2012 Overview of Forest Health Conditions in Southern B.C.

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Table of Contents

Introduction

This report summarizes the results of the 2012 Aerial Overview Surveys and special Forest Health 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 documents forest damage due to bark beetles, defoliators, and any 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 severity ratings used in the surveys.

The 2012 surveys were completed between July 18th and August 20th, 2012. A total of 292.5 hours of fixed-wing aircraft flying in 60 separate flights were required to complete the surveys, which covered the entire landbase of the Cariboo, Thompson Okanagan, and Kootenay Boundary Natural Resource Regions. This landbase totals over 25 million hectares, of which over 15 million hectares are forested land. Flying conditions were generally good, although some difficulties were caused by poor weather and haze from wildfires.

Conifer defoliating insects were the most commonly mapped damage, totaling 528,250 hectares. Bark beetles affected 371,000 hectares, and were the most prevalent tree mortality factor. Other major damage types recorded in 2012 were insect defoliators of deciduous trees (102,700 hectares) and conifer needle diseases (31,930 hectares). An assortment of other disturbances, such as root disease, animal damage, declines, and abiotic agents such as wildfire and windthrow, caused damage on another 18,750 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 2012 aerial overview surveys.

Timber Supply Area and Damaging Agent	Area of Infestation (hectares)					
	Trace	Light	Moderate	Severe	Very Severe	Total
Mountain Pine Beetle						
100 Mile House TSA	87.9	133.6	0.0	0.0	0.0	221.5
Arrow TSA	998.9	933.2	310.9	14.0	0.0	2,257.0
Boundary TSA	4,665.3	6,883.2	1,893.9	489.2	0.0	13,931.5
Cranbrook TSA	2,450.0	1,396.0	856.8	193.3	0.0	4,896.2
Golden TSA	2,080.1	462.8	289.8	11.1	0.0	2,843.8
Invermere TSA	2,577.0	4,002.9	1,374.5	237.4	32.9	8,224.7
Kamloops TSA	109.8	497.5	8.4	0.0	0.0	615.7
Kootenay Lake TSA	1,907.7	1,620.5	1,075.8	619.0	0.0	5,223.0
Lillooet TSA	754.2	3,040.6	966.2	90.3	11.2	4,862.5
Merritt TSA	4,184.1	4,384.0	255.6	19.4	7.2	8,850.2
Okanagan TSA	14,316.2	26,064.9	3,300.6	355.0	54.0	44,090.7
Quesnel TSA	0.0	10.0	0.0	0.0	0.0	10.0
Revelstoke TSA	48.2	31.8	7.9	59.9	0.0	147.7
Williams Lake TSA	4,583.6	8,321.6	94.5	6.6	0.0	13,006.4
Total	**38,762.9**	**57,782.7**	**10,434.8**	**2,095.2**	**105.3**	**109,181.0**
Douglas-fir Beetle						
100 Mile House TSA	379.1	2,432.2	514.5	18.5	0.0	3,344.3
Arrow TSA	0.0	80.2	71.5	7.4	0.0	159.1
Cranbrook TSA	14.6	121.0	0.0	0.0	0.0	135.6
Golden TSA	30.1	64.7	50.0	0.0	0.0	144.9
Invermere TSA	196.6	223.1	323.2	0.0	0.0	742.9
Kamloops TSA	0.0	108.1	187.5	35.9	12.7	344.2
Kootenay Lake TSA	0.0	122.1	0.0	0.0	0.0	122.1
Lillooet TSA	0.0	264.5	95.3	4.2	2.5	366.5
Merritt TSA	0.0	54.1	10.7	5.7	0.0	70.5
Okanagan TSA	0.0	247.4	315.7	57.5	55.2	675.8
Quesnel TSA	271.7	1,184.1	115.3	0.0	0.0	1,571.1
Revelstoke TSA	0.0	10.8	0.0	0.0	0.0	10.8
Williams Lake TSA	3,170.6	3,156.3	524.1	0.0	0.0	6,851.0
Total	**4,062.7**	**8,068.7**	**2,207.8**	**129.1**	**70.4**	**14,538.7**
Spruce Beetle						
100 Mile House TSA	665.8	4,961.4	3,845.1	1,360.4	66.2	10,898.8
Golden TSA	29.0	22.3	0.0	11.1	0.0	62.4
Invermere TSA	0.0	146.7	243.8	0.0	159.5	550.0
Kamloops TSA	0.0	694.7	878.9	312.4	0.0	1,886.0
Kootenay Lake TSA	0.0	5.7	31.2	0.0	0.0	36.9
Lillooet TSA	0.0	155.4	340.5	155.1	9.2	660.2
Merritt TSA	39.0	188.5	547.4	77.1	19.4	871.3
Okanagan TSA	0.0	0.0	213.5	0.0	0.0	213.5
Quesnel TSA	14.7	1,093.0	0.0	0.0	0.0	1,107.7
Williams Lake TSA	1,804.8	7,381.0	6,058.3	2,868.8	0.0	18,112.9
Total	**2,553.2**	**14,648.6**	**12,158.6**	**4,785.0**	**254.3**	**34,399.7**
Western Balsam Bark Beetle						
100 Mile House TSA	249.9	1,316.3	0.9	0.0	0.0	1,567.1
Arrow TSA	1,427.4	319.8	19.0	0.0	0.0	1,766.2
Boundary TSA	591.7	0.0	0.0	0.0	0.0	591.7
Cranbrook TSA	635.6	115.0	40.3	0.0	0.0	790.9
Golden TSA	1,537.7	320.9	8.5	0.0	0.0	1,867.0
Invermere TSA	893.4	200.0	0.0	0.0	0.0	1,093.4
Kamloops TSA	79,371.4	1,673.4	7.3	0.0	0.0	81,052.0
Kootenay Lake TSA	636.5	130.7	0.0	0.0	0.0	767.2
Lillooet TSA	1,601.1	0.0	0.0	0.0	0.0	1,601.1
Merritt TSA	9,132.4	84.9	0.0	0.0	0.0	9,217.3
Okanagan TSA	64,079.2	1,334.8	0.0	0.0	0.0	65,414.0
Quesnel TSA	2,204.7	17,431.2	0.0	0.0	0.0	19,635.9
Revelstoke TSA	39.9	37.4	0.0	0.0	0.0	77.2
Williams Lake TSA	6,378.4	17,873.3	2,864.1	15.7	0.0	27,131.4
Total	**168,779.1**	**40,837.5**	**2,940.1**	**15.7**	**0.0**	**212,572.4**

Table 2 continued. Area summaries for forest health factors mapped during the 2012 aerial overview surveys.

Timber Supply Area and Damaging Agent	Area of Infestation (hectares) Light	Moderate	Severe	Grey	Total
Western Spruce Budworm					
100 Mile House TSA	43,230.3	4,874.3	0.0	0.0	48,104.6
Boundary TSA	20,166.0	15,670.7	7,227.7	0.0	43,064.3
Cranbrook TSA	2,604.9	4,178.8	198.4	0.0	6,982.2
Golden TSA	0.0	0.0	33.7	0.0	33.7
Invermere TSA	0.0	21.4	0.0	0.0	21.4
Kamloops TSA	25,779.6	12,297.9	298.2	0.0	38,375.7
Lillooet TSA	15,608.0	18,370.9	464.2	0.0	34,443.1
Merritt TSA	58,012.2	33,259.0	523.6	0.0	91,794.9
Okanagan TSA	75,988.6	32,837.7	1,336.0	0.0	110,162.3
Quesnel TSA	829.6	0.0	0.0	0.0	829.6
Revelstoke TSA	674.9	912.2	115.6	0.0	1,702.8
Williams Lake TSA	73,108.0	6,508.9	0.0	0.0	79,616.9
Total	**316,002.2**	**128,931.9**	**10,197.4**	**0.0**	**455,131.4**
Two Year Cycle Budworm					
Kamloops TSA	20,592.8	1,073.0	0.0	0.0	21,665.7
Okanagan TSA	185.7	0.0	0.0	0.0	185.7
Quesnel TSA	31,260.6	797.3	0.0	0.0	32,057.9
Williams Lake TSA	7,146.6	1,301.5	0.0	0.0	8,448.1
Total	**59,185.6**	**3,171.7**	**0.0**	**0.0**	**62,357.4**
Western Hemlock Looper					
Golden TSA	327.8	247.8	40.5	0.0	616.1
Kamloops TSA	471.6	0.0	0.0	0.0	471.6
Okanagan TSA	1,087.9	146.8	0.0	0.0	1,234.7
Revelstoke TSA	212.2	110.6	0.0	0.0	322.8
Williams Lake TSA	4,443.4	961.6	52.4	0.0	5,457.4
Total	**6,542.8**	**1,466.8**	**92.9**	**0.0**	**8,102.5**
Douglas-fir Tussock Moth					
Kamloops TSA	2.2	21.8	25.5	1,970.5	2,019.9
Lillooet TSA	27.4	10.5	0.0	86.3	124.2
Total	**29.6**	**32.3**	**25.5**	**2,056.8**	**2,144.2**
Pine Needle Sheath Miner					
Kamloops TSA	45.3	53.0	0.0	0.0	98.3
Okanagan TSA	24.4	220.1	0.0	0.0	244.5
Quesnel TSA	68.8	105.7	0.0	0.0	174.5
Total	**138.5**	**378.9**	**0.0**	**0.0**	**517.4**
Aspen Serpentine Leaf Miner					
100 Mile House TSA	6,265.7	23.9	0.0	0.0	6,289.6
Arrow TSA	1,401.4	3,522.9	47.3	0.0	4,971.6
Boundary TSA	0.0	278.0	0.0	0.0	278.0
Cranbrook TSA	1,432.6	183.8	53.8	0.0	1,670.2
Golden TSA	3,248.9	788.8	18.4	0.0	4,056.1
Invermere TSA	79.7	126.3	0.0	0.0	206.0
Kamloops TSA	15,658.6	10,908.7	1,146.7	0.0	27,714.0
Kootenay Lake TSA	939.3	1,833.3	0.0	0.0	2,772.6
Merritt TSA	30.6	88.4	0.0	0.0	119.0
Okanagan TSA	4,797.9	2,807.0	694.4	0.0	8,299.3
Quesnel TSA	7,858.0	2,293.0	0.0	0.0	10,151
Revelstoke TSA	1,450.5	2,307.6	61.9	0.0	3,820.0
Williams Lake TSA	17,746.1	4,058.5	0.0	0.0	21,804.6
Total	**60,909.3**	**29,220.2**	**2,022.5**	**0.0**	**92,152.0**
Forest Tent Caterpillar					
Kamloops TSA	208.8	645.3	0.0	0.0	854.1
Okanagan TSA	276.7	175.0	0.0	0.0	451.7
Quesnel TSA	8,092.2	1,119.1	0.0	0.0	9,211.3
Williams Lake TSA	0.0	0.0	39.8	0.0	39.8
Total	**8,577.7**	**1,939.4**	**39.8**	**0.0**	**10,556.9**

Table 2 continued. Area summaries for forest health factors mapped during the 2012 aerial overview surveys.

Timber Supply Area and Damaging Agent	Area of infestation (hectares) Light	Moderate	Severe	Total
Larch Needle Blight				
Arrow TSA	5,884.7	3,078.9	93.6	9,057.2
Boundary TSA	1,417.8	2,485.6	136.0	4,039.4
Cranbrook TSA	5,514.0	1,559.9	72.8	7,146.7
Golden TSA	37.2	136.8	0.0	174.0
Invermere TSA	1,810.7	549.9	0.0	2,360.6
Kamloops TSA	19.0	18.6	0.0	37.6
Kootenay Lake TSA	5,826.1	2,663.9	49.0	8,538.9
Okanagan TSA	91.6	235.4	0.0	327.0
Revelstoke TSA	13.5	0.0	0.0	13.5
Total	**20,614.5**	**10,729.1**	**351.4**	**31,694.9**
Dothistroma Needle Blight				
Kamloops TSA	74.1	49.3	0.0	123.4
Merritt TSA	15.1	26.8	0.0	41.9
Okanagan TSA	0.0	70.0	0.0	70.0
Total	**89.2**	**146.1**	**0.0**	**235.3**
Aspen Decline				
100 Mile House TSA	74.5	0.0	17.1	91.6
Kamloops TSA	825.8	333.0	0.0	1,158.9
Lillooet TSA	54.4	33.7	3.2	91.3
Merritt TSA	2,100.1	719.7	25.4	2,845.1
Okanagan TSA	0.0	32.7	49.1	81.8
Quesnel TSA	23.8	0.0	0.0	23.8
Williams Lake TSA	0.0	0.0	8.2	8.2
Total	**3,078.6**	**1,119.2**	**103.0**	**4,300.8**
Wildfire				
100 Mile House TSA	27.5	0.0	420.6	448.1
Arrow TSA	0.0	0.0	48.3	48.3
Boundary TSA	0.0	0.0	7.4	7.4
Cranbrook TSA	0.0	0.0	56.0	56.0
Golden TSA	0.0	0.0	427.1	427.1
Invermere TSA	0.0	0.0	775.1	775.1
Kamloops TSA	0.0	0.0	259.4	259.4
Kootenay Lake TSA	0.0	0.0	74.0	74.0
Lillooet TSA	0.0	0.0	247.2	247.2
Merritt TSA	0.0	8.0	583.4	591.4
Okanagan TSA	0.0	0.0	501.4	501.4
Quesnel TSA	0.0	0.0	11.9	11.9
Revelstoke TSA	0.0	0.0	7.3	7.3
Williams Lake TSA	136.8	1,415.3	456.4	2,008.5
Total	**164.3**	**1,423.3**	**3,875.4**	**5,463.1**
Windthrow				
100 Mile House TSA	0.0	0.0	189.3	189.3
Boundary TSA	0.0	0.0	6.3	6.3
Cranbrook TSA	0.0	0.0	35.2	35.2
Golden TSA	0.0	0.0	153.4	153.4
Invermere TSA	0.0	0.0	358.4	358.4
Kootenay Lake TSA	0.0	0.0	205.0	205.0
Lillooet TSA	0.0	0.0	39.7	39.7
Okanagan TSA	0.0	0.0	38.5	38.5
Quesnel TSA	20.1	24.0	113.7	157.8
Revelstoke TSA	0.0	0.0	3.4	3.4
Williams Lake TSA	0.0	13.0	139.2	152.2
Total	**20.1**	**37.0**	**1,282.1**	**1,339.2**

Southern Interior Overview

Mountain Pine Beetle, *Dendroctonus ponderosae*

Area affected by mountain pine beetle has declined to 109,181 hectares in 2012 (Tables 2, 3; Figure 2). Red attack remained low across most of the Cariboo-Chilcotin, Kamloops, North Thompson, and Shuswap areas, and declined significantly in the Lillooet and Merritt-Princeton areas. Declines were also seen in the east and west Kootenays. Attack levels remained static overall in the Okanagan TSA, and increased slightly in the Boundary TSA.

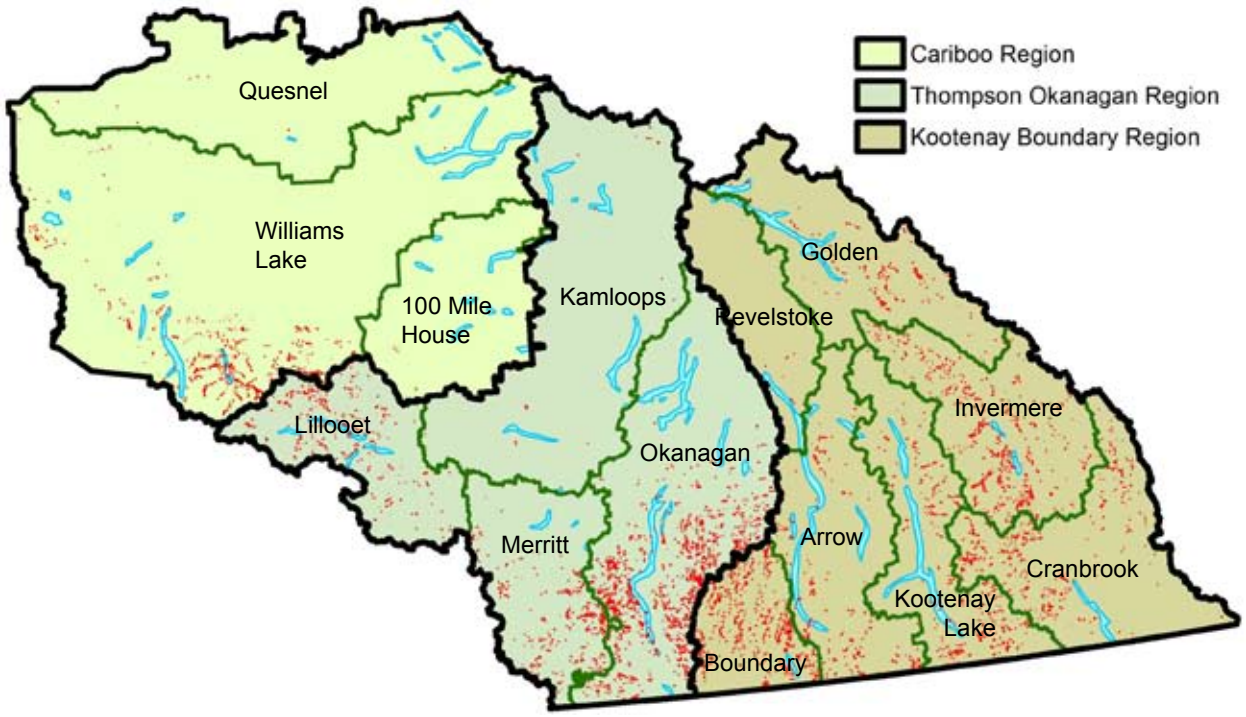


Figure 1. Mountain pine beetle infestations and Timber Supply Areas in the Southern Interior in 2012.

Table 3. Area infested, number of polygons, average polygon size, and number of trees killed in spot infestations, for mountain pine beetle in the Southern Interior, 2001-2012.

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

Beetle populations have declined for several years in a row due to a combination of factors: host depletion; overwinter mortality; more resistant host due to unseasonably cool spring and early summer weather; less synchronized beetle flights; and, in areas such as the Kootenays, geographic barriers to dispersal. The relative proportion of red attack intensity levels are once again similar to pre-outbreak conditions seen prior to 2003, with over 88% of the red attack falling into the trace to light categories. Despite this general decline, populations are still widespread across the South Okanagan, Boundary, Arrow Lakes, Purcell Mountains, and east Kootenay areas, where significant amounts of high hazard green pine remain unattacked. Additional yet declining tree mortality is expected to be seen in these areas for several years to come.

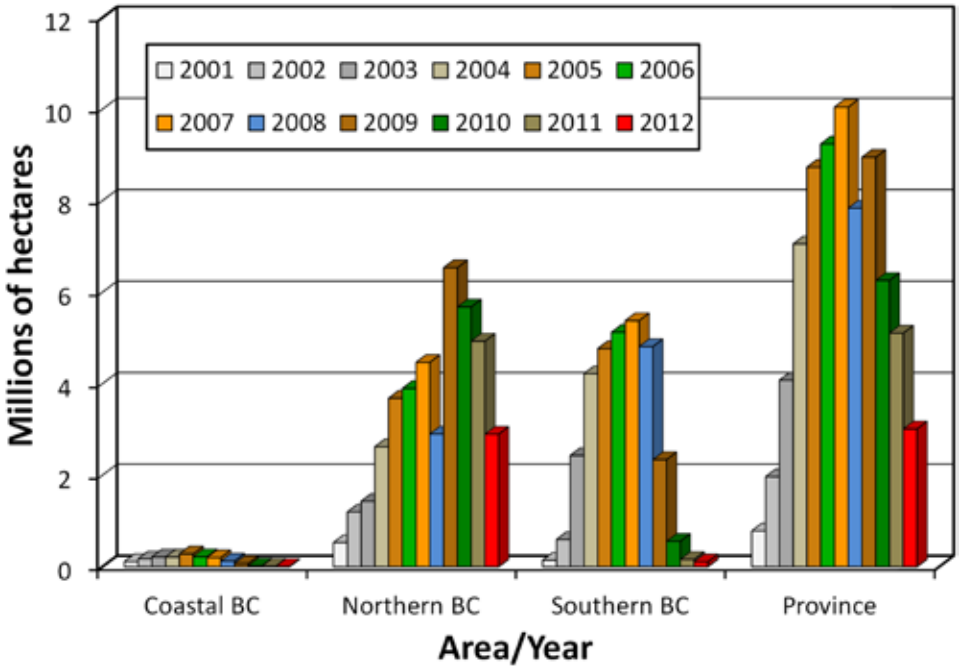


Figure 2. Area affected by mountain pine beetle from 2001 - 2012 in British Columbia, by geographic area.

Lodgepole pine stand 4-5 years post outbreak near Blackwell Lake, Okanagan TSA.

Attack in young lodgepole pine stands continued to decline, to just 391 hectares, mainly in the Merritt and Williams Lake TSAs. Most of this attack was at very low levels. A further 571 hectares of young lodgepole pine suffered scattered mortality due to various secondary bark beetles, including engraver beetles and twig beetles.

Ponderosa pine stands continue to be attacked, either by mountain pine beetle, or by a combination of mountain pine beetle, western pine beetle, and engraver beetles. Most of the ponderosa pine mortality was in the Okanagan TSA, around Summerland, Penticton, and Kelowna. Total area affected was 6,510 hectares. Whitebark pine is still being attacked in some areas of the Invermere, Cranbrook, and Lillooet TSAs. Total area affected was 2,200 hectares.

Douglas-fir Beetle, *Dendroctonus pseudotsugae*

The area affected by Douglas-fir beetle has increased by over 2.5-fold, to 14,539 hectares. The number of spot infestations increased slightly, to 2,355 (Table 4). Attack increased across much of the 100 Mile House and Williams Lake TSAs, where significant numbers of small, scattered infestations were mapped. Attack remained widespread but scattered in the Lillooet, Kamloops, and Okanagan TSAs, while smaller pockets were mapped in the Kootenays.

Table 4. Number of spot infestations of Douglas-fir beetle in the Southern Interior in 2012.

Timber Supply Area	Number of spot infestations	Number of trees
Williams Lake TSA	887	4,176
100 Mile House TSA	349	1,465
Okanagan TSA	329	2,413
Kamloops TSA	282	2,030
Lillooet TSA	165	1,216
Quesnel TSA	80	433
Invermere TSA	65	923
Kootenay Lake TSA	54	745
Cranbrook TSA	49	750
Merritt TSA	49	330
Arrow TSA	22	300
Boundary TSA	13	180
Revelstoke TSA	7	135
Golden TSA	4	62
Total	**2,355**	**15,158**

A mass-attacked Douglas-fir trap tree, Kamloops TSA.

Spruce Beetle, *Dendroctonus rufipennis*

Area affected by spruce beetle increased significantly in the 100 Mile House and Williams Lake TSAs, where nearly 85% of the 34,400 hectares affected was mapped. Beetle populations in these TSAs are in a fairly synchronized two-year cycle, which has resulted in significant annual fluctuations in affected area and attack intensity. Local minor increases were seen in the Lillooet and Quesnel TSAs, and Wells Gray Park. Other infestations in the Kamloops, Merritt, and Invermere TSAs continued, but remained relatively unchanged in size or extent.

Western Balsam Bark Beetle, *Dryocoetes confusus*

Western balsam bark beetle remains active across much of southern B.C., although 90% of the 212,570 hectares affected occurred in the Kamloops, Okanagan, Williams Lake, and Quesnel TSAs. Nearly all of the mortality was classified as Trace or Light.

Western balsam bark beetle damage near Grizzly Lake, Kamloops TSA.

Western Spruce Budworm, *Choristoneura occidentalis*

The total area defoliated by the western spruce budworm fell by 25% to 455,130 hectares, due mainly to population declines across most of the Williams Lake, Anahim Creek, Riske Creek, and McLeese Lake areas of the Williams Lake and Quesnel TSAs. However, defoliation extent and severity increased significantly in the Lillooet, Merritt, Kamloops, and Okanagan TSAs. Overall, the area classified as moderate or severe increased from 128,400 hectares to 139,130 hectares. The most heavily defoliated stands were in the Gold Bridge, Merritt, Stump Lake, south Okanagan, and Boundary areas.

Defoliation from previous years was severe in many stands scheduled for spraying in 2012, and cumulative impacts are becoming significant. Needle mining and budmining levels were very high throughout the Thompson Okanagan Region in the spring of 2012, and in the Merritt TSA and Okanagan TSA multiple larvae per shoot were observed on many sites. Such widespread and high density populations have not been observed since the late 1980's in this Region.

Heavy defoliation in understory Douglas-fir by western spruce budworm.

Severity of 2011 defoliation is evident on this shoot where a 2nd instar budworm larva is mining the expanding bud, June 2012.

Larva about to penetrate expanding bud, June 2012.

A total of 116,012 hectares of high priority stands were treated with Foray 48B (*B.t.k.*) between June 20 and July 7 in the Thompson Okanagan, Cariboo and Kootenay Boundary Regions. This was the largest spray program for the budworm since the operational program began in the late 1980's (Table 5). Treatment occurred relatively late due to cool, wet spring conditions. Therefore, there was high bud damage on many sites that were scheduled for treatment prior to spray application.

This outbreak is projected to continue in all regions with the most severe populations in the Cascades and Thompson Rivers (Kamloops) Districts. Over 20% of the sites sampled in the Cascades District have numbers predicting severe levels of defoliation in 2013. A full report of the 2012 spray program and predictive sampling can be found in the Special Projects section.

Table 5. History of western spruce budworm spray programs (1987-2012) in the southern interior of B.C.

	Area sprayed (hectares)				
Year	**Thompson Okanagan**	**Cariboo**	**Kootenay Boundary**	**Total**	**Product Used***
1987	890	0	0	890	Thuricide
1988	467	0	0	467	Thuricide
1989	550	0	0	550	Dipel
1990	0	0	0	0	
1991	4,000	0	0	4,000	Dipel 132
1992	35,918	0	0	35,918	Foray 48B
1993	33,945	0	0	33,945	Foray 48B
1994	14,695	0	0	14,695	Foray 48B
1995	7,600	0	0	7,600	Foray 48B & 76B
1996	160	0	0	0	Mimic
1997	3,660	12,960	0	16,620	Foray 48B; Mimic
1998	7,280	13,064	0	20,344	Foray 48B
1999	8,031	13,464	0	21,495	Foray 48B
2000	0	7,091	0	7,091	Foray 48B
2001	9,804	16,979	0	26,783	Thuricide 48LV
2002	4,548	23,110	0	27,658	Thuricide 48LV
2003	0	22,139	0	22,139	Thuricide 48LV & Foray 48B
2004	0	25,504	0	25,504	Foray 48B
2005	2,387	28,030	0	30,417	Foray 48B
2006	16,500	27,482	0	43,982	Foray 48B
2007	21,021	36,274	0	57,295	Foray 48B
2008[a]	33,800	28,182	0	61,982	Foray 48B
2009[b]	38,512	34,478	0	72,990	Foray 48B
2010	26,572	21,115	0	47,687	Foray 48B
2011	29,875	20,888	0	50,763	Foray 48B
2012	54,337	47,998	13,678	116,012	Foray 48B
Total	**354,552**	**378,758**	**13,678**	**746,827**	

* Thuricide, Dipel, Foray 48B and Foray 76B are all *B.t.k.* products. Mimic 240LV active ingredient is tebufenozide, which disrupts the normal molting process of lepidopertan larvae by mimicing the molting hormone ecdysone.

a - 833 ha sprayed in Chilliwack District

b - 1,474 ha sprayed in Chilliwack District

Douglas-fir Tussock Moth, *Orgyia pseudotsugata*

As predicted, Douglas-fir tussock moth populations continued to decline in 2012. Egg mass surveys in November 2011 indicated moderate to severe defoliation for 2012 in about 5% of the areas surveyed, and treatment was planned for two areas near Veasy Lake and the Deadman Valley. Monitoring in the spring of 2012 indicated that the populations were sporadic and declining naturally, therefore these areas were deleted from spray plans. Several small patches of new defoliation, covering 87 hectares, were detected near the old Carquile Rest Area north of Cache Creek. Ground checks of these stands revealed very few viable egg masses, indicating a low possibility of any further defoliation. This tussock moth outbreak has followed the typical eruptive pattern of past outbreaks, but has covered more terrain than any other recorded outbreak in B.C. (Figure 3). Populations of tussock moth reached outbreak levels in all five historic outbreak areas in southern B.C. (West Kamloops, Kamloops, Similkameen, Okanagan and Kootenays). A full report on 2012 population monitoring results can be found in the Special Projects section.

Detailed mapping of tree mortality caused by Douglas-fir tussock moth was conducted in 2010 and 2011 using a 206B helicopter. This mapping exercise was done to help quantify the actual mortality caused by this insect over the course of the outbreak cycle using a percent estimate of the tree mortality in each affected stand. By 2011, mortality had occurred on 8,800 hectares. During the 2012 aerial overview survey, using the same mortality categories, tussock moth mortality was mapped to capture any additional mortality since 2011. 2,144 hectares of additional tree mortality were mapped in the Deadman River - Cache Creek area. In total, nearly 10,850 hectares of low elevation Douglas-fir forests have sustained some level of tree mortality, over half of which sustained 50% or higher mortality (Figure 3).

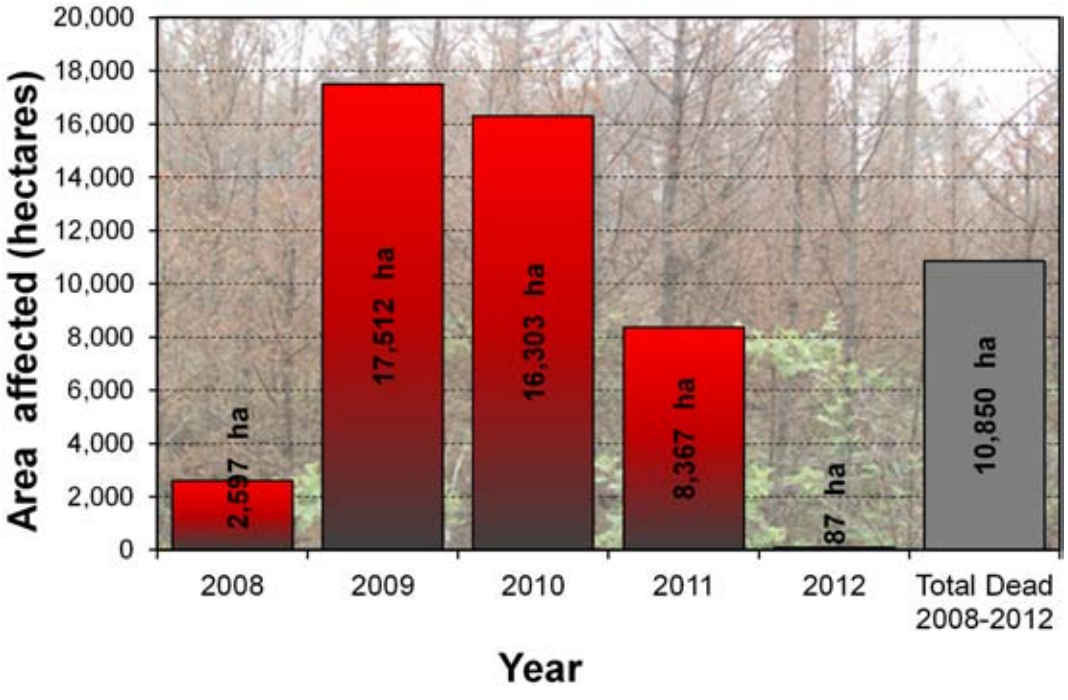


Figure 3. Area affected by Douglas-fir tussock moth in the southern interior of B.C. from 2008 to 2012. Red bars show annual area of defoliation and the grey bar shows the total area of tree mortality over the course of this outbreak period.

Western Hemlock Looper, *Lambdina fiscellaria lugubrosa*

Defoliation by western hemlock looper was up slightly to 8,100 hectares. 2012 may be the peak year in this outbreak cycle, as trapping results and larval sampling both indicate a population decline. The affected area included stands in the Quesnel Lake, Hobson Lake, and Seymour River areas, with additional scattered infestations mapped in the Salmon Arm, Mabel Lake, Rogers Pass, and Lake Revelstoke areas.

Approximately 11,981 hectares of high priority western hemlock forest was treated with Foray 48B (*B.t.k.*) between July 6 and July 11, 2012, in the Thompson Okanagan and Kootenay Boundary Regions. A full report on the control program and population monitoring results can be found in the Special Projects section of this report.

Two-Year Cycle Budworm, *Choristoneura biennis*

Defoliation levels decreased slightly when compared to the last "on" year in this defoliator's life cycle in 2010, from 70,700 hectares to 62,360 hectares. Defoliation was widespread across much of the eastern Quesnel TSA, and the Raft River, Mad River, and Wells Gray Park areas in the Kamloops TSA. An operational spray trial to evaluate the efficacy of *B.t.k.* for control of two-year cycle budworm was carried out in the vicinity of Mount Tom in the Quesnel District. Trial results can be found in the Special Projects section of this report.

Pine Needle Sheath Miner, *Zellaria haimbachi*

Pine needle sheath miner was again detected in several lodgepole pine plantations in the Okanagan, Kamloops, and Quesnel TSAs. In total, 517 hectares in 15 separate stands were affected. Defoliation levels remained light to moderate, and no permanent damage or tree mortality is expected at current damage levels. However, impacts from prolonged outbreaks of this insect have not been quantified and weakened trees may be more susceptible to attack by secondary bark beetles.

Lodgepole pine defoliated by pine needle sheath miner. Inset: closeup of feeding damage.

Western False Hemlock Looper, *Nepytia freemani*

During ground sampling in areas affected by western spruce budworm near Gold Bridge in the Lillooet TSA, high populations of western false hemlock looper were seen in several stands, which likely contributed to high damage levels in many of the more severe pockets of defoliation mapped in this area.

Aspen Serpentine Leaf Miner, *Phyllocnistis populiella*

Aspen serpentine leaf miner infestations continue to be widespread across wetbelt and transitional wetbelt areas of southern B.C. Defoliation was recorded on 92,160 hectares. Aspen often occurs in a patchy or scattered distribution within stands comprised of other species, and damage does not follow typical defoliation patterns. Typically the entire crown of the tree is affected. Because of this, capturing the extent and severity of damage has proven difficult. Beginning in 2012, damage severity ratings are now based on a percentage of the overall stand that is affected and uses the same damage level cutoffs as bark beetles and other mortality agents (Table 1). This revised rating system will allow for improved consistency, more thorough capture of areas with significant damage, and more useful comparisons of damage between different stands.

Close-up of aspen serpentine leaf miner feeding damage.

Forest Tent Caterpillar, *Malacosoma disstria*

Total affected area dropped from 42,790 hectares in 2011 to 10,560 hectares in 2012. Although the large infestation near Quesnel declined significantly, it accounted for the bulk of the mapped area. Other smaller infestations were mapped in the Shuswap area of the Kamloops and Okanagan TSAs.

Larch Needle Blight, *Hypodermella laricis*

The cool, wet weather during the spring and early summer contributed to widespread larch needle blight infections in the Arrow, Boundary, Kootenay Lake, Cranbrook, and Invermere TSAs. A total of 31,695 hectares of damage was recorded. Several larch plantations scattered through the Okanagan and Kamloops TSAs were also affected.

Larch needle blight damage. Lighter yellow needles show current year infection symptoms; darker needles with black fruiting bodies show past years' infection.

Birch Leaf Miner, *Fenusa pusilla*

Birch leaf miner damage levels remained stable at 2,832 hectares. Most of the damage occurred in the Kamloops, Okanagan, and Kootenay Lake TSAs.

Satin Moth, *Leucoma salicis*

Satin moth infestations were mapped on 102 hectares of trembling aspen in the Merritt and Okanagan TSAs. Damage was rated as moderate to severe.

Dothistroma Needle Blight, *Dothistroma septosporum*

Dothistroma needle blight was again detected on lodgepole pine plantations in the Adams River and Monashee Creek areas. These stands are in the interior cedar-hemlock ecosystem along valley bottoms. Damage is becoming pronounced and many trees have little live crown remaining. New infections were detected in two plantations in the Merritt TSA in the upper Tulameen River. However, damage levels are currently relatively low.

Aspen Decline

Aspen decline symptoms continued to increase in extent and severity, especially in the Merritt TSA. Nearly 4,300 hectares are exhibiting visible symptoms of decline, such as thinning crown, dead branches and tops, and tree mortality. These stands have not been assessed to determine the causal agent, however in other jurisdictions in North America, aspen decline has been linked to a combination of repeated drought conditions, low snowpacks, and a variety of insect and disease agents. Due to the increasing prevalence of decline, an improved damage rating criteria was adopted in 2012 (Table 1). Modified from the U.S. Department of Agriculture (USDA) Forest Service "sudden aspen decline" damage rating criteria (with input from Brian Howell and Bill Ciesela*)*, the new ratings better reflect actual damage symptoms and enable forest managers to more accurately quantify damage.

Gypsy Moth, *Lymantria dispar*

The B.C. Forest Service, in cooperation with the Canadian Food Inspection Agency and the Canadian Forestry Service, monitors for occurrence of European gypsy moth at many sites throughout the southern interior, such as woodland recreation sites and other similar sites. In 2009, a single European gypsy moth was caught in a regular monitoring trap near Revelstoke. Delimiting grids of 16 traps per square mile were deployed in this area and additional moths were caught in 2010 and 2011, however no moths were caught in 2012. If no further moths are caught in this grid in 2013, this population will be considered to have died out. A single moth was caught at a regular trapping site at Kokanee Creek Park (Kootenay Lake TSA) in 2009 and two additional moths were trapped in delimiting grids in 2010. However no more moths were trapped in delimiting grids in 2011 or 2012, and this population is considered to have died out. A single moth was caught near Kaslo in 2012; a delimiting grid of traps will be deployed in this area for two years.

Windthrow

Windthrow damage was mapped on 1,339 hectares, up from 500 hectares in 2011. Pockets of damage were mapped in the Kicking Horse River, Palliser River, and Summit Creek areas in the Kootenays, and in the Tatla Lake, Mosley Creek, and Timothy Mountain areas of the Cariboo. Over 60% of the affected stands were Douglas-fir or spruce leading, which raises concerns about future bark beetle population increases.

Wildfire

Wildfire activity was again relatively low in 2012, with only 5,463 hectares burned. However, another 11,495 hectares in the Quesnel and Williams Lake TSAs that were affected by lower intensity fires in 2010 and 2011, exhibited high levels of additional tree mortality this year. Several causal agents are responsible, including Douglas-fir beetle, other secondary insects, bark scorching, and crown and root damage, often all affecting the same tree. These stands have been tracked separately to distinguish them from other fire-killed or bark beetle-affected stands. This post-wildfire mortality may persist in these stands until most of the fire-damaged trees have been killed and secondary beetle populations decline.

Flooding

Extensive tree mortality caused by flooding was observed in the west Chilcotin, around Nimpo Lake, Charlotte Lake, and the Blackwater River. Other significant areas of flooding damage were detected along the Columbia River near Golden.

Bear Damage

Feeding by bears killed trees on 1,630 hectares. All of the affected stands were lodgepole pine plantations of approximately 20-30 years of age. Mortality rates tended to be higher in the Kootenays, and lighter in the Thompson-Okanagan and Cariboo. Porcupine feeding was also observed in several of the ground checked stands in the Cariboo.

Other

Several other damage agents were observed during the aerial surveys, including: 1,260 hectares of avalanche and slide damage (mainly in the Kootenays), 36 hectares of snow press east of Lillooet, 117 hectares of redbelt in the Chilcotin, 160 hectares of cottonwood leaf rust (*Melampsora occidentalis*) near the Adams River and Seymour Arm, 125 hectares of moderate birch decline near Falkland, and 290 hectares of drought-decline complex in Douglas-fir near Sugar Lake (see Okanagan Shuswap TSA section for details). During ground surveys, some minor frost damage was observed in larch plantations in the Trinity Valley and Shuswap Lake areas, and minor levels of larch casebearer (*Coleophora laricella*) were found in one larch plantation near Trinity Valley. Douglas-fir needle cast (*Rhabdocline pseudotsugae*) was noted at several locations during defoliator ground sampling in the East Kootenays. Armillaria root disease is prevalent throughout much of the southern interior, especially in Douglas-fir dominated ecosystems, and in Douglas-fir in the Interior Cedar-Hemlock ecosystem. However, Armillaria, along with other root diseases, is seldom detected during the aerial overview surveys as the damage signature is not readily visible due to timing of tree fade and needle drop.

Black cottonwood infected by cottonwood leaf rust, Melampsora occidentalis. *Inset shows fruiting bodies visible on underside of leaf.*

Thompson Okanagan Region Summary

The Thompson Okanagan portion of the aerial overview surveys was conducted between July 18th and August 3rd, 2012, and required 50 hours of flight time over 11 days. Surveys covered the Kamloops, Lillooet, Merritt, and Okanagan TSAs. Good conditions prevailed for most of the surveying, with only a few days of delay caused by poor weather or poor visibility. All surveys were conducted by Kevin Buxton (Ministry of Forests, Lands, and Natural Resource Operations) and Janice Hodge (JCH Forest Pest Management), and utilized a Cessna 206, operated by Westair Aviation out of Kamloops.

Kamloops TSA

Bark Beetles

Western balsam bark beetle was the most widespread damaging agent in the TSA from an affected area perspective, with just over 81,000 hectares mapped. This is an increase of over 50% from 2011 levels of 53,210 hectares. Most of the expanded infestation fell within the southern half of Wells Gray Park.

Although total area affected by **spruce beetle** declined slightly, from 2,317 hectares in 2011 to 1,886 hectares in 2012, infestation intensity remained high, with over 60% of affected stands suffering moderate to severe mortality. Infestations in the upper Mow Creek – Criss Creek and Sun Peaks – Cahilty Creek areas continued to move into new stands, and several new infestations were observed in Wells Gray Park, mostly around Falls Creek and Azure Lake.

Spruce beetle near Tsintsunko Lake, Kamloops TSA

Douglas-fir beetle trap trees located near Durand Creek, Kamloops TSA.

Douglas-fir beetle continued on a downwards trend. The area of larger patches was down by 40% to 344 hectares, and the number of small spot infestations was down by one-third to 282. Continued application of trap trees and aggressive salvage harvest through the small scale salvage program in the Thompson Rivers District has helped reduce Douglas-fir beetle populations within the District and TSA as a whole. Funnel traps, deployed in 3-trap groupings, were used in some high value stands in the Georges Creek area north of Monte Lake. Beetles were trapped in significant numbers weekly from early June through mid-August. However, infestations are still widespread throughout the southern two-thirds of the TSA and continued efforts will be required to further reduce beetle populations.

Mountain pine beetle populations remained very low in nearly all areas. A few small residual pockets of activity were seen in the Allan Creek, Albreda River, and Hat Creek areas. Area affected was only 615 hectares.

Conifer Defoliators

Western spruce budworm populations increased substantially throughout the Campbell Creek, Scuitto Lake, Stump Lake, Droppingwater Creek, Inks Lake, Meadow Creek Road, and Logan Lake areas. Defoliated area more than doubled to 38,375 hectares, and the area moderately to severely defoliated increased from less than 5,000 hectares to nearly 12,600 hectares. A total of 4,572 hectares of high-value Douglas-fir stands near Duffy Lake and Inks Lake were treated with Foray 48B (*B.t.k.*) to reduce budworm populations and damage. Egg mass samples collected during the fall of 2012 indicate that budworm populations will remain high in unsprayed areas in 2013, with 47 of 92 sites predicting moderate or severe defoliation. The highest populations are expected to be in the Stump Lake, Bleeker Lake, and Meadow Creek Road areas.

Western spruce budworm defoliation near Droppingwater Creek, Kamloops TSA.

2012 was an "on" year in the feeding cycle of **two-year cycle budworm**, and defoliation has increased by nearly three-fold from 2010. Total area affected was 21,665 hectares, most of which was classified as light. Affected stands were primarily in the Mad River, Raft River, Silence Lakes, and Murtle Lake areas.

Douglas-fir tussock moth populations were active in a small area around the old Carquile Rest Area north of Cache Creek, where 49 hectares were moderately to severely defoliated. No other current defoliation was observed. An additional 1,970 hectares of Douglas-fir were classed as having sustained mortality. This, combined with the previously mapped 7,740 hectares of mortality, brings the total to just over 9,700 hectares that have sustained some level of mortality during this outbreak cycle.

Pheromone trapping and larval beatings conducted in 2011 indicated that **western hemlock looper** populations were increasing in the North Thompson. Just over 4,000 hectares were treated with Foray 48B (*B.t.k.*) in early July to reduce larval populations; as a result of this and natural population decline, no defoliation was visible during the aerial surveys. 472 hectares of hemlock was lightly defoliated along Azure Lake in Wells Gray Park; however due to the remote location and protected area status, populations are not being monitored and no control actions are being considered.

Pine needle sheath miner again defoliated three separate lodgepole pine plantations near O'Connor Lake and Jamieson Creek, as well as a plantation just off the Cahilty Main west of the Adams Lake Sawmill. A total of 98 hectares were affected. No long term damage has occurred at any of the sites but more than one year of defoliation can lead to growth reductions.

Deciduous Defoliators and Decline Syndromes

Aspen serpentine leaf miner continued to cause widespread damage, mainly in the Wells Gray Park, Mad River, Vavenby, Adams River, Eakin Creek, and Hyas Lake areas. Defoliation was mapped on 27,714 hectares, down slightly from 2011 levels of 33,162 hectares. Populations of **birch leaf miner** increased slightly, with area defoliated totaling 1,065 hectares. Most damage was in the Eileen Lake, Fadear Creek, and lower Adams Lake areas. **Forest tent caterpillar** moderately to severely defoliated 854 hectares of mixed deciduous forest near Cayenne Creek and in the upper Adams River.

Aspen decline syndrome became more widespread in 2012, with symptoms visible on 1,160 hectares, up from only 25 hectares in 2011. Most of the affected stands were in the Darlington Forest Service Road area, with smaller areas in the Hat Creek, Sabiston Creek, Criss Creek, Watching Creek, Shumway Lake, Scuitto Lake, and Pinantan Lake areas. About two-thirds of the stands were showing light decline symptoms limited to thinning crowns, with the balance showing moderate symptoms, and some trees devoid of foliage and dead.

Foliar Diseases

Eight separate lodgepole pine plantations were affected by **Dothistroma needle blight**, in the TumTum Lake, Adams River, Adams Lake, Mad River, and Momich Lake areas. While total affected area was low, at 123 hectares, the plantations near TumTum Lake have now sustained repeated infections and damage is becoming severe. **Larch needle blight** was detected in a larch plantation near Raft Peak. A total of 38 hectares were affected, however damage levels were low to moderate and long-term impacts should be limited to growth losses. **Cottonwood leaf rust** (*Melampsora occidentalis*) infections were visible in several locations along the upper Adams River; a total of 139 hectares were affected.

Other forest health factors mapped during the aerial surveys included 191 hectares of **bear-damaged** lodgepole pine plantations near Blue River, 260 hectares of **wildfire**, 36 hectares of **landslide** damage, and 11 hectares of **flooding** damage.

Monitoring Activities

Thompson Rivers Natural Resource District staff have completed their target of 30 samples for SDM (Stand Development Monitoring), all of which were done by staff over the past three years.

Tree mortality in this lodgepole pine plantation was caused by bear feeding. Blue River, Kamloops TSA.

David Rusch, forest pathologist for the Cariboo and Thompson Okanagan Regions, demonstrating how to detect root disease during a training course near O'Connor Lake in the Kamloops TSA.

Thompson Rivers District staff heading out to conduct SDM surveys.

Merritt TSA

Bark Beetles

Mountain pine beetle populations continued to decline, with red attack area down from 32,737 hectares in 2011 and nearly 100,000 hectares in 2010, to just 8,850 hectares in 2012. This population collapse is due to a combination of host depletion and salvage harvesting in the lower elevation stands that are more suited for reproductive success. Much of the remaining mature lodgepole pine is at higher elevations where brood success has been poor. Most of the new red attack was mapped in the south and southeast portions of the TSA, around Siwash Creek, Red Creek, McNulty Creek, and Whipsaw Creek. Tree fade was later than normal in 2012 due to the cool wet spring, particularly in the higher elevation areas.

Mountain pine beetle salvage harvesting near Pennask Lake, Merritt TSA.

Western balsam bark beetle activity increased substantially in the Granite Creek, Whipsaw Creek, and Lodestone Mountain areas. Total area affected in the TSA nearly tripled, from 2011 levels of 3,200 hectares, to 9,220 hectares in 2012.

Populations of **spruce beetle** appear to be increasing as well, with new tree mortality recorded on 871 hectares, up from 385 hectares in 2011. Most of the affected stands are in high elevation drainages in the Pasayten River, Placer Creek, and Belgie Creek area.

Douglas-fir beetle activity remained at historically low levels in the Merritt TSA, with red attack recorded in five patches totaling 71 hectares, and 49 spot infestations. The most concentrated attack was east of Chapperon Lake and in the upper Nicola River area.

Western spruce budworm field trip, August 2012, Merritt TSA.

Defoliators

Western spruce budworm was the most widespread damaging agent in the TSA in 2012. Populations increased dramatically throughout the northern half of the TSA, with total area affected up by 2.5-fold to 91,795 hectares. Defoliation intensity also increased, with the area classified as moderate or severe increasing to 33,782 hectares. An aggressive *B.t.k.* spray program conducted in June 2012 helped to minimize damage on 23,278 hectares of high priority Douglas-fir forest. The most heavily defoliated stands were in the Shackan Creek, Coldwater River, Swakum Mountain, Nicola Lake, Stump Lake, and Peter Hope Lake areas. Egg mass sampling conducted during the fall of 2012 indicates that defoliation will be heaviest in the Peter Hope Lake, Douglas Lake, Midday Valley, Comstock Road, Kingsvale, and Coldwater River areas in 2013.

Douglas-fir understory damage from repeated defoliation by western spruce budworm, Merritt TSA.

Other defoliators detected during the aerial surveys were 120 hectares of **aspen serpentine leaf** miner and 60 hectares of moderate **satin moth** near Prospect Creek and Spius Creek.

Deciduous Decline Syndromes

Aspen decline symptoms were visible in many aspen and mixed aspen stands throughout drier central areas of the TSA, especially around Otter Creek Road, Aspen Grove, Kane Valley, Quilchena Creek, Nicola Lake, and Douglas Lake. A total of 2,845 hectares were visibly affected, which is a substantial increase from 2011 levels of 270 hectares. Nearly 750 hectares were moderately to severely affected, with many trees exhibiting very thin foliage and bare tops, with occasional tree mortality. Although a causal agent has not been determined, the pattern of damage appears to be similar to Sudden Aspen Decline syndrome which has been increasing in many western states.

Aspen stand exhibiting decline syndrome symptoms. Note thinning crown, dead tops, and dead stems. Near Nicola Lake, Merritt TSA.

Foliar Diseases

Foliar discoloration was observed in two plantations in upper Podunk Creek. Ground checks confirmed the causal agent as **Dothistroma needle blight**. This is the first instance of this pathogen causing visible damage anywhere in the TSA.

Monitoring

The Cascades Natural Resources District staff undertook several monitoring activities this year. The District was a pilot for both the Cumulative Effects Assessment project, and the Forest and Range Evaluation Program Multi Resource Value Assessment project. Approximately 120 additional samples for various values were completed in 2012 in support of these initiatives. The District also completed 22 Stand Development Monitoring samples in 2012 and plans to complete the remainder next year (target 30 samples). The District is hoping these data will help inform their upcoming Timber Supply Review process.

Severe galls from western gall rust infection on young lodgepole pine in the Teepee Lakes area of the Merritt TSA.

Lillooet TSA

Bark Beetles

Although **mountain pine beetle** remained widespread across much of the TSA, total area affected was down by nearly 50% to 4,863 hectares. Most infestations were small and scattered and of low severity, which was reflected in the increasing number of spot infestations of 5-20 trees, up from 211 in 2011, to 270 in 2012. Most of the remaining green pine stands are small diameter and/or high elevation and the downwards beetle population trend is expected to continue in 2013. Attacked tree fade was later then normal in 2012 due to the cool wet spring, particularly in the northwest end of the TSA near Gold Bridge and Tyaughton Creek.

Scattered mountain pine beetle attack near Carpenter Lake, Lillooet TSA.

Douglas-fir beetle remained quite widespread on dry slopes in the Fraser River, Bridge River, Carpenter Lake, Fountain Valley, Pavilion, and Duffy Lake Road areas. Infestations were small but numerous; 35 separate patches totaling 367 hectares were mapped, along with an additional 165 spot infestations of 5-50 trees each.

After a few years of decline, **spruce beetle** activity has increased, mainly in the Cayoosh Creek, Molybdenite Creek, Phair Creek, and Mission Ridge areas. Total area affected was 660 hectares, about three-quarters of which had moderate or severe tree mortality.

Western balsam bark beetle activity remained relatively low in 2012, with just 1,600 hectares of trace attack recorded. Most of the infestations were small and were scattered through high elevation drainages of the Lillooet and Bendor Ranges.

Defoliators

Western spruce budworm populations were up in 2012, with area affected at 34,443 hectares, over half of which was moderately or severely defoliated. Populations were especially high in the Gold Bridge, Bralorne, Gun Lake, and Tyaughton Lake areas, where extensive heavy defoliation was seen. Locally high **western false hemlock looper** populations likely contributed to high damage levels in many of the more severe pockets of defoliation mapped near Gold Bridge. Significant budworm defoliation was also detected along Downton and Carpenter Lakes, Botanie Valley, Nicoamen River, Sackum Creek, the upper Stein River, and along the Fraser River between Lytton and the Nahatlatch River. Egg mass sampling conducted during the fall indicates that budworm populations should remain high throughout the Gun Lake – Gold Bridge area in 2013, and further heavy defoliation is expected.

Heavy defoliation by western spruce budworm near Tyaughton Lake, Lillooet TSA.

As expected, most **Douglas-fir tussock moth** populations have subsided, with active defoliation limited to 38 hectares at Watson Bar Creek and Leon Creek. Tree mortality was recorded on 86 hectares of Douglas-fir near Pavilion Lake, in addition to the 528 hectares mapped in 2011, bringing the total area of mortality to 615 hectares. No defoliation is expected in 2013.

Other damaging agents detected during the aerial surveys were 247 hectares of **wildfire**, 40 hectares of **windthrow,** 36 hectares of **snow press** damage, 20 hectares of **landslide and avalanche** damage, and 5 hectares of **flooding** damage.

Windthrow damage with scattered Douglas-fir beetle above the Fraser River, Lillooet TSA.

Trees damaged by a slow moving earth flow east of Fountain Lake, Lillooet TSA.

Okanagan TSA

Bark Beetles

The area of **mountain pine beetle** red attack has remained nearly unchanged from 2011 levels, at 44,091 hectares, while the number of small spot infestations has declined slightly, to 683. In general, the mountain pine beetle has subsided in the north end of the TSA but continues to move and infest stands to the south. The area of attacked mature lodgepole pine has decreased slightly, from just over 40,000 hectares in 2011 to 38,022 hectares in 2012, while attack in ponderosa pine has increased, from 3,557 hectares to 5,800 hectares. Attack intensity remained low in most stands, with only 3,710 hectares, or 8% of the total area, being classified as moderate or severe. Red attack levels continued to decline throughout the Cherryville and Aberdeen Plateau areas, due mainly to host depletion. Attack is slowly increasing in the Hydraulic Lake - Highway 33, Keremeos - Winters Creek and Ellis Creek areas. Attack is still quite widespread throughout the Trepanier Creek, Brenda Mine, Eneas Lake, Trout Creek, June Creek, Mission Creek, Chute Lake, and Penticton areas. Areas east of Penticton have extensive high hazard pine stands that are still relatively free of attack but are at high risk. Mountain pine beetle is active in the Ashnola around Trapper Lake but otherwise remains endemic in that part of the TSA. Attack in plantation-aged pine was low, with only 263 hectares of trace mortality recorded. Ponderosa pine mortality was most widespread near Garnet Valley, Summerland, Shingle Creek, Faulder, and Winfield. A total of 5,806 hectares and 139 spot infestations were mapped.

A stand near Hydraulic Lake experiencing an increasing level of mountain pine beetle attack, Okanagan TSA.

Douglas-fir beetle activity increased in several areas, especially in the Mara Lake, Cherryville, Chase Creek, Ashnola River, and T.F.L. #33 areas. In addition, populations remained high in several other areas, including Shuswap Lake, Blurton Creek, Falkland, Ingram Creek, Salmon River, and Whiteman Creek. Overall area affected was up by over two-fold to 676 hectares, and an additional 329 spot infestations killed another 2,400 trees.

Stands where salvage harvesting has occurred to remove dead pine are experiencing increases in Douglas-fir beetle attack on residual Douglas-fir. These residual, open fir stands are more susceptible to blowdown and thus attack by Douglas-fir beetle. Similar scenarios in the Merritt TSA have also led to stands having higher susceptibility to damage from western spruce budworm.

Western balsam bark beetle populations continued to be active and widespread across many of the high elevation plateau areas in the TSA. The main infestation areas were Hunters Range, Greystokes Plateau, Winnifred Creek, Spa Hills, Lichen Mountain, Pukeashun Mountain, Tahaetkun Mountain, Whiterocks Mountain, and Pennask Mountain.

Although the area affected was not large, **spruce beetle** populations appear to be increasing in the Easygoing Creek drainage. A total of 214 hectares of new attack were mapped.

Conifer Defoliators

Western spruce budworm populations expanded around Westwold, Oyama, and Joe Rich, resulting in an increase in the total area affected by nearly 33,000 hectares to just over 110,000 hectares. However, an aggressive spray program which treated 26,511 hectares with *B.t.k.* helped to limit the total area of moderate and severe defoliation to the same level as 2011, at 37,174 hectares. The heaviest defoliation was in the Westwold, Shingle Creek, Orofino Mountain, Mount Kobau, Shuttleworth Creek, and Naramata areas. Populations continued to be high in many interior wetbelt areas, with defoliation visible on scattered dry Douglas-fir ridges throughout the Mabel Lake, Sugar Lake, Cherryville, and upper Shuswap River areas. Egg mass sampling carried out in the fall indicates that budworm populations should be somewhat lower in 2013, although pockets of moderate defoliation are still expected around Westwold, Sheep Creek, Grand Oro Road, and Camp McKinney Road.

A few small patches of light defoliation, totaling 186 hectares, were observed on subalpine fir near Mount Kathleen. It is unknown whether the budworm species was **two-year cycle budworm**, or western spruce budworm from adjacent Douglas-fir stands that had temporarily moved into subalpine fir. If this pattern persists into 2013, sampling will be done to positively identify the species.

Western spruce budworm defoliation near Trepanier Creek, in the Okanagan TSA.

Western hemlock looper populations reached outbreak levels in several small, discrete locations. Affected stands were detected in the upper Seymour River, Anstey Creek, Humamilt Lake, Larch Hills, Wap Creek, and Kingfisher Creek areas. Defoliation was mapped on 1,235 hectares, most of which was limited to light. Nine of the ten permanent sampling sites in the TSA were positive for larvae, although most counts were low. Adult moth catches at these sites decreased significantly from 2011, with the highest numbers at the Greenbush Lake, Kingfisher Creek, and Scotch Creek sites.

Defoliation by **pine needle sheath miner** was again visible in lodgepole pine plantations in the Gleneden Fire, as well as in new locations at Whiteman Creek, Bear Creek, Latewhos Creek, and Trinity Valley. Total area affected was 245 hectares, most of which was moderately defoliated.

Deciduous Defoliators

Aspen serpentine leaf miner damage increased from 4,385 hectares in 2011, to 8,300 hectares in 2012. Affected stands were scattered throughout the Shuswap, Monashee Mountains, and Fly Hills areas. **Forest tent caterpillar** defoliated 452 hectares of mixed aspen - cottonwood - birch forest along the west side of Seymour Arm. Little permanent damage was seen as this was the first year of defoliation at this location. Population levels of **birch leaf miner** remained relatively low, with defoliation being limited to 624 hectares, scattered in small patches in the Monashees and Fly Hills. Other minor deciduous defoliators included 42 hectares of **satin moth**, and 20 hectares of **cottonwood leaf rust**.

Forest tent caterpillar near Seymour Arm, Okanagan TSA.

Foliar Diseases

Most **larch needle blight** damage was seen in plantation-aged western larch, rather than in mature stands, and was scattered across the Cherryville, Trinity Valley, and Shuswap areas. Many of these stands also showed symptoms of larch needle cast (*Meria laricis*). One small area of damage in semi-mature larch was detected near Penticton Creek.

Dothistroma needle blight infections persisted in a few lodgepole pine plantations near Monashee Creek and Cherry Creek. In total 70 hectares were affected.

A mix of larch needle blight and larch needle cast affecting a larch plantation near Lee Creek, in the Okanagan TSA.

A Douglas-fir Drought-Decline Complex

During the aerial surveys, tree mortality of an unknown cause was detected along the west side of Sugar Lake. Four individual polygons covering 289 hectares were mapped. Follow-up ground assessments found a combination of Douglas-fir beetle and Armillaria root disease, although drought was likely the catalyst, as not all trees had a biotic causal agent associated with mortality. The soils in this area are very coarse, and therefore very sensitive to any water deficits. The stands examined were mature even-aged Douglas-fir with a minor component of western larch, western red cedar and western hemlock. Douglas-fir and western larch were the most prone to mortality. Most species, with the exception of western red cedar, have experienced poor growth over the last several years as exhibited by the crown symptoms. It is likely that both Douglas-fir beetle and Armillaria are responding to host stress; these symptoms may be indicative of changing climatic effects on dry transitional sites.

A hillside above Sugar Lake showing symptoms of drought/decline, root disease, and Douglas-fir beetle.

Similar but less extensive symptoms have been observed in the Kootenays for the last few years, most obviously near Trout Lake, where Douglas-fir on dry to mesic sites within the Interior Cedar-Hemlock zone have displayed thin crowns, dying tops, and scattered mortality. These symptoms have not been detectable from the air but have been observed during other ground survey work.

Several other minor damaging agents were detected during the aerial surveys. These included 20 hectares of **cottonwood leaf rust**, 24 hectares of **armillaria root disease**, 17 hectares of **bear damage**, 125 hectares of **birch decline** (near Falkland), 82 hectares of **aspen decline** (near Crater Mountain), 500 hectares of **wildfire**, 70 hectares of **windthrow**, 24 hectares of **flooding**, and two **landslides** that damaged 10 hectares of mature timber.

Flooding damage in the Larch Hills area of the Okanagan TSA.

Kootenay Boundary Region Summary

The Kootenay-Boundary portion of the surveys required 19 separate days and 100.5 hours between July 26th and August 20th. Weather conditions and visibility were generally good. Surveys covered the entire landbase of the Arrow, Boundary, Kootenay Lake, Cranbrook, Invermere, Revelstoke, and Columbia Timber Supply Areas. The surveyors were Neil Emery and Adam O'Grady of Nazca Consulting Ltd., using a Cessna 337 Skymaster operated by Babin Air.

Arrow TSA

Bark Beetles

Mountain pine beetle populations continued to decline. Total area affected was down by 60% to 2,260 hectares, and the number of spot infestations was down by nearly 70%, to just 260. Most of the red attack was seen in the southern portions of the TSA, in and around Lost Creek, Trail, and Monashee Pass, with a few smaller scattered pockets of red attack along Lower Arrow Lake. **Douglas-fir beetle** has increased slightly in the Pend D'Oreille River and Whiskey Point areas, although overall area affected is still relatively low at 160 hectares. Another 22 small spot infestations killed an additional 300 trees. **Western balsam bark beetle** activity remained quite scattered in small pockets. Affected area totalled 1,765 hectares, most of which was classified as trace.

Defoliators

Aspen serpentine leaf miner activity increased substantially from 343 hectares in 2011, to 4,970 hectares in 2012. Most defoliation was across the eastern and southeastern portions of the TSA, near Slocan Lake, Ymir, and Monashee Pass. Most of the defoliation was rated as light or moderate. **Birch leaf miner** activity was minimal, and was recorded on only 110 hectares.

Foliar Diseases

A second consecutive cool, wet spring and early summer led to higher infection rates of **larch needle blight** and as a result the mapped area expanded from 5,580 hectares in 2011, to 9,060 hectares in 2012. Affected stands were most prevalent in the Salmo, Rossland, and Slocan Valley areas. Most of the damage was light or moderate, and no tree mortality is expected.

Other damaging agents mapped during the aerial surveys were 22 hectares of **bear damage** in lodgepole pine plantations near Salmo, 48 hectares of **wildfire**, and 36 new or expanded **avalanche tracks** in the Bremner Creek, St. Leon Creek, and Halfway River areas.

Boundary TSA

Bark Beetles

Mountain pine beetle populations have continued to expand in the TSA, with total affected area up by over 40% to 13,932 hectares. Most of the mortality is still classified as trace or light and the number of small spot infestations has increased to 486, which reflects a highly scattered but viable beetle population. Most of the increased red attack was seen in the Lynch Creek, Grand Forks, and upper Granby River areas. Small patches of red attack were mapped across most other areas of the TSA, including the Kettle River, Beaverdell, Trapping Creek, Conkle Lake, lower Granby River, and Christina Lake areas. Other bark beetles had less impact, with trace levels of **western balsam bark beetle** being mapped on 590 hectares; **Douglas-fir beetle** was detected in only a few small, scattered pockets.

Mountain pine beetle attack in the West Kettle River valley, Boundary TSA.

Defoliators

Populations of **western spruce budworm** remained high in 2012, with just over 43,000 hectares of defoliation. Over half of the area was moderately or severely defoliated, with the area of severe defoliation increasing over five-fold to 7,730 hectares. The heaviest defoliation was concentrated around the Bridesville - Rock Creek area. Damage was seen as far east as Christina Lake, in stands with no previous record of defoliation. Three-tree beatings performed at nine permanent sample plots collected an average of 35 larvae per site. A total of 13,678 hectares of high-value Douglas-fir forests were treated with Foray 48B (*B.t.k.*) between June 30th and July 5th. Treatment was effective, as only 8% of sites sampled for eggmasses in the fall predicted moderate or severe defoliation in 2013.

The **Douglas-fir tussock moth** outbreak has subsided. No defoliation was visible, and moth catch at nine permanent sampling sites in the TSA was low, with only four sites having positive catches. Three sites averaged less than two moths per trap, and one site at Kettle Provincial Park averaged 6.5 moths per trap. Three-tree beatings were conducted at all sites, but no Douglas-fir tussock moth larvae were found.

Aspen serpentine leaf miner damage was minor, with just 278 hectares visibly affected.

Foliar Diseases

Area affected by **larch needle blight decreased**, from 14,040 hectares in 2011 to 4,040 hectares in 2012. However, many stands have been affected for two consecutive years and the impacts may be significant. Damage was scattered throughout the District.

Other damage detected during the aerial surveys were small areas affected by **bear damage**, **wildfire**, and **windthrow**.

Kootenay Lake TSA

Bark Beetles

Impacts from bark beetle activity have continued to decline in the TSA. Area affected by **mountain pine beetle** has dropped to the lowest level in nearly a decade, to 5,225 hectares. Red attack levels fell in most areas, although a slight increase was seen in the southeast portion of the TSA, around Yahk and the lower Goat River. This area of the TSA still has abundant green pine and the potential exists for populations to build in the future. **Douglas-fir beetle** infestation levels also declined, especially in the northern portion of the TSA, although several new spot infestations were detected northeast of Nelson, near Kokanee Creek. In total, light attack was recorded on 122 hectares and 54 spot infestations killed another 750 trees. **Western balsam bark beetle** activity remained very scattered in small patches. A total of 770 hectares were affected by trace and light mortality. **Spruce beetle** activity was limited to 37 hectares of moderate attack near Howser Creek.

Defoliators

Aspen serpentine leaf miner damage increased, from 640 hectares in 2011, to 2,775 hectares in 2012. Most of the defoliation was in the West Arm, Duncan Lake, and Lardeau River areas. In several additional areas of the TSA, low intensity defoliation was visible from the ground. **Birch leaf miner** defoliation was detected again in the Lardeau and Duncan River areas; affected area totalled 677 hectares. Damage levels were mostly light to moderate.

After a single **European gypsy moth** was caught in a pheromone trap at Kokanee Creek Park in 2009, delimiting grids of 16 traps per square mile were deployed. Two moths were caught in 2010, but after further delimiting grids were deployed in 2011 and 2012, no further moths were trapped in this area and the population is considered to have died out. In 2012, a single moth was caught near Kaslo; a delimiting grid will be deployed in the area in 2013.

Foliar Diseases

Larch needle blight infections increased from 2,420 hectares in 2011, to 8,540 hectares in 2012. Affected stands were scattered across the southern portion of the TSA, and in the Duncan Lake and Lardeau River areas. Most of the damage was light, and no tree mortality was noted.

Several additional but relatively minor damaging agents were detected during the surveys. These included several small patches of **windthrow** near Summit Creek totalling 205 hectares, 108 hectares of **bear damage** in lodgepole pine plantations, 70 new or expanded **avalanche tracks** covering 215 hectares, and 4 hectares of **wildfire**. Douglas-fir along the south side of Trout Lake continued to exhibit thinning crowns and scattered mortality, although the symptoms were only visible from the ground. Causal agent was undetermined, but it is likely the same as another similar site near Sugar Lake, where a combination of Armillaria root disease and low level Douglas-fir beetle was found, with drought stress acting as a catalyst.

Cranbrook TSA

Bark Beetles

Mountain pine beetle infestations continued on a declining trend in 2012. Area infested fell by nearly 60%, from 11,950 hectares to 4,895 hectares, and the proportion of attack classified as moderate or severe fell from 27% to 20%. The number of spot infestations fell by 75% to 345. The most significant declines were seen east of the Rocky Mountain Trench, with attack levels around the Elk River, Fording River, and Bull River falling sharply. Red attack was still widespread throughout the St. Mary River, Moyie, and Gold Creek areas. Attack in **whitebark pine** increased in the Matthew Creek area, totaling 260 hectares.

Douglas-fir beetle activity remained relatively low in the TSA, with just 136 hectares and fifty spot infestations of red attack mapped. Most of the beetle activity was in the Elk River area, although several new spot infestations were noted on the east side of Koocanusa Lake.

Most mortality associated with **western balsam bark beetle** occurred in small, widely scattered patches. Total affected area was 790 hectares in 2012.

Defoliators

Western spruce budworm defoliation increased slightly to 6,980 hectares, all of which was in the Flathead River area. Defoliation intensity has increased, and over 60% of the affected area was moderately or severely defoliated. Three-tree beatings performed at permanent sample plots near Grasmere and Elko were both positive for western spruce budworm larvae, however defoliation levels were too low to be detectable from the air. Results of egg mass sampling conducted in the fall of 2012 indicate that budworm populations and defoliation intensity will likely decline in 2013.

Western spruce budworm defoliation in the Flathead Valley, Cranbrook TSA.

Aspen serpentine leaf miner was mapped on 1,670 hectares in the St. Mary River and Flathead River areas, while **birch leaf miner** damage was limited to 23 hectares.

Foliar Diseases

Larch needle blight infections were fairly widespread in the Flathead River and Wigwam River areas, but scattered elsewhere. A total of 7,150 hectares were affected, down slightly from 2011 levels of 9,775 hectares. Damage severity was also down, with less than one quarter of the affected area classified as moderate or severe.

Other damage noted during the aerial surveys was limited to 79 hectares of **bear damage**. A small area of top-killed western red cedar was observed in the Teepee Creek area, however no mortality was noted and causal agent remains undetermined. During ground surveys, **Douglas-fir needle cast** was noted at several locations and appeared to be contributing to thinning crowns.

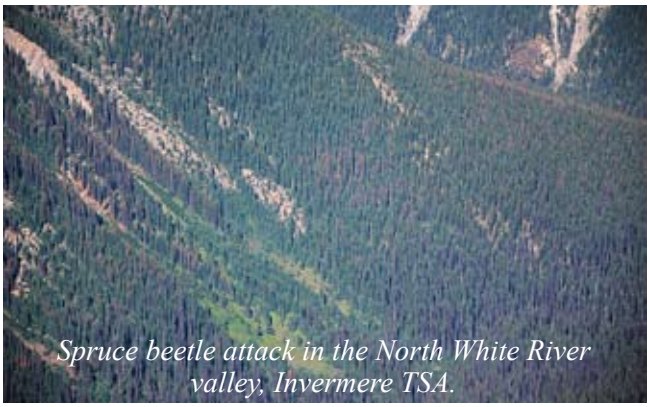
Invermere TSA

Bark Beetles

Mountain pine beetle infestations continued to decline, with area affected down by 50% to 8,225 hectares. The number of spot infestations was down as well, from 670 to 448. Areas east of the Rocky Mountain Trench, including the Kootenay River, Palliser River, and Lussier River, saw the most significant declines. However, despite the overall declining trend, red attack is still widespread, and present in most areas of the TSA. **Whitebark pine mortality** was common in the northwestern portion of the TSA, especially near Bobbie Burns Creek, Frances Creek, and the Spillimacheen River, with affected area increasing to 1,615 hectares.

Most active **Douglas-fir beetle** was in Kootenay National Park and in the lower Lussier River. Total affected area was up by 75% to 743 hectares. The number of spot infestations also increased from 36 to 65. A few other scattered pockets were mapped around East White River, Kindersley Creek, and Premier Lake.

The overall extent and intensity of an ongoing infestation of **spruce beetle** in the North White River drainage has remained relatively constant for several years, with mortality mapped on 550 hectares in 2012.



Spruce beetle attack in the North White River valley, Invermere TSA.

Western balsam bark beetle remained quite scattered in the TSA, with only 1,093 hectares of trace and light attack mapped.

Defoliators

Defoliator activity remained low in the TSA, with visible damage limited to 206 hectares of **aspen serpentine leaf miner** and six hectares of **birch leaf miner**.

Foliar Diseases

Larch needle blight damage increased from 900 hectares in 2011 to 2,361 hectares in 2012. Most of the damage was light, and was concentrated in the Kootenay River area.

Several other minor damaging agents were recorded during the aerial surveys, including 775 hectares of **wildfire**, 358 hectares of **windthrow**, 63 hectares of **bear damage**, and 31 hectares of **flooding**. In addition, 156 new or widened **avalanche paths** affected 333 hectares of spruce-balsam forests.

Left: bear damage in a lodgepole pine plantation, Spillimacheen River, Invermere TSA.

Right: extensive windthrow in the Palliser River valley, Invermere TSA.

Golden TSA

Bark Beetles

Mountain pine beetle infestations were down from 6,983 hectares in 2011, to just 2,844 hectares in 2012. Infestation intensity also declined, with nearly three quarters of the affected area classified as trace. The main infestations in Yoho National Park have nearly subsided, and beyond the park, most attack was scattered in small patches.

Douglas-fir beetle activity also declined, for the third year in a row. Red attack was mapped on just 145 hectares, and only 4 spot infestations were recorded. Most of the attack was in the Beaverfoot River area.

A few small **spruce beetle** infestations covering 62 hectares were observed in the Quartz Creek and Gold River areas. This is the first spruce beetle activity mapped in the TSA in several years.

Declining mountain pine beetle infestation in Yoho National Park.

Although nearly 2,000 hectares were affected by **western balsam bark beetle**, tree mortality levels remained low and patches of activity tended to be small and scattered.

Defoliators

Aspen serpentine leaf miner, Golden TSA.

Western hemlock looper defoliation was mapped on 616 hectares just west of Rogers Pass, in the Beaver River and Mountain Creek valleys. No population assessments were made and no treatments are planned for 2013. **Aspen serpentine leaf miner** populations increased, with defoliated area up over 7-fold to 4,056 hectares. Most of the affected stands were near Golden, the Beaverfoot River, and along the east side of Kinbasket Lake. The majority of the damage was rated as light. Other defoliator activity was light, with just 149 hectares of **birch leaf miner** detected in the Gold River – Kinbasket Lake area. Several small patches of severe **satin moth** defoliation were noted during three-tree beating surveys west of Golden, and between Spillimacheen and Parsons, however they were not visible during aerial surveys.

Other damaging agents included 174 hectares of **larch needle blight** near Donald, 440 hectares of **flooding damage** along the Columbia River near Donald and Golden, 427 hectares of **wildfire**, 153 hectares of **windthrow**, 72 hectares of **bear damage**, and 47 new or widened **avalanche paths** which affected 96 hectares. A few additional damaging agents were noted during defoliator three-tree beating surveys, including: a bud fungus, possibly *Dichorera gemmicola*, killing Douglas-fir buds near Donald; and a foliar disease, likely *Pucciniastrum epilobii*, causing light to moderate defoliation of semi-mature sub-alpine fir through Rogers Pass.

Revelstoke TSA

Bark Beetles

Bark beetle activity was limited in the TSA. Tree mortality mapped during the aerial surveys amounted to 148 hectares of **mountain pine beetle**, 77 hectares of **western balsam bark beetle**, and 11 hectares of **Douglas-fir beetle.**

Defoliators

Western hemlock looper defoliation was down from 597 hectares in 2011 to 323 hectares in 2012, due to a combination of naturally declining populations and treatment of several stands with aerially-applied *B.t.k.* For a complete report on spray operations and population monitoring activities, see the Special Projects section of this report.

Western hemlock looper defoliation along Lake Revelstoke.

Western spruce budworm defoliated 1,700 hectares of Douglas-fir along the east side of Revelstoke Lake, from Laforme Creek north to Mars Creek. This is the first record of defoliation in this area. Over 60% of the affected area was moderately or severely defoliated. Egg mass sampling was conducted in the fall of 2012 at six sites, all of which predict light defoliation for 2013.

In 2009, a single **European gypsy moth** was caught in a pheromone trap near Revelstoke. Delimiting grids were deployed in this area and additional single moths were caught in 2010 and 2011, however no moths were caught in 2012. If no further moths are caught in this grid in 2013 the population will be considered to have died out.

Leaf miner damage was prevalent, with **aspen serpentine leaf miner** mapped on 3,820 hectares near the Mount Revelstoke Resort and Mars Creek areas. **Birch leaf miner** was mapped on 182 hectares.

Aspen serpentine leaf miner, Revelstoke TSA.

Other

Other forest health agents noted during the aerial surveys included 14 hectares of **larch needle blight**, 12 new **avalanche paths** (36 hectares), and small areas of **wildfire** (7 hectares) and **windthrow** (3 hectares). During ground surveys, a foliar disease (likely *Pucciniastrum epilobii*), was observed causing light to moderate defoliation of semi-mature sub-alpine fir through Rogers Pass.

Cariboo Region Summary

The Cariboo portion of the aerial overview surveys was conducted between July 24th and August 14th, and required 30 flights and 142.1 hours of flight time. Conditions for the surveys were variable, however surveyors were able to work around poor weather due to successful pre-planning. The surveys covered the entire Cariboo Region (Quesnel, Williams Lake, and 100 Mile House TSAs) as well as the Robson Valley TSA and small portions of the Prince George, Lakes, Mid-Coast, Kingcome, and Sunshine Coast TSAs. One crew comprised of Don Wright and Mel Dodge surveyed the east half of the Region, while a second crew comprised of Joe Cortese and Bob Erickson surveyed the west half of the Region. Aircraft were chartered from White Saddle Air Services, Lawrence Aviation, Cariboo Air, and Lakes District Air Service, and utilized Cessna 180, 185, and 206 aircraft, both on and off floats.

Quesnel TSA

Bark Beetles

Western balsam bark beetle populations appear to be increasing in the TSA, with the affected area and attack intensity up from 2011 levels. A total of 19,635 hectares were affected, nearly 90% of which was classified as light attack; in 2011, only 1% of the affected area was classified as light attack.

An increase in **Douglas-fir beetle** attack was seen in the Victoria Creek, Swift River, and Ahbau Lake areas. A few scattered infestations were also detected near Beavermouth, Hill Lake, Deserters Creek, and Nazko. In total, 1,570 hectares, and 80 spot infestations, were mapped.

Spruce beetle populations remained relatively low. Light attack was detected on 1,110 hectares on TFL #52, near Barkerville and Coldspring House.

Mountain pine beetle was essentially absent from the TSA, with only 10 hectares of light attack in the Baezaeko River area.

Defoliators

Two-year cycle budworm damage has declined slightly from the last "on" year, from 46,845 hectares in 2010, to 32,060 hectares in 2012. Affected stands were all east of Quesnel, on and around TFL #52. A trial evaluating the efficacy of aerially-applied *B.t.k.* (Foray 48B) was conducted near Mount Tom. Three blocks covering nearly 900 hectares were treated. Results are discussed in the Special Projects section of this report.

As expected, **western spruce budworm** populations declined sharply in 2012. Defoliated area fell by over 95%, to just 830 hectares. Damage levels are expected to remain low in 2013, with all eleven eggmass sampling sites predicting very low population levels.

Area defoliated by **forest tent caterpillar** declined by nearly 80%, to 9,210 hectares. Damage intensity was also down, with the proportion of defoliation classed as moderate or severe declining from nearly 50% in 2011, to 12% in 2012. This downward trend was expected, based on ground checks conducted in 2011, which indicated that populations were declining. Most of the 2012 defoliation occurred in the 300 Road and 500 Road area. Many of the stands affected recently have also been affected by a combination of other pests such as aspen serpentine leaf miner and Venturia twig blight. This combination has led to dead tops and branch tips in several areas.

Aspen serpentine leaf miner damage increased from 3,315 hectares in 2011, to 10,155 hectares in 2012. Most defoliation was in the Umiti Creek, Ahbau Lake, Bowron Lake, and Sardine Creek areas.

A lodgepole pine plantation southeast of Ahbau Lake was defoliated by **pine needle sheath miner**. A total of 175 hectares were affected. The plantation near Garnet Road which was defoliated in 2011, appears to have recovered, with no new defoliation visible.

Post-Wildfire Mortality

In 2009 and 2010, several large, low-intensity wildfires damaged trees over several thousand hectares. New mortality, resulting from a combination of fire-damaged roots, stems, and crowns, and both primary and secondary bark beetles, was mapped in 2012, on 5,485 hectares. Tree species affected were Douglas-fir and lodgepole pine, and in most cases, mortality rates were moderate to severe. This post-wildfire mortality may continue until most of the fire-damaged trees in these areas are killed.

Other damage recorded by the aerial surveys were 24 hectares of **aspen decline,** 212 hectares of **flooding damage**, 158 hectares of **windthrow**, and 12 hectares of **wildfire**.

Williams Lake TSA

Bark Beetles

Mountain pine beetle activity was largely confined to the South and West Chilcotin, mainly in the Churn Creek, upper Taseko River, Chilko Lake, Ottarasko River, and Charlotte Lake areas. Although abundant green pine remains unattacked in this part of the TSA, most of the remaining red attack is at high elevation, in stands consisting of small-diameter stems, where reproductive success tends to be low. Attack is quite scattered, with nearly all of the 13,000 hectares mapped classified as trace or light. An additional 287 spot infestations were recorded.

Declining mountain pine beetle infestations in the Big Creek drainage, Williams Lake TSA.

Douglas-fir beetle continued to be widespread in the TSA, with attack being observed throughout the host range. As a result of a significant increase in red attack around Beaver Creek, Big Creek, Miocene, and Forest Lake, the total area of larger patches was up from 2,100 hectares in 2011, to 6,850 hectares in 2012. The number of small spot infestations of 5-50 trees also increased, from 800 to 887. Douglas-fir beetle incidence is increasing within stands damaged by the extensive, low-intensity wildfires of 2010 and the potential exists for these populations to move into green, undamaged timber over the next few years.

Spruce beetle activity has been slowly increasing over the past several years, with a total of 18,113 hectares mapped in 2012. About 50% of the mapped fade was moderate or greater severity. This is an increase from 2010 levels of 16,545 hectares, of which 34% was moderate or greater severity. Most spruce beetle populations in the TSA are in a synchronized two-year life cycle and this, combined with unreliable tree fade, leads to fluctuating hectares being mapped in any given year (4,862 hectares mapped in 2011). The affected stands were mostly in the Crooked Lake, MacKay River, upper Horsefly River, Warttig Lake, and Bill Miner Creek areas.

Overall area affected by **western balsam bark beetle** has remained unchanged from 2011 levels, at 27,130 hectares. However, attack intensity has increased; the proportion of affected stands with more than 1% red attack has increased from 27% in 2011, to 77% in 2012. Most of the affected stands were around Quesnel Lake, Keithley Creek, and Big Timothy Mountain. Scattered pockets of attack were also mapped in the Chilcotin Mountains, around Chilko Lake, Taseko River, Homathko River, and Mosley Creek.

Defoliators

A combination of aggressive spray programs (36,338 hectares in 2012, and 13,887 hectares in 2011) and natural population decline led to a sharp drop in area defoliated by **western spruce budworm** throughout the Anahim Lake, Riske Creek, Meldrum Creek, Williams Lake, Springhouse, McLeese Lake, and Knife Creek areas. Total area affected was down by over three-quarters to 79,617 hectares, and the area of moderate and severe defoliation fell from over 43,000 hectares in 2011, to 6,510 hectares in 2012. Egg mass sampling conducted in the fall of 2012 indicates that populations should remain low in most areas in 2013, with only 19 of 135 sites (14% of sites) predicting moderate or severe defoliation.

Western hemlock looper defoliation was recorded on 5,460 hectares, nearly unchanged from 2011 levels of 5,775 hectares. However, in most areas, larval populations declined sharply part way through the feeding cycle, in large part due to impact of spring egg parasitism and adverse spring and early summer weather conditions. This helped to limit damage levels to light defoliation in over 80% of affected stands. As well, most stands were only defoliated for one year, which should also limit long-term damage. Results of larval beatings, moth trapping, and egg collections in the fall all indicate that hemlock looper populations have declined, and 2013 damage is only predicted near Tasse Lake.

Area affected by **two-year cycle budworm** has remained nearly unchanged from the last "on" year in the feeding cycle (2010), at 8,448 hectares. Most of the defoliated stands were in the Keithley Creek, Cariboo Lake, and Little River areas.

Widespread defoliation of trembling aspen by **aspen serpentine leaf miner** continued, mainly in the Quesnel Lake, Horsefly River, and West Chilcotin areas. Damage was recorded on 21,805 hectares, which is up from the 2011 total of 7,045 hectares. This apparent increase is mainly due to the implementation of a new provincial damage classification standard which began in 2012 (see Regional Overview section for details).

Forty hectares of severe **forest tent caterpillar** defoliation were recorded near the border with the Quesnel TSA.

Post-Wildfire Mortality

New mortality of both Douglas-fir and lodgepole pine was observed within stands damaged by low-intensity 2010 wildfire activity. A total of 6,010 hectares were affected, over two-thirds of which experienced moderate to severe levels of mortality. Most affected stems experienced fire damage to roots, stems, and/or crowns and are now being killed by a combination of this and bark beetles, most notably Douglas-fir beetle.

Animal Damage

Damage patterns typical of animal feeding, including scattered tree mortality and dead tops, were observed in 22 separate lodgepole pine plantations in the eastern wet belt areas of the TSA. Ground checks confirmed the causal agent as **black bear**. Porcupine feeding was also observed in these and several other areas of the TSA. However it does not as often cause mortality in lodgepole pine past the seedling stage.

Other damage recorded during the aerial surveys were 8 hectares of severe **aspen decline**, 2,010 hectares of **wildfire**, 152 hectares of **windthrow**, six **landslide**s which covered 63 hectares, fourteen new **avalanche paths** covering 80 hectares, and 117 hectares of **red belt** at Lone Cabin Creek. **Flooding damage** was quite widespread across the West Chilcotin in 2012, especially around Nimpo Lake, Charlotte Lake, and Aktaklin Lake. Lodgepole pine was the most commonly affected tree species. However, Douglas-fir, spruce, cedar, hemlock, and subalpine fir were also affected.

100 Mile House TSA

Bark Beetles

After declining in 2011, **Douglas-fir beetle** activity increased sharply in the TSA in 2012. Affected area was up by nearly twenty-fold, to 3,344 hectares. An additional 349 spot infestations were mapped, up from 213 in 2011. Most of the attack was near Lac La Hache, Timothy Lake, Ruth Lake, Canim Lake, Spout Lake, Kelly Lake, and Loon Lake.

Spruce beetle attack was mapped on 10,900 hectares in 2012, nearly half of which experienced moderate or greater mortality. This is up significantly from 2011 levels of 1,705 hectares, but similar to the area mapped in 2010 (9,195 hectares), which shows that populations are relatively static in the TSA. Most of the affected stands were near Deception Creek, Mount Hendrix, and Boss Creek. As in other areas in the Cariboo, a combination of unreliable tree fade and a synchronized two year life cycle led to large fluctuations in detected area from 2010 - 2012.

Western balsam bark beetle attack has declined in the TSA, with new red attack being mapped on only 1,560 hectares. Most of the affected stands are near Deception Creek and Boss Creek.

Mountain pine beetle activity was limited to 222 hectares of new red attack near Jesmond and Kelly Lake.

Defoliators

As expected, **western spruce budworm** populations increased near Canoe Creek, China Gulch, Big Bar, and Jesmond; however, treatment of 14,870 hectares with *B.t.k.* reduced damage levels and helped to limit moderate and severe defoliation to 10% of the affected area. Larval populations and damage levels declined naturally around Clinton, Upper Loon Lake, and Dog Creek. Overall defoliated area declined from 62,265 hectares in 2011, to 48,105 hectares in 2012. Egg mass sampling conducted during the fall of 2012 indicates that defoliation should remain light in most areas in 2013, with a few pockets of moderate defoliation around Dog Creek and China Gulch.

The incidence of **aspen serpentine leaf miner** increased in the eastern portions of the TSA, from 987 hectares in 2011, to 6,290 hectares in 2012. Much of this increase is due to the new damage classification standard, which enables more thorough recording and tracking of leaf miner damage (see the Regional Overview section for details). Affected stands were scattered near Canim Lake, Mahood Falls, Bridge Lake, and Horse Lake.

Douglas-fir tussock moth pheromone traps deployed at 31 six-trap clusters caught an average of only 1.4 moths per trap. No defoliation was recorded in the TSA and none is expected in 2013.

Other damaging agents observed during the aerial surveys were 92 hectares of **aspen decline** near Green Lake and Sheridan Lake, 114 hectares of **black bear feeding** damage in lodgepole pine plantations near Spanish Creek and Deception Creek, 189 hectares of **windthrow** near Spout Lake, 448 hectares of **wildfire**, and nine hectares of **flooding damage**.

Left: Lodgepole pine killed by bear feeding near Pendleton Lakes, 100 Mile House TSA. Below: closeup of bear feeding damage symptoms.

Forest Health - Special Projects

2012 Western Spruce Budworm Program Summary

Operations Summary

The 2012 western spruce budworm spray program saw a total of 116,012 hectares of Douglas-fir forest treated with Foray 48B (*Bacillus thuringiensis* var. *kurstaki*, or *B.t.k.*, P.C.P. No. 24977) in southern B.C. (Thompson Okanagan, Cariboo and Kootenay Boundary Regions) (Table 1). Foray 48B was applied at 2.4 litres per hectare on all sites for a total of 278,430 litres of *B.t.k.* applied in the 2012 program.

To achieve optimum foliage protection, peak 4th instar larvae are targeted. Timing of spray is dependent upon a number of factors including, but not limited to:

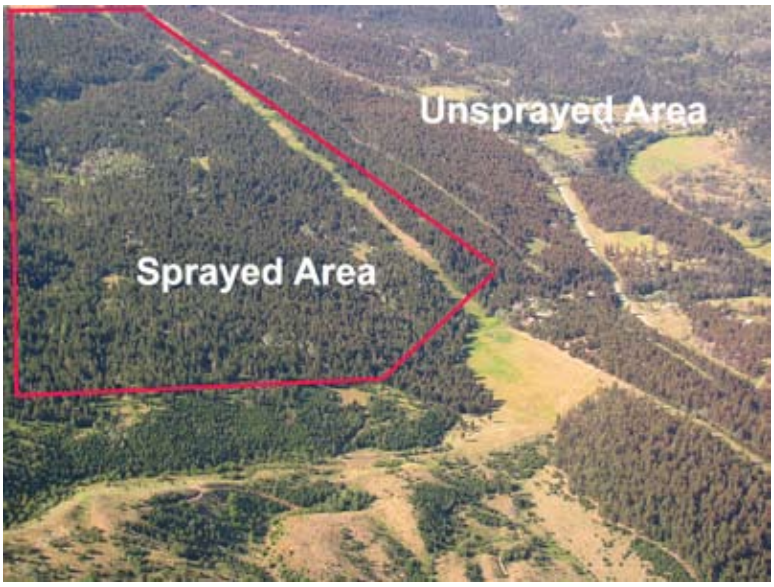
1. Foliage development – new shoot must be flushed and elongating;
2. Insect development – most budworm larvae should be in the 4th instar, but there will be some at earlier and later stages of development when treatment is applied; and,
3. Weather – preferably dry and warm so that larvae feed actively and ingest *B.t.k.* immediately after spray.

The above diagram describes the relationship between B.t.k. application timing, shoot development, and western spruce budworm larval instar stage.

Thompson Okanagan Region

The Thompson Okanagan Region treated a total of 54,337 hectares (Table 1; Figures 1, 2) for western spruce budworm, using 130,408 litres of *B.t.k*. The 2012 program was the largest program ever undertaken in the Region, with a 45% increase over the 29,875 hectares sprayed in 2011. May and June weather was cool and wet in 2012, but allowed for synchronized bud flush, larval dispersal, needle mining and bud mining. Needle mining and budmining levels were very high throughout all areas scheduled for treatment. Spraying began on June 20th, 2012, in the Okanagan, where just three days were required to complete treatment of 26,511 hectares. The program then moved north to the Merritt, Spences Bridge and Kamloops areas, where 27,826 hectares were completed in another three days. The entire program required 6 days, with production ranging from 6,955 hectares to 11,647 hectares per day (Table 2; Figure 2). Block size and placement in relation to staging sites, plus the ability to move efficiently between staging sites, is key to a smoothly executed program given tight biological windows. Larval development was slow until late June, at which time feeding rates and development moved ahead rapidly. Significant bud damage was incurred on many spray blocks prior to treatment due to this long period of larval feeding within buds and very high insect density.

Western Aerial Applications Ltd. conducted the aerial application for the Thompson Okanagan Region. Two 315B Lama helicopters and three Hiller UH12ET helicopters, each equipped with four Beecomist 361A ultra low volume hydraulic sprayers, were deployed. Mobile fuel trucks and loading crews were available for each staging site, and most spray mornings two staging sites operated simultaneously. Loading crews had the ability to re-locate to additional staging sites if conditions were suitable. In the Thompson Okanagan a total of 127, 1,000-litre bulk *B.t.k.* containers were delivered to 15 staging sites located in the Cascades, Okanagan Shuswap and Thompson Rivers Districts. The cost per hectare for the 2012 western spruce budworm program was approximately $31.43 for the Thompson Okanagan portion (cost breakdown is shown in Table 3). Cost per hectare typically ranges from $30 to $35 depending upon scale of the program and *B.t.k.* cost. The spray program was planned and implemented by Regional staff, contractors and co-op students with much appreciated support from Victoria and District staff. We acknowledge Tolko Forest Products for being able to use their Bear Creek log sort as a staging site for spray blocks in the West Kelowna area.



Spray block boundary near Tolman Creek in the Merritt TSA. Reduced defoliation in the sprayed area relative to the unsprayed area is clearly visible.

Table 1. Summary of all 2012 spray programs in southern B.C. The table is separated by target insect (western spruce budworm, western hemlock looper, and two-year cycle budworm) and lists by Region the area sprayed with *B.t.k.*, volume of *B.t.k.* applied, number of spray blocks, number of staging sites, and number of days required to complete each spray program.

	Thompson Okanagan	Kootenay Boundary	Cariboo	Total
Western Spruce Budworm				
Hectares sprayed	54,337	13,678	47,998	116,013
Litres *B.t.k.* applied	130,408	32,827	115,195	278,430
Number of. blocks	38	9	29	76
Number of staging sites	15	5	2	22
Number of days to complete	6	4	11	21
Western Hemlock Looper				
Hectares sprayed	4,014	7,967		11,981
Litres *B.t.k.* applied	9,634	19,122		28,755
Number of blocks	7	21		28
Number of staging sites	4	5		9
Number of days to complete	1	2		3
Two-Year Cycle Budworm				
Hectares sprayed			890	890
Litres *B.t.k.* applied			2,136	2,136
Number of blocks			3	3
Number of staging sites			2	2
Number of days to complete			1	1
Total hectares sprayed				**128,888**
Total litres *B.t.k.*				**309,321**

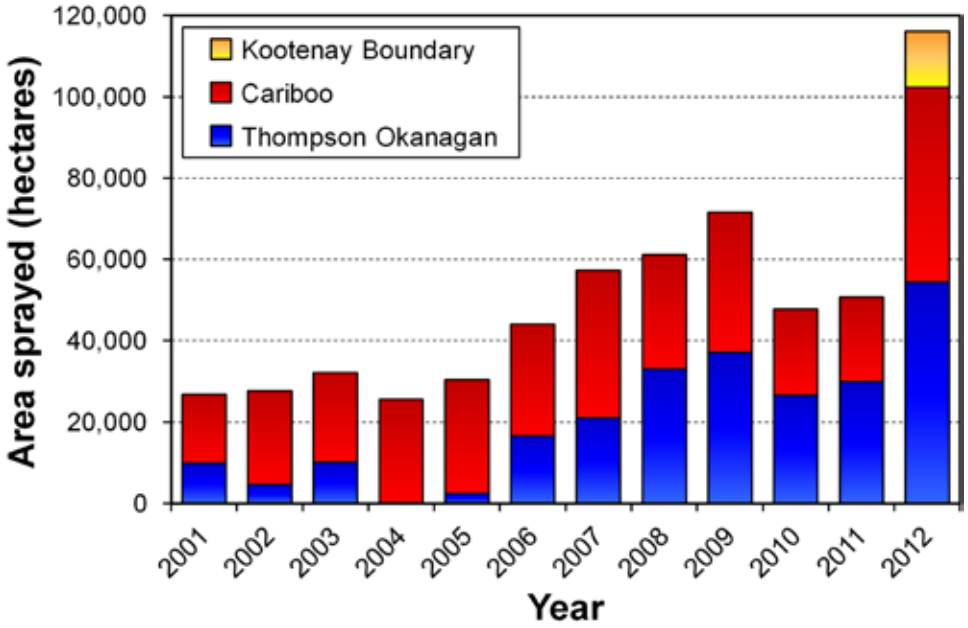


Figure 1. Area sprayed with *B.t.k.* for western spruce budworm from 2001 to 2012 in the Cariboo, Thompson Okanagan and Kootenay Boundary Regions.

Table 2. List of western spruce budworm spray blocks in the Thompson Okanagan Region treated with Foray 48B in 2012. The table lists by block number and location the area treated, litres of *B.t.k.* applied and date(s) sprayed.

Block #	Location	Area Sprayed (hectares)	Litres *B.t.k.*	Date Sprayed
OK3	Bear Creek	4,161	9,987	June 20
OK4	McDougall Creek	914	2,194	June 20
OK5	Smith Creek	1,421	3,410	June 20
OK6	Glenrosa Road	1,412	3,390	June 20
OK9	Yellowlake Creek	1,062	2,549	June 22
OK10	Mount Laidlaw	468	1,125	June 22
OK11	north of Yellow Lake	558	1,340	June 22
OK12	Orofino Mountain	7,778	18,668	June 22
OK14	Naramata Bench	1,553	3,726	June 21
OK16	Carmi Road	697	1,672	June 21
OK17	McLean Creek	505	1,212	June 22
OK18	Shuttleworth Creek North	651	1,561	June 22
OK19	Shuttleworth Creek South	62	1,498	June 22
OK20	Camp McKinney Road North	3,356	8,060	June 21
OK21	Camp McKinney Road South	1,348	3,234	June 21
M1	Clapperton Creek	84	200	June 27
M2	Clapperton Creek	323	776	June 27
M3	Clapperton Creek	869	2,085	June 27
M4	Clapperton Creek	198	476	June 27
M5	Clapperton Creek	216	518	June 27
M6	Swakum Mtn - Jesse Creek	489	1,174	June 27
M7	Swakum Mtn - Jesse Creek	2,225	5,339	June 27
M8	Swakum Mtn - Jesse Creek	616	1,479	June 27
M9	Guichon Creek	770	1,848	June 29
M10	Guichon Creek	721	1,730	June 29
M11	Guichon Creek	2,040	4,896	June 29
M11A	Mamit Lake	1,118	2,682	June 29
M12	West of Merritt	2,514	6,032	June 27-28
M13	West of Merritt	2,897	6,952	June 27-28
M14	West of Merritt	799	1,919	June 28
M15	Pimainus Creek	3,447	8,272	June 28
M16	Sackum-Soap Lake	2,438	5,852	June 28
M17	Sackum-Soap Lake	879	2,111	June 28
M18	Sackum-Soap Lake	307	737	June 28
M19	Sackum-Soap Lake	330	791	June 28
K1	Duffy Lake	1,628	3,906	June 29
K2	Inks Lake	2,170	5,209	June 29
K2A	Inks Lake	749	1,798	June 29
Thompson Okanagan Region Total		**54,337**	**130,408**	**June 20 - 29**

Table 3. Major cost categories for the Thompson Okanagan Region 2012 western spruce budworm spray program.

Activity	Cost
Fall 2011 egg mass sampling	$55,000
Aircraft (spray helicopters and planning flights)	$424,700
B.t.k.	$1,075,873
Weather monitoring and efficacy assessment	$60,000
Trucking *B.t.k.* to and from staging sites	$45,570
Advertisements & Communications	$11,704
Equipment, supplies and technical support	$7,000
Two co-op. students	$28,000
Total estimated cost	**$1,707,847**
Estimated cost per hectare	**$31.43**

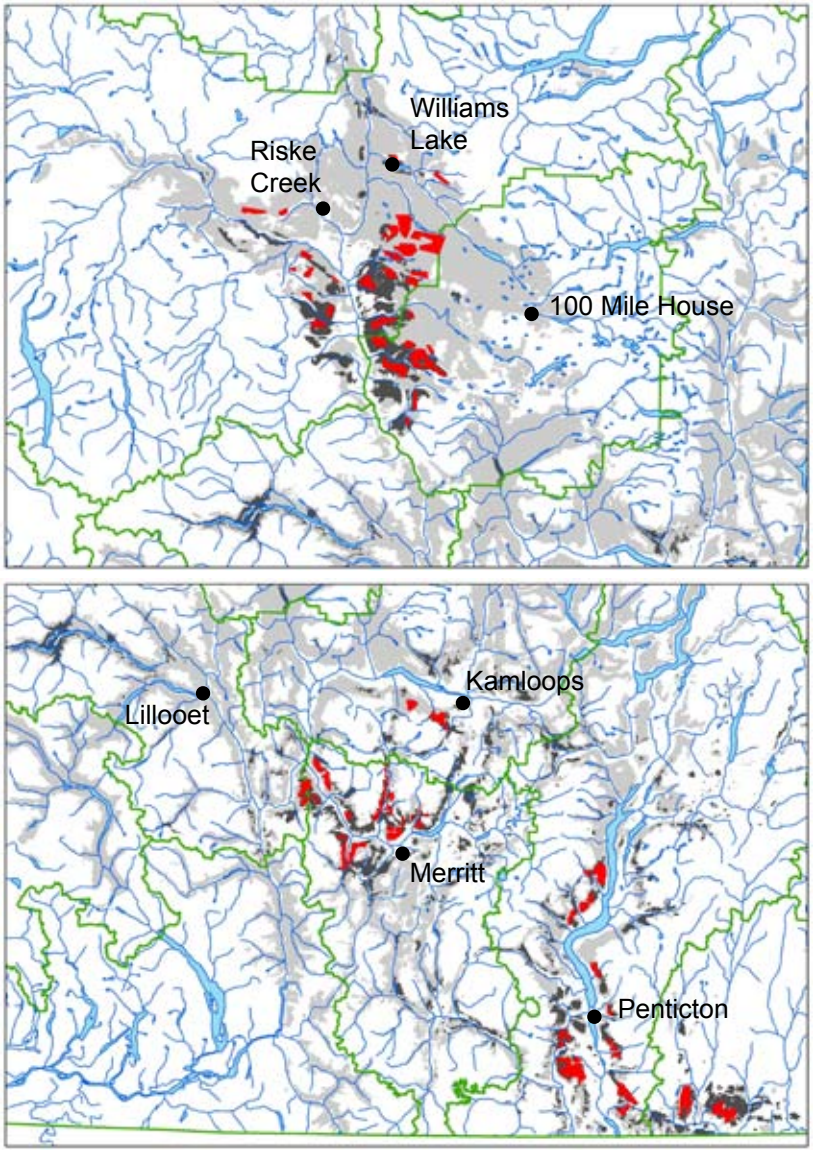


Figure 2. Map of the Cariboo (upper map) and Thompson Okanagan - Kootenay Boundary Regions (lower map) showing 2012 spray block locations for western spruce budworm (red), 2012 defoliation (dark grey), and historical defoliation from 1909 - 2011 (light grey).

Hiller spraying B.t.k. on budworm block.

Lama (in air) and Hiller (on ground) at staging site near Pimainus Creek.

Early season needle mining by 2nd instar budworm larvae.

High level of budmining and bud destruction by early instar larvae.

Defoliation of current year growth on a young Douglas-fir.

Douglas-fir stand showing defoliation damage.

Cariboo Region

The Cariboo program treated 47,998 hectares (Table 1; Figures 1, 2), using 115,195 litres of *B.t.k.* The program required 11 days to complete, between June 25th and July 7th, 2012 (Table 4). Production ranged from 2,075 hectares to 9,008 hectares per day. Start-up and completion of the Cariboo program was impeded by cool, wet weather throughout June. All treatments targeted 4th instar larvae and full bud flush.

The 2012 aerial application in the Cariboo Region was completed by Conair, using two AT-802F Air Tractors. The project was a collaborative effort between Region and District staff, the Provincial Air Tanker Centre, Conair and several forest health consultants. The *B.t.k.* was delivered to the Cariboo in tankers, where it was transferred to several 2,500 US gallon storage tanks located at the Williams Lake and 108 Mile airports, which were used as staging sites for the program.

Table 4. List of western spruce budworm spray blocks in the Cariboo Region treated with Foray 48B in 2012. The table lists by block number and location the area treated, litres of *B.t.k.* applied and date(s) sprayed.

Block #	Location	Area Sprayed (hectares)	Litres *B.t.k.*	Date Sprayed
2	601 Road Chilcotin	1,773	4,256	July 6-7
3	Harper Lake	707	1,696	July 6
7	Fox Mountain	811	1,946	June 25
9	Rideau Lake	1,156	2,773	June 25
12	Place Lake	2,032	4,877	July 5
13	Chimney Lake South	6,709	16,101	June 27, July 5
14	Alkali Lake	3,410	8,183	June 25,26
15	Alixton Lake	1,417	3,400	June 25
17	Gulatch Lake	1,359	3,262	June 27
18	Emerald Lake	1,443	3,463	July 4, 5
19	Joes Lake East	1,451	3,483	June 25
20	Joes Lake South	2,362	5,669	June 26
21	Cow Lake	326	783	July 6
22	Farwell Creek	1,007	2,418	June 25
23	Cargile Creek	387	928	July 6
24	2700 Road	999	2,397	July 6
26	Gaspard Camp	839	2,013	July 6
27	Word Creek South	1,014	2,434	June 26
28	Gaspard - Churn	1,430	3,432	June 26
29	Tinmusket	2,498	5,995	June 28, July 4
30	Pigeon Creek South	564	1,353	June 28
33	Canoe Creek North	1,812	4,349	July 2
34	Canoe Lake	1,050	2,519	July 2
35	Foxtail Flat	657	1,577	July 1
36	Clink Lake	5,795	13,907	June 29, July 1, 2
37	Canoe Creek - China Gulch	3,556	8,534	June 28
41	Hidden Valley	421	1,010	July 2
42	Jesmond	1,016	2,438	July 2
Cariboo Region total		**47,998**	**115,195**	**June 25 - July 7**

Kootenay Boundary Region

A total of 13,678 hectares in nine separate blocks were sprayed with *B.t.k.* in the Kootenay Boundary Region in 2012 (Table 1; Figures 1, 2). This was only the second spray program for western spruce budworm in the Boundary TSA since the program began in 1987. All treatment blocks were located in the Boundary TSA between Greenwood and Beaverdell. Treatment spanned over six days between June 30th and July 5th, 2012 (Table 5). There were numerous delays due to heavy cloud cover or precipitation.

Western Aerial Applications Ltd. conducted the aerial application. *B.t.k.* was delivered to five staging sites in 1,000 litre bulk containers. The spray operations were planned and implemented by Regional and District Forest Health staff with support from consultants.

Table 5. List of western spruce budworm spray blocks in the Kootenay Boundary Region treated with Foray 48B in 2012. The table lists by block number and location the area treated, litres of *B.t.k.* applied and date(s) sprayed.

Block #	Location	Area Sprayed (hectares)	Litres *B.t.k.*	Date Sprayed
BO 1	Rock Creek – Sidley Mountain	242	581	July 4
BO 2	Rock Creek – Johnstone Creek	4,769	11,446	July 4-5
BO 3	Rock Creek – Bridesville	559	1,341	July 4
BO 4	Rock Creek – Dolomite	249	599	July 4
BO 5	Kerr Creek – Nicholson Woodlot	322	772	July 4
BO 6	Kerr Creek – Ingram Mountain	4,900	11,759	June 30, July 2, 4
BO 7	Kerr Creek – Marshall Woodlot	115	276	June 30
BO 8	Kerr Creek – Deadwood	1,382	3,318	June 30, July 2, 4
BO 9	Beaverdell – Tuzo/Logan	1,140	2,735	July 5
Kootenay Boundary total		**13,678**	**32,827**	**June 30 - July 5**

Efficacy Assessment

Starting in May each year, candidate spray blocks are monitored for evidence of needle mining and budmining to evaluate budworm abundance and assess the synchrony of populations with bud flush. In 2012, very high levels of both needle and budmining were observed throughout the Thompson Okanagan project area. There were often multiple larvae per shoot observed ranging from 2nd instar to 5th instar in the same 3-bud cluster. Given this observation, it was decided that significant larval assessments were needed pre- and post-spray to evaluate spray efficacy and follow the natural mortality of the budworm population.

Thompson Okanagan Region

A total of 270 trees, 185 in sprayed areas and 85 in untreated control areas, were sampled for budworm larvae pre- and post-spray (Table 6). Many spray blocks did not have comparable unsprayed areas nearby (e.g. similar elevation, insect density, development stage), therefore fewer unsprayed control areas were sampled. Pre-spray sampling was normally conducted on the day prior to treatment, with the exception of a few control areas, where pre-spray sampling occurred on the day of treatment. The density of larvae at the pre-spray sample time ranged from 36 to 348 larvae per m^2 foliage with an average of 211 larvae per m^2 foliage. Insect density was very high at all sites treated in 2012. Generally after spraying, the larval density was quickly and significantly reduced (Figure 3; Table 7). The four geographic areas highlighted in Figure 3 show a dramatic reduction in budworm numbers by the first post-spray sampling time within the spray blocks compared to unsprayed areas. There is always a natural reduction in density as the larvae mature, but one of the measurements of treatment efficacy is the rapid decrease in larval numbers afforded by *B.t.k.* application (Figures 3 and 4).

Table 6. Number of trees sampled to assess western spruce budworm populations in control and treatment areas showing date of pre-spray sampling.

		Number of Trees		Pre-spray
District	**Location**	**Treated**	**Control**	**sampling date**
Okanagan	Glenrosa	15	15	June 19
Okanagan	Sheep Creek	15	15	June 21
Okanagan	McKinney	15	15	June 21, 22
Okanagan	Orofino	15	N/A	June 22
Okanagan	Carmi	15	N/A	June 20
Thompson Rivers	Duffy	15	15	June 30
Cascades	Swakum	10	N/A	June 26
Cascades	Kirby	10	10	June 26
Cascades	Tolman	15	15	June 28
Cascades	Sackum-1	15	N/A	June 29
Cascades	Sackum-2	15	N/A	June 29
Cascades	Pimainus-1	15	N/A	June 28
Cascades	Pimainus-2	15	N/A	June 28
Total # Trees		**185**	**85**	

Abbott's corrected mortality compares the mortality caused by the *B.t.k.* (percent mortality) to the natural mortality observed in untreated control areas (Table 7).

Percent mortality and Abbott's corrected mortality are calculated as follows:

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

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

This calculation ranged from 37% at the 1st post-spray assessment in the Sheep Creek area to over 88% in the Duffy Lake area. Both the Sackum and Pimainus areas had very high budworm numbers at the time of spray but by the 2nd post-spray assessment, Sackum had 84% larval mortality and Pimainus had over 98% larval mortality (Table 7). Populations in the Tolman spray block decreased so drastically after spray compared to the control that no 2nd post-spray sample was taken (Figure 3). The majority of larvae were 3rd instar with a good complement of 4th instar on the Tolman spray block when treated. The lower elevation control site had an equal distribution of 3rd, 4th and 5th instars (Figure 5). The graph in Figure 5 clearly shows the development shift in the Tolman control site to predominantly 4th instar and 5th instar larvae by the 1st post-spray assessment coupled with the drastic population decline in the spray block. Due to the extended cool, wet weather in May through June 2012 larval development was slow but the very high larval numbers caused significant feeding damage to buds and new foliage before the majority of the population reached 4th instar. At the pre-spray sampling time 81% of insects sprayed were 3rd or 4th instars with over 50% still 3rd instar (Figure 6). By mid-July when the 2nd post-spray sample was conducted in most locations approximately 64% of budworm were 5th or 6th instars (Figure 6). If spraying had been delayed to allow for the insects to develop further (typically peak 4th instar larvae are targeted) then the defoliation in blocks would have been unacceptable.

*Clockwise from above: Snakeflies (Raphidiidae), coneworms (*Dioryctria pseudotsugella*), and sawflies (*Neodiprion*) are commonly encountered when conducting larval sampling.*

Table 7. Summary of 2012 pre- and post-spray sampling of western spruce budworm in the Thompson Okanagan Region. The table lists by site and treatment the larval density (number of larvae per m^2 foliage), the percent larval mortality (percent), and Abbott's corrected mortality (percent) at the three sampling times.

	larval density (# larvae/m^2 foliage)			% mortality			
				Uncorrected		Abbott's corrected	
Location	**pre-spray**	**1st post**	**2nd post**	**1st post**	**2nd post**	**1st post**	**2nd post**
Glenrosa treated	175.0	47.9	28.5	72.6	83.7	67.7	77.9
Glenrosa control	105.4	89.3	77.6	15.3	26.4		
Sheep Cr treated	302.6	118.3	58.4	60.9	81.8	37.3	71.3
Sheep Cr control	327.2	204.1	207.2	37.6	36.7		
McKinney treated	212.8	87.1	4.1	59.1	98.1	62.1	26.7
McKinney control	227.7	246.2	6.0	-8.1	97.4		
Orofino treated	300.2	285.6	7.5	4.9	97.5		
Carmi treated	179.2	74.6	80.4	58.4	55.1		
Duffy treated	86.4	17.6	-	79.6	-	88.4	
Duffy control	35.5	62.3	-	-75.4	-		
Swakum treated	120.2	57.7	115.4	52.0	4.0		
Swakum-M6*			21.2		82.3		
Kirby treated	284.8	120.5	62.2	57.7	78.2	35.5	64.2
Kirby control	292.6	192.1	178.6	34.4	39.0		
Tolman treated	98.9	8.8	-	91.1	-	81.6	
Tolman control	258.3	125.2	-	51.5	-		
Sackum-1 treated	292.2	16.6	46.6	94.3	84.1		
Sackum-2	347.8	20.0	52.5	94.3	84.9		
Pimainus-1 treated	206.6	126.5	4.0	38.7	98.1		
Pimainus-2	161.9	98.1	2.3	39.4	98.6		
Average	**211.3**	**105.2**	**59.5**	**45.2**	**71.6**	**62.1**	**60.0**
Maximum	**347.8**	**285.6**	**207.2**	**94.3**	**98.6**	**88.4**	**77.9**
Minimum	**35.5**	**8.8**	**2.3**	**-75.4**	**4.0**	**35.5**	**26.7**

* An additional post-spray sample was taken in a different location within the spray block

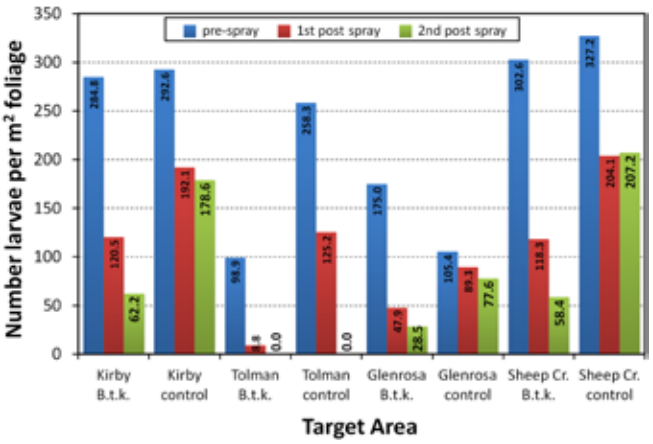


Figure 3. Density of western spruce budworm larvae (per m^2 foliage) in four target areas comparing treated and untreated control sites at the pre-spray, first post-spray and second post spray time. Kirby and Tolman are in the Cascades District and Glenrosa and Sheep Creek are in the Okanagan Shuswap District.

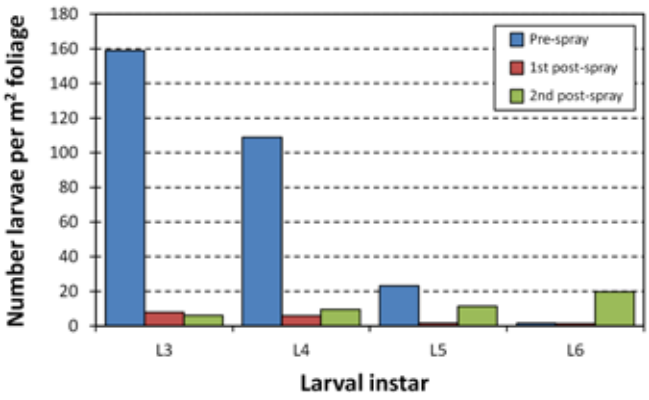


Figure 4. Distribution and abundance of western spruce budworm larval instars in the Sackum spray block at the three sampling times. Larval instars are as follows: L3=3rd instar; L4=4th instar; L5=5th instar; L6=6th instar.

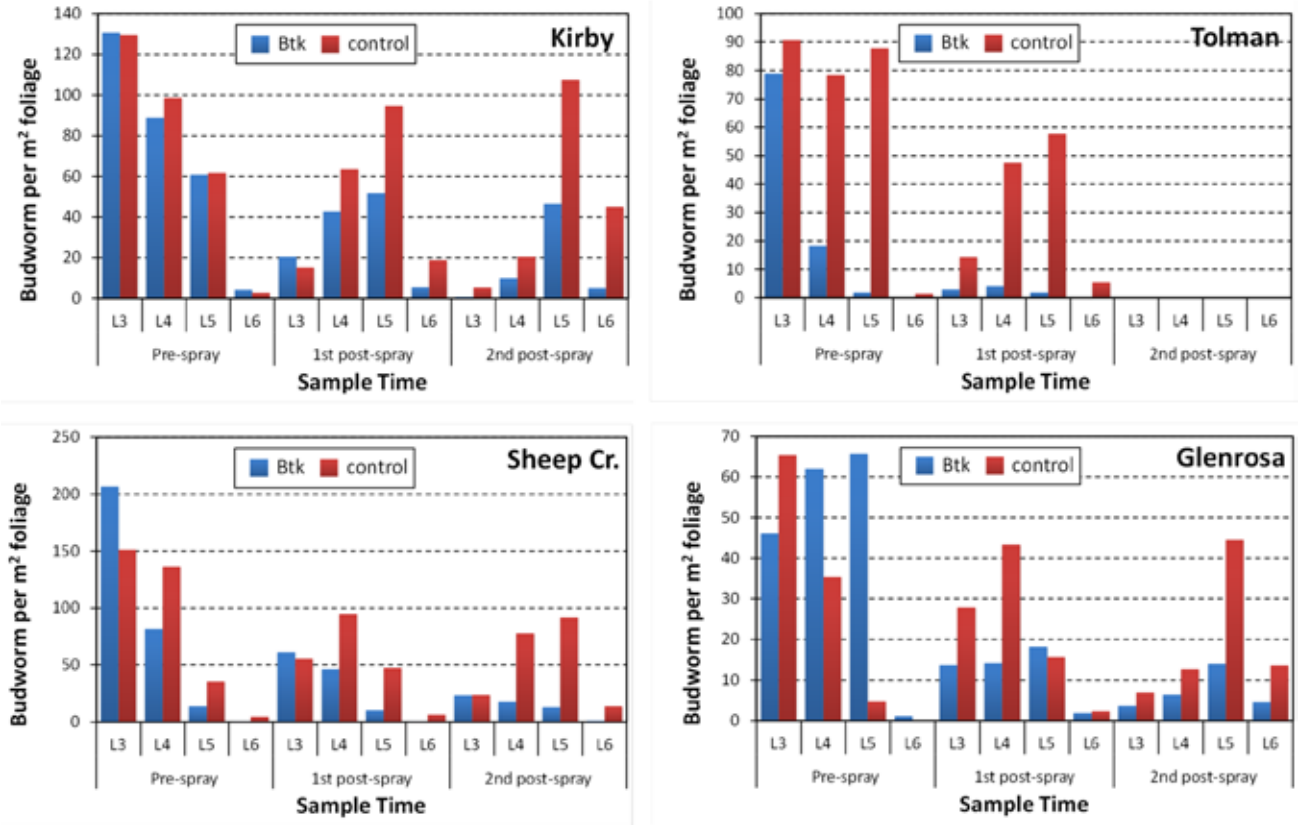


Figure 5. Density and distribution of western spruce budworm larvae by instar (larvae per m^2 foliage) in four target areas comparing treated and untreated control sites at the pre-spray, first post-spray and second post-spray time. Kirby and Tolman are in the Cascades District and Glenrosa and Sheep Creek are in the Okanagan Shuswap District. Larval instars are as follows: L3=3rd instar; L4=4th instar; L5=5th instar; L6=6th instar.

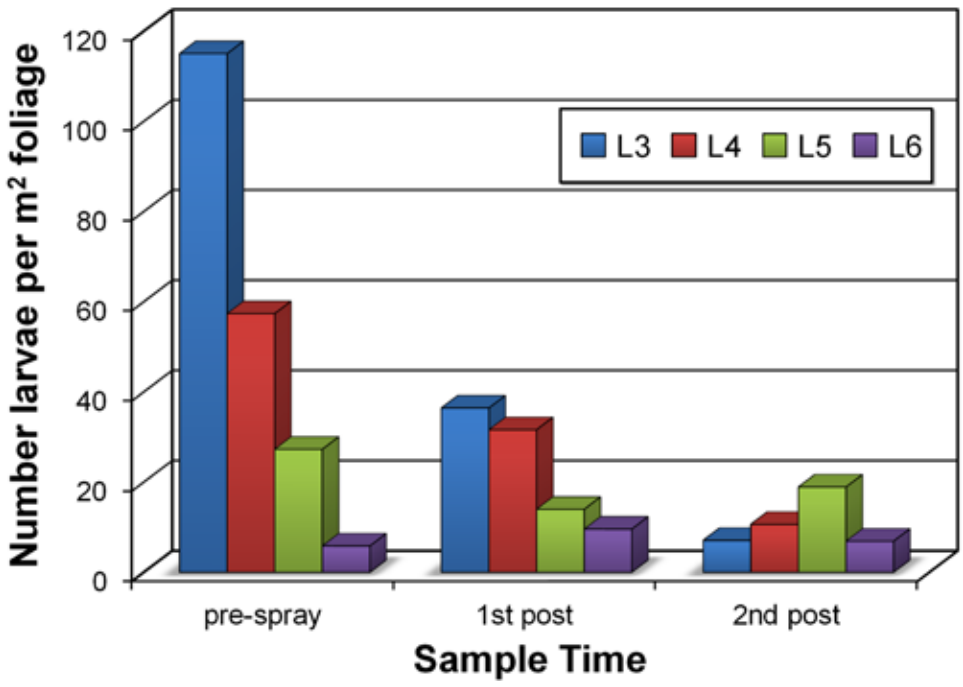


Figure 6. Average density of budworm larvae (number per m^2 foliage) at each sample time (pre-spray, first and second post-sprays) combining all 2012 treated sites in the Thompson Okanagan Region.

Kootenay Boundary Region

A total of 13,678 hectares were sprayed with *B.t.k.* in the Kootenay Boundary Region in 2012. To assess spray efficacy 60 trees, 30 in sprayed areas and 30 in untreated control areas, were sampled. Pre-spray samples were taken June 22-24. Post-spray samples were taken at 10-12 day intervals, with the final sampling date on June 22nd. Budworm populations were high in the blocks sampled, ranging from 122 to 147 larvae per m^2 foliage (Table 8), but lower than observed in the Thompson Okanagan. Percent mortality ranged from 63% to 92% and Abbott's corrected mortality varied from 44% to 79% mortality. The control block sampled in Beaverdell had discernibly fewer larvae than the treatment area, so did not adequately reflect the mortality caused by *B.t.k.* (Table 8). All larvae assessed in the pre-spray sampling were late 3rd instar or 4th instar and open feeding. By the first post-spray assessment, most larvae were 5th instar with a few late 4th or early 6th instars.

Spray operations near Beaverdell, July 2012.

Table 8. Summary of 2012 pre-spray and post-spray sampling of western spruce budworm in the Kootenay Boundary Region.

	# larvae/m^2 foliage			Percent mortality			
				Uncorrected		Abbott's corrected	
Location	**pre-spray**	**1st post**	**2nd post**	**1st post**	**2nd post**	**1st post**	**2nd post**
Beaverdell							
Btk	146.6	71.9	10.1	52.9	92.2	28.9	78.7
Control	40.7	30.8	17.5	33.7	63.4		
Kerr Creek-Marshall Woodlot							
Btk	121.8	84.5	11.6	22.0	87.1	-82.4	43.5
Control	116.2	41.6	20.3	57.2	77.1		
Rock Creek-Bridesville							
Btk	142.0	17.2	10.7	84.5	91.6	54.9	51.2
Control	165.4	47.1	23.2	65.7	82.9		

Western spruce budworm larval sampling crew for the Kootenay Boundary Region. L-R: Sheri Walsh, Chris Dionne, Neil Emery, Adam O'Grady.

2012 Population Monitoring - Results and Predictions for 2013

Western spruce budworm egg mass sampling was conducted at 620 sites in the Cariboo, Thompson Okanagan and Kootenay Boundary Regions. Sampling sites were selected based upon 2012 defoliation, recent past defoliation, stand hazard rating, historic outbreak range, stand structure and composition. The average number of egg masses per 10 m^2 foliage was higher in the Thompson Okanagan than in the Cariboo and Kootenay Boundary Regions, at 70.7, 29.9, and 23.3, respectively. Over 50% percent of the sites sampled in the Thompson Okanagan Region predict moderate or severe defoliation for 2013, compared to just 13% of the sites in the Cariboo. Over 90% of surveyed sites in the Kootenay Boundary Region had low egg mass numbers, predicting light defoliation in 2013 (Table 9).

Table 10 summarizes the results of egg mass sampling within more localized geographic areas in the Kootenay Boundary and Thompson Okanagan Regions, identifying the location of potentially significant budworm populations. In the Kootenay Boundary, the highest populations were found at sites near Grand Forks and east of Rock Creek. This Region plans to treat 5,000 hectares with *B.t.k.* in 2013.

In the Thompson Okanagan Region, areas sampled from south of Kamloops through Merritt and down to the Coldwater River indicated significant budworm populations (Table 10). The Douglas-fir forests surrounding Seton Lake, Downton Lake, Marshall Lake and the Gold Bridge area will see another year of high budworm. This area was defoliated in 2011-12 and egg mass counts remain high (Table 10). A public meeting was held in Gold Bridge on September 3rd, 2012, to inform Gun Lake area residents about budworm and possible control options. Approximately 6,500 hectares in this area are proposed for treatment with *B.t.k.* in 2013. An additional 26,000 hectares in the Cascades District are proposed for spraying, as well as 17,500 hectares south and west of Kamloops. In total, the Thompson Okanagan Region is planning to treat 45,000 hectares in 2013.

The Cariboo Region has approximately 25,000 hectares scheduled for spraying with *B.t.k.* next year.

Table 9. Results of fall 2012 western spruce budworm egg mass sampling in southern B.C.

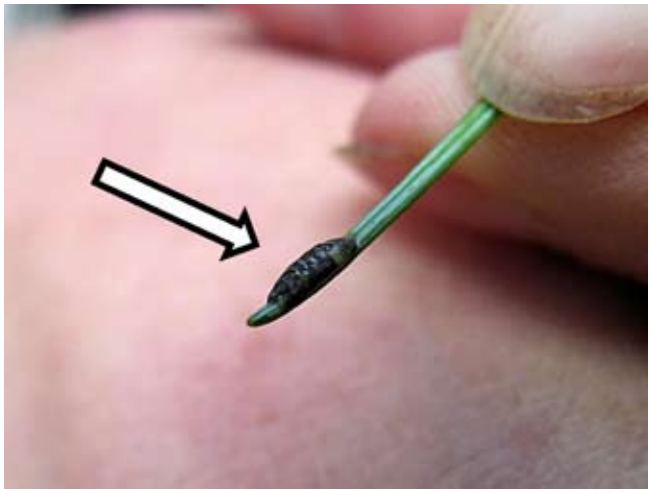
	Percent of sites in each defoliation category				Number	Avg. # egg masses
District	**Nil**	**Light**	**Moderate**	**Severe**	**of sites**	**per 10m² foliage**
Cariboo Region						
100 Mile House	6%	82%	11%	1%	85	31.2
Central Cariboo	1%	85%	13%	1%	107	33.1
Chilcotin	36%	50%	14%	0	28	21.5
Quesnel	18%	82%	0	0	11	10.5
Region Average	**8%**	**80%**	**12%**	**1%**	**231**	**29.9**
Thompson Okanagan Region						
Cascades	3%	25%	51%	21%	115	92.0
Kamloops	5%	43%	37%	14%	92	75.9
Okanagan Shuswap	5%	65%	30%	0	84	35.7
Region Average	**4%**	**43%**	**41%**	**13%**	**291**	**70.7**
Kootenay Boundary Region						
Boundary	2%	91%	8%	0	64	22.4
Revelstoke	0	100%	0	0	6	13.7
Rocky Mountain	0	89%	11%	0	28	26.0
Region Average	**1.0%**	**91%**	**8%**	**0**	**98**	**23.3**
Southern B.C. average	**5%**	**64%**	**25%**	**6%**	**620**	**37.4**

Table 10. Summary of the average number of western spruce budworm egg masses per 10 m^2 foliage and predicted 2013 defoliation by sampling area in the Kootenay Boundary and Thompson Okanagan Regions.

Region/District/Area	Number of Sites	Avg. # egg masses per 10 m^2 foliage	2013 defoliation prediction	Number of sites moderate or greater
Kootenay Boundary				
Boundary				
Beaverdell	5	11.2 ± 4.1	light	0
Grand Forks	19	30.3 ± 4.3	light	3
Rock Creek East	23	26.5 ± 3.4	light	2
Rock Creek West	17	14.5 ± 2.5	light	0
Revelstoke				
Carnes Creek	2	10.4 ± 5.1	light	0
Laforme Creek	2	9.6 ± 4.7	light	0
Mars Creek	2	19.9 ± 6.6	light	0
Rocky Mountain				
Flathead	19	20.3 ± 3.5	light	0
Grasmere	9	35.3 ± 6.2	light	3
Thompson Okanagan				
Cascades				
Lower Nicola	6	32.5 ± 8.0	light	1
Princeton	6	52.5 ± 13.9	moderate	3
Gun Lake area	66	87.7 ± 7.0	moderate	49
Merritt North	22	121.0 ± 23.8	moderate	17
Coldwater River	19	117.4 ± 17.3	moderate	16
Peter Hope-Stump Lake	27	130.9 ± 21.0	moderate	9
Kamloops				
Pinantan	9	24.3 ± 7.4	light	1
Kamloops Northwest	21	42.8 ± 8.4	light	6
Monte Lake-Westwold	20	49.0 ± 11.6	light	8
Kamloops West	11	85.1 ± 17.8	moderate	7
Peter Hope-Stump Lake	17	119.6 ± 18.1	moderate	13
Merritt North	14	136.8 ± 28.1	moderate	12
Okanagan Shuswap				
West Kelowna	8	25.5 ± 4.6	light	0
East Kelowna	13	26.6 ± 4.7	light	2
Penticton	31	35.5 ± 4.5	light	10
Monte Lake-Westwold	32	42.3 ± 5.3	light	13

Above: Lucy Stad receiving budworm egg mass survey training near Merritt.

Below: budworm pre-spray egg mass sampling near Orofino Mountain, June 2012, Okanagan TSA.



Western spruce budworm egg masses.
Top: new egg mass
Middle: hatched egg mass
Bottom: parasitized egg mass

2012 Western Hemlock Looper Spray Program Summary

Trap catch data and egg sampling results from 2011 indicated that western hemlock looper, *Lambdina fiscellaria lugubrosa*, would reach outbreak levels in several locations in the southern interior in 2012. Planning for spray programs in the Cariboo, Thompson Okanagan and Kootenay Boundary Regions using *B.t.k.* was initiated. Up to 7,500 hectares in the Cariboo Region near Quesnel Lake were scheduled, but early summer monitoring indicated very low larval populations throughout the planned treatment area. Therefore, the Cariboo spray program was cancelled.

In total 12,797 hectares were treated with Foray 48B (*B.t.k.*) in 2012 to manage western hemlock looper populations (Table 11). Treatment rate in all blocks was 2.4 litres per hectare. In the Thompson Okanagan Region, a total of 4,014 hectares were treated on July 11, 2012, near Serpentine Creek and Mud Lake, in the North Thompson River area (Table 11). Approximately 5,700 hectares were originally proposed for treatment in this Region, but a few areas in the upper Shuswap River and near Finn Creek, were deleted due to low larval numbers. In the Kootenay Boundary Region, 7,967 hectares of high priority mountain caribou habitat in the Lake Revelstoke and Mica areas were treated on July 6-7, 2012 (Table 11).

Table 11. Thompson Okanagan and Kootenay Boundary Regions western hemlock looper 2012 spray summary showing by block location the hectares sprayed, litres of Foray 48B (*B.t.k.*) applied and date sprayed.

Region	Location	Area Treated (hectares)	Litres of *B.t.k.* applied	Date Sprayed
Thompson Okanagan	Serpentine Creek (3 blocks)	1,645	3,948	July 11
Thompson Okanagan	Mud Lake (5 blocks)	2,369	5,686	July 11
Kootenay Boundary	Yellow Creek (3 blocks)	816	1,958	July 6
Kootenay Boundary	Pat Creek (5 blocks)	1,005	2,413	July 7
Kootenay Boundary	Bigmouth (10 blocks)	3,612	8,668	July 6
Kootenay Boundary	Goldstream (3 blocks)	2,691	6,458	July 7
Kootenay Boundary	Downie Creek (3 blocks)	659	1,583	July 7
Total	**32 Blocks**	**12,797**	**30,713**	

Spray efficacy sampling for the hemlock looper program was conducted in three areas in the Kootenay Boundary Region (Table 12). Three 3-tree beatings were done in each spray and control block for each area. Lower branches of each tree selected (nine trees per site) were beaten onto a 1.5 metre x 1.5 metre tarp (area=2.25 m^2) and all larvae in the sample were identified and tallied. At the pre-spray assessment, western hemlock looper density ranged from 1-2 insects per sample at the Goldstream and Downie treatment sites, up to 28 larvae per sample at the Mica site (Table 12). The effect of *B.t.k.* was immediate and significant, with larval mortality over 90% in all spray blocks. Abbott's corrected percent mortality (comparing treated to control areas) ranged from 73 to 99% (Table 12).

Table 12. Summary of 2012 pre- and post-spray sampling for western hemlock looper in the Kootenay Boundary Region. The number of larvae per site is based on a nine tree beating sample using a 2.25 m^2 beating sheet. The overall percent morality and Abbott's corrected mortality (percent) is shown for each site.

Geographic Area and	Larval density (# per 2.25 m^2)			% Mortality	
Treatment Type	Pre-spray	1st post	2nd post	Uncorrected	Abbott's corrected
Downie Creek. - control	10.6	6.7	1.8	83.0	
Downie Creek. - *B.t.k.*	1.7	0.6	0.01	99.4	96.5
Goldstream - control	6.8	6.8	2.1	69.1	
Goldstream - *B.t.k.*	1.2	0.2	0.1	91.7	73.0
Pat Cr-Mica Townsite - control	8.7	9.8	11.8	-35.6	
Pat Cr-Mica Townsite - *B.t.k.*	27.9	1.4	0.2	99.3	99.5

One of the cancelled spray areas in the Thompson Okanagan Region (the Greenbush Lake block) was sampled in early August to follow-up on the decision to not treat the area. Six 3-tree beatings were done between 65 km and 68 km on the Sugar Lake Road August 7, 2012, to assess defoliator population and tree defoliation. The western hemlock looper was the most abundant defoliator (Table 13) averaging just under 8 larvae per site. Less than 5% total tree defoliation was noted overall.

Table 13. Abundance of defoliating larvae in the Greenbush Lake area, August 7, 2012, listing the most prevalent larvae in six sites sampled (three tree beating at each site).

Defoliator Species	**Average # of larvae per site**
Western hemlock looper, *Lambdina fiscellaria lugubrosa*	7.8
Yellowlined forest looper, *Cladara limitaria*	2.7
Twolined larch sawfly, *Anoplonyx laricivorous*	1.7
Sawflies, *Neodiprion* sp.	1.5
Western spruce budworm (pupae), *Choristoneura occidentalis*	1.3

*Beating sheet used to monitor defoliator abundance with inset showing filament bearer larva (*Nematocampa*).*

Aerial spraying of B.t.k. for western hemlock looper control along Kinbasket Lake, Revelstoke TSA.

Western Hemlock Looper Monitoring in the Kootenay-Boundary and Thompson-Okanagan Regions

Western hemlock looper populations are monitored on an annual basis at 41 permanent sample sites in the Kootenay Boundary and Thompson Okanagan Regions (Figure 7). Three-tree beatings are conducted in mid-July at all 41 sites to monitor larval populations of western hemlock looper as well as other defoliator species. Six-trap clusters are deployed at 27 of the sites to monitor western hemlock looper moth populations. The traps are placed concurrently with the larval beatings, and are collected during late September or early October after moth flight is complete.

Three-Tree Beatings

Western hemlock looper and sawflies were the most common and abundant defoliators, recorded at 65% and 55% of the sites sampled, respectively (Table 14). For the second consecutive year, the highest levels of western hemlock looper were at Beaver River, followed by Jumping Creek, Greenbush Lake and Bigmouth Creek. However, the numbers were lower than in 2011. Trace defoliation was recorded at two sites north of Revelstoke at the Goldstream and Pitt Creek sites and northeast of Vernon at Greenbush Lake.

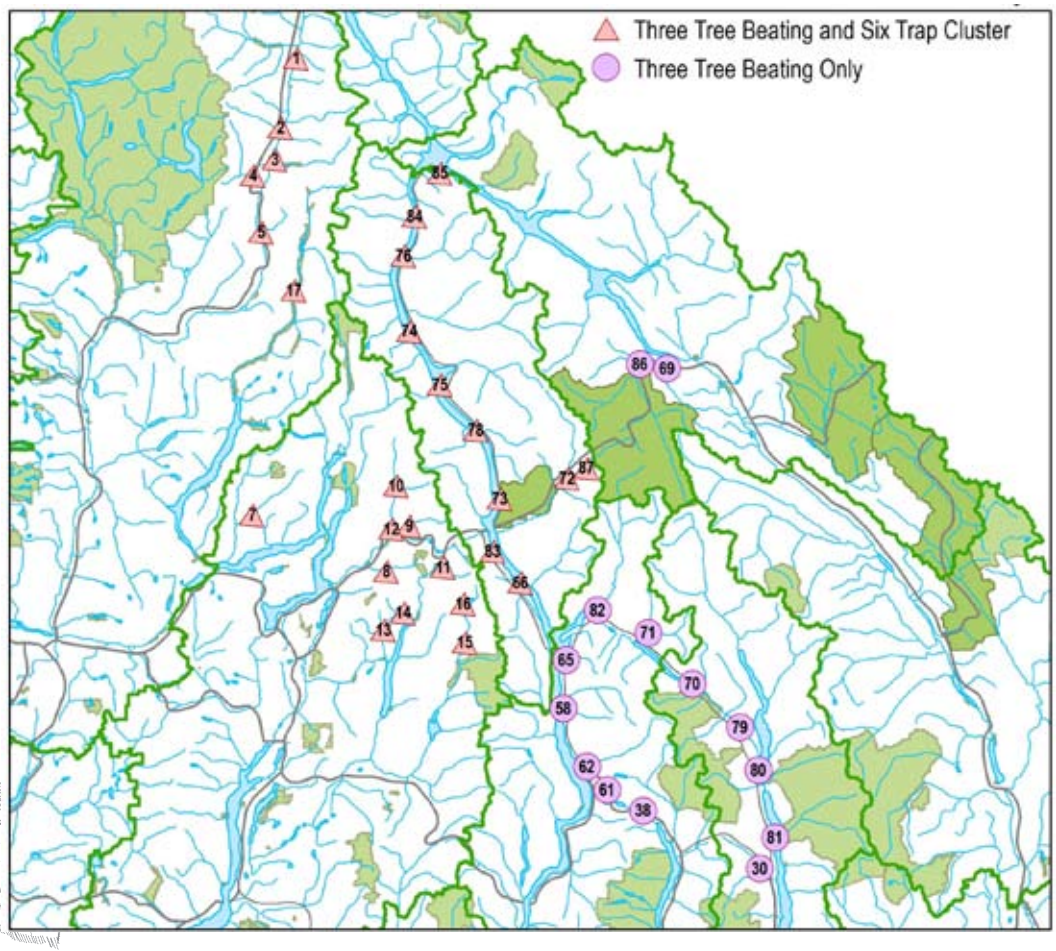


Figure 7. Location of western hemlock looper monitoring sites in the Kootenay Boundary and Thompson Okanagan Regions.

In the Thompson-Okanagan Region, western hemlock looper was found at 69% of the 16 three-tree beating sites sampled, with an average of 9.6 larvae per site, down from 28.0 larvae per site in 2011. Decline of the hemlock looper in the Serpentine and Mud Lake sites was likely due to the operational spray program undertaken in 2012. In the North Thompson, few larvae were recorded at Finn Creek and TumTum Lake and no larvae were found at Serpentine Creek, Thunder River, Mud Lake and Murtle Lake (Table 14). Population trends in the Mabel Lake/ Three-Valley Gap to Scotch Creek area varied, with small increases at Perry River North and Yard Creek, and significant decreases at Three Valley Gap, Perry River South and the Mabel Lake area (Kingfisher Creek and Noisy Creek). Minor decreases in larval abundance were noted at Scotch Creek and Crazy Creek. Larval populations increased slightly, just south of Sugar Lake along the Shuswap River and Greenbush Lake. Figure 8 shows the variation from 2010 to 2012 in the number of western hemlock looper larvae present in three-tree beatings at sites in the Thompson Okanagan Region.

In the Kootenay-Boundary Region, western hemlock looper was recorded at 63% of the 25 three-tree beating sites sampled, compared to 84% in 2011, and 71% in 2010 (one site was not sampled in 2012 due to flooding). Larval counts were down slightly with an average of 18.9 per site in 2012 compared to 21.9 per site in 2011. The highest larval counts were east of Revelstoke at Beaver River and Jumping Creek, followed by two sites north of Revelstoke at Bigmouth and Pitt Creeks. The only sites with notable larval increases were Sutherland Falls, Martha Creek and Jumping Creek. Overall populations south of Revelstoke decreased from an average of 5.6 larvae per site to 1.8 larvae per site, while north and east of Revelstoke, the average larval count decreased from 39.5 larvae per site to 21.0 larvae per site (Figure 9). These decreases are in part due to the 2012 operational spray program conducted north of Revelstoke at the Goldstream and Downie Creek sites. Trace defoliation was noted at two sites: Goldstream River and Pitt Creek.

The three major defoliators found during the 2001 to 2003 outbreak in the Kootenay Boundary Region were western hemlock looper, sawflies and western blackheaded budworm, in order of relative abundance. Since 2008, sawflies numbers have remained consistent, while hemlock looper numbers increased in 2011 and 2012. Very low numbers of western blackheaded budworm have been observed since 2006.

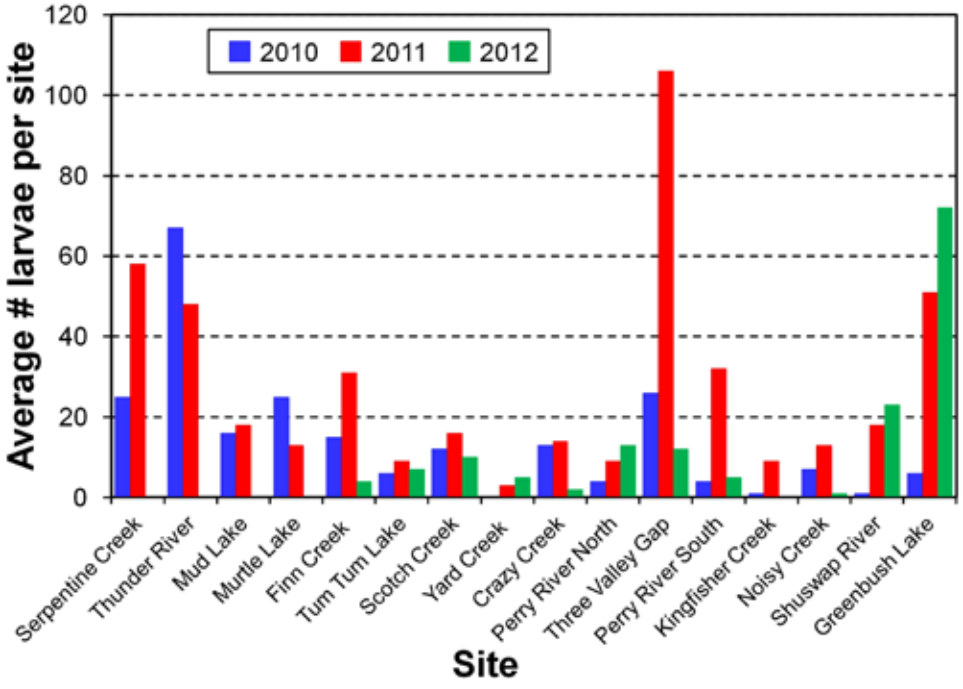


Figure 8. Western hemlock looper larval counts at sixteen sites in the Thompson Okanagan Region from 2010 through 2012.

Table 14. Summary of the number of primary and secondary defoliators found in three-tree beatings at 41 monitoring sites in the Thompson Okanagan and Kootenay Boundary Regions in 2012. Defoliation at sites was also noted: N = no defoliation; T = trace defoliation.

Site	Location	Western Hemlock Looper	Black-headed Budworm	Sawflies	Green-striped Forest Looper	Defoliation
1	Serpentine Creek	0	0	0	0	N
2	Thunder River	0	0	0	0	N
3	Mud Lake	0	0	0	0	N
4	Murtle Lake	0	0	0	0	N
5	Finn Creek	4	0	2	0	N
7	Scotch Creek	10	0	0	0	N
8	Yard Creek	5	0	20	1	N
9	Crazy Creek	2	0	0	1	N
10	Perry River north	13	1	3	1	N
11	Three Valley Gap	12	2	0	5	N
12	Perry River south	5	0	0	0	N
13	Kingfisher Creek	0	0	0	2	N
14	Noisy Creek	1	0	1	0	N
15	Shuswap River	23	0	43	0	N
16	Greenbush Lake	72	2	68	0	T
17	TumTum Lake	7	0	0	0	N
Thompson Okanagan Total		**154**	**5**	**137**	**10**	
30	Keen Creek	0	0	0	0	N
38	Hills	0	0	0	0	N
58	Halfway River	0	0	0	1	N
61	Box Lake	0	0	0	0	N
62	Kuskanax Creek	0	0	0	3	N
65	Shelter Bay Ferry	2	0	2	1	N
66	Sutherland Falls	12	0	9	0	N
69	Quartz Creek	1	0	2	0	N
70	Gerrard	0	0	8	2	N
71	Trout Lake	Not sampled - inaccessible due to flooding				
72	Tangier FSR	46	0	9	0	N
73	Martha Creek	31	0	0	0	N
74	Goldstream River	15	0	1	0	T
75	Downie Creek	19	0	12	0	N
76	Bigmouth Creek	68	0	2	0	N
78	Carnes Creek	19	0	0	0	N
79	Lardeau FSR	0	0	40	1	N
80	Meadow Creek	0	1	16	2	N
81	Schroeder Creek	0	0	0	0	N
82	Beaton	8	0	12	0	N
83	Begbie Creek	17	0	19	0	N
84	Pitt Creek Rec Site	53	0	55	0	T
85	Kinbasket Lake	11	0	30	0	N
86	Beaver River	79	0	65	0	N
87	Jumping Creek	72	0	61	1	N
Kootenay Boundary Total		**453**	**1**	**343**	**11**	

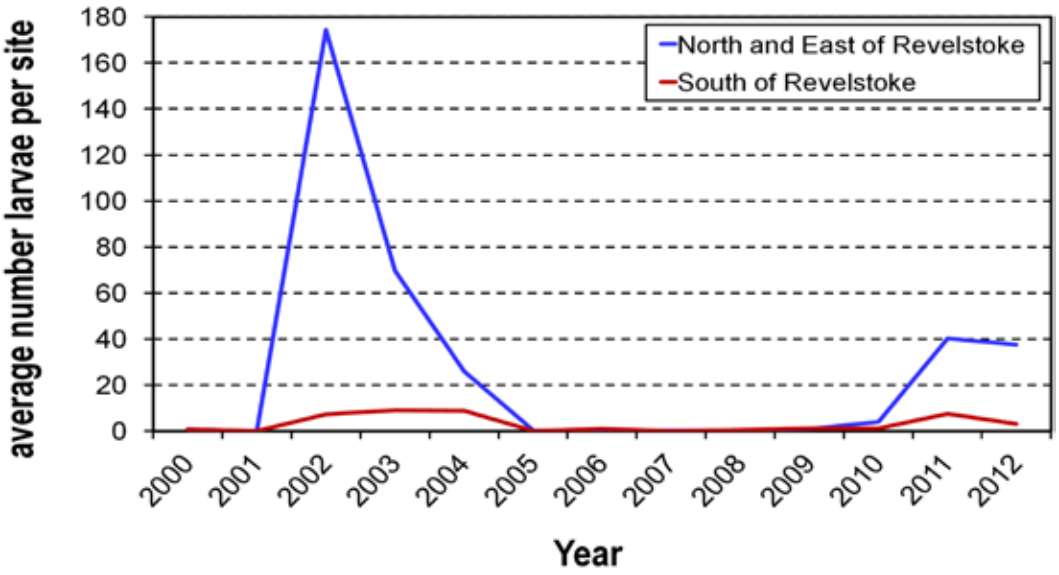


Figure 9. Average number of western hemlock looper larvae from 2000 through 2012, grouped by permanent sample plots north and east of Revelstoke and those south of Revelstoke.

Six-Trap Clusters

In general, the average number of western hemlock looper moths caught in traps declined at the permanent trapping sites across the southern interior (Figure 10, Table 15), with a few site specific exceptions. Of the 26 trapping sites that were assessed (one site was inaccessible due to road washout), 19 sites (73%) saw a significant decrease in the average number of moths caught per trap indicating a population decline and less risk of defoliation for 2013. Trap catches decreased significantly in most locations in the Thompson Okanagan Region, with the exception of Scotch Creek, Crazy Creek and Perry River, where slight increases were seen, and at Three Valley Gap, where numbers were fairly static (Table 15). Overall trap catches were down in the Kootenay-Boundary Region from an average of 724 moths in 2011, to an average of 484 moths in 2012. Localized increases were noted near Revelstoke at Martha Creek, Carnes Creek, and Tangier River (Table 15).

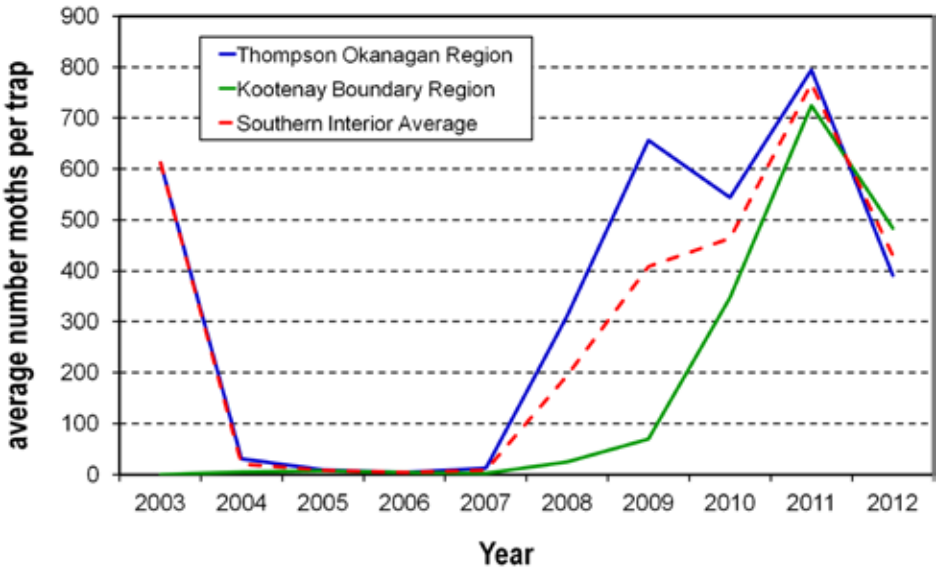


Figure 10. Average number of western hemlock looper moths caught per trap at 27 permanent trapping sites in the Thompson Okanagan and Kootenay Boundary Region, from 2003 through 2012.

Table 15. Average number of moths per six- trap cluster at 27 western hemlock looper monitoring sites in the Thompson Okanagan and Kootenay Boundary Regions from 2006-2012.

Site	Location	2006	2007	2008	2009	2010	2011	2012
Thompson Okanagan Region								
1	Serpentine Creek	2	14	232	898	325	412	26
2	Thunder River	3	44	864	729	575	645	79
3	Mud Lake	4	14	310	1,070	574	876	52
4	Murtle Lake	12	21	576	1,218	968	1,376	88
5	Finn Creek	4	6	781	450	312	613	35
7	Scotch Creek	2.8	6	107	621	610	582	705
8	Yard Creek	11	4	66	805	417	508	no traps
9	Crazy Creek	1	7	154	logged	438	256	410
10	Perry River N	6	18	206	714	510	323	197
11	Three Valley Gap	5	9	169	85	849	319	240
12	Perry River S	4	9	82	623	801	314	410
13	Kingfisher Creek	3	5.3	227	535	316	1,608	732
14	Noisy Creek	1	10	606	698	525	1,091	450
15	Shuswap River	2	2.8	72	341	416	842	411
16	Greenbush Lake	2	logged	29	450	533	2,682	1,530
17	TumTum Lake	3	13	512	613	534	264	501
	Region Average	**4**	**12**	**312**	**657**	**544**	**794**	**391**
Kootenay Boundary Region								
66	Sutherland Falls	1	1	29	30	221	328	222
72	Tangier FSR	2	1	22	75	384	284	390
73	Martha Creek	2	1	8	6	259	228	281
74	Goldstream River	4	3	4	81	303	689	597
75	Downie Creek	1	1	29	60	372	1,135	743
76	Bigmouth Creek	13	1	9	29	318	769	645
78	Carnes Creek	2	1	16	31	313	373	518
83	Begbie Creek	3	1	24	55	551	635	557
84	Pitt Creek Rec Site	3	2	16	130	431	1,274	865
85	Kinbasket Lake	17	8	89	237	468	1,533	304
87	Jumping Creek	1	1	27	30	196	no traps	201
	Region Average	**4**	**2**	**25**	**69.5**	**347**	**725**	**484**
Southern Interior Average		**4**	**8**	**195**	**408**	**463**	**768**	**430**

Western Hemlock Looper Population Assessment/Monitoring in the Cariboo Region

Western hemlock looper egg monitoring during the fall and winter of 2011 in the Cariboo Region predicted potential significant defoliation at several sites in 2012. However, this did not occur and most locations saw no defoliation and had very low level populations. The decline was likely due in part to spring egg parasitism and adverse early summer weather conditions. In the summer of 2012, further monitoring occurred by doing three-tree beatings and establishing pheromone trap clusters at various locations throughout the susceptible area, as well as performing egg counts in the fall (Tables 16, 17). Based on the recent data collected, only one site is projected to suffer moderate to severe defoliation in 2013.

There is an ongoing study to calibrate two egg collection methods for western hemlock looper in the Cariboo. These two methods are: standard arboreal lichen collection, and a less time-consuming method using foam strips stapled to the boles of trees. The data have not yet been completely analyzed, however there does not seem to be any direct correlation between moth trap catches and either method for egg counts (Tables 16, 17). A similar study in the Kootenay Boundary Region being conducted by Dr. Art Stock will help clarify this relationship.

Based on current western hemlock looper population data, no population control will be necessary in 2013. To further monitor and assess population levels, lichen samples should be collected in spring of 2013 in western hemlock looper hotspots such as Tasse Lake to assess the level of egg parasitism. Pheromone trap clusters for adults and foam strips for eggs should be deployed in mid-summer in those same areas. Methodology for foam strip deployment involves the use a white polyurethane (10 mm thick) foam strip (17 cm × 30 cm) placed above breast height (as high as possible) on the bole of a western hemlock tree, stapling only the top portion of the foam. The foam is curved slightly outward at the top, so moths are able to access the lower side of the foam to lay eggs. Foam strips should be placed at least 10 metres from opening edges to reduce the impact of exposure to wind, rain, and road dust. Lichen samples should be collected at western hemlock looper foam egg monitoring sites to aid with the calibration of the foam egg data. Based on 2012 moth catches, additional three-tree beating sampling should be performed in areas with high moth numbers, as well as at regular sampling locations.

Table 16. Results of three-tree beatings, western hemlock looper moth trap catches, and egg monitoring in 2012. Eggs were counted from foam strips and lichen placed at two trapping sites.

Location	Average Number of Moths per Trap	Number of Healthy Eggs		Number of larvae
		Foam	Lichen[1]	
Archie/Bouldery Creek (6108 km)	141	11	n/a	n/a
Archie/Bouldery Creek (6110 km)	333	38	n/a	n/a
Archie/Bouldery Creek (6113 km)	190	37	n/a	n/a
Archie/Bouldery Creek (6114.5 km)	139	5	n/a	n/a
Abbott Creek 27	1,072	7	n/a	n/a
Abbott Creek 28	700	n/a	n/a	n/a
Cariboo Lake 8411 km	367	0	n/a	n/a
Hen Ingram Lake	144	7	7	43
Tasse Lake 3T96	1,913	200	44	127

1 number of healthy eggs per 100 grams of dry lichen
2 number per three-tree beating

Table 17. Comparison of healthy, infertile and parasitized western hemlock looper eggs collected on foam strips and lichen at Hen Ingram Lake and Tasse Lake, 2012.

Site	# Eggs per Foam Strip[1]			# Eggs/100 g Dry Lichen				
	Healthy	Infertile	Parasitized (new)	Healthy	Infertile	Parasitized (new)	Parasitized (old)	Old
Hen Ingram Lake	7	0	10	7	3	2	44	17
Tasse Lake	200	10	41	44	5	21	11	27

1 number of eggs per 17X30 cm foam strip. There were no old eggs or old parasitized eggs on the foams because they were placed after looper egg oviposition for 2011.

Evaluation of Foray 48B for Control of Two-Year Cycle Budworm, *Choristoneura biennis*

Robert Hodgkinson, Ken White, David Rusch, B.C. Forest Service Regional Entomologists

The two-year cycle budworm, *Choristoneura biennis*, causes defoliation of Engelmann spruce and sub-alpine fir-dominated forests in the interior of B.C. Like other budworms, repeated defoliation causes top-kill, tree mortality and volume loss in affected forest settings. The range of the two-year cycle budworm is adjacent to, or overlapping with, the ranges of three other species of *Choristoneura,* but these other species generally have a one-year life cycle. *C. biennis* moths emerge from mid-July through early August, mate, oviposit and die. Each female can deposit up to 150 eggs in several flattened, shingle-like masses on the underside of needles. Eggs hatch within two weeks and newly emerged larvae immediately seek shelter to spin their hibernacula and overwinter as 2nd instar larvae. The following spring in late May to early June, larvae become active, disperse on webs to mine needles and buds for 3 to 4 weeks, then once again spin hibernacula where they overwinter as 4th instar larvae. Larval development continues the spring of the second year when the greatest amount of feeding (damage) occurs. The insect pupates in July and emerges as an adult.

Damage at times can be severe and there are current studies underway to determine if *C. biennis* defoliation on spruce or sub-alpine fir may predispose hosts to attack by bark beetles such as *Dendroctonus rufipennis* and *Dryocoetes confusus*, respectively. There is currently no management strategy for *C. biennis*. Therefore, an operational trial was set-up to evaluate the timing and efficacy of *B.t.k* (Foray 48B) when sprayed in year two of *C. biennis* life history, targeting peak 5th or 6th instar. Future trials may investigate treating in year one to target 4th instar larvae just before they spin their overwintering hibernacula.

A suitable spray trial area in the ESSFwc3 biogeoclimatic zone was located near the Mount Tom research installation east of Quesnel in the Cariboo Region. There was light defoliation in 2011 and assessment of the site in the fall confirmed a substantial budworm population. Three blocks of spruce and subalpine fir trees totalling 890 hectares were selected for treatment with Foray 48B. The stands were infested with two-year cycle budworm, and were reasonably accessible for monitoring and sampling.

Spray operations and efficacy assessment

Three blocks comprised of spruce and subalpine fir trees totalling 890 hectares, infested with two-year cycle budworm, were aerially treated with Foray 48B (*B.t.k.*) at a rate of 2.4 litres per hectare on July 5, 2012. Subalpine fir shoot flush and elongation was slightly ahead of spruce. Larval development was peak 5th instar in blocks 1 & 2 and peak 6th instar in block 3 at the time of treatment. Spray application was performed by Western Aerial Applications Ltd., utilizing a single Hiller UH12ET helicopter under good early morning spray conditions. On each treatment block, 10 spruce and 10 subalpine fir mid-canopy sample trees were chosen. A control area was selected with 15 spruce and 15 subalpine fir. The mean elevation of all sample trees was 1,510 metres. Pre- and post-spray samples consisted of two mid-crown branches per tree removed from opposite aspects. Post spray samples were collected 7-9 days after treatment and again 14-15 days after treatment.

Branches were bagged in the field and brought to processing facilities in Quesnel and Prince George. Insect densities were based on the number of larvae and pupae per m^2 of foliage, per 100 buds, and per 100 grams of foliage. The coefficient of variation was less for branch weight, so this was used in all data analysis. Overall defoliation (as a percent of foliage on sampled branches) was recorded at the second post spray sample (Table 18).

The second post spray sample revealed significant population reduction due to treatment, in the range of 75-95% on subalpine fir, and 36-72% on spruce. Defoliation was significantly lower on treated subalpine fir in all three blocks, and on spruce in one of the 3 blocks (Table 18). A more detailed report will be available in 2013.

Table 18. Efficacy of Foray 48B (*B.t.k.*) applied at 2.4 litres per hectare on two-year cycle budworm at Mount Tom in 2012.

Spray Block	Tree Species	Larval density ± SE[a]			Percent mortality[b]		Average Percent Defoliation[c]
		Pre-spray	1st post-spray	2nd post-spray	1st post-spray	2nd post-spray	
Treated 1	Bl	3.5 ± 0.4	0.2 ± 0.1	0.3 ± 0.1	98.9	88.7*	19.3 ± 3.2*
	Se	4.5 ± 1.0	2.8 ± 0.7	1.2 ± 0.3	14.8	63.4*	38.3 ± 6.7
Treated 2	Bl	5.2 ± 0.8	1.4 ± 0.6	0.2 ± 0.1	52.0	95.0*	50.3 ± 6.4*
	Se	6.8 ± 0.9	2.8 ± 0.6	1.4 ± 0.3	43.6	71.8*	66.3 ± 6.5
Treated 3	Bl	1.6 ± 0.5	1.3 ± 0.3	0.3 ± 0.1	0	75.4*	34.9 ± 4.4*
	Se	3.0 ± 0.8	2.9 ± 0.7	1.4 ± 0.5	0	36.0**	30.5 ± 8.3**
Untreated (Control)	Bl	2.5 ± 0.4	1.4 ± 0.2	1.9 ± 0.2	-	-	74.5 ± 5.4
	Se	3.7 ± 1.0	2.7 ± 0.5	2.7 ± 0.6	-	-	49.8 ± 6.7

a Mean number of live larvae and pupae per 100 grams of foliage per tree (± standard error)
b Abbott's corrected percent mortality
c Based on 100 grams foliage per tree (± standard error). Mean percent defoliation per tree at 2nd post-spray sample
*, ** Significant reduction at $P < 0.01$ and $P < 0.05$, respectively

Clockwise from top left: Ken White sampling two-year cycle budworm larvae; Jen Burleigh processing budworm larval samples in lab; Robert Hodgkinson with sampling basket; the site at Mount Tom; Kim Scott sampling two-year cycle budworm larvae.

Three-Tree Beatings

In 2012, 42 sites in the Thompson Okanagan Region were monitored for Douglas-fir tussock moth populations using a combination of three-tree beatings and six-trap clusters. A map showing the Douglas-fir tussock moth historic outbreak areas (West Kamloops, Kamloops, Okanagan, and Similkameen) with the location of three-tree beating and six-trap cluster monitoring sites can be found in the "2011 Overview of Forest Health for Southern British Columbia" report (page 53). In late June/early July, three-tree beatings were conducted at 29 of these sites. Milk carton pheromone traps were deployed at the time of the beatings and were collected in late September.

Douglas-fir tussock moth larvae were found at 59% of the three-tree beating sites, representing a minimal change from 57% in 2011. However, larval numbers averaged 6.9 larvae per beating site compared to 44.3 larvae per beating site in 2011. The largest decreases were in the West Kamloops outbreak area.

Defoliator diversity and abundance also decreased in 2012, with 20 defoliator species recorded, compared to 28 species in 2011. Most insects collected were solitary feeders and do not contribute to any visible defoliation. Western spruce budworm was the most common and abundant defoliator found in 2012, with 86% of the plots being positive (average of 35 larvae per positive beating site), twice as many as were recorded in 2011. The highest levels were at Blue Lake, Inks Lake, and June Springs (Table 19). Douglas-fir tussock moth numbers were approximately15% of those found in 2011, supporting the prediction that 2012 marks the end of this outbreak cycle.

In 2009, nine PSPs 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. Both three-tree beatings and pheromone traps were used to monitor populations. Historical records indicate that Douglas-fir tussock moth defoliation has been noted near Grand Forks, Rock Creek, Kettle Valley, Christina Lake, and Cascades. The last major defoliation event was recorded in 1983 when approximately 2,275 ha of light to severe defoliation were recorded between Johnstone Creek and Midway and north towards Westbridge. The most recent notable defoliation occurred near Rock Creek in 2008, where a small patch of Douglas-fir was severely defoliated. In 2009, more single tree defoliation occurred in Rock Creek and Cascades, and two larger patches were also recorded west of Rock Creek and east of Midway.

Douglas-fir tussock moth larvae were not recorded at any of the beating sites in the Boundary area (Table 20). All plots were positive for western spruce budworm with an average of 36 larvae per site, up from 23 larvae per site in 2011. Light budworm defoliation was observed at two sites and trace defoliation at four sites. Greenstriped forest looper, western false hemlock looper, and western hemlock looper counts were down significantly from 2011 levels. High levels of a defoliating scarab beetle, *Dichelonyx backi*, were noted at Johnstone Creek and Kettle Valley Provincial Park.

Douglas-fir tussock moth milk carton sticky strap with pheromone.

Table 19. Total number of larvae per three-tree beating for the top seven defoliators found in Douglas-fir tussock moth monitoring sites in 2012, by general outbreak area in the Thompson Okanagan Region.

Site Number	Outbreak Area & Location	Douglas-fir tussock moth	Western spruce budworm	Western Hemlock Looper	Western False Hemlock Looper	Sawflies (*Anoplonyx laricivorus*)	Sawflies (*Neodiprion sp.*)	Greenstriped forest looper
Kamloops Outbreak Area								
1	McLure	13	4	7	-	-	-	1
2	Heffley Creek	5	9	1	-	-	1	1
3	Inks Lake	1	162	1	-	-	6	
4	Six Mile	35	14	1	-	1	-	5
9	Stump Lake	0	68	1	-	-	13	1
10	Monte Creek	1	-	1	2	-	2	1
11	Chase	0	-	3	2	-	-	
Total		**55**	**257**	**15**	**4**	**1**	**22**	**9**
Okanagan Outbreak Area								
12	Yankee Flats	1	-	-	11	1	-	1
13	Vernon	4	3	-	-	3	-	
14	Winfield/Wood Lake	3	3	-	-	-	1	
15	Kelowna/June Springs	0	105	1	-	-	-	
16	Summerland	0	46	-	-	-	-	
17	Kaleden	0	21	-	1	-	-	
18	Blue Lake	0	230	-	-	-	1	
Total		**8**	**408**	**1**	**12**	**4**	**2**	**1**
Similkameen Outbreak Area								
33	Red Bridge Rec Site	0	2	-	-	1	-	
36	Hwy 3 Lawrence Ranch	0	-	-	-	-	-	2
39	Hwy 3 Winters Creek	0	-	-	-	-	-	
40	Hwy 3 Nickelplate Rd	1	2	-	-	1	-	
41	Stemwinder FSR	0	8	-	1	-	-	
42	Old Hedley Road	0	84	-	-	-	-	
43	Pickard Creek Rec Site	0	11	-	-	-	-	
Total		**1**	**107**	**0**	**1**	**2**	**0**	**2**
West Kamloops Outbreak Area								
5	Battle Creek	3	1	-	-	-	1	
6	Barnes Lake	20	6	-	-	2	-	
7	Carquille/Veasy Lake	19	2	-	-	2	-	
8	Pavilion	17	38	-	-	1	-	
21	Spences Bridge	54	30	1	-	3	-	
26	Venables Valley	3	6	5	-	2	-	
27	Maiden Creek	20	1	-	-	1	1	
29	Cornwall 79	1	5	-	-	2	1	1
Total		**137**	**89**	**6**	**0**	**13**	**3**	**1**
Region Total		**201**	**861**	**22**	**17**	**20**	**27**	**13**

Table 20. 2012 larval counts for nine sites in the West Kootenays/Boundary area as determined by three-tree beatings.

Site	Location	Western Spruce Budworm	Douglas-fir Tussock Moth	Western Hemlock Looper,	Western false hemlock looper	Greenstriped Forest Looper	Sawflies, *Neodiprion* spp.	*Dioryctria pseudotsugella*	*Ectropis crepuscularia*	*Eupithecia palpata*	*Pero morrisonaria*	*Macaria unipunctaria*	*Cosmia praeacuta*	*Feralia comstocki*	*Dichelonyx backi*	Defoliation*
2	Johnstone Crk Rd	16	-	-	-	-	-	-	-	-	-	-	-	-	16	L
3	Kettle Valley Park	54	-	1	-	1	-	-	-	-	-	-	-	1	20	L
5	Eholt	94	-	-	-	-	-	1	-	-	-	-	-	-	-	T
8	Grand Forks	41	-	1	-	-	-	-	-	-	1	-	-	-	-	T
9	Christina Lake	23	-	-	1	2	-	-	-	1	-	-	-	-	-	N
10	Cascades	20	-	-	-	-	-	-	1	-	-	-	-	-	-	N
12	Midway	58	-	-	-	-	3	-	-	-	-	2	1	-	-	T
20	Waneta	2	-	-	-	-	-	-	-	-	-	-	-	-	-	N
55	Wallace Road	16	-	-	-	-	-	-	-	-	-	-	-	-	-	T
	Total	**324**	**0**	**2**	**1**	**3**	**3**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**36**	

* T = trace defoliation; L = light defoliation; N = Nil

Six Trap Clusters

Overall moth catches decreased throughout the Thompson Okanagan Region except for a few sites in the Kamloops and Okanagan outbreak areas (Table 21). The Heffley and Six Mile sites saw moderate increases and subsequent ground checks identified a scattered, light incidence of new egg masses. Trap catches in McLure declined, but remained above the threshold of 25 moths per trap and discrete pockets of egg masses were found. Two sites in the North Okanagan (Table 21) had increased trap catches from 2011, but ground checks did not reveal evidence of cocoons or egg masses near the trap sites.

Trap catches also declined in the West Kootenay Boundary Region from an average of 73 moths per trap in 2011 to just one moth per trap in 2012 (Table 21). Four of the sites were positive for Douglas-fir tussock moth, down from 8 positive sites in 2011. It appears that the tussock moth population has subsided in this outbreak area.

In the Cariboo Region, trap catches at 58 sites were similar to 2011, with an average of 1.6 moths per trap in 2011 and 1.4 moths per trap in 2012 (Table 21). Two sites, at the old Carquille Rest Area south of Clinton and at Big Bar Creek along the Fraser River, averaged nine moths per trap.

It appears that most Douglas-fir tussock moth populations are static or in the decline phase throughout the southern interior of the province.

Table 21. Average number of Douglas-fir tussock moths caught per six-trap cluster site in four outbreak areas of the Thompson-Okanagan Region (Kamloops, Okanagan, Similkameen, West Kamloops), the Kootenay-Boundary Region (near Rock Creek and Midway) and the Cariboo Region (Clinton-Big Bar area).

		Average moth catch per trap									
Site	**Location**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Kamloops											
1	McLure	6.3	3.3	0	9.8	33.3	65.7	4.5	25.6	40.5	29.0
2	Heffley Creek	76.3	5.5	38	14.8	34.2	89.8	15.8	2	3.3	33.4
3	Inks Lake	30	1.5	0.3	10.2	5.6	58.8	26.6	1	6.2	6.0
4	Six Mile	67	9.7	33.6	52.5	73.5	73.3	51	48.8	19.2	29.0
9	Stump Lake	3.2	1.2	3.8	2.8	8.7	61.8	15.6	22.7	79.8	0.7
10	Monte Creek	10.7	13.8	40.2	18.3	80.5	75.2	9.2	21.7	54.5	59.2
11	Chase	36.3	11.2	9.3	0	0	25.3	7.8	0	1.8	8.6
	Average of sites	**32.8**	**6.6**	**17.9**	**15.5**	**33.7**	**64.3**	**18.6**	**17.4**	**29.3**	**23.7**
Okanagan											
12	Yankee Flats	1	0.3	2	0	0	38.5	2.2	3	32.0	42.7
13	Vernon	24.8	22.7	79.8	12.2	1.3	24.8	24.3	22	35.2	38.2
14	Winfield/Wood Lake	1.4	6.7	11	0.3	1	38.8	50.8	34	14.7	6.8
15	Kelowna/June Springs	-	-	-	-	-	-	-	46.8	0.7	0.0
16	Summerland	0	0	4.5	1	0.3	43.5	13.2	0	8.5	0.5
17	Kaleden	0.3	0.3	18.6	11.6	29	55.4	27.7	2.9	3.7	0.3
18	Blue Lake	9.2	8.4	39.8	8.3	1.3	63.2	5.2	0	0.5	0.5
	Average of sites	**6.1**	**6.4**	**26.0**	**5.6**	**5.5**	**44.0**	**20.6**	**15.5**	**13.6**	**12.7**
Similkameen											
19	Stemwinder Park	1.2	1	29.5	1.5	17.8	40.2	30.7	0	0.0	0.3
20	Ashnola River	0.5	0	14.3	0	12.3	43.3	20.5	0	0.8	n/a
32	Olalla	-	-	-	-	-	-	-	5.7	3.7	2.0
33	Red Bridge Rec Site	-	-	-	-	-	-	-	0.3	0.0	0.0
34	Ashnola River Road	-	-	-	-	-	-	-	0	0.0	0.2
36	Hwy 3 Lawrence Ranch	-	-	-	-	-	-	-	0	0.8	0.7
37	Hwy 3 Willow Heights	-	-	-	-	-	-	-	0	0.0	0.2
38	Hwy 3 Bradshaw Creek	-	-	-	-	-	-	-	0	3.2	0.3
39	Hwy 3 Winters Creek	-	-	-	-	-	-	-	0	1.2	0.8
40	Hwy 3 Nickelplate Rd	-	-	-	-	-	-	-	0	6.2	0.0
41	Stemwinder FSR	-	-	-	-	-	-	-	0	3.0	0.0
42	Old Hedley Road	-	-	-	-	-	-	-	0	0.4	0.0
43	Pickard Creek Rec Site	-	-	-	-	-	-	-	0.3	2.5	1.0
44	5.7 km Old Hedley Road	-	-	-	-	-	-	-	5.7	0.7	0.8
	Average of sites	**0.9**	**0.5**	**21.9**	**0.8**	**15.1**	**41.8**	**25.6**	**0.9**	**1.6**	**0.5**
West Kamloops											
5	Battle Creek	67.7	5.6	1.2	14	34.8	64.5	12.3	46.5	2.5	0.0
6	Barnes Lake	52.2	6.7	1.5	34.5	21.3	58	0.5	24.3	37.5	4.7
7	Carquille/Veasy Lake	83	2.7	0	13.8	22.5	59	13	38.2	54.5	16.0
8	Pavilion	9.7	0.3	0	1.5	15.7	40	15.7	7.8	82.5	3.2
21	Spences Bridge	21.3	1.5	0	1.5	10.2	5.7	29.5	59.3	68.5	56.0
22	Veasy Lake	-	-	-	-	-	-	-	27.8	68.0	16.2
23	Veasy Lake	-	-	-	-	-	-	-	5.6	43.3	3.3
24	Veasy Lake	-	-	-	-	-	-	-	6.8	76.3	14.5
25	Highway 99	-	-	-	-	-	-	-	11.0	23.0	7.4
26	Venables Valley	-	-	-	-	-	-	-	24.3	39.7	11.5
27	Maiden Creek	-	-	-	-	-	-	-	3.5	8.0	3.5
28	Highway 99	-	-	-	-	-	-	-	3.0	9.3	7.2
29	Cornwall 79	-	-	-	-	-	-	-	28.8	49.5	1.2
30	Cornwall 80	-	-	-	-	-	-	-	2.0	6.0	0.2
31	Barnes Lake	-	-	-	-	-	-	-	7.7	9.8	0.8
	Average of sites	**46.8**	**3.4**	**0.5**	**13.1**	**20.9**	**45.4**	**14.2**	**19.8**	**38.6**	**9.7**
Boundary (Avg of 9 sites)		**-**	**-**	**-**	**-**	**-**	**-**	**4.0**	**2.0**	**73.0**	**1.0**
Cariboo (Avg of 58 sites)		**-**	**-**	**-**	**-**	**-**	**2.3**	**4.0**	**1.7**	**1.6**	**1.4**

Impacts of Western Balsam Bark Beetle and Two-Year Cycle Budworm on High Elevation Forests in the Southern Interior

The two-year cycle budworm, *Choristoneura biennis*, periodically defoliates Engelmann spruce (*Picea engelmannii*), white spruce (*P. glauca*), Engelmann-white spruce hybrid, and subalpine fir (*Abies lasiocarpa*) in the interior of British Columbia. Repeated outbreaks and sustained defoliation by this budworm can cause top-kill, tree mortality, and loss of timber volume. The recorded range of two-year cycle budworm in British Columbia includes, among others, the Engelmann spruce-subalpine fir forests north of Kamloops and Blue River where this current study is located (Shepherd et al. 1995; Unger 1984; Stehr 1967). Defoliation by the two-year cycle budworm often occurs adjacent to or overlaps with the range of the western balsam bark beetle, *Dryocoetes confusus*.

Dryocoetes confusus is the most destructive insect pest of subalpine fir in B.C. (Garbutt 1992). *D. confusus* selectively kills small groups of subalpine fir at a relatively low, but constant level each year in infested stands, resulting in high levels of cumulative mortality after one to two decades (Maclauchlan and Brooks 2004; Unger and Stewart 1992; Stock 1991).

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 freshly downed subalpine fir, and large diameter standing live trees, often suppressed or showing reduced growth compared to other trees in the stand. The selective and patchy distribution of mortality suggests that *D. confusus* may be limited by the abundance and distribution of susceptible hosts, as well as by the harsh environment. In part, this study was initiated to look at the possible pre-disposition of subalpine fir to attack by *D. confusus* after a defoliation event by two-year cycle budworm.

The life cycle of *C. biennis* was described by Unger (1984). Moths emerge from mid-July to early August, mate, and oviposit approximately 150 eggs in several masses on the needles of the host tree. Eggs hatch within two weeks and newly emerged larvae seek shelter, spin hibernacula and overwinter as second-instar larvae. The following year, larvae become active in late May to early June, mine needles and buds for 3-4 weeks, then spin hibernacula and enter a second diapause to overwinter as fourth instar larvae. Larval development is completed during the spring of the second year when the greatest amount of feeding occurs. A short pupation period in July precedes the emergence of adults.

In the southern interior of B.C., adult *D. confusus* 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 along the gallery. The eggs hatch the same summer they are laid. Adults overwinter in the galleries. The following spring, females continue laying eggs until June when they emerge to re-attack the same tree or a new one. Normally the insect requires 2 years to complete development. Western balsam bark beetle is closely associated with the pathogenic fungus *Ophiostoma sp*.

This study continues and expands on the investigation of the ecology of *D. confusus*, describing the temporal and spatial outbreak dynamics and the relationship to stand succession. Ten one-hectare permanent sample plots were established between 1998-2002 in stands within the ESSFwc, ESSFmw, and ESSFxc, and were categorized as early, mid- and late-phase succession as related to *D. confusus* attack in the stand. An additional one-hectare plot was established in 2012 within a stand having past and current records of two-year cycle budworm defoliation and recent attack by *D. confusus*. The plot location was selected by first conducting an overlay analysis of past two-year cycle budworm defoliation as recorded in the aerial overview survey data (MFLNRO Aerial Overview Survey 2012) and occurrence of *D. confusus*. Rotary wing flights were then conducted to determine the extent of current defoliation, level of *D. confusus* attack and accessibility of potential sites. A stand in the North Raft River drainage located in the ESSFwc2 biogeoclimatic zone at 1,500 meters elevation was ultimately selected.

This stand has records of defoliation in 2008, 2010 and 2012.

Plot Methodology and Data Summary

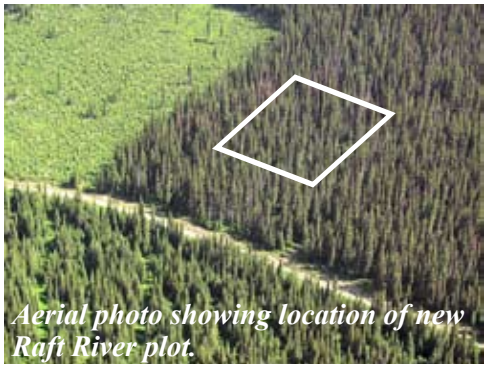
Within the newly established Raft River plot, all trees greater than or equal to 15 cm diameter at breast height (DBH) were tagged, stem mapped, measured and assessed for pest damage. Data collected included DBH of all trees, a sub-sample of tree heights and ages, tree status (live/dead/down), pest incidence, and *D. confusus* attack data. Current defoliation by two-year cycle budworm was evident in the entire stand so the level of defoliation given in the 2012 aerial overview survey was used as the measurement for the plot. In this way future evaluations can be compared to this measure of defoliation. At plot establishment, only standing trees were tagged and assessed (live or dead). Future assessments will record any new blowdown to get an estimate of tree fall over time. The study is ongoing, and the data are now being analyzed using regression techniques for the mensurational data, spatial and time series analysis, CED statistic incorporating Voronoi polygons and area potentially available (APA) and multi-variate analysis.

There were a total of 870 trees (stems per hectare) comprising four species with subalpine fir dominating, making up 66% of the total stem count. All trees estimated to be 15 cm or greater at DBH were tagged but when measurements were made some trees were slightly smaller. There was a wide range of diameters, with spruce being the largest followed by subalpine fir and cedar. Subalpine fir ranged from 10.3 - 53.2 cm DBH, with an average of 22.8 cm (Table 22). About 6% of the stems in the plot were 40 cm DBH or greater, equally represented by spruce and subalpine fir.

Over 75 percent of subalpine fir in the Raft River plot is alive, with 13.3% dead due to *D. confusus* and 11.6% dead from other causes (Figure 11). Almost half the attack by *D. confusus* has occurred recently, in 2011 and 2012 (Figure 11). 3.9% of trees killed by *D. confusus* were classified as "snags". Snags represent those trees which have been dead for several years, and which no longer have foliage or fine branches, and have peeling bark. *D. confusus* was the most prevalent mortality factor in the stand. Light defoliation from *C. biennis* was noted on most spruce and subalpine fir and many trees had broken tops. Eight subalpine fir were killed by a *Pissodes* weevil, alone or in combination with *D. confusus*.

Table 22. Summary of all trees assessed in the Raft River Plot.

	Number of trees	Diameter at Breast Height (cm)	
		Average	Diameter Range
Subalpine fir	570	22.8	10.3 - 53.2
Spruce	198	26.9	11.3 - 69.2
Cedar	96	21.7	10.8 - 53.9
Hemlock	6	20.7	12.1 - 31.3



Aerial photo showing location of new Raft River plot.

Several criteria were used to select stands for the original *D. confusus* monitoring plots (Table 23), including the estimated attack phase of *D. confusus* in the stand (early phase; mid-phase; and, late-phase). Attack phase designations were based upon the level of current and past attack, density, and amount of blowdown, among other factors. Using these designations, the Raft River plot falls into the early phase of an infestation. From the diameter distribution in Figure 11, it is evident that the largest subalpine fir were attacked first, leaving smaller diameter host unattacked. Tree ring analysis is underway to determine if past defoliation events by *C. biennis* may have predisposed trees to attack by *D. confusus,* and if the current budworm outbreak may result in another increase in *D. confusus* attack levels.

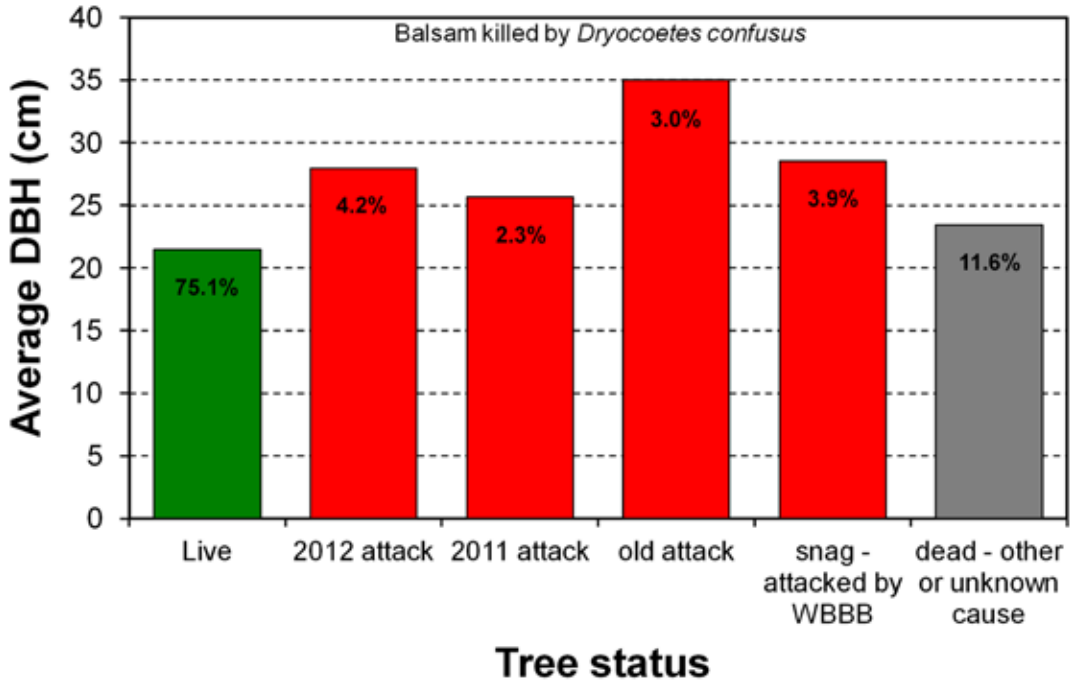


Figure 11. The average diameter at breast height (DBH) of all subalpine fir in the Raft River plot is displayed, by tree status. Trees are grouped by living (green bar) or dead (grey bar) with the red bars indicating trees killed by *D. confusus* (year or age of attack on the x-axis). The percent of trees in each category is indicated on each bar of the graph.

Table 23. List of eleven one hectare permanent sample plots established to monitor attack dynamics of *D. confusus* and other pests of subalpine fir forests. For each plot the following is listed: geographic location; year of plot establishment and last assessment; plot elevation; biogeoclimatic zone (BEC); attack phase at stand establishment; stems per hectare of all species and subalpine fir; and, percent subalpine fir killed by *D. confusus*.

Geographic location	Year Established	Year Last Assessed	Elevation (meters)	BEC zone	Attack Phase	Stems per ha		%Bl killed
						all spp.	Bl	
Buck Mountain	1999	2009	1,725	ESSFxc	early to mid-	1,321	1,211	42.9
Cherry Creek	1998	2009	1,650	ESSFwc4	mid- to late-	496	425	52.7
Home Lake-1	1999	2008	1,800	ESSFxc	early to mid-	1,207	996	50.4
Home Lake-2	1999	2008	1,750	ESSFxc	early to mid-	1,330	1,163	44.5
Martin Creek	2000	2009	1,675	ESSFwc2	early	1,417	1,161	30.9
Scotch Creek	2002	2011	1,575	ESSFwc2	mid- to late-	724	637	35.8
Sicamous Creek	1998	2009	1,650	ESSFwc2	mid- to late-	930	723	48.4
Spius Creek-1	2002	2008	1,470	ESSFmw	early	791	617	31.9
Spius Creek-2	2002	2008	1,610	ESSFmw	early	861	693	15.3
Torrent Creek	1998	2008	1,750	ESSFwc2	mid- to late-	597	515	24.7
Raft River	2012	2012	1,503	ESSFwc2	early	870	570	13.3

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Unusual Larch Growth in Arrow TSA

Art Stock, Forest Entomologist, Kootenay Boundary Region.

In the summer of 2012, David Jackson (Interfor Forest Products), noted that young western larch (from about 7 years old) were displaying unusual growth patterns over much of the extent of TFL #23 and neighbouring tenures (Nakusp, Burton, Fauquier, Edgewood, Castlegar, Renata, and the Paulson Summit). In 2011, some trees lost all foliage on the main leader, and occasionally on laterals. This resulted in a bottlebrush look when the trees refoliated in 2012. Further, it appeared that buds, including terminal buds, died on the 2011 leader growth. Leader death occurred on some trees, but the 2011 leader woody growth was usually alive and apparently fine. Some trees showed "candelabra-like" multiple leaders, possibly due to repeated occurrence of the damage.

Field observations in August at Nakusp by David Jackson and Art Stock (BC MFLNRO) indicated some evidence of insect damage (pitch blobs, frass, webbing and an unknown looper larva) on some wilting leaders and buds. However, there was no consistent pattern. Larch shoot miner (also called larch shoot moth), *Argyresthia* spp., probably *columbiana*, killed up to 12 % of terminal shoots of dominant and co-dominant larch in spaced stands in the East Kootenays in 1994.

Foliar disease was evident on a number of trees, but again there was no consistent pattern. Foliar disease might be responsible for the death of buds on existing leaders. Annual infections of foliar disease (larch needle cast, *Meria laricis*, and larch needle blight, *Hypodermella laricis*) on larch have become common and widespread within the Kootenay-Boundary Region over the last decade, but the impact of repeated infections on young trees is not known. The damage might also be a response to the previous year's drought conditions, but does not appear to be restricted to dry sites.

Detection of this damage depends on ground-based observations, and is not possible from fixed-wing aircraft used in the aerial overview. Consequently, some effort should be made to conduct an assessment of young stands to assess causes and overall extent of the situation. Long-term sample plots could be established to monitor progress of affected young stands if the damage is widespread and common.

Unusual larch growth, Nakusp, August 2012. Left: Bare live leader with dead terminal and lateral buds (Photo: Art Stock). Centre: Wilting 2012 "bottlebrush" foliage (Photo: David Jackson). Right: Bare leader and laterals with 2012 "bottlebrush" foliage (Photo: David Jackson).

Bear Impacts on Growth of Lodgepole Pine

Michael Murray, Forest Pathologist, Kootenay/Boundary Region

Bear damage to trees is one of the most common maladies observed in young stands of the Kootenay/Boundary Region. Based on two separate and recent ground surveys of the Kootenay Lake TSA (Stand Development Monitoring and Young Stand Monitoring), 2-4% of trees observed were impacted. Incidence in individual stands can reach over 50% of trees. Overall, bear-injured trees outnumber any single disease or insect.

Bears tend to remove bark of young trees during the springtime to eat new sapwood tissue (Radwan 1969). When bears damage all of the cambium, fatal girdling can result. Bears seem to prefer young pines (less than 20 years old), but damage on older red cedar is also common. Species selected by bears varies in different regions.

Lodgepole pine killed by bear feeding near Kaslo River.

Sampling bear scar with an increment borer.

Actual coping mechanisms of damaged trees are poorly understood. As with other physical scar agents (e.g. fire, bole scraping), wounds can gradually close by growing annual healing tissue at the margins. However, before wounds close-over, trees are vulnerable to secondary damage from disease and insects. Tree survivorship and growth after bear damage are not well-understood.

Three young plantations in the West Kootenays were examined in 2012 to gain insight on bear impacts on radial growth. These lodgepole pine stands are at Bombi Summit, Rosebud Lake, and the Kaslo River (all between the U.S. Border and Kaslo area). Plantation ages were between 14-24 years. At each site ten trees were sampled including an undamaged (control) tree. Each bole was examined for the amount of circumference (%) of cambium removed by bear. The tree was then sampled with an increment borer. Trees were bored through the entire stem, entering the undamaged living tissue and exiting through the bear scar. This yielded a core-sized cross-section of each tree with a dateable scar year. Ring widths were then measured using the Velmex sliding tray system at the Tree Ring Lab in Nelson. This data provided a comparison of tree growth before and after bear damage occurred.

Findings indicate that bears may need to remove at least a 70%-circumference of tree cambium before an impact on radial growth is evident. Most trees examined received less than 70% removal. With all trees combined, there was no significant reduction in post-damage growth ($F=0.67$, $P<0.05$). Nor was there a significant difference when each site was analyzed separately ($T=0.67$-0.93, $P<0.05$). Changes in growth among individual trees were not uniformly negative or positive, revealing no apparent relationship. These findings echo a study conducted on coastal Douglas-fir which yielded no significant differences after simulated modest logging injury (Shea 1967). Miller et al. (2007) also examined bear damage on mature coastal Douglas-fir. They found growth rates increased after bear damage for most trees. They suggested that accelerated growth of partially girdled trees contributed to the recovery of volume lost to mortality. No thresholds were identified where growth begins to decline, however trees suffering more than 93% damage ceased growth or died. Barnes and Engeman (1995) found that all lodgepole pine in their Oregon study with greater than 75% girdling died.

This study acknowledges that the severity of girdling, as measured by circumference removed, is an important consideration in assessing bear damage. Overall, lodgepole pines may be least impacted by girdling levels below 70%. Future repeated surveys could provide information to estimate the degree of volume change by more closely examining radial trends, heights, and survivorship.

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Armillaria Root Disease: Tree Rings Reveal Yearly Mortality

Michael Murray, Forest Pathologist, Kootenay/Boundary Region

Root disease caused by *Armillaria ostoyae* infects up to 80% of trees in many stands of the Interior Cedar Hemlock (ICH) zone in the BC Southern Interior. *Armillaria* root disease threatens sustainable forest management in this region due to its ability to cause tree mortality, and to reduce the growth rate of all live trees that become infected. Increased infection rates have been associated with logging activities because this pathogen can quickly colonize stumps and roots of cut trees lacking living defenses. The remaining stumps then become a source of inoculum and spread to adjacent regenerating seedlings and saplings.

The spread and physical evidence of *Armillaria* is hidden beneath soil and bark. Aboveground symptoms can be recognized by trained field personnel, however, most trees fail to show symptoms prior to mortality. Thus, monitoring the spread of *Armillari*a within a plantation is challenging and typically yields a rough estimate based on snapshots in time.

To better understand the progression of root disease, we examined a 21-year old plantation near Grand Forks. The study site is an arrangement of 20 permanent plots consisting primarily of Douglas-fir, lodgepole pine, and western larch. In 2011, we re-inventoried about 3,200 regenerating trees, of which 160 were found to be dead with signs of *Armillaria*. For each of these, we sawed and collected a cross-section sample of the stem from both the base and at breast height (1.3 metres). Samples were then sanded to better reveal ring patterns before scanning each cross-section at the Nelson Tree Ring Lab for computer software analysis. Based on this analysis, some key findings include:

1. *Armillaria* disease is evident in tree rings. There is a marked decrease in ring width upon infection. Each subsequent growth ring is also narrow until death. Thus, a 'signature' is consistently evident. In comparing samples taken from stem bases versus breast height, the signature was more reliably seen at breast height.

2. Mortality peaked at 16 year after plantation establishment. After this time period, morality sharply declined and by 21 years, was insignificant.

3. Heavy mortality was detected during marker years. Findings indicate that a majority of trees died in 2003, 2005, and 2007. This pattern is common for all tree species occurring at the site. Thus, it is likely that an influence (e.g. climate) may play a role.

Armillaria-*induced growth reduction prior to death in a 16-year old Douglas-fir.*

The potential role of climate influencing fluctuations in annual mortality is being investigated. Our findings have implications for species selection, the timing of free-growing surveys and for future yield projections for managed stands in the southern interior where root disease is prevalent. Results may also help predict how climate change will influence forest health in plantations.

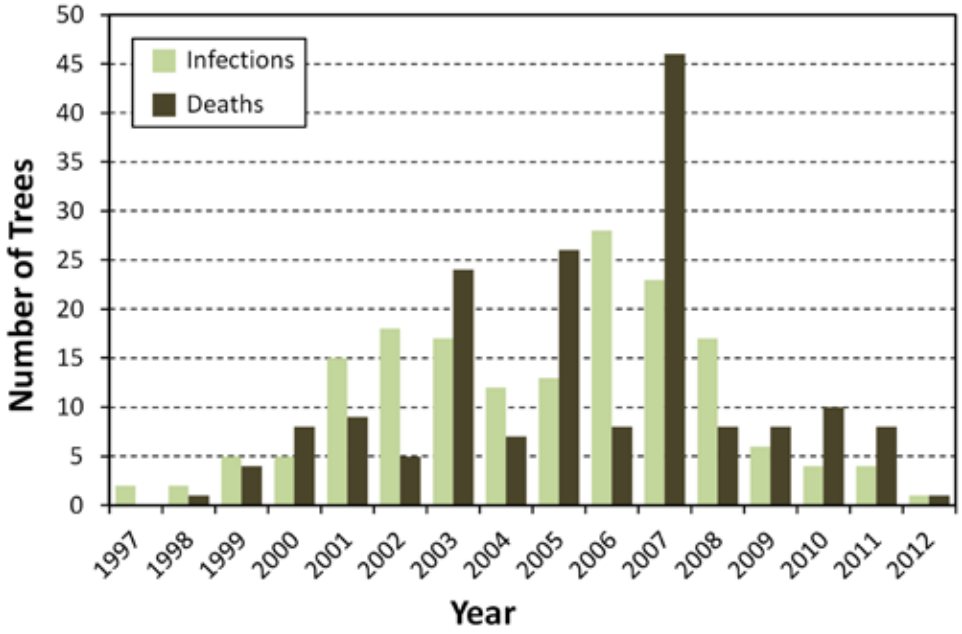

Figure 12. Annual infections and deaths associated with *Armillaria* (trees planted 1991 and 1995).

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