.2% (range 18.7% to 68.9%). The corrected mortality was about the same at the second post-spray, ranging from 0% to 69.8% (Table 8).

The corrected mortality is lower than percent mortality because natural insect mortality is captured in this calculation by comparing to the mortality observed in control blocks. However, sometimes it can be higher, as in the case of the Anderson Lake sampling sites (Table 9) when the number of larvae counted is higher at later sampling times (usually due to late larval emergence, intra-tree dispersal and movement). The Anderson Lake control site had extremely high numbers of budworm larvae throughout the sampling period, ranging from 326 to 44 larvae, at the pre-spray and second post-spray respectively. Budworm density was also high in the spray block and was brought down dramatically by the *B.t.k.* application.

Feeding on the new Douglas-fir shoots is also assessed using the Fettes defoliation scale at each sampling time (Fig. 9, Table 9). The level of defoliation in the Anderson Lake control area increased from 1.0 at the pre-spray (1-20% defoliation) to 3.2 (>60% defoliation) at the second post-spray, compared to the treated block going from 0.1 (<10% defoliation) to 0.7 (<20% defoliation), at the pre-spray and second post-spray, respectively. The Bush Lake spray and control sites showed similar patterns. At the pre-spray both sites had very similar budworm populations but over the two week sampling period post-spray, the treated sites saw a significant decline in budworm density coupled with only a marginal increase in shoot defoliation, going from Fettes of 1.2 at pre-spray to 1.4 at the second post-spray (Table 9).

Table 8. The percent mortality and Abbott's corrected mortality (%) of western spruce budworm larvae due to *B.t.k.* treatment at each post-spray sampling time. The four Thompson Okanagan Region control sites were used to compare with all treatment sites in that region.

	Percent Mortality and Sampling Time					
	Uncorrected			Abbott's Corrected		
	1st*	2nd*	3rd*	1st	2nd	3rd
Thompson Okanagan Region						
Robbins Range 1d	53.2	58.6		39.3	35.5	
Robbins Range 2	68.6	73.0		59.3	57.9	
Robbins Range 3	75.4	76.3		68.1	63.1	
Scuitto Lake 1	63.3	63.8		52.4	43.6	
Scuitto Lake 2	76.0	72.1		68.9	56.5	
Guichon Creek	68.1	63.5		40.5	0.0	
Haywood Farmer	56.4	69.4		18.7	4.4	
Anderson Lake	57.7	61.2		64.1	69.8	
Bush Lake	73.0	59.3		58.7	50.4	
Robbins Range control	22.9	35.8				
Haywood Farmer control	46.4	68.0				
Anderson Lake control	**	**				
Bush Lake control	34.7	18.0				
Cariboo Region						
Block 1	77.7	76.0	82.8	30.2	15.6	39.5
Block 2	84.5	89.6	87.6	80.7	85.3	79.1
Block 3	88.8	92.2	96.5	81.2	87.0	92.6
Block 1 control	68.0	71.6	71.6			
Block 2 control	19.7	29.5	40.8			
Block 3 control	40.6	39.9	52.5			

* 1st = first post-spray sample; 2nd = second post-spray sample; 3rd = third post-spray sample
** larval numbers were higher at the two post-pray sampling times compared to the pre-spray

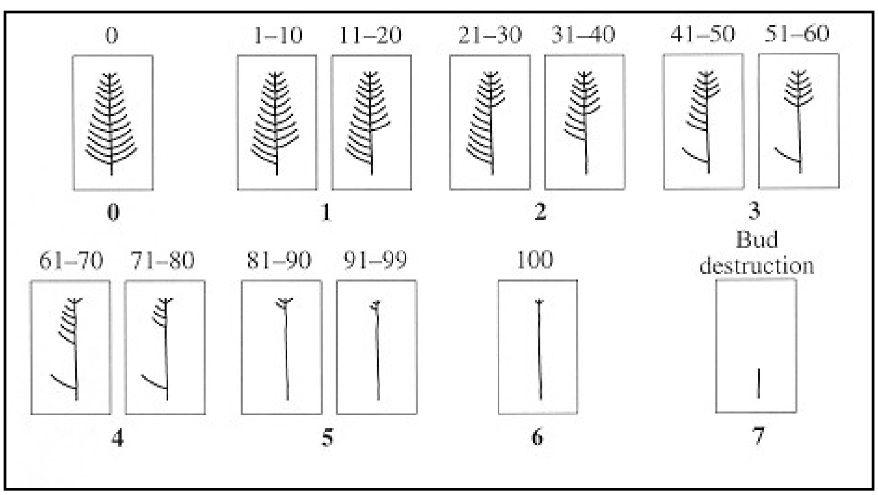


Figure 9. Fettes scale of defoliation for current year foliage. Numbers above diagrams indicate range of defoliation and the number below is the Fettes rating, with 7 being 100% defoliation with shoot destruction.

Table 9. Total number of budworm larvae and average current year Fettes defoliation for the Anderson Lake area (treated and control) at the pre-spray and two post-spray sampling times.

	Total # insects tallied			Average Fettes defoliation		
Site name	Pre-spray	1st post	2nd post	Pre-spray	1st post	2nd post
Anderson Lake *control*	326	417	444	1.0	2.2	3.2
Anderson Lake *Btk*	242	96	82	0.1	0.6	0.7
Bush Lake *control*	276	207	224	0.4	1.6	2.1
Bush Lake *Btk*	287	61	99	1.2	1.5	1.4

Trends in Western Spruce Budworm Density Over the Past Three Decades in the Thompson Okanagan Region

Larval abundance, or density, expressed as the number of larvae per square meter of foliage, is the primary factor that determines the amount of damage to trees and stands. The degree of damage incurred is tightly correlated to the timing of budflush, spring larval emergence and dispersal, and subsequent degree of budmining. When insects spend significant time in the buds, feeding prior to shoot elongation, the damage is typically more severe. When planning spray treatments, the spray should be delayed until most budworm larvae are open feeding. However, by this time significant damage has already occurred. The number of larvae per square meter of foliage is used to determine budworm population and density and gives us a way to compare damage and populations over time. Table 10 provides an overview of budworm density and Fettes defoliation at the pre-spray time in the nine years listed between 1987 and 2013. There are many other influencing factors to be considered when looking at these numbers but they give an indication of relative population trends and spray timing. What is immediately obvious is the high populations in 2011 to 2013, with the average number of larvae per square meter foliage well over 200 in all three years. Another interesting trend is the Fettes defoliation estimate at the pre-spray which is higher prior to 2011, which may indicate higher levels of budmining in these years and a shift in our spray timing to a slightly earlier instar. We have found our goal of foliage protection is increased if we can spray when a significant proportion of larvae are in their late 3rd to early 4th instar.

Table 10. Nine years of western spruce budworm data comparing larval density at the pre-spray sampling time (sites are all within the Thompson Okanagan Region).

	# sites	# larvae/m^2/tree		Fettes defoliation
Year	(10-15 trees/site)	Average±S.E.	Range	Average±S.E.
2013	19	296.8 ± 24.5	132 - 531	1.3 ± 0.2
2012	10	213.2 ± 8.4	11 - 889	1.5 ± 0.2
2011	9	221.4 ± 21.5	124 - 302	0.8 ± 0.2
2008*	3 (240 trees)	43.2 ± 4.4	0 - 246	2.0 ± 0.2
2002	10 (359 trees)	94.5 ± 7.6	0 - 624	3.6 ± 0.6
2001	11	182.6 ± 26.3	0 - 1020	1.6 ± 0.2
1997	20 (242 trees)	83.9 ± 11.4	0 - 550	3.4 ± 0.3
1996	7 (162 trees)	85.9 ± 6.8	0 - 568	2.5 ± 0.3
1987	7 (105 trees)	100.4 ± 4.2	0 - 348	

* research trial

Western Spruce Budworm Population Monitoring

A total of 563 sites in the southern interior were surveyed for western spruce budworm eggmasses in the fall of 2013. The density of new eggmasses at each site sampled, expressed as the number of new eggmasses per 10 square meters of foliage, gives an indication of potential budworm populations in the coming year and thus the expected defoliation (see right).

Number of new eggmasses per 10 square meters foliage	Predicted defoliation
0	Nil
1 – 50	Light
51 – 150	Moderate
Over 150	Severe

Thompson Okanagan Region

Of the 214 sites surveyed for budworm egg masses in the Thompson Okanagan Region, over half the sites are predicted to have the same defoliation levels in 2014 as observed in 2013. Approximately 28% of sites are predicted to have a decrease in defoliation level from 2013 and 7% of sites surveyed will increase in defoliation severity in 2014.

Of the sites predicted to have near static population levels in 2014, 67% will remain light and 33% will remain moderate. Forty-five (22%) of the 214 sites assessed predict budworm populations that will cause moderate to severe defoliation in 2014 (Table 11). The main areas of concern for 2014 include stands near Logan Lake, Leighton Creek and north of Tunkwa Lake. The other main areas of concern lie north of Kamloops on both the west and east side of the North Thompson River, around Tranquille, McQueen Lake and Jamieson Creek on the west side, and north of Heffley Lake and Edwards Creek on the east side (Table 12). These will be the main target areas for *B.t.k.* treatment in 2014.

Of the 16 sites predicted to increase in defoliation severity, 88% are increasing from light defoliation this year to moderate or severe in 2014. 83% of sites predicted to decrease in defoliation severity suffered moderate to severe defoliation in 2013. Egg mass density typically declines in sites that have been heavily defoliated for a year or more, as some moths disperse out of these stands that are highly impacted and contain trees with a lower quality and quantity of foliage available.

Table 11. Results of fall 2013 western spruce budworm egg mass sampling in southern B.C.

Resource Region and TSA	Percent of sites in each defoliation category: Nil	Light	Moderate	Severe	Total Number of sites	Average # egg masses per 10m² foliage
Thompson Okanagan Region						
Kamloops TSA	6	69	23	2	195	34
Merritt TSA	0	100	0	0	6	16
Lillooet TSA	25	75	0	0	4	9
Okanagan TSA	0	89	11	0	9	20
Region Average & Total	**6%**	**71%**	**21%**	**1%**	**214**	**32.5**
Cariboo Region						
Williams Lake TSA	15	74	9	1	140	25.1
100 Mile HouseTSA	9	67	24	0	89	36.3
Quesnel TSA	36	64	0	0	11	5.1
Region Average & Total	**20%**	**68%**	**11%**	**<1%**	**240**	**28.3**
Kootenay Boundary Region						
Revelstoke TSA	100	0	0	0	4	0
Boundary TSA	56	44	0	0	77	4.8
Cranbrook TSA	38	62	0	0	26	5.3
Region Average & Total	**65%**	**35%**	**0%**	**0%**	**109**	**4.7**

Table 12. Results of the fall 2013 western spruce budworm egg mass sampling in the Thompson Okanagan Region. List of areas sampled, by Timber Supply Area, showing average number of eggmasses per 10m^2 foliage and 2014 predected defoliation severity for each geographic area. One or more sample sites may be within each geographic area.

TSA and Geographic Area	Average # eggmasses per 10 m² foliage	2014 Defoliation prediction
Kamloops TSA		
Georges/Robbins Creek	5.9	Light
Campbell Creek	6.2	Light
Black Pines	6.5	Light
Barnes Lake East	7.1	Light
Gallager/Cornwall Creek	7.8	Light
Sabiston Creek West	8.9	Light
Lac Du Bois	9.9	Light
Mowich Lake/Trimble Creek	10.3	Light
Heffley Lk-Knouff Lk	11.8	Light
Criss Creek North	11.8	Light
Logan Lk-Tunkwa Lk	11.9	Light
Lac Le Jeune	15.5	Light
Goose Lk-Edith Lk	15.6	Light
Moulton/Pinantan	15.8	Light
O'Connor Lk	17.4	Light
Noble Creek	29.4	Light
Jamieson Creek	30.3	Light
Heffley Lake North	35.8	Light
Tranquille	38.6	Light
Dropping Water Creek	43.2	Light
Anderson Creek	46.9	Light
Knouff/Orchard/Coyote Lakes	48.1	Light
Leighton/Tunkwa Lake North	49.5	Light
Clarence lake	59.3	Moderate
McQueen Lake	59.6	Moderate
Edwards Creek	61.0	Moderate
Pinantan/Paul Lake North	64.4	Moderate
Indian Gardens	72.5	Moderate
Logan Lake South & East	72.5	Moderate
Logan Lake North	93.6	Moderate
Lillooet TSA		
Turnip Lake	9.1	Light
Merritt TSA		
Lindley Creek	15.8	Light
Okanagan TSA		
Finlay Creek	21.9	Light
Georges/Robbins Creek	7.9	Light

Cariboo Region

Of the 240 sites surveyed for budworm egg masses in the Cariboo Region, 84% (204 sites) predict nil to light levels of defoliation in 2014 (Table 11). Only two sites predict severe defoliation in 2014 and these are located at West Pasture and Lockhart Road in the Williams Lake TSA. Moderate defoliation is predicted at 13 other sites in the TSA, notably near Gaspard and the 2200 Road (Table 13). In the 100 Mile House TSA, 89 sites were surveyed, and 21 sites (24%) are predicted to incur moderate levels of defoliation in 2014 (Table 11). The highest egg mass counts occurred south of Helena Lake, south of Big Bar, north of 2400 Road, noth of Clink Lake and near Stable Creek (Table 13). All twenty-two sites sampled within the 2013 spray blocks in the Cariboo predict light defoliation in 2014.

Table 13. Summary of the fall 2013 western spruce budworm egg mass sampling in the Cariboo Region. List of sites sampled, by Timber Supply Area, that had 2014 defoliation predictions of moderate or severe, and the average egg masses per 10 m² foliage.

TSA and Sampling Site	Average # eggmasses per 10 m² foliage	2014 Defoliation prediction
Williams Lake TSA		
800A Rd. - Lockhart Rd.	56	Moderate
Pipeline Road	57	Moderate
Westwick Lakes	60	Moderate
Enterprise/San Jose	61	Moderate
Meldrum Creek	62	Moderate
2800 Rd-Gang Ranch	63	Moderate
Stack Valley Rd.	67	Moderate
South Gaspard	70	Moderate
Farwell-Gaspard Cr.	79	Moderate
Lockhart Road	81	Moderate
White Lake	83	Moderate
Gaspard/Canoe	91	Moderate
2200 Rd @ 22km	133	Moderate
Lockhart Road	152	Severe
West Pasture	172	Severe
100 Mile House TSA		
West of Big Lake	52	Moderate
South of Big Lake	54	Moderate
Goose Lake	56	Moderate
South of Big Lake	58	Moderate
Brigade Creek	60	Moderate
Jesmond	62	Moderate
N. of Moose Valley	65	Moderate
Ridge Lake	66	Moderate
Loon Creek	67	Moderate
Doug Cr.-1100 Rd	68	Moderate
West of IR2	72	Moderate
Rock Creek	73	Moderate
N. of Big Lk-Helena Lk	76	Moderate
North of Wild Goose Lakes	79	Moderate
Alberta Lake	85	Moderate
N. of Meadow Lake	89	Moderate
South of Big Bar	95	Moderate
North of Clink Lake	95	Moderate
Stable Creek	101	Moderate
South of Helena Lk	122	Moderate
N. of 2400 Rd	123	Moderate

Kootenay Boundary Region

A total of 109 sites were surveyed for western spruce budworm egg masses in the Kootenay Boundary Region. Results indicate very low populations, with 65% of sites predicting no defoliation in 2014, and 35% of sites predicting light defoliation (Table 11).

In 2007, thirteen permanent three-tree beating sample plots, formerly monitored by the Forest Insect and Disease Survey Unit of Forestry Canada, were re-established in the East Kootenays to monitor the incidence of western spruce budworm and western false hemlock looper, *Nepytia freemani* (Fig. 10). Only 2 of 13 plots were positive for western spruce budworm larvae in 2013, down from 7 positive plots in 2012. Diversity of other defoliator species was very low.

The East Kootenays do not have a long history of mapped defoliation by western spruce budworm. However, starting in 2010, significant areas of defoliation (3,130 hectares) were detected in the Flathead River drainage. This expanded to 7,167 hectares in 2011, and included areas near Grasmere. Defoliation was noted on 6,982 hectares in 2012, but only in the Flathead drainage (no defoliation near Grasmere). Populations now appear to have collapsed, with only 172 hectares of defoliation recorded in the east Kootenays in 2013. Considering climate change and Douglas-fir encroachment throughout the Rocky Mountain Trench, conditions may become even more favorable for continued expansion, and more extended periods of western spruce budworm defoliation.

Western spruce budworm populations are generally projected to decline in most areas of the southern interior through 2014. However, the historic trend indicates that within a few years budworm populations could return to outbreak levels throughout many parts of the southern interior.

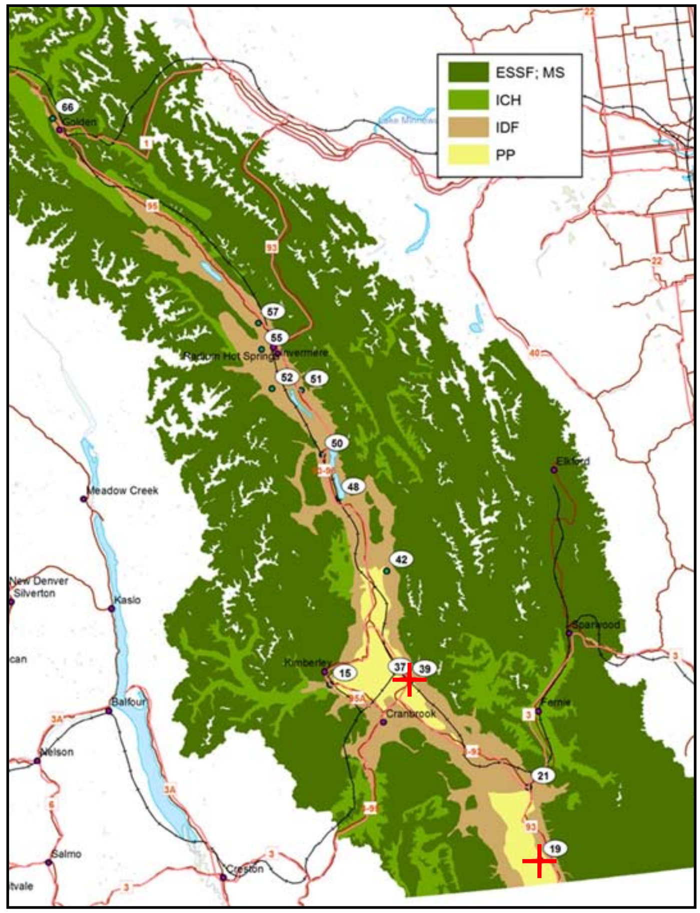


Figure 10. Location of western spruce budworm three-tree beating sites in the East Kootenays. Plots positive for western spruce budworm larvae in 2013 are marked with a ”+”.

Western spruce budworm defoliation in the Flathead River valley, Cranbrook TSA.

Douglas-fir Tussock Moth, *Orgyia pseudotsugata*

No Douglas-fir tussock moth defoliation was detected during the 2013 aerial overview survey, down from 87 hectares mapped in 2012. Defoliation by western spruce budworm may have masked any trace or light defoliation by tussock moth since their ranges overlap. Trace amounts of defoliation by tussock moth were noted while conducting ground checks in the Heffley Creek, McLure, Six Mile Ranch and south Rose Hill areas.

Douglas-fir Tussock Moth Population Monitoring

Douglas-fir tussock moth population trends are monitored at 42 permanent sample sites in the Thompson Okanagan Region, 9 sites in the Kootenay Boundary Region, and 30 sites in the Cariboo Region (Table 14) (Figure 11). The sites are located in areas with a history of tussock moth outbreaks, or in areas of anticipated range expansion. Each permanent sampling site is comprised of a six-trap cluster which is used to monitor moth populations (milk-carton sticky trap with pheromone lure) and at a subsample of these sites, three-tree beatings are performed to monitor larval abundance (31 sites in the Thompson Okanagan Region and all 9 of the sites in the Kootenay Boundary Region). The 6-trap clusters are deployed in late June through early July and are collected in early to mid-September. Three-tree beatings are conducted at the time of trap deployment. Figure 11 shows the locations of these permanent sample sites and delineates Douglas-fir tussock moth historic outbreak regions.

Douglas-fir tussock moth larvae were found at only 38% of the three-tree beating sites in 2013, compared to 59% of sites in 2012. The abundance of tussock moth larvae at the positive sites was also down significantly from 2012: 47 larvae in 2013 compared to 201 larvae in 2012. The highest number of tussock moth larvae was found at the Six Mile permanent sampling site, where 28 of the 47 larvae were collected. Two other defoliators commonly found were sawflies (*Neodiprion* species) and the green striped forest looper (*Melanolophia imitata*).

General defoliator diversity and abundance continued to decline at these sites in 2013. Western spruce budworm was the most common and abundant defoliator. It was found in 69% of sites sampled, but numbers have decreased significantly from 2012 (average of 11 larvae per positive beating site in 2013 compared to 35 larvae per positive site in 2012). This reflects the general decline in area defoliated by budworm throughout the southern interior tin 2013.

Table 14. Average number of Douglas-fir tussock moths caught per 6-trap cluster in the Thompson Okanagan Region, Boundary and Cariboo Regions. Vertical red line indicates collapse year of the last outbreak.

		Average moth catch per trap					
Site	Location	2008	2009	2010	2011	2012	2013
Kamloops							
1	McLure	65.7	4.5	25.6	40.5	29.0	7.2
2	Heffley Creek	89.8	15.8	2.0	3.3	33.4	27.7
3	Inks Lake	58.8	26.6	1.0	6.2	6.0	6.3
4	Six Mile	73.3	51.0	48.8	19.2	29.0	5.3
9	Stump Lake	61.8	15.6	22.7	79.8	0.7	0.3
10	Monte Creek	75.2	9.2	21.7	54.5	59.2	18.2
11	Chase	25.3	7.8	0	1.8	8.6	0.3
	Average of sites	64.3	18.6	17.4	29.3	23.7	9.3
Okanagan							
12	Yankee Flats	38.5	2.2	3.0	32.0	42.7	-
13	Vernon	24.8	24.3	22.0	35.2	38.2	2.0
14	Winfield/Wood Lake	38.8	50.8	34.0	14.7	6.8	0.0
15	Kelowna/June Springs	-	-	46.8	0.7	0.0	0.0
16	Summerland	43.5	13.2	0	8.5	0.5	0.0
17	Kaleden	55.4	27.7	2.9	3.7	0.3	0.0
18	Blue Lake	63.2	5.2	0	0.5	0.5	0.0
	Average of sites	44.0	20.6	15.5	13.6	12.7	0.3
Similkameen							
19	Stemwinder Park	40.2	30.7	0	0.0	0.3	0.2
20	Ashnola River	43.3	20.5	0	0.8	n/a	n/a
32	Olalla	-	-	5.7	3.7	2.0	0.0
33	Red Bridge Rec Site	-	-	0.3	0.0	0.0	0.0
34	Ashnola River Road	-	-	0	0.0	0.2	0.0
36	Lawrence Ranch	-	-	0	0.8	0.7	0.0
37	Hwy 3 Willow Heights	-	-	0	0.0	0.2	-
38	Hwy 3 Bradshaw Creek	-	-	0	3.2	0.3	2.0
39	Hwy 3 Winters Creek	-	-	0	1.2	0.8	0.2
40	Hwy 3 Nickelplate Road	-	-	0	6.2	0.0	0.4
41	Stemwinder FSR	-	-	0	3.0	0.0	0.3
42	Old Hedley Road	-	-	0	0.4	0.0	0.0
43	Pickard Cr Rec Site	-	-	0.3	2.5	1.0	0.2
44	Old Hedley Road	-	-	5.7	0.7	0.8	0.0
	Average of sites	41.8	25.6	0.9	1.6	0.5	0.3
West Kamloops							
5	Battle Creek	64.5	12.3	46.5	2.5	0.0	0.2
6	Barnes Lake	58.0	0.5	24.3	37.5	4.7	0.5
7	Carquille/Veasy Lake	59.0	13.0	38.2	54.5	16.0	27.7
8	Pavilion	40.0	15.7	7.8	82.5	3.2	0.7
21	Spences Bridge	5.7	29.5	59.3	68.5	56.0	4.0
22	Veasy Lake	-	-	27.8	68.0	16.2	16.8
23	Veasy Lake	-	-	5.6	43.3	3.3	9.3
24	Veasy Lake	-	-	6.8	76.3	14.5	29.3
25	Hwy 99	-	-	11.0	23.0	7.4	4.0
26	Venables Valley	-	-	24.3	39.7	11.5	1.2
27	Maiden Creek	-	-	3.5	8.0	3.5	0.7
28	Hwy 99	-	-	3.0	9.3	7.2	3.8
29	Cornwall 79	-	-	28.8	49.5	1.2	0.7
30	Cornwall 80	-	-	2.0	6.0	0.2	0.8
31	Barnes Lake	-	-	7.7	9.8	0.8	1.2
	Average of sites	45.4	14.2	19.8	38.6	9.7	6.7
Boundary (Avg of 9 sites)		-	4.0	2.0	73.0	1.0	0.6
Cariboo (Avg of 30 sites in 2013)*		2.3	4.0	1.7	1.6	1.4	3.6

* Average of 58 sites 2008-2012

Tussock moth trap catches declined at most permanent sample sites throughout the Thompson Okanagan Region (Figure 12). Twenty-nine of 42 sites caught fewer moths, or no moths. In the Kamloops outbreak area, 2013 marked the second consecutive year that the Heffley Creek trap site caught over 25 moths per trap (Table 14). Two consecutive years of 20-25 or more moths per trap is a threshold which indicates that an outbreak may be imminent. Ground checks were conducted near this site in July, after nearby residents reported seeing tussock moth caterpillars around their homes, and numerous larvae were observed throughout the area. A follow-up survey in the fall found spatially discrete, light levels of egg masses. Scattered larvae were found near the Monte Lake trap site but no sizable population was detected. This trap site declined to below an average of 20 moths per trap after 3 consecutive years of over the threshold trap catch.

In the West Kamloops outbreak area, three of the four trap sites near Veasy Lake continued to trap near or just above the threshold level. Tussock moth populations in this area have stayed at sub-outbreak level for the past four years with very light defoliation noted. Portions of the Veasy Lake area have been treated with *B.t.k.* for budworm, which may also keep rising tussock moth populations in check. Tussock moth populations remained at endemic levels throughout the Okanagan and Similkameen outbreak areas in 2013.

In the Cariboo Region, 21 of the 30 trapping sites saw an increase in the average number of moths caught, with only 9 sites declining (Figure 12). None of the Cariboo sites eceeded the threshold of two consecutive years of 20-25 moths per trap (Table 14). Three trapping sites south of Clinton near Bonaparte River and Alkali Lake caught ±15 moths per trap, almost doubling the average trap catch of 2012. However, ground checks did not detect any defoliation or egg masses. A significant number of tussock moths were also trapped along the east side of the Fraser River near Big Bar Creek, with trap sites 54 and 56 catching an average of 16.7 and 9.5 moths per trap per site, respectively. In 2009-2010, patches of tussock moth defoliation were mapped nearby, on the west side of the Fraser River in the Lillooet TSA.

In 2009, nine permanent sampling sites formerly monitored by the Forest Insect and Disease Survey Unit of Forestry Canada were re-established in the West Kootenays/Boundary area to monitor the incidence of Douglas fir tussock moth and other defoliating insects. Only one site recorded any tussock moth larvae in the three-tree beatings (Cascades, east of Grand Forks) whereas western spruce budworm larvae were present in all but two sites. Light budworm defoliation was observed at two sites (Kettle Valley Provincial Park and Eholt), with trace levels at three other sites. There were very few other defoliators present in the samples. Six of the nine sites caught moths in the six-trap clusters however average trap catches were very low, averaging less than three moths per trap at all sites. The overall average declined to an average of 0.6 moths per trap per site, from 2.2 in 2012.

Douglas-fir tussock moth is in the endemic to pre-outbreak phase throughout the southern interior. Monitoring will continue in 2014 in key geographic locations.

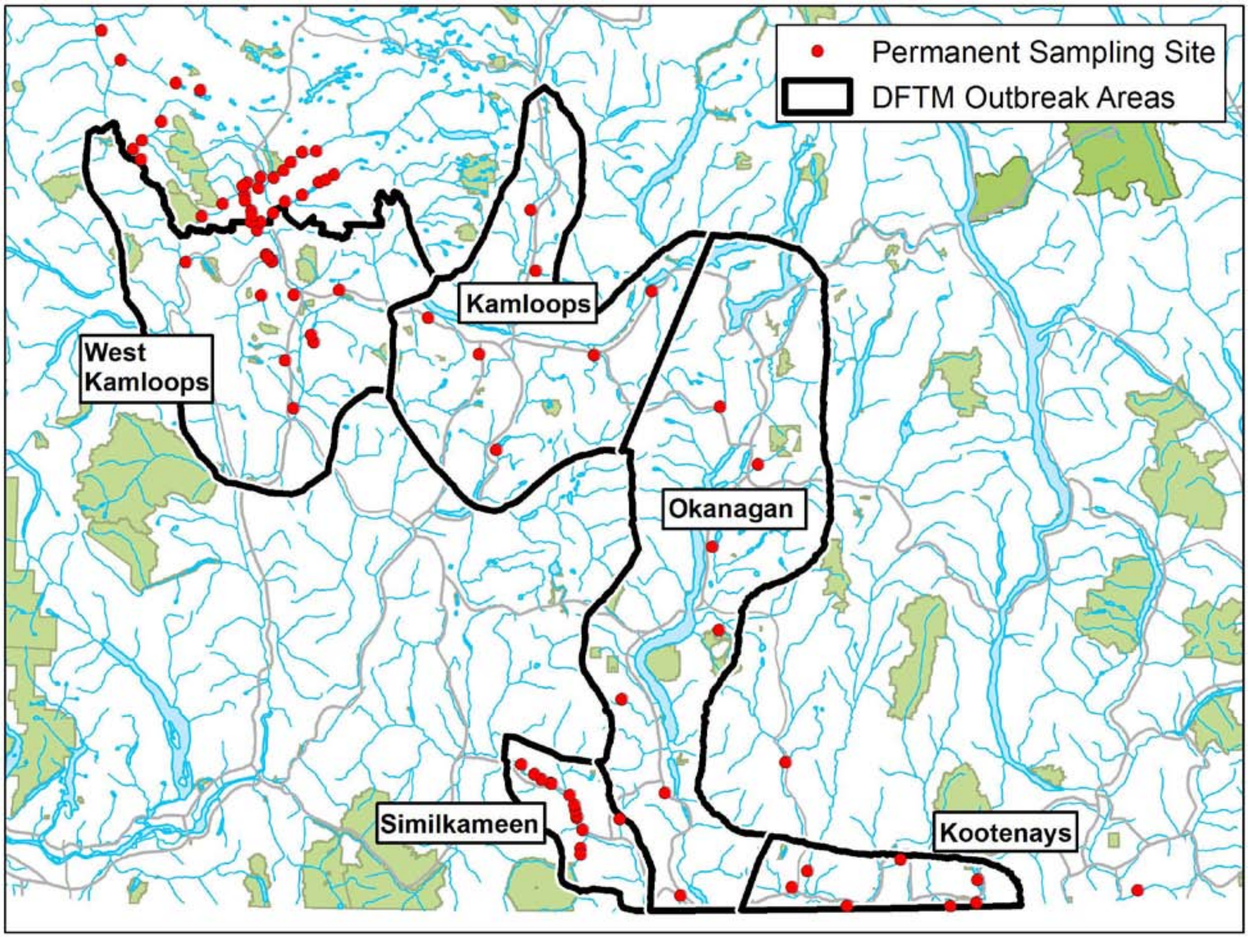


Figure 11. Location of Douglas-fir tussock moth permanent sampling sites in the Southern Interior in relation to historical outbreak areas.

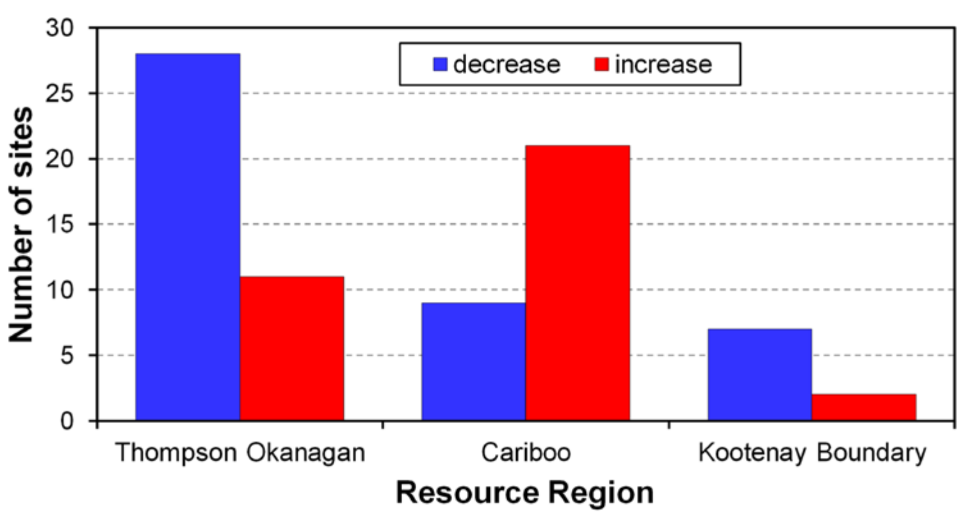


Figure 12. Number of sites showing an increase or decrease in average number of moths caught per 6-trap cluster from 2012 to 2013 in the Thompson Okanagan, Cariboo and Kootenay Boundary Regions. A decrease means there were no moths caught in either year or the number was less in 2013.

Western Hemlock Looper, *Lambdina fiscellaria lugubrosa*

Defoliation by western hemlock looper declined from 2012, to 842 hectares: 502 hectares near Carnes Creek (Revelstoke TSA); 190 hectares on the east side of Trout Lake (Arrow and Kootenay Lake TSAs); and, 150 hectares east of Rogers Pass (Golden TSA). Mortality from the most recent outbreak totalled 84 hectares and 1,094 hectares, in the Okanagan and Williams Lake TSA's, respectively.

Western Hemlock Looper Population Monitoring

Western hemlock looper and associated defoliating insects are monitored on an annual basis at several permanent sample sites in the Kootenay Boundary and Thompson Okanagan Regions using pheromone traps for moths and three-tree larval beatings. In 2013, both six-trap clusters and three tree-beatings were used at a total of 27 sites (16 in the Thompson Okanagan Region and 11 in the Kootenay Boundary Region), with two additional sites in the Kootenay Boundary Region utilizing three tree beatings only (Figure 13).

Three-tree beatings were conducted in mid July to monitor the larval populations of western hemlock looper as well as other defoliating insects. Traps were placed concurrently with the larval sampling and collected in late September to early October after moth flight is complete.

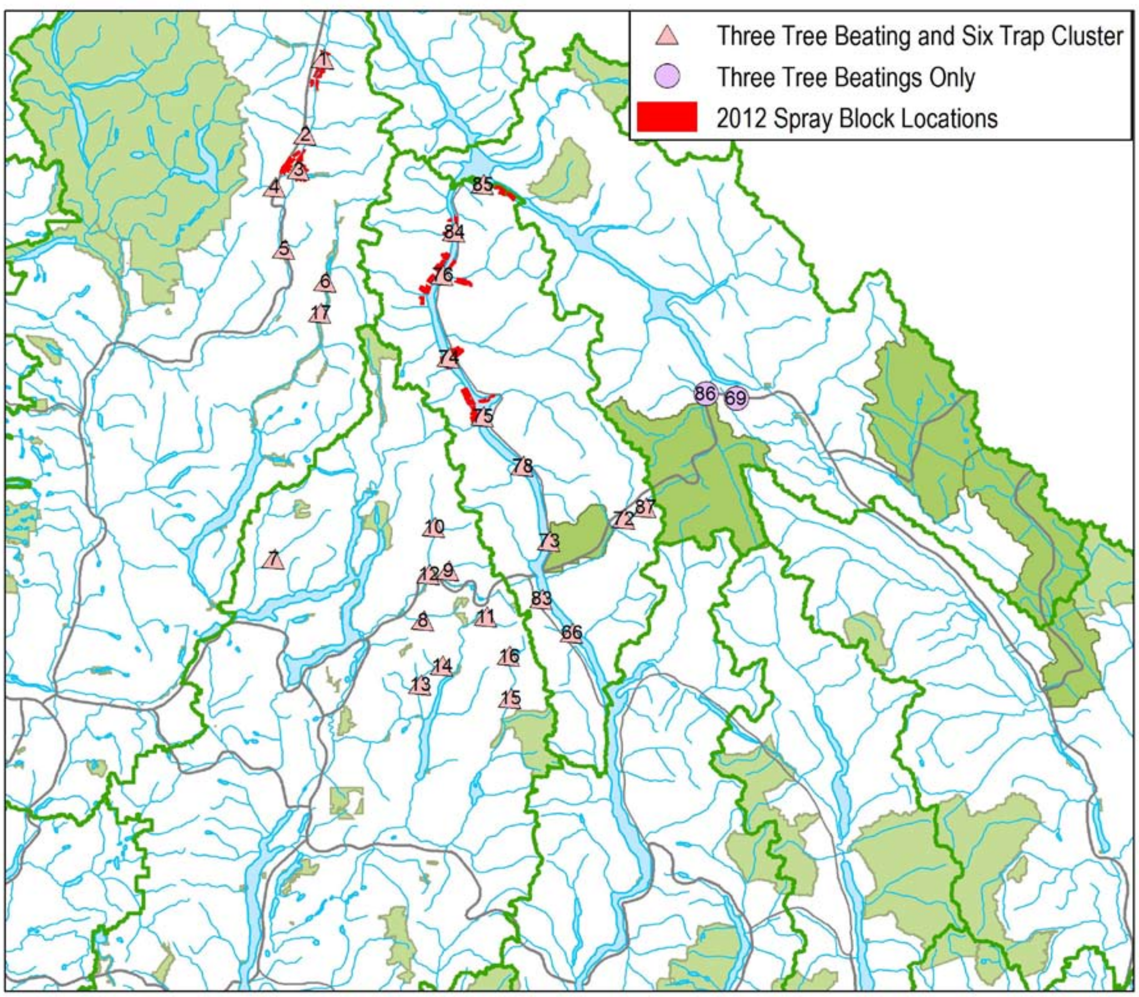


Figure 13. Location of the 2012 *B.t.k.* spray blocks for western hemlock looper in relation to six-trap clusters and three-tree beating sites in the Thompson Okanagan and Kootenay Boundary Regions.

Both Regions experienced a sharp decline in average western hemlock looper moth catches in 2013 (Figure 14). All six-trap cluster sites saw a significant decrease in the average number of moths caught per trap. However the Yard Creek, Noisy Creek, Tangier FSR, Martha Creek, Downie Creek, and Begbie Creek sites still averaged over 100 moths per trap. A number of trapping locations, or stands near these locations, were sprayed with *B.t.k.* in 2012 and subsequently saw a significant decline in the number of moths trapped in both 2012 and 2013. For example, the average catch at Site 3 (Mud Lake) declined from 876 moths per trap in 2011, to 52 in 2012, and 4 in 2013.

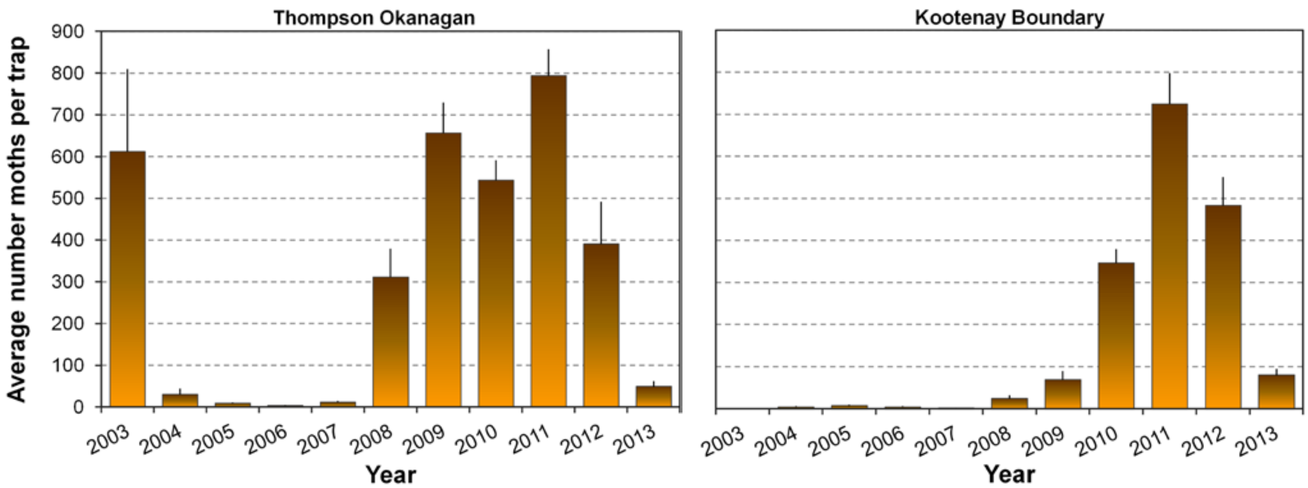


Figure 14. Western Hemlock looper annual moth catches in 6-trap clusters (average number moths per trap + S.E.) (2003-2013) in the Thompson Okanagan Region (left graph – average of 16 sites) and Kootenay Boundary Region (right graph – average of 11 sites).

Diversity and abundance of defoliating insect larvae collected in the three-tree beatings was low this year at all permanent sample sites. Western hemlock looper, blackheaded budworm (*Acleris gloverana*), and sawflies (*Neodiprion* species) were the most commonly encountered defoliating insects (Table 15). Western hemlock looper was collected more consistently in the three-tree beatings at sites in the Kootenay Boundary Region than sites in the Thompson Okanagan Region, with 92% of the Kootenay Boundary sites positive, compared to 50% of the Thompson Okanagan sites.

The average number of hemlock looper larvae per site in the Thompson Okanagan Region was 1.5, down from 9.6 in 2012. The decline at the Serpentine River, Thunder River, Mud Lake and Murtle Lake sites is likely due to the 2012 spray program. There was a spray block planned near the Finn Creek site but the block was not treated due to low larval presence at the time of spray. Populations have remained low in this area. The average number of hemlock looper larvae per site in the Kootenay Boundary Region was 11.1, down from 18.9 in 2012.

Population trends in all three categories - trapping, larval sampling and mapped defoliation - indicate that this outbreak cycle has collapsed and that hemlock looper is back to endemic levels. This outbreak cycle was minimal in terms of hectares damaged and tree mortality when compared to the severe outbreaks between 1991-93 or 2002-2006, which caused extensive hemlock mortality and topkill.

Table 15. Results of three-tree beatings at permanent sample sites in the Thompson Okanagan and Kootenay Boundary Regions.

	Western hemlock looper	Blackheaded budworm	Sawflies
Thompson Okanagan Region (16 sites)			
Total number found	24	23	66
Average number per site	1.5	1.4	4.1
Number of sites where larvae found	16	6	11
Kootenay Boundary Region (13 sites)			
Total number found	144	61	417
Average number per site	11.1	2.4	16.7
Number of sites where larvae found	12	9	12

Two-Year Cycle Budworm, *Choristoneura biennis*

Defoliation levels increased slightly from 62,360 hectares in 2012, to 72,960 hectares in 2013. Damage was widespread across eastern Quesnel and northern Williams Lake TSAs, despite 2013 being an "off" year in the feeding cycle. In the Kamloops TSA, only scattered patches of defoliation were detected, all within Wells Gray Park; however, from the ground, defoliation was fairly widespread through the Spahats Creek and Mad River areas north of Clearwater. Despite being year 1 of the feeding cycle, defoliation was significant. 2014 will be an "on" year in the feeding cycle, and as such, damage levels are expected to increase. The feasibility of operational control programs using *B.t.k.* is currently being investigated.

Pine Needle Sheath Miner, *Zellaria haimbachi*

Pine needle sheath miner damage was detected on 280 hectares in 15 separate lodgepole pine plantations, scattered across the Kamloops, Lillooet, and Okanagan TSAs. Several stands north of Kamloops have now been defoliated for three years and although impacts have not been quantified, growth loss and increased risk of attack by other secondary insects are likely.

Aspen Serpentine Leaf Miner, *Phyllocnistis populiella*

Aspen serpentine leaf miner continued to be widespread across much of the eastern Williams Lake and 100 Mile House TSAs, and the northern and central portions of the Kamloops TSA. Area affected increased from 92,160 hectares in 2012, to 114,466 hectares in 2013.

Aspen serpentine leaf miner.

Forest Tent Caterpillar, *Malacosoma disstria*

Forest tent caterpillar populations increased in the Quesnel TSA, with area affected more than doubling to 22,293 hectares. Defoliation also expanded slightly in the Shuswap area.

Birch Leaf Miner, *Fenusa pusilla*

Birch leaf miner populations remained low, with only 1,415 hectares of defoliation recorded. Most of the damage was scattered in small pockets throughout the Monashee and Purcell Ranges, and in transitional wetbelt areas in the Kamloops TSA.

Satin Moth, *Leucoma salicis*

Satin moth populations remained scattered, with damage limited to several small, widely scattered patches of trembling aspen totaling 234 hectares. The damage signature for most of these patches was atypical, with affected trees exhibiting a thinning, yellowish appearance similar to flooding damage symptoms. This is likely due to a delayed onset of feeding due to cool spring weather patterns. A stand near the 100 Mile House TSA - Kamloops TSA boundary was affected by satin moth in combination with variable levels of aspen-poplar twig blight (*Venturia* spp.) and low levels of forest tent caterpillar.

Larch Needle Blight, *Hypodermella laricis*

Despite a generally cool, wet spring and early summer, larch needle blight infection rates were lower than anticipated, with only 6,303 hectares affected. Most damage was confined to small scattered patches in the Kootenay Lake and Cranbrook TSAs. A little over half (3,365 hectares) of the damage was in alpine larch, with the balance in western larch. Several plantations in the Okanagan and Kamloops TSAs were also affected, although surrounding mature trees were generally uninfected.

Pine Needle Diseases

Lodgepole pine plantations were affected by several needle diseases. Pine needle cast (*Lophodermella concolor*) caused light damage to several plantations, totalling 180 hectares, east and south of Princeton. A *Lophodermium* species, probably *seditiosum*, was identified as the pathogen damaging two plantations in the upper Tulameen River. Finally, red band needle blight (*Dothistroma septosporum*) caused light to moderate damage to 314 hectares of plantations in the upper Adams River, Sugar Lake, and Cherry Creek areas.

Bear Damage

Mortality in young lodgepole pine stands caused by bear feeding was recorded on 4,970 hectares. The most widespread damage was in the eastern Cariboo, near Quesnel Lake, Crooked Lake, and Deception Peak. Damage was more scattered in the Kootenays and Thompson-Okanagan.

Aspen Decline

Although aspen decline symptoms continued to be widespread, especially in the Merritt TSA, many stands appear to be recovering. Visible symptoms were mapped on 1,950 hectares, down from nearly 4,300 hectares in 2012. Over the past few years, most affected stands have been coded light to moderate, which corresponds to stands with thinning tops and either no tree mortality, or light tree mortality. Many of these affected trees have re-foliated and there was no additional mortality in 2013.

Gypsy Moth, *Lymantria dispar*

MFLNRO, 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 will be deployed in the area for two years to monitor population status. In 2012, a single moth was captured in a monitoring trap near Kaslo. A delimiting grid of traps was deployed in the area in 2013, but no further moths were caught. A delimiting grid in the area will again be deployed in 2014.

Wildfire

New wildfire activity remained low in 2013, with only 7,057 hectares burned. Several areas damaged by the large fires of 2010 and 2011 in the Cariboo Region continue to exhibit additional tree mortality. Causal agents are numerous, and include Douglas-fir beetle and other secondary insects, bark scorching, crown damage, and root damage. Total area affected by this post-wildfire mortality was 6,092 hectares.

Flooding

Flooding caused extensive mortality of lodgepole pine in the west Chilcotin again in 2013. The ongoing effects of flooding are likely due to a raised water table, which in turn has been linked to tree mortality caused by mountain pine beetle. Additionally, several valley bottoms in the east Kootenays sustained severe flooding damage in the spring. Total area affected was 3,540 hectares.

Other

Other damaging agents recorded during the aerial surveys included 102 hectares of aspen-poplar twig blight (*Venturia* species), 336 hectares of landslide damage, 420 hectares of windthrow, 710 hectares of cottonwood leaf rust (*Melampsora*), 130 hectares of Douglas-fir decline, 62 hectares of fertilizer burn, and small areas of *Chrysomela* leaf beetle defoliation of poplar (50 hectares), drought (48 hectares), and avalanche damage (4 hectares).

Thompson Okanagan Region Summary

The Thompson Okanagan aerial overview surveys were conducted between July 15th and July 30th, 2013, and required 55.1 hours of flight time over 13 days. Surveys covered the Kamloops, Lillooet, Merritt, and Okanagan TSAs. Good conditions prevailed for most of the surveying. All surveys were conducted by Kevin Buxton (Ministry of Forests, Lands, and Natural Resource Operations) with assistance from Joan Westfall (Entopath Management) and Tim Ebata (Resource Practices Branch). The surveyors utilized a Cessna 206, operated by Westair Aviation out of Kamloops.

Kamloops TSA

Bark Beetles

Western balsam bark beetle infestations remained widespread, at 71,782 hectares. Most of the affected stands were in the northern half of the TSA, in Wells Gray Park, and around the Raft River, Mad River, Dunn Peak, upper Adams River, Cayenne Creek, and Kwikoit Creek areas.

Western balsam bark beetle, TFL 18, Kamloops TSA.

Spruce beetle infestations declined, in both extent and severity. Area affected was down from 1,886 hectares in 2012, to 1,502 hectares in 2013, and the proportion of infestations rated as moderate to severe declined from over 60% to 25%. Salvage harvesting has limited spread in the upper Mow Creek - Criss Creek area, although that infestation has moved into new stands in Porcupine Meadows Park. Beetle populations continued to be active in the Cahilty Creek and lower Wells Gray Park areas, producing small scattered pockets of mortality.

Douglas-fir beetle infestations remained scattered but widespread across the southern portions of the TSA. Larger patch infestations was down slightly to 236 hectares, with another 247 separate spot infestations. Aggressive trap tree use and salvage harvesting over the past several years has helped reduce beetle populations in several areas. Scattered single tree blowdown events in spring have led to concerns that populations could re-build. Funnel trapping activities are planned for the spring of 2014 in several old-growth management areas.

Mountain pine beetle activity was at its lowest level in many years, with only 67 hectares of trace to light attack recorded.

Conifer Defoliators

Western spruce budworm defoliation south of Kamloops.

Damage from **western spruce budworm** declined in the TSA, in both extent and severity of defoliation. Area affected was down from 38,375 hectares in 2012, to 31,411 hectares in 2013, while the area of moderate to severe defoliation fell from 12,600 hectares to just over 3,500 hectares. Much of this decline was due to the treatment of nearly 29,800 hectares with Foray 48B (*B.t.k.*). Only 10% of the treated stands sustained visible defoliation. Egg mass sampling conducted in the fall of 2013 indicates that the highest populations in 2014 will be in the Durand Creek, Indian Gardens Creek, Paul Lake, Isobel Lake, O'Connor Lake, and Watching Creek areas.

Two-year cycle budworm damage was low, as 2013 was an "off" year in the feeding cycle. Light defoliation was recorded on 1,135 hectares in Wells Gray Park. Defoliation was also visible from the ground throughout the Spahats creek and Mad River areas.

Pine needle sheath miner populations remained high in the Jamieson Creek area, where several different lodgepole pine plantations suffered light to moderate defoliation. New damage was seen in a stand near Paxton Lake. Total area affected in the TSA was 159 hectares.

Deciduous Defoliators and Decline Syndromes

Aspen serpentine leaf miner damage increased by nearly 60%, to 44,104 hectares. The most widespread defoliation was mapped in lower Wells Gray Park, with scattered patches common throughout the Raft River, Mad River, Adams River, Louis Creek, and North Thompson areas. **Forest tent caterpillar** caused light to moderate defoliation of aspen on 1,335 hectares near Harper Creek and Cayenne Creek. **Birch leaf miner** damage was down, being mapped on just 307 hectares in the Fadear Creek and Louis Creek areas. **Satin moth**, in combination with variable levels of **aspen-poplar twig blight** (*Venturia spp.*) and low levels of forest tent caterpillar, defoliated 20 hectares of aspen on the Kamloops - 100 Mile House TSA boundary near the upper Deadman River.

Damage from **Aspen decline** syndrome declined in 2013, to 151 hectares. Most of the stands with symptoms were in the Hat Creek area. Other stands affected in 2012 appear to have recovered.

This damage signature was a result of satin moth and aspen-poplar twig blight. Near Vidette Lake, on the border of Kamloops and 100 Mile House TSAs.

Foliar Diseases

Dothistroma needle blight continued to affect several lodgepole pine plantations, covering 110 hectares, in the upper Adams River. No tree mortality has resulted from these infections, but some trees are showing signs of growth reductions. **Cottonwood leaf rust** was also visible in low lying areas along the upper Adams River, with a total affected area of 220 hectares. **Larch needle blight** continued to affect a stand of larch near Raft Peak; however damage levels declined and only 3.5 hectares were mapped.

Other

Several other damaging agents were recorded during the aerial surveys. **Bear feeding** caused scattered mortality and top kill on 109 hectares of lodgepole pine plantations near Jamieson Creek and Blue River. Sixty-two hectares of mixed Douglas-fir, cedar, and hemlock were damaged by **fertilizer burn** near the loading site in Spahats Creek. Damage signatures included a reddening and loss of needles and dead tops of all tree species in a pattern radiating in one direction from a large landing. Several other minor abiotic factors were observed including **wildfire** (2,944 hectares), **post-wildfire mortality** (65 hectares), **flooding** (15 hectares), **slide damage** (9 hectares) and **windthrow** (8 hectares).

Damage caused by fertilizer burn, Spahats Creek, Kamloops TSA.

Merritt TSA

Bark Beetles

Most **mountain pine beetle** activity was confined to the southeast portion of the TSA near Red Creek and McNulty Creek. In most other areas of the TSA, populations have either collapsed due to host depletion and extensive salvage harvesting, or are very scattered in high elevation, low hazard stands. A total of 3,517 hectares of new red attack was mapped in patches, nearly all of which was classified as trace and light.

W**estern balsam bark beetle** populations remained stable, with a slight increase from 9,220 hectares in 2012, to 10,352 hectares in 2013. Nearly all attack was classified as trace. Most affected stands were scattered across the southwestern parts of the TSA, near Whipsaw Creek, Granite Creek, Spius Creek, and the Tulameen River.

Area affected by **spruce beetle** was unchanged at 870 hectares. Most infested stands were in the Pasayten River, Placer Creek, Willis creek, and Paul Creek areas.

Although **Douglas-fir beetle** populations remained relatively low, there was an increase in small spot infestations especially in the Otter Creek and Allison Creek areas. Attack levels also increased slightly around Chapperon Lake and Beak Creek. Overall area affected was 65 hectares, with an additional 570 trees killed in 108 spot infestations. A wind event in late April resulted in scattered single tree blowdown in several areas. This may lead to further localized population increases.

Douglas-fir beetle infestation east of Chapperon Lake, Merritt TSA.

Defoliators

Western spruce budworm populations declined, with visible defoliation falling by over 90% to just 1,680 hectares. The decline can be attributed to two years of aggressive *B.t.k.* spray programs and cool, wet weather this spring. All of the 2013 defoliation was classified as light. Populations are expected to remain low in 2014.

Other defoliating insects mapped in 2013 included 2,050 hectares of trace to light **aspen serpentine leaf miner** near Princeton and Douglas Lake, and 19 hectares of light **satin moth** near Spius Creek.

Deciduous Decline Syndromes

Aspen decline symptoms, similar to those observed in the western United States, remained widespread throughout the central areas of the TSA, especially at low elevation, dry sites adjacent to grasslands. A total of 1,580 hectares were affected, nearly 700 hectares of which exhibited bare tops and occasional tree mortality.

Foliar Diseases

A needle blight infection affected several low elevation lodgepole pine stands near Stemwinder Mountain, Larcan Creek, and Sunday Summit. A total of 181 hectares were lightly defoliated. Two lodgepole pine stands covering 62 hectares in upper Podunk Creek exhibited light foliage discoloration; the main causal agent was identified as the needle blight ***Lophodermium seditiosum***, combined with other minor needle damage likely caused by other unidentified pathogens and/or environmental stress.

Other

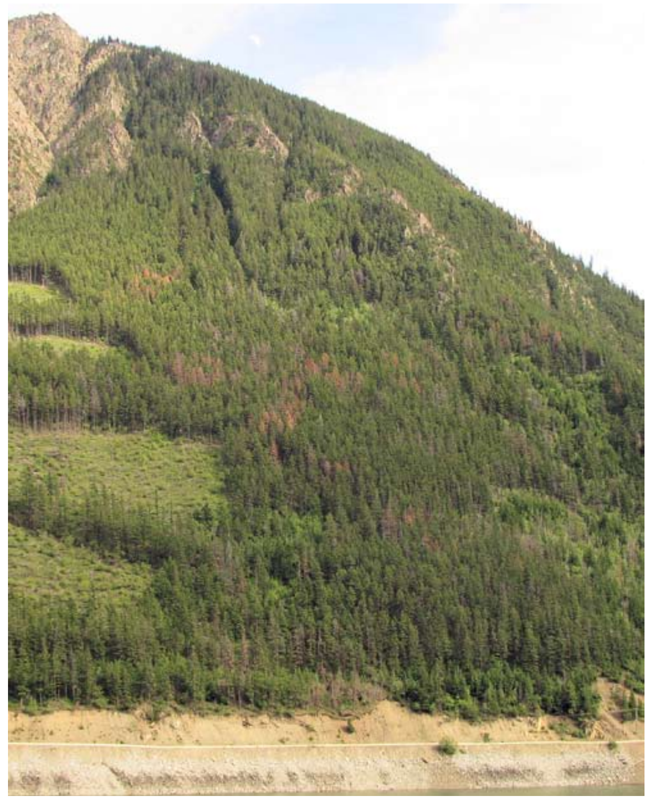
Approximately 182 hectares of **wildfire mortality** was mapped.

Lodgepole pine plantation showing signs of pine needle cast infection, Stemwinder Creek, Merritt TSA.

Lillooet TSA

Bark Beetles

Mountain pine beetle populations remained active across much of the TSA, although most infestations were small and scattered at high elevations or in smaller diameter stands. Total area affected was 4,852 hectares, with 90% of the attack classified as trace and light. Ground checks revealed low green attack levels for 2013. Just over 900 hectares of the affected area was in whitebark pine stands in the Tyaughton Creek, Gun Creek, and Hurley River areas.



Douglas-fir beetle along the south side of Carpenter Lake, Lillooet TSA.

Douglas-fir beetle populations were up in the TSA, with the number of small spot infestations more than doubling from 165 to 360. An additional 40 small patches covered another 440 hectares. Most of the increased activity was along the west side of the Fraser River, and around Carpenter Lake, Marshall Lake, Downton Creek, and the upper Stein River.

Spruce beetle activity declined, from 660 hectares in 2012, to 290 hectares. Attack was scattered in small patches near Cayoosh Creek and Mission Ridge, and a new infestation was mapped in Paradise Creek.

Western balsam bark beetle populations remained relatively low with only 2,625 hectares of trace to light attack recorded. Infestations were scattered across high elevation stands in the southern portions of the TSA.

Top-kill resulting from western spruce budworm defoliation, Gun Lake, Lillooet TSA.

Defoliators

Western spruce budworm populations were down in most areas, due to a combination of *B.t.k.* treatment and cool, wet spring weather. Mapped defoliation fell from 34,440 hectares in 2012, to just 1,660 hectares in 2013. Most affected stands were in the Mission Pass and Laluwissin Creek areas. **Aspen serpentine leaf miner** defoliation was limited to 505 hectares, **and pine needle sheath miner** lightly defoliated three lodgepole pine plantations (40 hectares) in the upper Hurley River.

Other forest health damaging agents observed during the aerial surveys were 110 hectares of **aspen decline** near Botanie Creek and Pavilion Creek, 100 hectares of **post-wildfire mortality** (mainly of lodgepole pine and Douglas-fir), 35 hectares of new **wildfire** activity, 40 hectares of light **pine needle sheath miner** damage to a lodgepole pine plantation in the Hurley River drainage, and 18 hectares of **flooding damage**.

Okanagan TSA

Bark Beetles

Area affected by **mountain pine beetle** fell by over 75% to 10,588 hectares, with the number of small spot infestations falling by over 20% to 524. Populations collapsed in most areas on the west side of Okanagan Lake, leaving just a few remnant patches of red attack around Trout Creek, and scattered ponderosa pine mortality near Peachland and Summerland. Populations also declined on the east side of Okanagan Lake. However, patches of red attack continued to be widespread in the Aberdeen Plateau, Mission Creek, Highway 33, Penticton Creek, Winnifred Creek, and West Kettle River areas. Three lodgepole pine plantations (totalling 33 hectares) near Ideal Lake suffered light attack. Most red attack in the south Okanagan remained scattered, as either small patches or spot infestations. Extensive live, susceptible pine still exists across much of the south and southeast portions of the TSA and there is the potential for expansion of mountain pine beetle populations.

Douglas-fir beetle populations continued to expand in the TSA, with affected area totalling 905 hectares in 50 small patches and 450 spot infestations. Red attack increased most significantly in the Chase Creek, Turtle Valley, Seymour Arm, and Lumby-Cherryville areas, and a number of small infestations were recorded in the south Okanagan near Penticton Creek, Shuttleworth Creek, and Keremeos Creek. The scattered nature of the infestations, coupled with minimal salvage harvest activity has made management activities difficult.

Area affected by **western balsam bark beetle** declined from 65,415 hectares in 2012, to 50,770 hectares in 2013. Attack remained widespread, especially in the Graystokes, Winnifred Creek, Hunters Range, Scotch Creek, and TFL 49 areas.

A few new patches of **spruce beetle** were observed near Silver Star Mountain, Graystokes Park, and Crater Mountain, while scattered infestations continued in and around Easygoing Creek and Young Creek. A total of 350 hectares were affected, up from 215 hectares in 2012.

A small patch of mid-aged lodgepole pine near Celista Creek was lightly attacked by an unidentified species of **engraver beetle** (*Ips* spp.).

Conifer Defoliators

Western spruce budworm populations fell across the TSA, due to a combination of natural factors, a cool, wet spring, and an extensive spray program in 2012. Visible defoliation was down more than 98% to just 1,765 hectares. The cool, wet spring weather in 2013 resulted in a late larval dispersal in many areas, which led to a "bottom-up" defoliation pattern. This type of defoliation pattern is especially difficult to detect during aerial surveys and was an additional factor in the decline in area mapped. Limited egg mass sampling was carried out in the TSA in 2013. Sites surveyed in the Peachland Creek area predict light defoliation for 2014.

Western hemlock looper populations crashed and no new defoliation was detected. However, a few stands (totalling 84 hectares) near Humamilt Lake and Larch Hills experienced tree mortality of approximately 15% tree mortality. No defoliation is expected in 2014.

Pine needle sheath miner continued to defoliate lodgepole pine plantations in the Gleneden Fire, although severity was light. New defoliation was observed near Glen Lake, west of Peachland. Populations in other previously affected stands have declined to non-damaging levels. Total area affected in 2013 was 83 hectares.

Deciduous Defoliators

Area affected by **aspen serpentine leaf miner** remained nearly unchanged, at 8,130 hectares. Affected stands were scattered across the central and northern parts of the TSA. **Forest tent caterpillar** populations increased near Ross Creek, Seymour Arm, Humamilt Lake, and the Perry River. Defoliation was mapped on 3,390 hectares, up from 450 hectares in 2012. **Satin moth** was active in several small pockets near Shingle Creek, Bear Creek, McCulloch Road, and upper Mission Creek. Total area affected was 170 hectares.

Left: scattered patches of satin moth defoliation, Liddell Road, Okanagan TSA. Below: satin moth larvae emerging from egg mass.

Foliar Diseases

Larch needle blight damage was confined to a few widely scattered western larch plantations totalling 260 hectares near Trinity Valley, Hidden Lake, and Kwikoit Creek. **Dothistroma needle blight** was detected on 205 hectares of lodgepole pine plantations near Reiter Creek, Cavanaugh Creek, Cherry Creek, and Outlet Creek. Damage levels were light. **Cottonwood leaf rust** affected 490 hectares of black cottonwood in low-lying areas near Seymour Arm, Malakwa, Mabel Lake, and Cherryville.

Other damaging agents recorded during the aerial surveys included 92 hectares of **birch leaf miner** in Sitkum Creek, 130 hectares of **Douglas-fir drought-decline complex** near Sugar Lake, 110 hectares of **bear damage** to lodgepole pine plantations, 212 hectares of **wildfire**, 28 hectares of **flooding damage**, and 27 hectares of **aspen decline**. During ground checks, locally high levels of **fall webworm** were noted, although damage was generally limited to shrubs and domestic fruit trees.

Fall webworm near Yankee Flats Road, Okanagan TSA.

Monitoring Activities

District staff completed an additional nine Stand Development Monitoring samples in 2013. This brings the total number of samples to 24 over the past four years.

Kootenay Boundary Region Summary

The Kootenay-Boundary portion of the surveys required 98 hours over 18 days of flying, between July 22nd and August 16th. Weather conditions and visibility were generally good, with thunderstorm activity and smoke causing some delays in the latter portions of the survey period. Surveys covered the entire landbase of the Arrow, Boundary, Kootenay Lake, Cranbrook, Invermere, Revelstoke, and Golden Timber Supply Areas. The surveyors were Neil Emery and Adam O'Grady of Nazca Consulting Ltd. Surveyors used a Cessna 337 Skymaster operated by Babin Air.

Arrow TSA

Bark Beetles

Area affected by **mountain pine beetle** continued to decline, dropping from 2,260 hectares in 2012, to just 834 hectares in 2013. At the same time, the number of small spot infestations remained high, at 302. Most red attack was scattered across the Lower Arrow Lake, Rossland, Trail, Castlegar, and Sheep Creek areas. **Douglas-fir beetle** activity increased, with numerous new infestations near Pend D'Oreille River, Beaver Creek, Slocan Lake, and Beaton Arm. Total area affected was 452 hectares, with the number of small spot infestations increasing from 22 to 140. **Western balsam bark beetle** attack was mapped at trace levels on 1,515 hectares.

Defoliators

Western hemlock looper populations increased to damaging levels along the east side of Trout Lake, where 107 hectares were moderately to severely defoliated. **Aspen serpentine leaf miner** defoliation was mapped on 2,130 hectares near New Denver and Trout Lake. **Birch leaf miner populations** remained low, with light defoliation mapped on 105 hectares in South Fostall Creek. Eighty hectares of moderate **western spruce budworm** defoliation was detected in a mixed stand at Caribou Creek. This area has no previous record of western spruce budworm; the causal agent was confirmed by a ground check.

Foliar Diseases

Larch needle blight infestation rates declined, from 9,060 hectares in 2012, to just 675 hectares in 2013. Most of the affected stands were near Erie Creek and Big Sheep Creek.

Several other minor damaging agents were mapped during the aerial surveys, including 384 hectares of **bear damage** to lodgepole pine and western white pine plantations, 50 hectares of ***Chrysomela* leaf beetle** defoliation in a mixed poplar stand east of Castlegar, 277 hectares of **wildfire**, 36 hectares affected by **landslides**, 19 hectares of **windthrow**, and 14 hectares of **flooding damage**. Twenty-four hectares of western red cedar in a mixed cedar-hemlock stand in Rioulx Creek sustained moderate damage to upper crown foliage; ground checks indicate that **drought** was the likely cause.

Above: drought-damaged western red cedar, Rioulx Creek, Arrow TSA.

Left: western spruce budworm defoliation, Caribou Creek, Arrow TSA.

Boundary TSA

Bark Beetles

Mountain pine beetle attack north of Conkle Lake, Boundary TSA.

Mountain pine beetle populations continued to increase, with red attack area up over 50% to 21,253 hectares. Attack is very scattered but also widespread across nearly all areas of the TSA, with 440 patches. Nearly 700 small spot infestations mapped.

Western balsam bark beetle activity was limited to 1,035 hectares in the Granby River and Rendell Creek areas, and **Douglas-fir beetle** populations remained low, with one 13-hectare patch and 27 spot infestations mapped.

Defoliators

Area defoliated by **western spruce budworm** declined sharply, from over 43,000 hectares in 2012, to 1,250 hectares in 2013. Affected stands were scattered in several locations, near the Granby River, Arlington Lakes, Christina Lake, and Boundary Falls. Egg mass sampling carried out in the fall indicates that population will remain low in 2014.

Western spruce budworm defoliation near Paulson Pass, Boundary TSA.

Other damage detected during the aerial surveys were 133 hectares of **larch needle blight**, 18 hectares of **bear damage** to a lodgepole pine plantation south of Lightning Peak, and 14 hectares of **windthrow**.

Kootenay Lake TSA

Bark Beetles

Mountain pine beetle populations continue to decline overall, with affected area down from 5,225 hectares in 2012, to 3,750 hectares in 2013. In general, red attack was increasingly scattered, with nearly 375 separate infestations recorded, and nearly 80% of all attack classified as trace or light. Suppression activities have continued in the southeast portion of the TSA, where abundant green, unattacked pine remains.

Douglas-fir beetle activity remains at low levels in the TSA, with 220 hectares of red attack mapped in 11 patches and 71 spot infestations. A slight increase in activity was seen around the north end of Kootenay Lake. **Western balsam bark beetle** attack remained scattered, with only 466 hectares recorded.

Defoliators

Moderate to severe **western hemlock looper** defoliation was recorded along the southeast side of Trout Lake. Area affected totalled 83 hectares. **Aspen serpentine leaf miner** damaged increased in the Meadow Creek area, with 2,017 hectares of light to moderate defoliation recorded. **Birch leaf miner** damage was down, with only 82 hectares of light to moderate defoliation near Duncan River.

In 2012, a single **European gypsy moth** was caught in a pheromone trap near Kaslo. A delimiting grid was deployed in the area in 2013, but no further moths were trapped. This delimiting grid will again be deployed in 2014.

Foliar Diseases

Larch needle blight infection rates declined, with affected area falling from 8,540 hectares in 2012, to 2,255 hectares in 2013. Three-quarters of the affected stands were alpine larch, the balance being western larch.

Several other minor forest health factors were detected during the surveys, including 170 hectares of **bear damage** to lodgepole pine plantations, 262 hectares of **wildfire**, 70 hectares of **windthrow**, and eight **landslides** that affected 70 hectares.

Cranbrook TSA

Bark Beetles

M**ountain pine beetle** populations continued to drop in the Cranbrook TSA. Total red attack area was down nearly 50% from 2012 levels, and nearly 80% from 2011 levels, to 2,510 hectares. The number of small spot infestations also declined, from 345 to 292. Attack levels east of the Rocky Mountain Trench continued to show significant declines, with only a few scattered patches of mortality being mapped. Attack also declined around Kimberley, and in the Redding Creek, St. Mary River, and Moyie River areas. The 53,000 hectare Perry-Moyie Beetle Management Unit has been upgraded from Holding Action to Suppression in response to population declines in the area.

Douglas-fir beetle remained in small, scattered patches, with most of the activity in the Elk River and Kookanusa Lake areas. A total of 162 hectares of attack were recorded, in nine patches and 62 small spot infestations.

Area affected by **western balsam bark beetle** increased from 790 hectares in 2012, to 1,340 hectares in 2013. Most of the attack was east of the Rocky Mountain Trench, in the Bull River and lower Elk River areas.

Defoliators and Foliar Diseases

As expected, **western spruce budworm** populations in the Flathead River area declined in 2013. Area affected declined from nearly 7,000 hectares in 2012, to just 172 hectares in 2013. Eggmass sampling conducted at 27 sites indicates that budworm populations will remain low in 2014. **Aspen serpentine leaf miner** was active in the Elk River valley, with 1,055 hectares of light to moderate defoliation mapped. **Birch leaf miner** defoliation was limited to a single 74 hectare patch in the upper Elk River. **Larch needle blight** damage was mapped on 2,555 hectares, in small patches of both western and alpine larch, scattered across the Elk River, St. Mary River, Flathead River, and Wardner areas.

Other damaging agents mapped during the aerial surveys included 405 hectares of **bear damage** in lodgepole pine stands, 400 hectares of **flooding** damage, 175 hectares of **wildfire**, 94 hectares of **windthrow**, and seven **landslides** which damaged 56 hectares of timber.

Invermere TSA

Bark Beetles

Area affected by **mountain pine beetle** was up from 8,225 hectares to 9,950 hectares thus reversing the declining trend which has been seen since infestations peaked in 2010. Most red attack was mapped in and around Buhl Creek, Skookumchuck Creek, and Findlay Creek, as well as in the Spillmacheen River and Bobbie Burns Creek areas, where nearly 2,000 hectares of whitebark pine stands were attacked. Attack levels fell in and around the Bugaboo Creek, Frances Creek, and Horsethief Creek areas, where the Steamboat and Dunbar-Templeton Beetle Management Units have been upgraded from Holding Action to Suppression.

Douglas-fir beetle continued to be active in Kootenay National Park and along the lower Kootenay River. A total of 490 hectares of attack were mapped in 25 patches and 66 small spot infestations. The **spruce beetle** infestation in the North White River/Fenwick Creek area expanded significantly, from 550 hectares in 2012, to 2,130 hectares in 2013. Attack intensity was high, with over 90% of the infested areas being rated as moderate or severe. Nine beetle management units, totalling nearly 300,000 hectares of the TSA landbase, were downgraded from Suppression to Holding Action strategy for spruce beetle. **Western balsam bark beetle** attack increased across much of the TSA, although most infestations remain small and scattered. Area affected totalled 4,050 hectares, with most of the areas classified as trace.

Defoliators and Foliar Diseases

Defoliator activity was low in the TSA, with 179 hectares of **aspen serpentine leaf miner** recorded. **Larch needle blight** levels were also low, with 350 hectares mapped.

Other damaging agents mapped during aerial surveys were 395 hectares of light **bear damage** in lodgepole pine plantations, 250 hectares of severe **flooding damage** in the Cross River and upper Palliser River areas, 58 hectares of **windthrow**, 26 hectares of **wildfire**, and 10 **landslides** that damaged 130 hectares.

Golden TSA

Bark Beetles

Mountain pine beetle activity remained low in the TSA in 2013. Most of the red attack was within Yoho National Park and in scattered pockets in the Blaeberry River and Valenciennes River valleys. A total of 3,070 hectares and 54 spot infestations were mapped. **Douglas-fir beetle** activity also remained low, with three patches totalling 190 hectares and 18 small spot infestations. Most activity was in Yoho National Park. **Spruce beetle** was again detected in the Quartz Creek area on 64 hectares; however the infestation does not appear to be expanding. **Western balsam bark beetle** infestations remained scattered and of low intensity. 2,630 hectares were affected, with most infestations classified as trace.

Defoliators

Western hemlock looper defoliation was again detected in Glacier National Park, just east of Rogers Pass and in Ursus Creek. Damage was limited to 150 hectares, and no treatments are planned for 2014. **Aspen serpentine leaf miner** was again widespread throughout the Rocky Mountain Trench around Golden, where 3,685 hectares of trembling aspen were defoliated. **Birch leaf miner** levels increased slightly to 315 hectares, most of which was in the Wood Arm and Gold River areas.

Other damaging agents noted during the aerial surveys were 72 hectares of **larch needle blight** affecting alpine larch in Kootenay National Park, 145 hectares of light **bear damage** in lodgepole pine plantations, 93 hectares of **wildfire**, and small areas of **flooding**, **windthrow**, and **landslide** damage.

Black bear feeding damage to plantation-aged lodgepole pine near Kinbasket Lake, Golden TSA.

Revelstoke TSA

Bark Beetles

Bark beetle activity remained low in the TSA in 2013. Damage was limited to 150 hectares of **mountain pine beetle**, 233 hectares of **western balsam bark beetle**, and 77 hectares plus 20 small spot infestations of **Douglas-fir beetle**. Limited salvage harvesting of Douglas-fir has been taking place near Revelstoke.

Defoliators

Western hemlock looper moderately to severely defoliated 500 hectares of western hemlock near Carnes Creek in areas not sprayed with *B.t.k* in 2012. Populations are declining and no further defoliation is expected in 2014.

Most other visible defoliator activity was on broadleaf species. **Aspen serpentine leaf miner** lightly defoliated 1,208 hectares of trembling aspen north of Revelstoke, while 440 hectares of **paper birch** were affected by **birch leaf miner** in the Akolkolex River valley. **Western spruce budworm** defoliation was limited to one small 15-hectare patch north of Carnes Creek.

The only other forest health agents detected during the aerial surveys were small areas of **wildfire**, **flooding**, **windthrow**, and **landslide** damage.

Aspen serpentine leaf miner damage to cottonwood, Revelstoke TSA.

Cariboo Region Summary

The Cariboo portion of the aerial overview surveys required 135.3 hours of flight time, over 26 separate flights between July 22nd and August 8th. Conditions were generally favorable with good visibility. The surveys covered the entire landbase of the Cariboo Chilcotin Resource Region, as well as adjoining portions of the West Coast, South Coast, Omineca, and Skeena Resource Regions. 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

Area affected by **western balsam bark beetle** declined from nearly 20,000 hectares in 2012, to 4,945 hectares in 2013. Most attack occurred within Bowron Lake Provincial Park and around the Wells/Barkerville area. **Douglas-fir beetle** activity declined in the Victoria Creek and Swift River areas, with area affected in patches falling from 1,570 hectares in 2012 to 160 hectares in 2013. However, activity increased in the Nazko and Blackwater River areas, where wildlife habitat, visual quality, and access issues limit management options. District staff will conduct funnel trapping for Douglas-fir beetle in the Nazko area in 2014. **Spruce beetle** populations remained relatively low in the TSA, with only 170 hectares of trace and light attack in Bowron Lake Provincial Park. **Mountain pine beetle** was limited to four small spot infestations.

Defoliators

Despite 2013 being an "off" year in the feeding cycle, the area defoliated by **two-year cycle budworm** was at its highest levels of the last five years. A total of 54,250 hectares of light defoliation was recorded. Typically, odd numbered years produce peak defoliation in the Prince George TSA to the north, and minimal defoliation in the Quesnel TSA. This extensive defoliation may be indicative of a either very high population levels, or an influx of insects on an odd-year cycle from the Prince George TSA. Further assessments in 2014 should help to determine population trends and status.

Forest tent caterpillar populations increased, with defoliation mapped on 17,250 hectares in the Blackwater, Dragon Mountain, Gravelle Ferry, and Cottonwood House areas. Damage intensity remained low, with over 90% of the defoliation classified as light.

Aspen serpentine leaf miner affected aspen, mostly in mixed stands, on 7,820 hectares. Damage decreased in the eastern portion of the District, but increased in the Tsacha Lake and Euchiniko River areas.

Less than 50 hectares were lightly defoliated by **western spruce budworm**. Damage levels will remain very low in 2014 in the TSA, based on eggmass sampling results.

Other

Several stands of lodgepole pine and Douglas-fir in and around the 2010 Tsacha Lake fire continued to suffer additional **post-wildfire mortality**. Total area affected was 995 hectares, including 160 hectares of plantations.

Other damaging agents recorded were: 175 hectares of **bear damage** to lodgepole pine plantations, 266 hectares of **wildfire**, 230 hectares of **flooding damage**, and small areas affected by **aspen-poplar twig blight** (*Venturia* spp.) and **landslides**.

Black bear feeding damage in a lodgepole pine plantation near Quesnel Lake, Quesnel TSA.

Williams Lake TSA

Bark Beetles

Mountain pine beetle continued to decline, with only 2,565 hectares of new red attack recorded. Populations remain very scattered, in small pockets throughout the Chilko Lake, upper Taseko River/Taseko Lake, upper Churn Creek, and Dash Creek areas. Reproductive success of the beetle has been very low in these areas, as most of the pine stands are at high elevations and consist of small-diameter stems.

Red attack levels of **Douglas-fir beetle** declined overall across the TSA, from 6,850 hectares in patches and 887 spot infestations in 2012, to 2,035 hectares in patches and 580 spot infestations in 2013. Most decline was seen in the northeastern portion of the TSA, where red attack levels dropped sharply. Elsewhere in the TSA, red attack levels increased especially along the Chilcotin River, Taseko River, and Chilanko River valleys, and around Puntzi Lake and Meldrum Creek. Ground surveys in the Chilcotin have found red-to-green ratios in excess of 40 green attack trees to 1 red attack tree, with some reconnaissance coming back at 80:1. The large wildfires fires of 2009 and 2010 were likely a primary contributor to this burgeoning population. Limited attack may have occurred after the fires in 2010. In 2011 and 2012, many fire scarred and stressed trees were attacked by Douglas-fir beetle. 2013 marked year three post-fire, where fire-scarred trees were no longer suitable habitat for Douglas-fir beetles, resulting in the spread to green trees. Many scattered pockets of green attack throughout the eastern and northeastern portion of the TSA are likely due to population build-up triggered from small fires, although to a lesser extent than observed in the Chilcotin.

Due to most populations being in a two-year cycle, lower levels of **spruce beetle** were detected, with affected area dropping from 18,000 hectares in 2012, to 4,100 hectares in 2013. It is expected that high levels of attack will be detected again in 2014. Due to poor access and steep ground, little salvage harvesting has occurred.

Western balsam bark beetle populations were again widespread throughout the Chilcotin and Columbia mountain ranges, although total area affected declined by 30%, from 27,130 hectares in 2012, to 19,030 hectares in 2013. Attack intensity also declined, as the proportion of stands with more than 1% red attack fell to 27%.

Defoliators

Western spruce budworm defoliation extent and severity continued to decline throughout most of the TSA. The affected area dropped from 79,600 hectares in 2012, to 39,695 hectares in 2013. Less than 500 hectares of moderate defoliation was mapped, with the balance classified as light. This decline is due to a combination of aggressive spray programs in 2011, 2012, and 2013, and natural factors. Population levels are expected to remain low in 2014, with only 15 of 140 eggmass sampling sites predicting moderate or severe defoliation.

Western hemlock looper populations that were active in the Quesnel Lake area collapsed partway through the season in 2012, and no new defoliation was observed in 2013. Tree mortality due to defoliation was mapped on nearly 1,100 hectares along both shores of Quesnel Lake, between Lynx Creek and Peninsula Bay. The affected stands suffered between 5% and 40% mortality.

As in the Quesnel TSA, **two-year cycle budworm** defoliation was recorded on the largest area of the past five years (16,800 hectares), despite 2013 being an "off" year in the feeding cycle. Whether this is an indication of a general population increase, timing of larval and tree/bud development, or an influx of insect population from areas in the Prince George TSA that are on an odd year cycle, is unknown at this time. Most of the defoliation was in the Likely, Keithley Creek, and North Arm Quesnel Lake areas.

Aspen serpentine leaf miner damage continued to expand, with total area affected up from 21,800 hectares in 2012, to 32,685 hectares in 2013. Most of the affected aspen is a component of mixed stands and as such most areas were rated as light. Defoliation was most extensive around Quesnel Lake and the Horsefly River. Defoliation was also recorded across much of the West Chilcotin, although affected stands tended to be small and very scattered.

Forest tent caterpillar was observed defoliating 320 hectares of aspen near Tezla Lake. Most of the defoliation was moderate, but no tree mortality is expected.

A single **European gypsy moth** was caught in a pheromone trap at the McLeese Lake campground. A delimiting grid will be deployed in the area for the next two years to monitor the population.

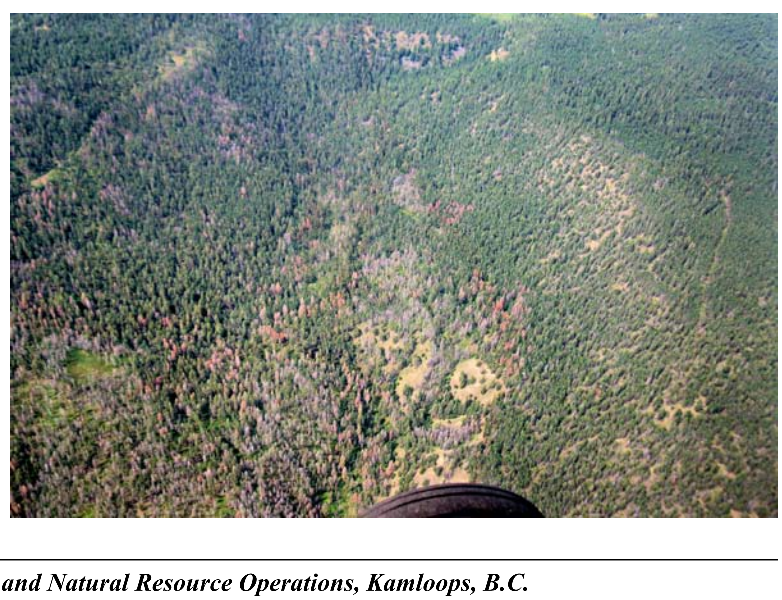
Other

Several areas of leading lodgepole pine and/or Douglas-fir affected by 2009-2010 wildfires continue to exhibit additional **post-wildfire mortality**. Most of the mortality has been in trees which experienced fire damage to roots, stems, and/or crowns and have subsequently been attacked by Douglas-fir beetles and other secondary bark beetles. The severity and extent of this mortality has declined from last year's high of over 6,000 hectares, to 4,457 hectares, over three-quarters of which had only light or trace mortality levels.

Extensive **flooding damage** to lodgepole pine was recorded throughout the west Chilcotin. Most of the affected area consisted of small, scattered patches along the low lying floodplain of the Dean River drainage, between Anahim Lake and Kleena Kleene. Total affected area was 2,520 hectares. **Wildfires** damaged nearly 2,500 hectares with the largest fires near Itcha-Ilgachuz Provincial Park, Riske Creek, and Farwell Canyon.

Damage to lodgepole pine plantations from **bear feeding** was common in the eastern portion of the TSA in 2013, especially around Bill Miner Creek and Killdog Creek near the eastern end of Quesnel Lake, around Likely and Kiethley Creek, and in the Horsefly River area. A total of 44 separate plantations were affected, totalling 2,820 hectares.

Other damage noted during the aerial surveys included small areas of **engraver beetles** (22 hectares) in lodgepole pine, **aspen-poplar twig blight** (13 hectares), **windthrow** (22 hectares), **avalanche damage** (4 hectares), and **aspen decline** (12 hectares).



Post-wildfire mortality in Douglas-fir, Till Lake, Williams Lake TSA.

100 Mile House TSA

Bark Beetles

Douglas-fir beetle declined overall in the TSA, from 3,345 hectares in 2012, to 290 hectares in 2013. Another 83 small spot infestations were mapped. A significant drop in red attack was seen throughout the Lac La Hache to Canim Lake area. Most of the current red attack was in and around the Canoe Creek, Big Bar, Kelly Lake, and Loon Lake areas.

Spruce beetle attack was mapped on 415 hectares in 2013, down from 10,900 hectares in 2012. A synchronized two-year life cycle in the TSA tends to produce large fluctuations in area exhibiting tree fade, although indications from ground work are that spruce beetle populations are overall stable and high.

Western balsam bark beetle activity remained largely confined to the northeast portion of the TSA. Just over 1,900 hectares of trace attack was recorded near Coffee Lake and Spanish Creek.

Mountain pine beetle activity was limited to two small spot infestations.

Defoliators

Area defoliated by **western spruce budworm** remained nearly unchanged, at 50,205 hectares. Most of the affected stands were in the Big Bar Creek, Canoe Creek, and Exeter areas. Aerial spraying of several blocks near Big Bar Creek and Dog Creek helped reduce defoliation intensity, limiting moderate or severe defoliation to less than 6% of the total area. Egg mass sampling results indicate that defoliation intensity may increase slightly in 2014, with 21 of 89 sampling sites predicting moderate defoliation.

2013 was an off year in the life cycle of **two-year cycle budworm**, and visible defoliation was limited to 770 hectares near Hendrix Lake.

Aspen serpentine leaf miner damage to aspen continued to be widespread in the northeast portions of the TSA, around Canim Lake. Total affected area was 8,905 hectares.

Satin moth, mixed with variable levels of **aspen-poplar twig blight**, severely defoliated 26 hectares of aspen east of Vidette Lake, along the 100 Mile House TSA - Kamloops TSA boundary.

Other damage observed during the aerial surveys were 240 hectares of **bear feeding damage** to lodgepole pine plantations near Deception Creek, 475 hectares of **post-wildfire mortality** of Douglas-fir and lodgepole pine within and bordering the 2009 Kelley Lake wildfire, 48 hectares of new **wildfire** activity, 70 hectares of light to moderate **aspen decline**, and 15 hectares of **flooding** mortality.

Satin moth (upper photo) and aspen-poplar twig blight (lower photo) were both present in an aspen stand east of Vidette Lake on the border of the 100 Mile House and Kamloops TSAs.

Armillaria Root Disease Trials: Gaining 33 Years of Insight

Michael Murray, Forest Pathologist, Kootenay Boundary Region

Root disease caused by *Armillaria* is one of the most widespread and impactful forest health agents in Southern Interior BC. In the Kootenay-Boundary Region, this disease challenges forest management due to its ability to increase following harvest, reduce tree growth and cause mortality, especially in young regeneration. In unmanaged forests, where *Armillaria* is endemic, it plays an important role in forest ecosystems through its ability to weaken or kill trees, and contribute to stand structure, forest succession, decomposition, and nutrient cycling processes. However, from a timber production perspective, *Armillaria* can reduce volume within plantations by 25% or more. Because smaller trees tend to be most prone to rapid mortality from this disease, young plantations (5-20 years old) are especially vulnerable.

The removal of stumps soon after harvest has been commonly practiced in the southern interior of BC since the early 1990s. Until recently, the effectiveness of stumping in limiting root disease had been under-studied. Although some evaluative trials were established in the 1980s, results have been limited. This is because *Armillaria*-induced mortality within a plantation tends to peak between 12-20 years old, thus requiring considerable time for relevant findings to emerge.

A young western red cedar killed by Armillaria root disease.

Since the 1980s, the Southern Interior and adjacent northwestern USA have accumulated the largest collection of root disease research trials in the world. Each trial is typically divided spatially into separate treatments (stumps removed and stumps retained) with some variations (e.g. roots raked, trees planted 1.5 meters from any stump). At several sites, an additonal treatment relies on the application of a potential biocontrol (*Hypholoma fasiculare*) on stumps. The most commonly measured tree responses are growth (height and diameter) and incidence of forest health agents (e.g. root disease).

A considerable number of plantation trials are now of sufficient age to yield measurable amounts of *Armillaria* incidence. During 2011-2013, twelve trials were surveyed in the Kootenay Boundary and Thompson Okanagan regions (Table 1). Trees were examined for *Armillaria* root disease and other agents, as well as diameter and height. The resulting dataset is composed of nearly 30,000 trees, representing eight conifer species. Analysis began in December, 2013. The earliest findings indicate that there is less root disease wherever stumps were removed. Subsequent analysis of this dataset will help answer questions such as: Which tree species are more resistant to root disease? Which treatment is most beneficial to height and diameter growth? How does treatment affect stocking levels? How much less root disease occurs in stumped treatments? Answers to these questions will provide useful guidance for plantation managers.

Table 1. Research trials surveyed between 2011 and 2013.

Trial name and geographic location		
Big White (Beaverdell)	Knappen Creek (Grand Forks)	Phoenix Creek (Grand Forks)
Boundary (Westbridge)	Marl Creek (Golden)	Rover LTSP (Nelson)
Columbia West (Golden)	McPhee LTSP (Castlegar)	Sutherland (Christina Lake)
Gates Creek (Golden)	Nine Mile (Canal Flats)	Zibin's Woodlot (Christina Lake)

White Pine Blister Rust Inoculation Trials for Whitebark Pine

Michael Murray, Forest Pathologist, Kootenay Boundary Region

During the past several years, demand for disease resistant whitebark pine (*Pinus albicaulis*) seedlings has grown in Canada. Seedlings are used for restoration by parks, mines, and First Nations. Burned, disturbed, and harvested Crown land is increasingly being re-planted with whitebark pine. In 2012, whitebark pine was designated as a federally endangered species in Canada. With a federal recovery strategy being drafted now, it is likely that the dissemination of disease-resistant trees will be a key component of the strategy.

The artificial inoculation of seedlings is a commonly applied step in the screening process to identify genotypes (or parent trees) of pines that are resistant to the blister rust fungus (*Cronartium ribicola)*. The successful white pine (*P. monticola*) program has resulted in re-establishment of this valuable species. Although applied operationally in the USA, there have been no artificial inoculations of whitebark pine conducted in Canada until the effort reported here. During August, a team of MFLNRO staff consisting of Randy Armitage, Vicky Berger, Michael Murray, Ward Strong, and Nick Ukrainitz gathered at Kalamalka Forestry Centre near Vernon, B.C. to initiate some trials.

Seedlings representing 10 whitebark pine families were entered into screening. An additional family represents a susceptible 'control'. Each family consists of 50 individuals. To produce inoculum (basidiospores), we relied on leaves collected from a cultivated currant hedge of *Ribes nigrum* (Ben variety) located at the Ministry's nearby Skimikin Seed Orchard (Tappen, BC).

Michael Murray prepares seedling chamber for an inoculation run.

A successful inoculation run was achieved in the greenhouse chamber meeting the target spore load of approximately 3,000 spores/cm^2. These methods were replicated for the same 10 families at the US Forest Service Genetic Resource Center, Dorena, Oregon. Thus, we will be able to compare results by annually assessing these seedling families for signs of blister rust over the next several years. Seedlings from an additional 30 families are ready to be inoculated during the summer of 2014.

Publications

Murray, M.P. and J. Krakowski. 2013. Silvicultural options for the endangered whitebark pine. Silviculture Magazine. Winter: 22-23.

Long-Term Impacts of *Dryocoetes confusus* on Subalpine Fir Forests in Southern B.C.

Lorraine Maclauchlan, Forest Entomologist, Thompson Okanagan Region

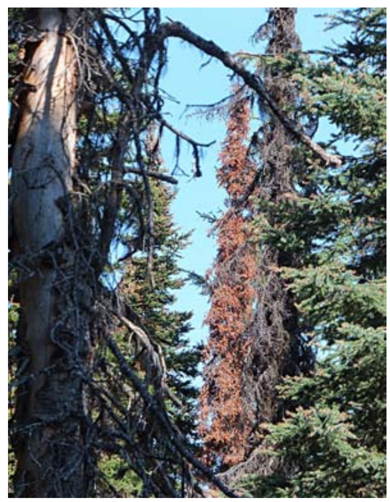
The western balsam bark beetle (*Dryocoetes confusus* Swaine, Coleoptera: Scolytinae) is the major cause of subalpine fir mortality in B.C. (Garbutt 1992). *D. confusus* selectively kills small groups of subalpine fir at relatively low, but constant, levels every year in infested stands. Over time, the cumulative mortality can be significant and *D. confusus* is considered the primary successional force in these high elevation forests (Maclauchlan and Brooks 2004; Stock 1991; Unger and Stewart 1993).

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

The specific events that trigger insect outbreaks and allow some bark beetles to kill healthy hosts are the subject of numerous studies, but are not well understood for many species. *D. confusus* attacks and colonizes large diameter, standing live trees that often suppressed or showing reduced growth compared to other trees, and occasionally downed subalpine fir. The selective and patchy distribution of mortality suggests that *Dryocoetes* may be limited by the abundance and distribution of susceptible hosts, as well as by climatic conditions. Successfully attacked trees typically have slower growth rates, smaller crowns and belong to the older cohort, but are not necessarily the biggest trees. The increased susceptibility of older trees seems to be associated with senescence and declining host vigour (Bleiker *et al*. 2003). Trees with low vigour are slower growing and produce less secondary resin, which results in beetles having higher successful attack rates compared to vigorous, faster growing trees with more resin production (Bleiker *et al*. 2005).

In the southern interior of B.C., *Dryocoetes confusus* typically displays a 2-year life cycle. New adults emerge in late June at temperatures greater than 15°C. Males find a suitable host tree through primary attraction and excavate a nuptial chamber beneath the bark. There, beetles release the aggregation pheromone, exo-brevicomin, which attracts females to the tree. Males are polygamous, and mate with 3-4 females. The females excavate egg galleries, laying single eggs in niches. The eggs hatch that same summer. In mid-August to early September there is a smaller second flight comprised primarily of re-emerged second year adults. Adults overwinter in the galleries. The following spring, females continue laying eggs until June when they emerge to re-attack the same tree or to choose a new one. Normally the insect requires two years to complete development. Western balsam bark beetle has a close association with a fungus (*Grosmannia dryocoetidis* = *Ceratocystis dryocoetidis*), which is transmitted to the colonized trees.

Evidence of old Dryocoetes attack: two parent gallery systems.



Photograph on left shows defoliation of new growth by Choristoneura biennis; photograph on right shows stand with both C. biennis and D. confusus activity.

Background and Project Description

This study continues to expand on the investigation of the ecology of *D. confusus*, describing the temporal and spatial outbreak dynamics and the relationship to stand succession. Ten permanent sample plots were established between 1998-2002, with an eleventh (final) plot established in 2012. Plots are located within the ESSFwc, ESSFmw, and ESSFxc biogeoclimatic zones. The final plot (Raft River) was established to investigate the interaction between *Dryocoetes confusus* and two-year cycle budworm (*Choristoneura bienni*s (Freeman), Lepidoptera: Tortricidae). The two-year cycle budworm periodically defoliates Engelmann spruce, white spruce, Engelmann-white spruce hybrid, and subalpine fir.

All plots are one hectare in size. All trees within the plot that were greater or equal to 15 cm diameter at breast height (dbh) were tagged, stem mapped, measured and assessed for forest health agents and damage. Data collected included: dbh of all trees; a sub-sample of heights and ages (increment core taken); tree status (live/dead/down); pest incidence; and, detailed information on western balsam bark beetle attack. At the time of plot establishment, only standing trees were tagged and assessed (live or dead). All tagged trees were stem mapped. In subsequent assessments, new fall down was recorded to obtain an estimate of tree fall over time.

In 2013, nine plots (the Scotch Creek and Raft River plots were assessed in 2011 and 2012, respectively) were assessed for *D. confusus* attack, fall down and any other new forest health agents or damage. At establishment, the stands in which plots were located were classified as early, mid- and late-phase succession as related to the dynamics of *Dryocoetes* attack in the stand. The validity of this early assessment will be discussed.

Point pattern analysis was conducted on stem map data, looking at the spatial distribution of live trees and combinations of dead or down trees. Nearest neighbour distances were used to calculate the Clark-Evans Donnelly test (Clark and Evans 1954) for spatial randomness with corrections for edge effects (Donnelly 1978). The Clark-Evans Donnelly test (CED) uses nearest neighbour (NN) distances to measure the extent to which the density of mapped points varies within a sampled area, and determine the assess the pattern (uniform, random., or aggregated) of sampled points. The CED is compared to the Z-value for normal distributions; CED values of less than 0 indicate a tendency towards an aggregated distribution of mapped points, and positive values indicate a tendency towards a regular pattern of points. The statistic is considered a simple but powerful test for spatial randomness of points distributed in 2 dimensions, where n is > 7 within an area "with a reasonably smooth boundary" (Donnelly 1978, Sinclair 1985).

Results and Discussion

These data reflect 11-16 years of monitoring stand dynamics of subalpine fir forests (Table 1). *D. confusus* continues to be the most dominant mortality factor in all plots with total attack in stands ranging from 25% to over 53% (Table 1). Total mortality in stands, which combines trees killed by *D. confusus* as well as trees killed by other or unknown causes, is much higher, ranging from a low of 16% in the new Raft River plot to 72% in the Buck Mountain plot (Table 1). Many of the trees classified as dead from other causes may actually have been killed by *D. confusus*, but due to decay or absence of galleries on the lower bole where the assessment is conducted, mortality cannot be definitively attributed to *D. confusus*.

Table 1. List of permanent sample plots (one hectare in size) established to monitor attack dynamics of *Dryocoetes confusus* in subalpine fir forests. Attributes listed are: geographic location; biogeoclimatic zone (BEC); number of years from plot establishment to last assessment; percent mortality (all trees) since establishment; average percent annual mortality; percent subalpine fir killed by *D. confusus* at final assessment; percent dead trees in 2013 (all species); and, the attack phase assigned to each plot at establishment.

Plot Name	BEC	Years since establishment	subalpine fir mortality since plot establishment: total mortality all causes	subalpine fir mortality since plot establishment: annual mortality all causes	Total % Bl killed by *D. confusus*	Total % dead all species	attack phase at establishment
Spius Crk-1	ESSFmw	12	5.0%	0.5%	30.7%	41.9%	early
Spius Crk-2	ESSFmw	12	18.6%	1.7%	25.5%	38.0%	early
Martin Cr	ESSFwc 2	14	38.6%	3.0%	37.0%	53.8%	early
Scotch Cr	ESSFwc 2	11	18.6%	1.9%	35.8%	66.1%	mid- to late-
Sicamous Crk	ESSFwc 2	16	26.7%	1.8%	51.9%	63.0%	mid- to late-
Torrent Crk	ESSFwc 2	16	14.2%	0.9%	26.0%	39.0%	mid- to late-
Cherry Crk	ESSFwc 4	16	9.2%	0.6%	53.1%	60.3%	mid- to late-
Buck Mtn.	ESSFxc	15	38.0%	2.7%	44.3%	72.0%	early to mid-
Home Lk-1	ESSFxc	15	39.9%	2.9%	53.1%	67.3%	early to mid-
Home Lk-2	ESSFxc	15	35.0%	2.5%	47.9%	71.2%	early to mid-
Raft River*	ESSFwc 2	new	N/A	N/A	24.9%	16.3%	early

* Data from 2012 evaluation

The new Raft River plot will not be included in the following discussion as it was only established in 2012. Overall, plots within the ESSFmw incurred the lowest *D. confusus* mortality and total mortality, with the two Spius Creek plots averaging 28% mortality from *D. confusus* and 40% mortality in total (Table 1). By comparison, the two Home Lake plots located in the ESSFxc have very high mortality from *D. confusus* (average 51% for the two plots) and total mortality (average 70% for the two plots). Annual mortality ranged from 0.5% annually (Spius Creek-1) to 3.0% annually (Martin Creek) (Table 1). Except for the Martin Creek plot (early phase), the highest annual mortality rates were observed in plots classified at establishment as "early to mid-phase". This classification was a subjective label based on age, tree size, density and relative activity of *D. confusus* in the stand at the time of plot establishment.

Red, grey, and healthy subalpine fir.

The Martin Creek plot had the highest stem density (Table 2), and was the youngest of the original ten plots at establishment, while Cherry Creek had the lowest density and Spius Creek-2 the oldest subalpine fir. The Martin Creek plot had the lowest annual fall down rate of subalpine fir, representing approximately 0.2% of all stems per year. One subalpine fir in the Martin Creek plot had a bole infection of *Pineus abietinus* Underwood and Balch. Due to concerns surrounding the movement and colonization of Balsam woolly adelgid, *Adelges piceae* (Ratz.), a sample was sent for verification to Dr. Gabriella Zilahi-Balogh, Canadian Food Inspection Agency, Kelowna, B.C. Buck Mountain and the two Home Lake plots had the highest rates of subalpine fir fall down (Table 2) at 10 stems per hectare and greater. The rate of fall down seems to increase with increasing mortality in stands. The majority of down trees were killed by *D. confusus*. Very few live trees have fallen within these plots.

Pineus abietinus on tree #993 (subalpine fir) in the Martin Creek plot.

Kevin Buxton at Martin Creek plot tree #993 showing excised samples of adelgid.

Table 2. The table lists total trees per plot (all species), average age of subalpine fir at plot establishment, annual fall down rate of subalpine fir and the percent this represents of total original plot trees (all species) in ten permanent sample plots.

	Num. trees at establishment (all spp.)	Avg. age of Bl (± Std Dev.)	Annual fall down rate of Bl	
			stems per hectare	percent of total trees at establishment
Spius-1	784	164 ± 35	7	0.8%
Spius-2	840	162 ± 22	6	0.7%
Martin	1,417	70 ± 18	2	0.2%
Scotch	723		10	1.3%
Sicamous	930	118 ± 31	7	0.8%
Torrent	597	115 ± 44	3	0.6%
Cherry	496	108 ± 27	6	1.3%
Buck	1,316	103 ± 18	13	1.0%
Home-1	1,200	129 ± 32	10	0.8%
Home-2	1,312	108 ± 24	11	0.9%

Blowdown in the Spius Creek - 2 plot.

Figure 1 shows the progression over time of *D. confusus* attack, mortality and fall down in the Sicamous Creek plot. When the plot was established in 1998, the number of live and dead trees was almost equal (over 350 stems per hectare) and subalpine fir killed by *D. confusus* was less than 250 stems per hectare. Sixteen years later (equates to 15 potential attack seasons for *D. confusus*), less than 160 live subalpine fir per hectare remain and over 450 subalpine fir per hectare are dead (77% of the subalpine fir) (Fig. 1). Trees are falling at a rate of just under 1% per year but typically blowdown events are spatially and temporally clumped, often depending on snow-loading and wind events.

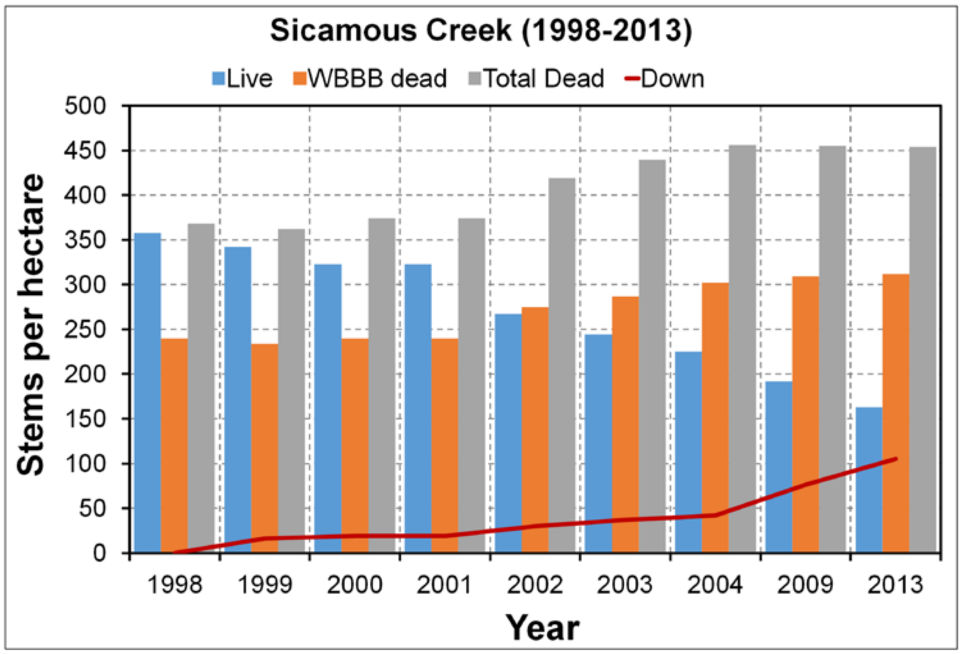


Figure 1. The status of subalpine fir (stems per hectare) in the Sicamous Creek plot between 1998-2013 showing: live; killed by WBBB; total dead (all causes); and, down. Years shown on the x-axis denote years in which the plot was assessed.

The original designations of early-phase through late-phase in the outbreak, or successional, dynamics of these stands was dependent upon a number of factors. After monitoring the plots for 10-15 years, it is clear that many factors are influencing the ecology of these sites; including *D. confusus* - caused mortality, which creates canopy gaps and allows for understory development. Figure 2 compares the ten plots, grouped by outbreak phase, at initial and final assessment times.

The four plots designated mid- to late-phase are all fairly comparable in that initial stem density was low to moderate and mortality did not increase at as high rates as observed in the early and mid-phase plots, but proportionally all suffered over 60% mortality (except for Torrent Creek at 39%) by 2013. The insect dynamics of the Torrent plot better matched the two Spius Creek plots; however, the latter two plots were significantly older than the Torrent plot (>160 years compared to 115 years; Table 2).

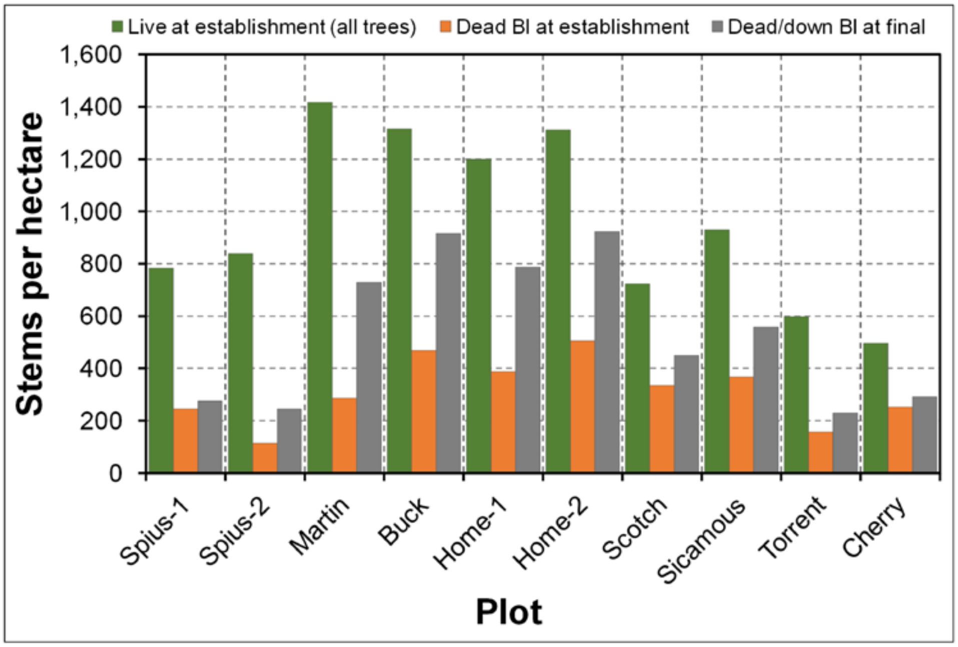


Figure 2. The graph displays: total live stems per hectare at plot establishment (all species); total dead subalpine fir per hectare at plot establishment; and, total dead and down subalpine fir per hectare at the final assessment. Plots are grouped by attack phase: early phase; early to mid-phase; and, mid- to late-phase.

The Scotch, Sicamous, Torrent, and Cherry plots had the largest subalpine fir, live and dead, which could be an attribute of subzone and age (Table 1 and 3). In comparison, the Martin plot, being the youngest, had on average the smallest diameter subalpine fir (Table 2 and 3), live and dead.

The spatial distribution of host trees within the plots and consequently attack by *D. confusus* is clumped. Therefore when dead trees begin to fall this forms a clumped, or aggregated, pattern as well (Figure 3). Stem size, density and spatial distribution, as well as ecosystem are the important factors driving *D. confusus* attack and thus stand succession.

An in-depth report on this project will be completed later in 2014.

Table 3. Average diameter at breast height (DBH) of subalpine fir and spruce in ten plots, sorted by tree status in the 2013 assessment: live; killed by *D. confusus* (WBBB); dead from other causes; and, live and dead spruce. DBH was measured at the 2008 assessment.

	Avg. subalpine fir DBH (cm)			Avg. spruce DBH (cm)
	Live	Dead WBBB	Dead other	live & dead
Spius-1	25.1	35.8	25.4	37.1
Spius-2	23.5	25.6	22.9	36.4
Martin	19.9	19.3	17.6	22.3
Scotch	27.9	30.2	24.4	37.0
Sicamous	26.1	29.5	23.7	29.3
Torrent	28.1	32.2	30.2	30.4
Cherry	35.0	39.0	22.0	39.9
Buck	20.1	23.1	19.2	40.1
Home-1	20.8	23.8	16.0	31.1
Home-2	20.3	22.8	19.7	31.3
Average	24.7	28.1	22.1	33.5

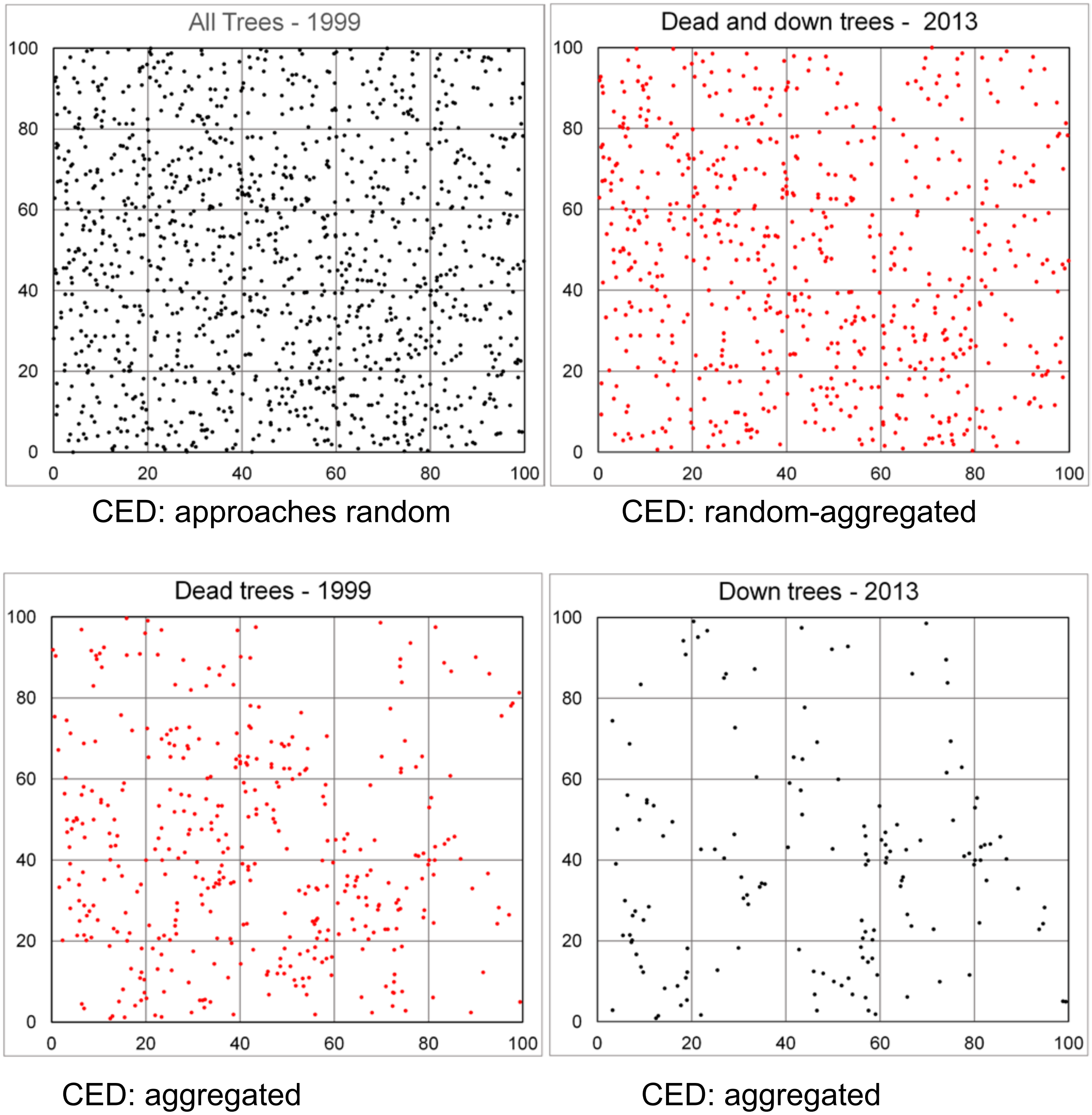


Figure 3. Spatial configuration of trees in the Home Lake-1 plot. Clockwise: all trees; dead and down trees in 2013; dead trees in 1999; and, down trees only in 2013. The spatial distribution of trees as described by the Clark Evans Donnelly statistic (CED) is shown under each plot.

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Summary Report on Re-Assessment of 24 Plots Established to Monitor Mountain Pine Beetle Attack in Young Pine Stands

Lorraine Maclauchlan, Forest Entomologist, Thompson Okanagan Region

Background

After mapping nearly 280,000 hectares of young pine mortality in 2004, twenty four permanent sample plots (50 m x 50 m) were established between 2005-2006 in young lodgepole pine plantations (aged 20-55 years) throughout the mountain pine beetle-devastated areas in the central core of British Columbia. These plots were established to assess and monitor the impact of mountain pine beetle and other secondary insects, as well as to generally assess the risk and susceptibility of young stands during such an unprecedented, and future, outbreak events. The plots were located in a variety of ecological zones and at chronologically different phases of the outbreak. Many parameters, such as age, height, diameter, proximity to mature stands, stand treatment, phloem thickness, type of bark (rough or smooth), larval gallery density and brood survival, as well as secondary insect attack were initially assessed. All permanent sample plots were predominantly lodgepole pine. By 2009, it was determined that stand age, tree diameter and proximity to an active area within the outbreak were the most crucial characteristics for susceptibility. Observations over this eight-year period indicated that young trees degraded rapidly due to woodpecker activity, bole checking and bark sloughing, and that biogeoclimatic zone also played a role on the rate of decay (Figure 1).

Figure 1. Photographs of the Blanc Creek plot: stand condition (left); and, typical bark sloughing and checking on mountain pine beetle killed tree (right).

Reassessment

In the summer of 2013, after a hiatus of four years, all 24 permanent sample plots were revisited to quantify mortality due to mountain pine beetle and other secondary bark beetles, and to measure the decline of the stands (degree of bole checking, bark sloughing and fall down) (Figure 2). The remaining live trees in each plot were assessed for mountain pine beetle and other secondary bark beetle attack (Table 1). Other forest health factors affecting tree health, as well as any ingress in the openings created by gaps in the canopy were noted.

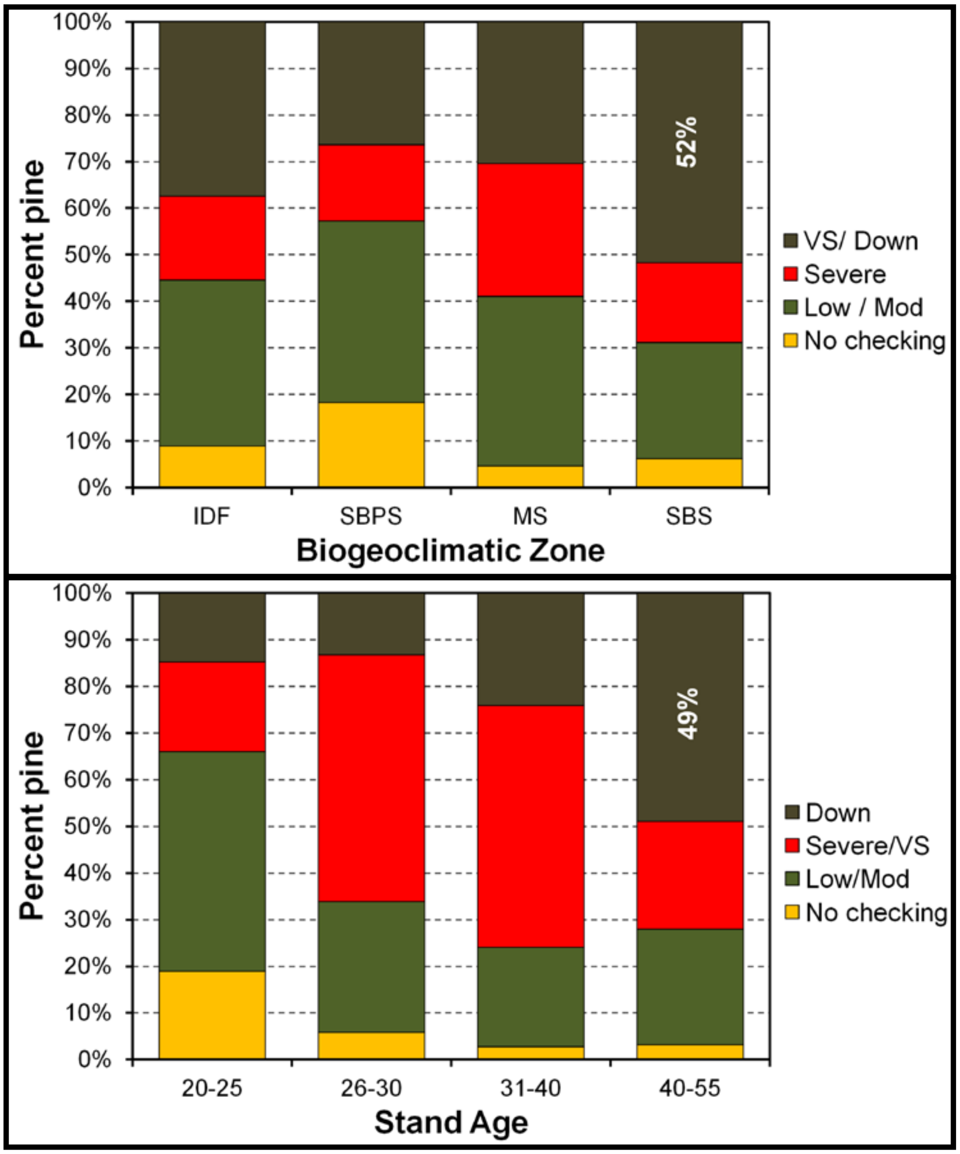

Figure 2. Relationship of biogeoclimatic zone (upper graph), stand age (lower graph) and tree decay (checking and fall down). Tree decay codes: VS=very severe; severe; low to moderate; and no checking.

Only two of the twenty four permanent sample plots have not sustained any mountain pine beetle mortality since plot establishment. Of the remaining twenty two plots, twelve plots are considered '*not satisfactorily restocked*' (NSR) (BCMFR-stocking and free growing guidelines), based on levels of mountain pine beetle mortality, secondary bark beetles and other causal agents, in particular comandra blister rust, Warren's root collar weevil, and snow damage (major top breakage). Another seven plots would be NSR based on the presence of non-lethal (currently) stem rusts. Out of twenty two mountain pine beetle-impacted plots, only three would be considered sufficiently stocked to meet mid-term rotation expectations, without intervention, provided the remaining trees were well spaced. The majority of these plots were established in areas with significant investment through silvicultural treatments (spacing, pruning and fertilization). Although there has been little new mountain pine beetle mortality since the height of the outbreak, other forest health factors coupled with high mortality due to the beetles, have created significant gaps in satisfactorily restocked young stands over the long term.

The cumulative mortality due to mountain pine beetle in plots ranged from less than 1% mortality to 84% mortality (average over 24 plots = 53% mortality) (Table 1). On average, 3.8% of pine mortality other than mountain pine beetles was attributed to pathogens, secondary insects or abiotic agents. Total trees killed by factors other than mountain pine beetle in plots, ranged from zero to just under 12% dead. There was a 2 percent increase in mortality due to other factors since the 2008 assessment. Trees affected with other damaging agents ranged from 4% affected, to 69% affected in some plots. Stem rusts (western gall rust, comandra blister rust and stalactiform blister rust) were the most abundant forest health factor after mountain pine beetle. Other problems noted were snow press, animal damage and stem cankers (Figure 3). Older stands (40-55 years, Figure 2) in the SBS and IDF displayed the highest rates of fall down and severe checking. By 2013, 52% of attacked trees in the SBS had fallen and 49% of attacked pine in stands 40-55 years had fallen. A saprophytic fungus, *Trichaptum abietinum*, infects the root collar at the base of attacked trees, accelerating rapid decay and fall down.

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An in-depth report on this project will be completed later in 2014.

Table 1. Mortality due to mountain pine beetle between 2005 and 2013, coupled with other forest health factors, organized by Forest District and stand age. The Borthwick* and Binta Lake* plots were partially or completely logged.

				% mortality			
Age	Plot Name	Forest District	Number of trees (Pl)	2008 MPB	2013 MPB	Other FHF	Total % mortality
20-25	500 FSR	100 Mile House	329	34.3	34.3	3.0	37.3
26-30	Borthwick*	100 Mile House	285	66.7	logged		
26-30	Chasm	100 Mile House	220	42.7	44.1	0.9	45
41-50	Little Fort	100 Mile House	356	76.1	78.1	0.8	78.9
51-55	Exeter FSR	100 Mile House	181	76.8	76.8	0.6	77.4
26-30	Spius Creek	Cascades	247	15.4	33.2	1.6	34.8
20-25	Colpit Lake	Central Cariboo	352	64.8	65.1	0	65.1
26-30	McLeese Lake	Central Cariboo	311	32.5	32.5	1.6	34.1
26-30	Strouse Lake	Central Cariboo	301	11.3	11.3	1.0	12.3
26-30	Spokin Lake	Central Cariboo	307	24.4	25.1	1.6	26.7
31-40	Meldrum Creek	Central Cariboo	409	42.8	43.0	0.5	43.5
26-30	Jamieson Creek	Kamloops	207	81.2	83.1	0	83.1
31-40	Community Lakes	Kamloops	406	60.1	64.8	2.2	67
20-25	Binta Lake*	Nadina			logged		
26-30	Wistaria	Nadina	282	61.3	61.3	2.1	63.4
20-25	Blanc FSR	OK Shuswap	285	73.3	75.1	0	75.1
20-25	Tagai Lake	Prince George	384	50.5	50.8	1.6	52.4
31-40	Bobtail FSR	Prince George	342	48.5	48.8	0.9	49.7
51-55	Pelican FSR	Prince George	349	79.4	79.4	1.4	80.8
20-25	Nazko	Quesnel	302	0	0	0.7	0.7
31-40	Dragon Lake	Quesnel	201	45.8	46.8	1.5	48.3
31-40	Fish Lake	Quesnel	209	62.7	63.2	1.9	65.1
20-25	Kluskus Lake	Vanderhoof	248	0	0	0.4	0.4
26-30	Kenney Dam	Vanderhoof	320	52.8	53.1	1.9	55

Figure 3. Chasm plot: damage caused by old *Pissodes terminalis* attack (left); and, *Saperda* attack on aspen (right).

Monochamus galloprovincialis (Coleoptera: Cerambycidae) Trapping Trial

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Background

The pine sawyer, *Monochamus galloprovincialis* (Coleoptera: Cerambycidae), is a secondary insect that colonizes newly dead or dying pine trees all over Europe. It has also been found in the Caucasus, Siberia, Mongolia, China and North Africa. All pine tree species are susceptible of being settled by this species but also the genera Abies, Picea and Larix. The importance of *M. galloprovincialis* is based on the transmission of *Bursaphelenchus xylophilus* (pinewood nematode), a lethal pathogen responsible for pine tree wilt disease.

Dr. Celia Boone, a post-doctoral Fellow at Université Libre de Bruxelles, Lutte Biologiques et Ecologie Spatiale, Brussels, Belgium, solicited my collaboration to conduct a trapping trial in to detect and monitor *Monochamus* species in southern B.C. (Figure 1). This trapping trial was replicated in numerous other locations throughout North America and Europe in 2013. There are many *Monochamus* species in North America that vector the pinewood nematode so the trial was designed to trap at various sites in North America to guarantee a representation of several of the *Monochamus* species (e.g. *M. mutator*). The trial was set-up July 30, 2013, in two separate locations in the Thompson Okanagan Region.

Figure 1. A native British Columbia Cerambicidae: *Monochamus scutellatus*.

Methods

Two sites in lodgepole pine mixed species stands were selected. Two traps were established at each site. Collections were made periodically until late September. The following information was recorded:

1) GPS waypoints of each site where the traps are placed;
2) dates of deployment, collections and takedown; and,
3) number of each species of *Monochamus* captured.

Site 1 – Melba FSR south of Kamloops. The stand is composed of MPB-killed lodgepole pine with a minor component of Douglas-fir and spruce (Fig. 2a).

Elevation: 1,331 meters.

Site 2 – Ketchan FSR south of Merritt. The stand is a mix of aspen, lodgepole pine (live and MPB-killed) and scattered understory spruce (Fig. 2b).

Elevation: 1,197 meters.

a. Melba trap site　　　　a. Ketchan trap site

Figure 2. Photographs of *Monochamus* trapping sites: a. Melba Forest Service Road; and, b. Ketchan Forest Service Road.

Four trap collections were made from each site (Table 1). A rough sort was done of all collections and the numbers of insects caught was recorded for each trap site and collection date (Table 2). The most commonly caught insect was *Monochamus scutellatus* with 51 individuals caught over the trapping period at the Melba site 1 and 57 individuals caught at the Ketchan site 2, for a total of 108 beetles (Table 2). Other *Monochamus* species were caught as well as unidentified species of Cerambycidae, Elateridae, Cleridae and assorted other insects.

Table 1. Dates of the 2013 *Monochamus* trapping trial listing set-up date, collection times and take-down date, for the two trapping locations.

	Dates	
Description	Melba FSR	Ketchan FSR
Trap set-up	July 30, 2013	July 30, 2013
1st collection	Aug. 9, 2013	Aug. 14, 2013
2nd collection	Sept. 4, 2013	Sept. 4, 2013
3rd collection	Sept. 13, 2013	Sept. 13, 2013
4th collection and take-down	Sept. 26, 2013	Sept. 26, 2013

Table 2. List of species, and specimens caught, at each sampling date for the Melba and Ketchan sites.

Site and collection time	*Monochamus scutellatus*	Other *Monochamus*	*Xylotrechis longitarsis*	Other Cerambicidae	*Megasemum asperum*	Siricidae	Ichneumonidae	Elateridae	Cleridae
Melba FSR									
1	7	3	2		3				
2	29	4	2					2	26
3	12								6
4	3			3					3
Total	**51**	**7**	**4**	**3**	**3**	**0**	**0**	**2**	**35**
Ketchan FSR									
1	13				1			5	6
2	30	11	1	1		1	7	9	8
3	6						1	1	
4	8	1		4					4
Total	**57**	**12**	**1**	**5**	**1**	**1**	**8**	**15**	**18**

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