Summary of Aerial Overview Surveys in the Kamloops Forest Region - 1999

1999 Overview of Forest Health in the Kamloops Forest Region

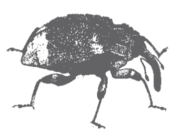
Mountain pine beetle

Introduction

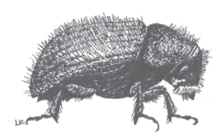
The 1999 aerial overview surveys of the Kamloops Forest Region were conducted from July 22 - August 23, 1999. In total, 16.5 days (88.9 hours) were required for full coverage of the Region.

The results of the overview surveys are reported by major pest detected, and by forest district. Surveys were completed to the standards set out by the Ministry of Forests Aerial Overview Surveys Forest Insect and Diseases Training Program. At the end of the overview surveys report is a brief summary of research projects underway in the region.

Mountain pine beetle, western balsam bark beetle, and drought caused stress and mortality were the most serious forest health issues in the Kamloops Forest Region in 1999, in terms of area affected. Other pests and diseases causing less significant damage were Douglas-fir beetle, spruce beetle, western pine beetle, satin moth, and pine needle cast. Abiotic factors such as flooding, windthrow, and wildfire caused scattered mortality and / or damage (Table 1).



Poplar and willow borer



Spruce beetle

Table 1. Area affected by damaging agents in the Kamloops Region as mapped during the 1999 Aerial Overview Pest Survey.

Damaging agent	Hectares affected
Mountain pine beetle	29,750
Douglas-fir beetle	235
Spruce beetle	340
Western balsam bark beetle	17,230
Western spruce budworm	1,130
Drought mortality	10,035
Total affected area	58,720 ha

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Regional Overview

Mountain Pine Beetle, *Dendroctonus ponderosae*
Mountain pine beetle caused mortality was mapped on over 29,750 hectares in 1999 throughout the Region. This represents an expansion of 10,349 ha from what was mapped in 1998 (19,401 ha). Most mountain pine beetle mortality occurred in the Merritt and Kamloops Forest Districts (Fig. 1). The main areas of infestation were south of Princeton throughout the Similkameen River drainage system, Red Plateau-Red Lake, and Louis Creek south through to Monte Creek and TFL 49 (Georges Creek). Other significant mortality occurred between Princeton and Merritt, as well as several areas around Cache Creek, and Snehumption Creek. The greatest expansion was seen in the Red Lake-Red Plateau area, Hayes Creek, Monte Hills, and Chase Creek areas.

The Kamloops Region has experienced three years of relatively mild weather, particularly during the winter (1996-98). Mild conditions have allowed mountain pine beetle populations to increase. In 1998, the Region had a very early spring and the warm weather persisted until late September. Many lodgepole pine sites experienced drought stress by early summer and shut down translocation. In addition, the mountain pine beetle had a very early flight period; during June in most areas. The flight was very synchronised which allowed successful mass attacks to occur. There was little resistance from trees due to their drought stress condition, which also produced many asymptomatic attacks (no pitch tubes, only sawdust around the base of trees). In warmer areas, some of the brood was able to develop through to adults and emerge to attack new trees. In addition, many parent beetles emerged to attack new host trees during the same season.

This phenomenon was one of the reasons for the tremendous expansion seen in 1998-99 (Table 2). Mountain pine beetle population trends can be estimated by calculating the ratio of currently attacked trees (green) to one-year-old attacked trees (red). A ratio of >1 indicates an increasing population; a ratio of <1 indicates a declining population. The green-to-red ratio was about 10:1 to 20:1 throughout the Region in 1998.

The weather changed in 1999; spring and summer were cool and wet. Mountain pine beetle development was delayed due to this fact. Thus, the emergence and attack period were not synchronized. The flight was very late and sporadic, forcing many beetles to disperse. Therefore, the number of green attacks to red attacks (green-red ratio) decreased from that of

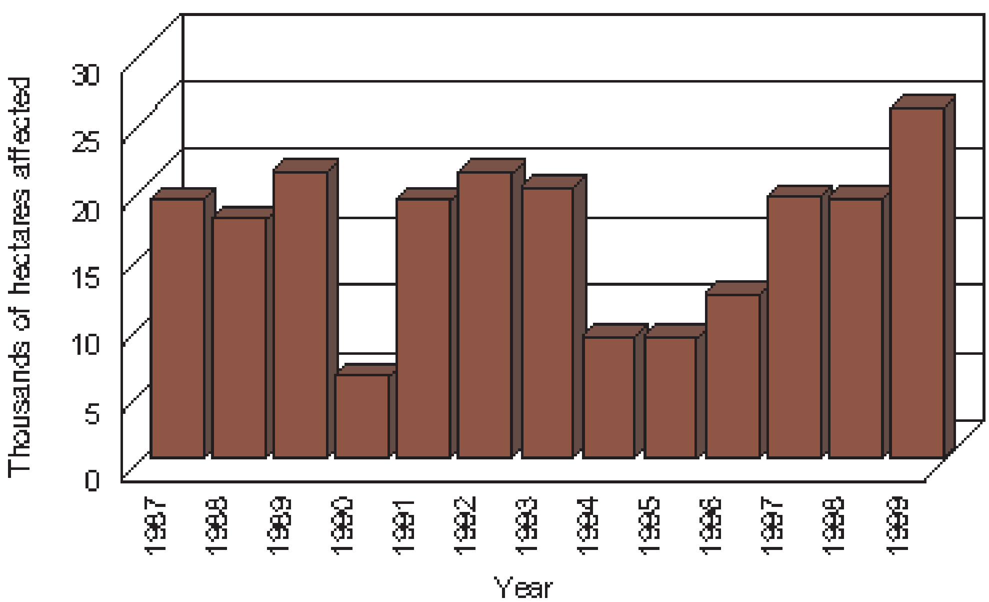


Figure 1. Area of mature lodgepole pine killed annually by the mountain pine beetle in the Kamloops Region (Taken from F.I.D.S. Annual Reports 1987-95 and MOF data 1996-99).

1998. The average green-to-red ratio was about 1:1 throughout the Region (Table 3). However, increases in mountain pine beetle populations are still being observed due to the enormous expansion that occurred in 1998.

Mountain pine beetles were still flying in late September and early October. As a result, the galleries are very short and there is little or no brood. Even in trees attacked earlier in the season, brood development is minimal. Beetle development was greatest in pheromone-baited trees. It is possible that there will be significant overwinter mortality. An opportunity exists to aggressively manage mountain pine beetle, because management activities will have a relatively greater impact on beetle populations due to reduced vigour. However, population trends may quickly reverse if the weather in 2000 is near normal or warmer.

Mountain pine beetle

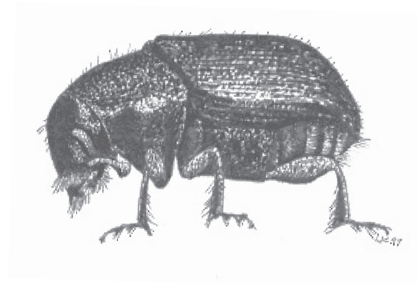


Table 2. Area under attack by the mountain pine beetle in the Kamloops Forest Region.

District	Area mapped in 1998 (ha)	Area mapped in 1999 (ha)
Clearwater	170	75
Kamloops	2,790	11,275
Salmon Arm	459	1,240
Vernon	950	2,005
Penticton	1,912	1,440
Merritt	12,390	12,855
Lillooet	730	860
Region Total	19,401 ha	29,750 ha

Table 3. 1999 green to red ratios for the mountain pine beetle (MPB) in the 7 forest districts in the Kamloops Forest Region.

	Clearwater	Kamloops	Salmon Arm	Vernon	Penticton[a]	Merritt	Lillooet
MPB	1.5:1 (Pl)	2:1	1.5:1	2.5:1	1.5:1	1:1	1:1
	4:1 (Pw)						

[a] Snehumption Creek only

Douglas-fir Beetle, *Dendroctonus pseudotsugae*
Little Douglas-fir beetle (DFB) was mapped in 1999. Mortality caused by DFB was often indistinguishable from drought-caused mortality. There were local "hot-spots", particularly in the Salmon Arm District in and around the Silver Creek fire and in scattered areas throughout Wells Gray Park in the Clearwater District. In 1998, over 6,500 ha of predominantly Douglas-fir forest was burned in a wild fire near the community of Silver Creek in the Salmon Arm District. Trees that had moderate to heavy scorching from the fire, but survived, became highly susceptible to Douglas-fir beetle. During 1999 field reconnaissance, it was determined that most larger diameter Douglas-fir on about a 3,000 ha area in and around the fire, were infested by Douglas-fir beetle. The Salmon Arm District will endeavour to control DFB in spring 2000 by deploying ±800 Lindgren funnel traps to mass trap

the beetle, in combination with MCH (3-methyl-2-cyclohexen-1-one), an anti-aggregation pheromone. The use of MCH is intended to prevent the beetles from killing additional high value trees and stands. MCH is being used under a research permit to the Salmon Arm District.

Spruce Beetle, *Dendroctonus rufipennis*
The area of spruce beetle mortality was down again for the third year in a row. Local populations still exist in the Penticton, Merritt and Clearwater Districts.

Western Balsam Bark Beetle, *Dryocoetes confusus*
Western balsam bark beetle was active on over 17,230 hectares, an increase from 7,650 ha in 1998. Most increases were observed around Spius Creek, west of Barriere, north of Clearwater near the Mad and Raft Rivers, Murtle Lake, and the north end of Hunters Range. Attack levels decreased slightly in the Buck Mountain–Greystokes area and in the south Okanagan.

Western Spruce Budworm, *Choristoneura occidentalis*
Western spruce budworm populations decreased significantly from 1998 to 1999, most likely due to a very hot, dry fall followed by a wet, cold spring and summer, and increased parasitism. As a result, visible defoliation was only mapped on 1130 hectares, down from over 61,000 hectares in 1998.

Between June 28-30, 1999, approximately 8,031 ha were sprayed with Foray 48B (*Bacillus thuringiensis* var. *kurstaki*) to decrease populations of the western spruce budworm (Table 4). The treated area was split into 8 separate blocks, all within the Kamloops District, north of Cache Creek. Based on population predictions from 1998 egg mass sampling (Table 5), over 12,000 ha were scheduled for treatment. However, early season monitoring showed population declines in many areas. Thus, the area treated was reduced to 8000 hectares.

The spray program began late in1999 due to cool, moist weather conditions in early summer. Cooler temperatures and high humidity caused delayed larval development and increased larval mortality. The extended, warm summer of 1998, followed by a late, cool spring in 1999, caused a significant decrease in the budworm population throughout much of its range in the Kamloops (Table 6) and Cariboo Forest Regions.

Western Hemlock Looper, *Lambdina fiscellaria lugubrosa*
No defoliation was detected during the 1999 overview surveys. However, based on historical outbreak cycles, populations are expected to increase to damaging levels in the next 1-2 years. In 1999, 18 permanent sampling sites were re-established by the BCFS at old F.I.D.S. (Forest Insect & Disease Survey, Canadian Forest Service) sites (Fig. 2). Each site consists of a 6-trap cluster, with each trap containing a pheromone lure that attracts the male looper moth. Half the trapping sites had average trap catches of over 20 moths per trap (Table 7). The trapping system has not been

Table 4. By spray block, the dates of treatment, block area and quantity of Foray 48B applied.

Block	Date	Geographic	Ha Sprayed	Litres *B.t.k.*
K1 - north	28-Jun-99	Scottie Creek	1,351	3,242
K1 - south	28-Jun-99	Scottie Creek	343	823
K2 - north	29-Jun-99	5100 Rd.	535	1,284
K2 –middle	29-Jun-99	5100 Rd.	1,085	2,604
K2 - south	29-Jun-99	5100 Rd.	274	658
K4	30-Jun-99	Maiden Creek	3,054	7,330
K5	30-Jun-99	Gallagher	923	2,215
K10	29-Jun-99	Hart Ridge	466	1,118
Total			8,031 ha	19,274.4 L

Table 5. Summary of 1999 western spruce budworm population sampling in the Kamloops Forest Region. By district, the total number of sites sampled (on average 10 trees/site), the average number of egg masses per 10m^2 of foliage per site, and the number of sites falling into each defoliation prediction category. The number of budworm egg masses/10m^2 of foliage for each defoliation category is: nil=0; light=1-50; moderate=51-150; and, severe>150.

District	Total no. sites	Ave. no. egg masses/10m^2 foliage, per site	No. sites	defoliation rating
Kamloops	15	10.3	5	nil
			10	light
Salmon Arm	30	0	30	nil
Vernon	49	1.4	42	nil
			7	light
Penticton	56	10.7	28	nil
			27	light
			1	moderate
Merritt	30	49.1	3	nil
			18	light
			8	moderate
			1	severe
Lillooet	47	2.0	33	nil
			14	light
Regional total	178	14.4	141	nil
			76	light
			9	moderate
			1	severe

Table 6. Change from 1998 to 1999 in the number of sites having predictions of nil, light, moderate or severe defoliation by the western spruce budworm. The number of budworm egg masses/10m^2 of foliage for each defoliation category is: nil=0; light=1-50; moderate=51-150; and, severe>150.

District	1998 Defoliation Prediction (no. sites)				1999 Defoliation Prediction (no. sites)			
	nil	light	moderate	severe	nil	light	moderate	severe
Kamloops	115	27	6	0	5	10	0	0
Salmon Arm	34	2	3	1	30	0	0	0
Vernon	18	16	6	13	42	7	0	0
Penticton	11	27	17	1	28	27	1	0
Merritt	8	31	27	9	3	18	8	1
Lillooet	23	38	5	1	33	14	0	0
Region total	93	100	60	25	141	76	9	1

fully calibrated, so it remains uncertain what these numbers indicate in terms of population dynamics. Researchers at the Pacific Forestry Centre, Canadian Forest Service, are developing a hazard rating system for the western hemlock looper. They have been trapping western hemlock looper using similar traps since the last outbreak in the early 1990's (Table 8). Figure 2 shows the location of the 18 BCFS 6-trap clusters.

Two-Year Cycle Budworm, *Choristoneura biennis*

No high elevation subalpine fir/spruce forests were visibly defoliated in 1999 by the two-year cycle budworm. It is expected that 2000 will show significant areas of defoliation, primarily in the Clearwater District. The current outbreak is estimated to cover over 35,000 ha, as determined by aerial mapping in 1998. Scientists from the Pacific Forestry Centre, CFS, and BCFS are conducting research into the population dynamics and impact of this insect.

Table 7. Mean number of western hemlock looper moths, *Lambdina fiscellaria lugubrosa*, caught per 6-trap cluster in 1999.

Site	Location	Average no. moths/trap (±SD)
1	Lempriere	0.2 ± 0.4
2	Thunder River	12.6 ± 7.2
3	Mud Lake	14.7 ± 8.2
4	Murtle Lake road	13.7 ± 11.7
5	Finn Creek	26.7 ± 7.0
6	Tumtum Lake	logged
7	Scotch Creek	23.2 ± 10.2
8	Yard Creek	13.7 ± 8.9
9	Crazy Creek	22.5 ± 4.9
10	Perry River	28.0 ± 8.1
11	Three Valley Lake	22.0 ± 3.8
12	Hidden Lake	30.7 ± 4.9
13	Kingfisher Creek	25.7 ± 8.9
14	Noisy/Kingfisher Creek	28.3 ± 4.9
15	Shuswap River	7.3 ± 7
16	Greenbush Lake	6.7 ± 6.4
17	Adams River	36.2 ± 11.3
18	Finn Creek	26.7 ± 6.2

Table 8. Mean number of western hemlock looper moths, *Lambdina fiscellaria lugubrosa*, caught per 6-trap cluster at 7 sites established by the Canadian Forest Service (1992-1999). The trapping is part of a research project lead by Dr. Imre Otvos.

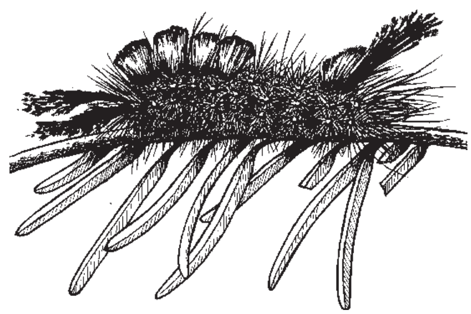
	No. males found in traps							
Location	1992	1993	1994	1995	1996	1997	1998	1999
Helmcken Falls	851	158	4	1	0	-	61	83
Clearwater Lake	988	1265	2	14	0	1	410	287
Avola	497	325	3	10	4	11	628	369
Finn Ck.	887	177	1	6	0	1	57	95
Peddie Mtn.	1527	22	0	3	0	1	176	92
Murtle Lake Rd.	3067	152	3	0	0	0	19	14
Mud Lake	6150	367	1	0	0	1	61	76
Average:	1,995	352	2	5	0.6	2.5	202	145

subalpine fir, *Abies lasiocarpa*

Douglas-fir Tussock Moth, *Orgyia pseudotsugata*

No defoliation was visible in 1999 aerial surveys. The cool and wet early summer weather affected the development of the Douglas-fir tussock moth much as it did the budworm. A small epicentre in Knox Mountain Park, Kelowna, was treated with NPV (nuclear polyhedrosis virus) in May to control the building population detected in 1998-99.

On average trap catches were down from 1998 except in the Penticton and Merritt Districts (Table 9; Fig. 2). Traps near Kelowna, Summerland and Kaleden in the Penticton District had trap catches of 25 moths or greater (Table 10). Similarly, near Princeton at the Stemwinder and Ashnola sites catches were >25 moths per trap. Ground surveys for egg masses were done in the fall of 1999 but only scattered egg masses were located. Monitoring will continue in 2000 as an outbreak is predicted in the next 1-2 years.



Douglas-fir tussock moth larva

Drought Damage

Drought caused mortality, resulting from extremely dry weather conditions in the summer of 1998, caused mortality over 10,035 hectares in the region. Most mortality was observed in the north Okanagan TSA, in Vernon and Salmon Arm Districts, from Little Shuswap Lake south through to Kelowna and Aberdeen Lake. Smaller areas of mortality were mapped in many other low-to-mid elevation sites throughout the Kamloops Region. Most observe mortality was in mature lodgepole pine and Douglas-fir; however, some pine plantations, especially in the Aberdeen Lake area, also experienced high mortality.

Table 9. Average number of Douglas-fir tussock moths caught per trap (single trap per site) over time in the Kamloops Region

District	Kamloops (±100 traps)	Vernon (±46 traps)	Penticton (27-30 traps)	Merritt (±30 traps)	Lillooet (15 traps)
1994	19.5	NT[a]	NT[a]	0.7	8.0
1995	10.4	0.5	3.6	3.4	NT[a]
1996	1.9	1.5	4.4	1.9	1.2
1997	17.0	2.5	9.1	17.0	1.6
1998	25.8	10.6	24.4	25.8	4.9
1999	4. 8	6.8	27.0	19.7	2.5

[a]NT=No trap

Table 10. Mean number of male Douglas-fir tussock moths, *Orgyia pseudotsugata*, caught per 6-trap cluster in 1999.

Site	Location	Average of 6-trap cluster (±SD)
1	McLure	1.8 ± 1.7
2	Heffley Creek	3.5 ± 2.3
3	Cherry Creek	2.2 ± 3.0
4	Six Mile	1.8 ±1.5
5	Battle Creek	0.8 ± 0.8
6	Barnes Lake	0.8 ± 1.6
7	Carquille/Veasey Lk.	12.5 ± 5.0
8	Pavilion	16.3 ± 5.5
9	Stump Lake	7.2 ± 3.8
10	Robbin’s Range	1.3 ± 1.5
11	Chase	0.2 ± 0.4
12	Yankee Flats	0.5 ± 0.5
13	Vernon	10.8 ± 6.9
14	Winfield/Wood Lake	13.7 ± 6.4
15	Kelowna	32.8 ± 5.4
16	Summerland	24.8 ± 5.8
17	Kaleden	27.5 ± 3.3
18	Blue Lake	7.8 ± 5.3
19	Stemwinder park	32.7 ± 8.7
20	Ashnola River	26.7 ± 3.9
21	Spences Bridge	5.2 ± 2.4

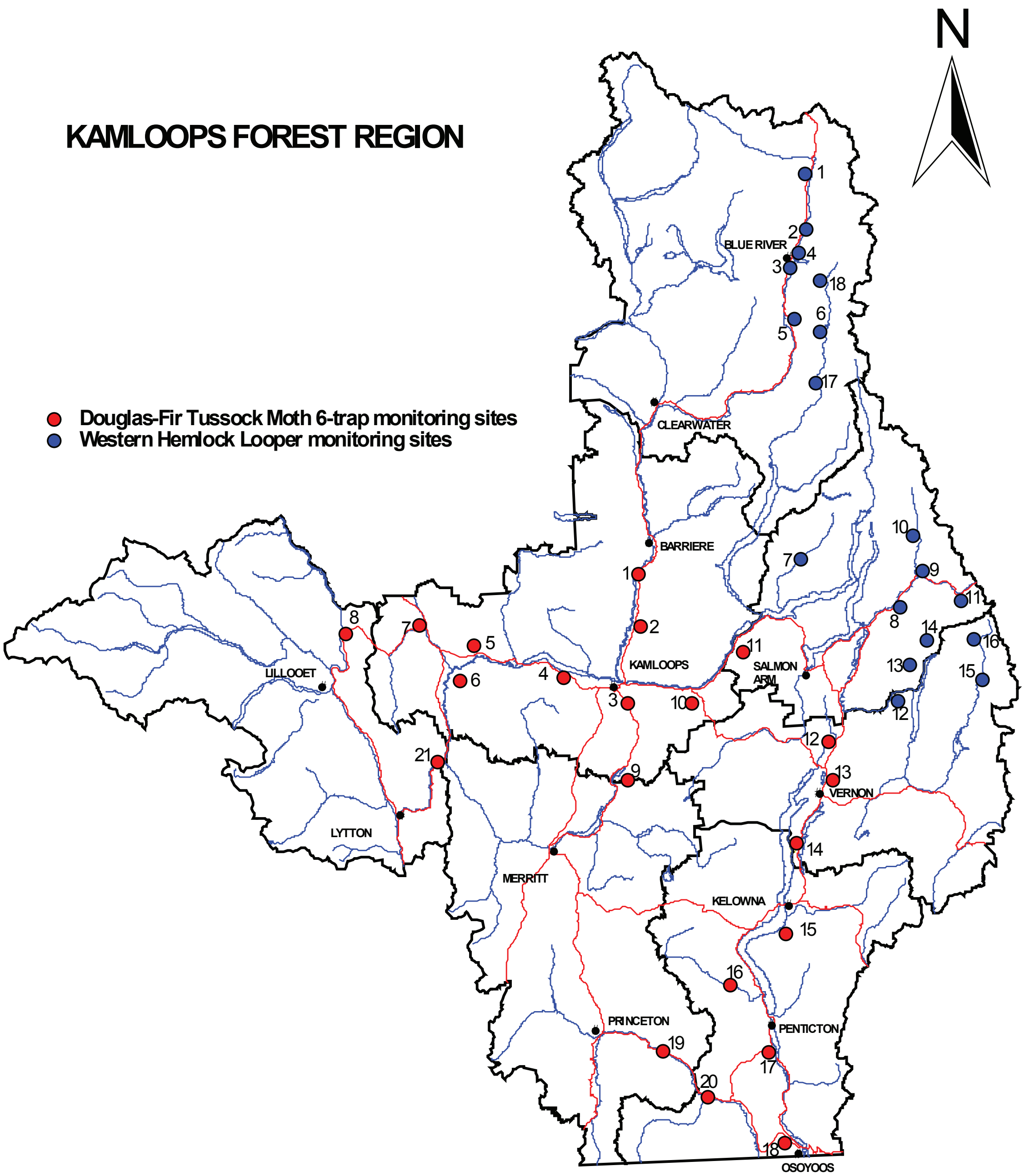


Figure 2. Location of the permanent sample sites (6-trap clusters) for monitoring Douglas-fir tussock moth and western hemlock looper populations.

Kamloops TSA

Kamloops Forest District

Mountain Pine Beetle
Mountain pine beetle was mapped over 11,275 hectares in the district in 1999, an increase from 2,790 hectares in 1998. There were a total of 6,150 ha of light attack, 4,175 ha of moderate attack and 950 ha of severe attack in Kamloops (Table 11). Major expansions were observed in the Red Lake–Red Plateau areas (Fig. 3), Opax Mountain, Pass Lake, west of Barriere, in the Fishtrap Creek–Peterson Creek areas, northwest of Monte Lake and in several areas near Cache Creek. Infestations also continued in the Louis Creek–Heffley Lake areas, Pinantan Lake, Paxton Valley, and several other minor areas in the District. As noted in Table 3, green to red attack ratios decreased significantly from last year to 2:1 in 1999.

Douglas-fir Beetle
Douglas-fir beetle infestations in the Kamloops District were mapped on only 44 ha, all of which was light attack. Attack by Douglas-fir beetle was closely related to drought stress.

Western Balsam Bark Beetle
Western balsam bark beetle infestations expanded to 3,800 hectares in 1999, most of which occurred in the Thompson Plateau southeast of Bonaparte Lake. 3,060 ha were considered light attack, while 740 ha were recorded as moderate attack.

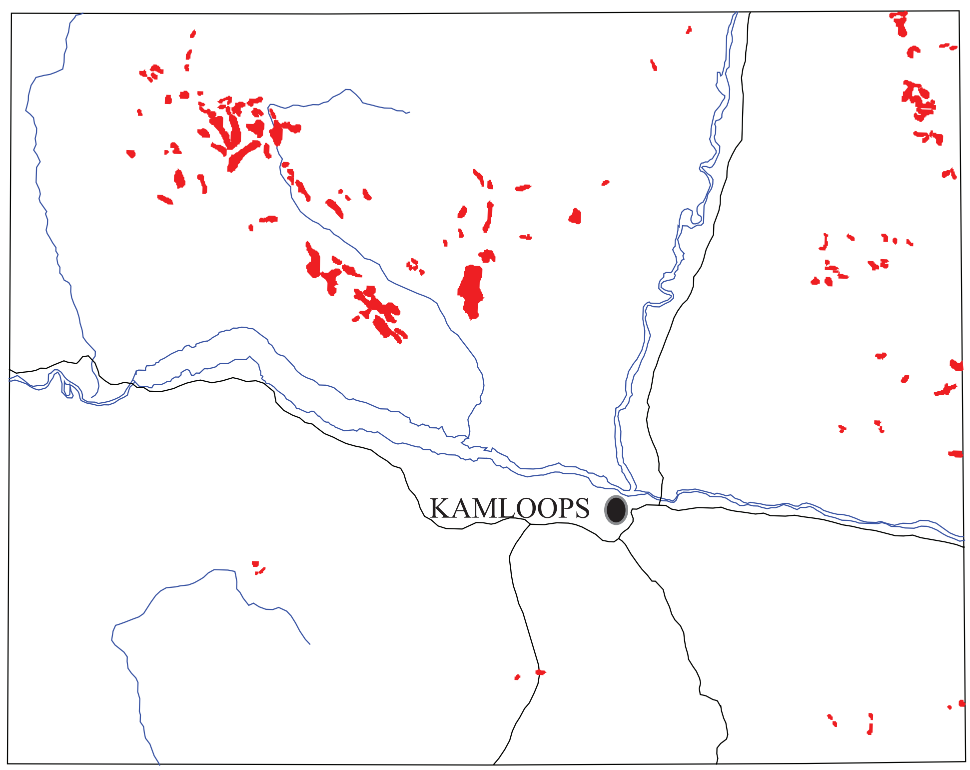
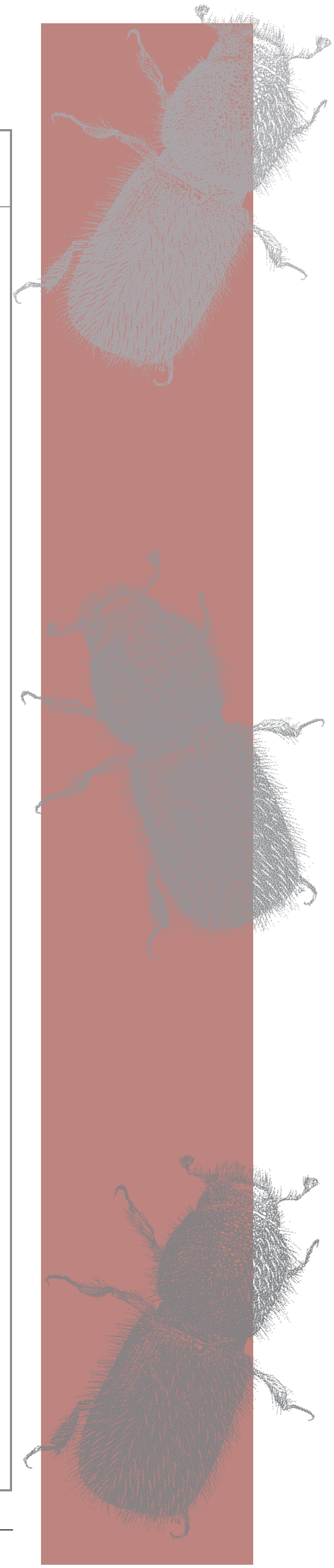


Figure 3. Area under attack by the mountain pine beetle, in the Red Lake area (Kamloops TSA, mapsheet 92INE), as mapped by the 1999 aerial overview surveys.

Table 11. Summary of the 1999 Kamloops Forest Region's aerial overview surveys, showing hectares affected, by district, by major forest insect pests.

Forest District and pest type	Area of Infestation (ha) Light	Moderate	Severe	Total
Mountain pine beetle				
Clearwater	75	0	0	75
Kamloops	6,150	4,175	950	11,275
Salmon Arm	940	300	0	1,240
Vernon	1,125	670	210	2,005
Penticton	740	670	30	1,440
Merritt	5,820	6,080	955	12,855
Lillooet	510	250	100	860
Total	**15,360**	**12,145**	**2,245**	**29,750**
Douglas-fir beetle				
Clearwater	30	0	0	30
Kamloops	60	0	0	60
Salmon Arm	10	0	0	10
Vernon	50	65	20	135
Penticton	0	0	0	0
Merritt	0	0	0	0
Lillooet	0	0	0	0
Total	**150**	**65**	**20**	**235**
Spruce beetle				
Penticton	240	0	0	240
Merritt	100	0	0	100
Total	**340**	**0**	**0**	**340**
Western balsam bark beetle				
Clearwater	2,930	50	0	2,980
Kamloops	3,060	740	0	3,800
Lillooet	1,230	0	0	1,230
Merritt	2,870	150	0	3,020
Vernon	2,680	100	20	2,800
Penticton	810	160	0	970
Salmon Arm	2,430	0	0	2,430
Total	**16,010**	**1,200**	**20**	**17,230**
Western spruce budworm				
Lillooet	580	70	0	650
Merritt	480	0	0	480
Total	**1,060**	**70**	**0**	**1,130**
Drought Mortality				
Clearwater	230	0	0	230
Kamloops	700	0	0	700
Salmon Arm	3,170	750	110	4,030
Vernon	3,670	535	170	4,375
Penticton	380	180	40	600
Merritt	50	0	0	50
Lillooet	50	0	0	50
Total	**8,250**	**1,465**	**320**	**10,035**



Drought Mortality and Other Forest Health Factors

Drought mortality was mapped on 700 hectares, primarily in the Chase area. Pine needle cast caused defoliation on 550 hectares in the Criss Creek–Deadman Creek area. Other damaging agents included small areas of satin moth (25 ha), and wildfire.

Clearwater Forest District

Mountain Pine Beetle

Although the level of mountain pine beetle attack increased in 1999 (Table 11), there was only a small area of mortality observed in the Clearwater Forest District. Seventy-five hectares of light attack and scattered small groups of attacked trees or single trees were noted. The most significant increase in mortality was seen in western white pine throughout the district. Some of the red attacked lodgepole pine mapped from the air was drought stressed and killed by secondary insects such as the lodgepole pine beetle, *Dendroctonus murrayanae*, *Ips pini* and others.

Douglas-fir Beetle

Douglas-fir beetle attacked numerous patches and scattered single trees, in Wells Gray Park (24 ha). Ground reconnaissance in the fall of 1999 showed highest concentrations of attack around the Helmcken Falls area.

Western Balsam Bark Beetle

Western balsam bark beetle increased from 170 hectares in 1998 to almost 3,000 ha in 1999. Most infestations occurred in the Mad and Raft River drainages, and around Murtle Lake in Wells Gray Provincial Park.

Two-Year Cycle Budworm

No two-year cycle budworm defoliation was observed in the district this year. The life cycle of this budworm is such that there was no larval feeding expected in 1999.

Drought Mortality and Other Forest Health Factors

Other damaging agents observed included drought mortality (209 ha), pine needle cast, wildfire, and windthrow.

Okanagan TSA

Salmon Arm Forest District

Mountain Pine Beetle

Mountain pine beetle infested 1,240 hectares in 1999 (Table 11), an increase from the 1998 level of 459 hectares. Most of the attacks were in the Chase Creek–Charcoal Creek area. 940 ha were categorized as light attack, while 300 ha were rated as moderate attack.

Douglas-fir Beetle

Scattered to heavy infestations of Douglas-fir beetle were ground detected on over 3,000 ha in and around the Silver Creek fire. Other small patches of DFB were noticed in combination with drought throughout the District.

Western Balsam Bark Beetle

Western balsam bark beetle caused significant mortality on over 2,430 hectares in the district. This is a significant increase from the 300 hectares that were affected in 1998. Most expansions occurred in the Fly Hills, upper Scotch Creek, and Hunters Range areas.

Drought Mortality and Other Forest Health Factors

Drought mortality was mapped on 4,030 hectares. Nearly 3,200 ha were classified as light, with 750 ha as moderate and 110 ha as severe. Most mortality was seen in mid-to-low elevation, dry sites near Little Shuswap Lake, Chase Creek, Sicamous, Malakwa, Tappen, Salmon Arm south to Enderby, and along the east side of Adams Lake.

Other forest health factors mapped included pine needle cast, and wildfire.

Vernon Forest District

Mountain Pine Beetle

Mountain pine beetle infested 2,005 hectares in the Vernon District in 1999 (Table 11), an increase from 950 ha in 1998. 1,125 ha were classified as light infestation, 670 ha as moderate and 210 ha as severe attack. Most of the attack was mapped on TFL 49 near Monte Hills (Fig. 4) and the Salmon River. This year, due to inclement weather conditions, the green to red ratio for beetles decreased to 1:1 (Table 3).

Therefore, populations would be expected to remain static for the coming year.

Douglas-fir Beetle

Damage caused by the Douglas-fir beetle covered 135 hectares in 1999, similar to the 125 ha in 1998. 50 ha were categorized as light attack, while 65 ha were moderate and 20 ha were severe. Most of the damage was seen south of Falkland, with spot infestations occurring along Okanagan Lake and near Coldstream.

Western Balsam Bark Beetle

Western balsam bark beetle caused mortality on 2,800 hectares, down from nearly 4,100 in 1998. The majority of the infestations were considered light attack. The Buck Mountain/Harris Creek infestation south of Lumby continued on from previous years. Other infested areas occurred between Okanagan Lake and the Salmon River on TFL 49.

Western Spruce Budworm

Moderate to severe defoliation was predicted in the Fintry and Ellison Park area. A spray program was planned (using *B.t.k.*) for the spring of 1999. Population monitoring in May-June showed high levels of insect mortality from the cool weather and increased larval parasitism, so no spray was warranted. No defoliation was visible in 1999.

Drought Mortality and Other Forest Health Factors

Drought mortality was mapped on 4,375 hectares of low-to-mid elevation stands in the District. Most affected areas were located near Ingram Creek, east of the Armstrong valley, and in several scattered areas from Oyama Lake to Aberdeen Lake. Many of the worst affected areas were pine plantations around Aberdeen Lake, where some very high mortality rates were observed.

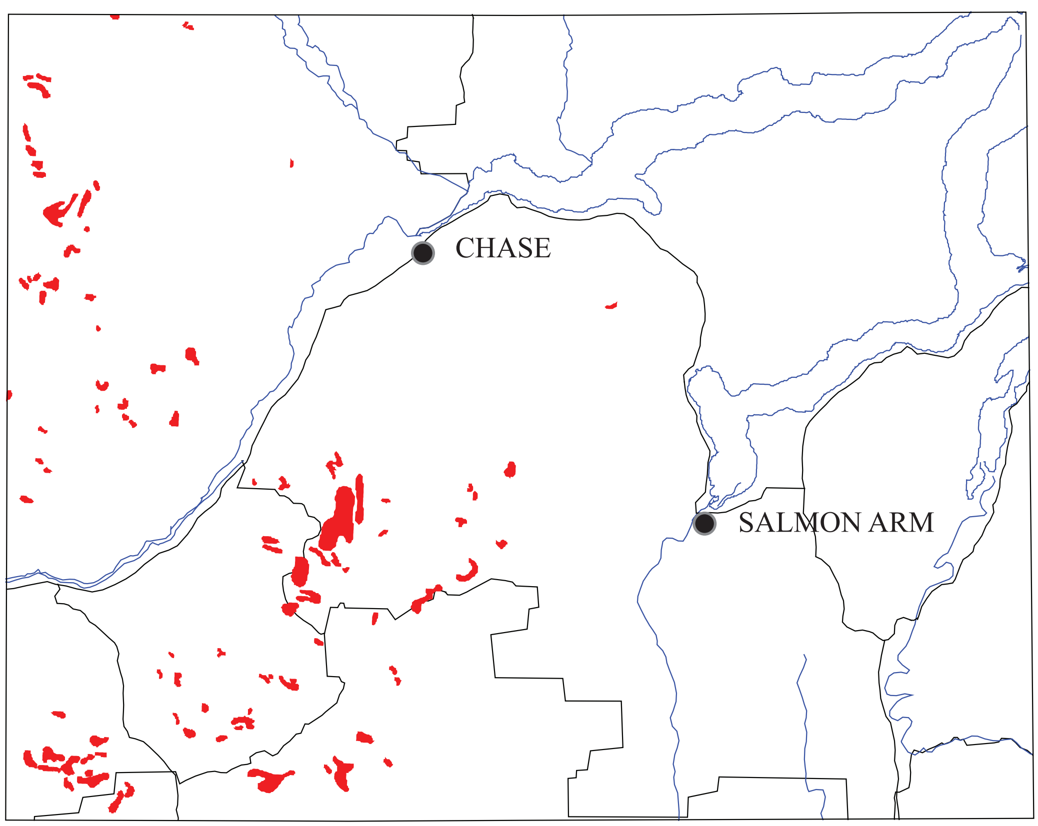


Figure 4. Area under attack by the mountain pine beetle, in the Chase Creek area (Okanagan TSA, mapsheet 82LNW), as mapped by the 1999 aerial overview surveys.

Other forest health factors mapped in the aerial overview survey were small areas of satin moth (17 ha) and wildfire.

Penticton Forest District

Mountain Pine Beetle
Mountain pine beetle mortality was mapped on 1,440 hectares, of which 740 ha were light attack, 670 ha were moderate attack, and 30 ha were rated as severe attack (Table 11). Most of the damage was mapped in the Snehumption Creek area, an infestation now in its fourth year. Significant mortality also occurred in Juniper Creek, Susap Creek, June Creek, Beak Creek, Peachland Creek, Trepanier Creek, and the Ashnola River areas.

Spruce Beetle
Local populations of spruce beetle are still active in the Ashnola and Greyback areas. Other small patches of spruce beetle are scattered throughout the district but seem to be declining.

Western Balsam Bark Beetle
Western balsam bark beetle caused mortality on 970 hectares in the District in 1999, down from the 1998 total of 1,600 hectares. Green Mountain, Penticton Creek, KLO Creek, and Mission Creek all had significant levels of western balsam bark beetle.

Drought Mortality and Other Forest Health Factors
Drought mortality occurred on 600 hectares of low-to-mid elevation stands near Olalla Creek, Okanagan Mountain Park, Ratnip Lake, Mission Creek, Belgo Creek, and near the Kelowna Airport.

A satin moth infestation on aspen in Finlay Creek was responsible for moderate and severe defoliation on on approximately 105 hectares. Other damaging agents noted in the aerial surveys included small patches of Douglas-fir beetle, wildfire, and flooding.

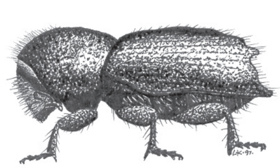
Merritt TSA

Merritt Forest District

Mountain Pine Beetle
Mountain pine beetle mortality was mapped on 12,855 hectares in the District, over half of which was either moderately or severely attacked (Table 11). This shows the beetle remaining fairly static from 1998; however, mapping standards changed in 1999 to include the use of 1:100,000 scale orthographic photos; and, aggressive sanitation harvest was being conducted throughout the Merritt District. The person mapping infestations was better able to separate affected areas into smaller, discrete polygons. Overall, the mountain pine beetle experienced a significant increase because of the favourable conditions of 1998, but due to more precise mapping and aggressive control measures, the area of infestation remained about the same over the 2 year period.

Most of the infested areas occurred south of Princeton, in the Whipsaw Creek, Similkameen River, Pasayten River, Willis Creek and Wolfe Creek areas (Fig. 5). Other large areas of mortality occurred near the Tulameen River, Hayes Creek, Summers Creek, and in and around Kentucky-Alleyne Park. Smaller areas of mortality occurred near Clapperton and Guichon Creeks, and south of Highland Valley Copper Mine. The most significant expansions occurred in Manning Park, Hayes Creek, Willis Creek, Arkat Creek, Kentucky-Alleyne Park, Clapperton Creek, Guichon Creek, and south of Highland Valley.

The green to red ratio decreased significantly from 20:1 in 1998, to 1:1 in 1999 due to the cool, wet conditions that occurred over the spring and early summer last year.



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Western Balsam Bark Beetle

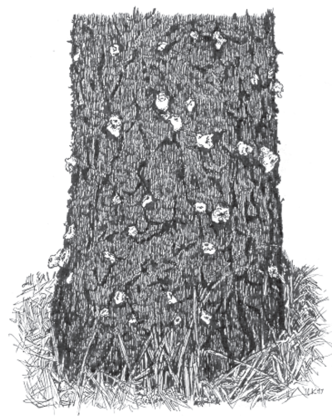
Western balsam bark beetle mortality increased to 3020 hectares in 1999, up significantly from 515 hectares in 1998. Most of the active areas were mapped west of the Coquihalla Highway, from Stoyoma Mountain south to Coldwater Creek.

Western Spruce Budworm

The level of western spruce budworm defoliation that was mapped in 1999, decreased to 480 hectares from over 16,500 ha mapped in 1998. This light defoliation occurred on Promontory Hill and near Peter Hope Creek. No moderate or severe defoliation was noted during the aerial overview surveys. A combination of aggressive management (using *B.t.k.*) over the past 3 years, combined with cool, wet weather and high levels of parasitism, caused a decrease in infestation levels.

Drought Mortality and Other Forest Health Factors

Mortality due to drought occurred on 50 ha in the Merritt district. Small areas of spruce beetle (100 ha), satin moth (41 ha) and flooding were also noted during the aerial overview surveys.



Mountain pine beetle attack

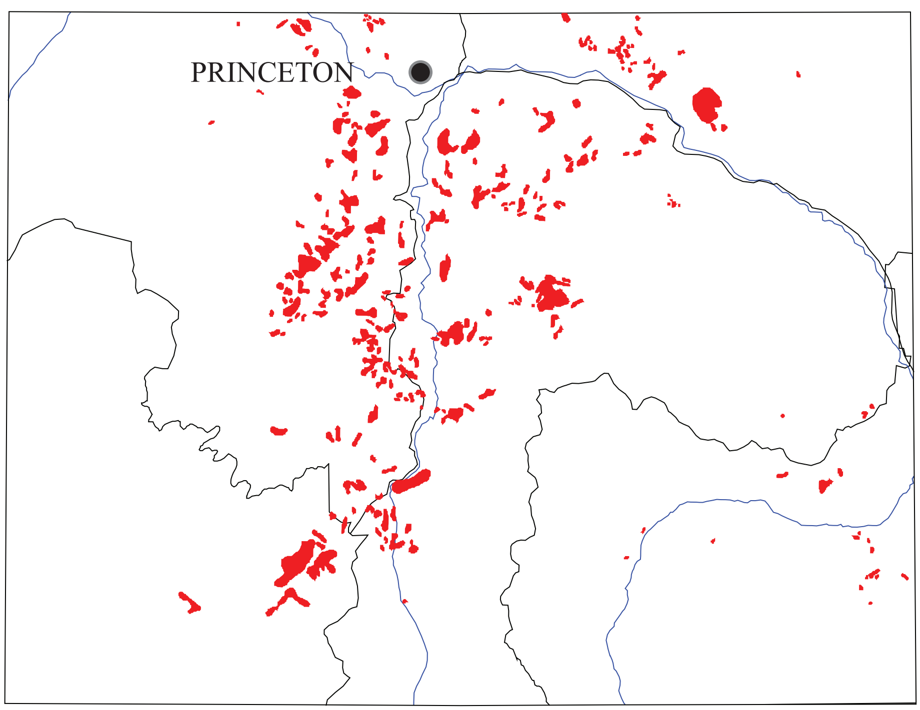


Figure 5. Area under attack by the mountain pine beetle, in the Princeton area (Merritt TSA, Mapsheet 92HSE), as mapped by the 1999 aerial overview surveys.

Lillooet TSA

Lillooet District

Mountain Pine Beetle

Mountain pine beetle caused mortality on 860 hectares in the Lillooet District (Table 11), down from 950 ha in 1998. Almost half the mortality was moderate or severe. Major areas of attack were in Sleetsis Creek, Skoona Creek, Murray Creek, Tyaughton Creek and Lost Valley Creek.
Average green to red attack ratios of 1:1 in 1999 indicate that mountain pine beetle populations are stable in the district (Table 3).

Western Balsam Bark Beetle

Significant mortality caused by the western balsam bark beetle was mapped on 1,230 hectares. Most of the damage occurred in the upper Bridge River, where the insect has been observed for three consecutive years. Other infestations included those found in North Kwoiek Creek, Gun Creek, Hurley River, and Lost Valley Creek.

Western Spruce Budworm

Western spruce budworm caused light and moderate defoliation on 650 hectares in the West Pavilion area, and near Gold Bridge. This represents a significant decline from the 6,800 ha that were lightly defoliated in 1998. Egg mass sampling from 1998 showed that light to moderate defoliation would occur in much of the West Pavilion area in 1999. Monitoring in the summer of 1999 indicated that the population had decreased significantly as in other locations throughout the Region.

Drought Mortality and Other Forest Health Factors

Drought mortality was mapped on 50 hectares of the Lillooet Forest District. Spot infestations of Douglas-fir beetle, small areas of pine needle cast and windthrow were also recorded.

Research Update

Western balsam bark beetle project

The western balsam bark beetle, *Dryocoetes confusus*, has been identified as the most serious cause of mortality of subalpine fir in British Columbia. However, the incidence and impact of this beetle is not well quantified at the stand or landscape level. *D. confusus* plays a major role in the natural succession processes of subalpine forests. The bark beetle typically kills 0.5-1.5% of mature stems in a stand annually, and over a period of about 60 to 80 years causes the stand to “turn-over”. Periodically during this time, higher levels of attack can be seen, but seldom has more than 6% annual mortality been documented. Once a stand is over 100 years old, it is susceptible to attack by *Dryocoetes*. In a mature stand, it is not necessarily the oldest trees that are attacked, but the largest trees, or those that are predisposed to attack because of other damaging agents. Most attack occurs on trees 22-44 cm in diameter. As stems are slowly eliminated from a stand, gaps are created, allowing understorey trees to release and fill in the canopy. This induces a very slow turnover, but one that is fairly continuous over a long time period.

Age class 6 stands (101-120 yrs) are usually the first to show evidence of *Dryocoetes* attack. Once a stand is over 120 years, it becomes very susceptible to attack. In a study recently undertaken at the Sicamous Research area, it was determined that many of the dead balsam on site were 250 to 300+ years old. Stand reconstruction indicated that these trees remained suppressed in the understorey layer for 100 years or more. Then, as overstorey trees died or were blown over, the suppressed trees were released and became part of the overstorey complex. Therefor, care must be taken when discussing the relative “age” of trees.
Attack by *D. confusus* is very clumped. The clumps occur in a regular or random distri-

bution throughout a stand. From research conducted at the Sicamous Creek Research Area, it was determined that *Dryocoetes* preferentially attacks the stem between 2-11 m in height, where the diameter averages 21-32 cm. The primary area where resin is found streaming is above the optimal area of attack at 11-13 m in height and 19-21 cm diameter. Streaming resin, and frass and sawdust caught in the lichen are often the only signs of green attack on a tree.

Like many other aggressive scolytid species, *Dryocoetes* is symbiotically associated with a lethally pathogenic "blue stain" fungus, *Ceratocystis dryocoetidis*, which it introduces into living trees during the initial phase of attack. *Dryocoetes* carries the fungus on thoracic mycangia (special repositories for transporting and maintaining fungi). The fungus may also be carried as a contaminant of the beetle exoskeleton, as well as on phoretic mites (common on emerging *D. confusus*).

Males initiate attack in early June by excavating a nuptial chamber beneath the bark. Each male attracts numerous (3-8) females by releasing attractive pheromones (*endo-brevicomin* & *exo-brevicomin*). The adults mate within the nuptial chamber and the females initiate gallery construction and egg laying. Each female constructs her own egg gallery, which results in the diagnostic star-shaped gallery system of *Dryocoetes* (Fig. 6). Eggs are laid in niches along the galleries. First instar larvae hatch and mine through the phloem. They develop to 3rd instar larvae and overwinter. By the 2nd winter, the larvae have developed to teneral adults. During the 3rd summer, the new adults emerge and attack new hosts. Occasionally, there will be a second flight in August composed of new and old adults. However, little additional tree mortality is observed due to this flight. Rather, insects appear to join those in already constructed gallery systems.

During the 2nd season, female beetles continue gallery construction and egg laying in the same tree or they may move to another acceptable host. In the 3rd season, the females may leave that tree and initiate new attack. For example, a tree initially attacked in 1999, will exhibit signs of fresh sawdust and frass again in 2000. By late summer of 2000, the tree will contain larvae and teneral adults from the 1999 attack, as well as 2ndand 3rd instar larvae from the continued egg deposition by females during the second summer. In 2001, new adults will emerge from the 1999 attack; in 2002, insects from the 2000 attack.

Research Objectives

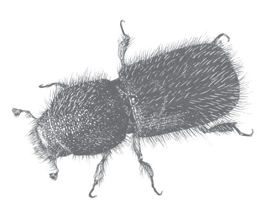
1. Describe the attack patterns both spatially and temporally on individual trees and further elucidate aspects of *Dryocoetes confusus* biology.

2. Quantify temporal and spatial patterns of old and recent mortality (i.e. red, grey trees) from various scales of aerial photography. Spatial patterns will be used to generate a hypothesis about the underlying mechanisms of attack in different harvest regimes and in unmanaged forests.

3. Test and demonstrate the feasibility of various stand management regimes in terms of minimizing impacts from *D. confusus*.

4. Estimate basal area or volume losses for *A. lasiocarpa* due to *D. confusus* in susceptible ecosystems within the Kamloops Forest Region.

5. Develop a hazard and risk model for *D. confusus*.



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List of projects in-progress and completed:

1. Continue the graduate research study on the susceptibility and suitability of sub-alpine fir to *D. confusus* attack. (In-progress; UNBC).

2. Install permanent, large-scale (1 ha) sample plots to study the attack dynamics and impact of *D. confusus* (6 completed).

3. Conduct stratified, systematic aerial surveys of susceptible forests to determine the incidence of *D. confusus*-caused mortality. Conduct ground surveys (Surveys for Pest Incidence) on a sub-sample of stands assessed by air, to compare relative accuracy and to verify mortality causing agent (completed).

4. Install paired plots in order to obtain data on individual trees, both attacked and unattacked, within stands. The paired plot system gives information on the relative size and spatial orientation of attacked as well as neighbouring trees. Plots are established in pairs within select polygons surveyed by air and consist of one attack plot and one comparison plot. The attack-centre plot collects data on recently attacked trees and the comparison plot acts as an unbiased control (completed).

5. Various parameters of attack by *Dryocoetes confusus* were analysed using large-scale aerial photography (70 mm). The distribution and spatial attack characteristics of *D. confusus* will be analysed by examining different stages of an infestation,

Figure 6. Photograph of bark peeled away from a sub alpine fir that was attacked by *D. confusus.* Each female constructs an egg gallery out from the central nuptial chamber constructed by the male beetle. This results in the diagnostic star-shaped gallery system seen above.

edges and interiors of forests, and different silviculture systems (cutting regimes) (in-progress).

6. Evaluate stands baited for *D. confusus* one and two years following baiting to determine: is most attack localized around the previous year's attack? Are trees that are unsuccessfully or lightly attacked in one year, subsequently mass attacked the following year? How does baiting in a stand influence attack dynamics of *D. confusus* within and around that stand? (completed)

   Conduct a trial examining different baiting configurations for D. confusus (completed as part of a graduate thesis; SFU).

7. Develop a degree-day model for *D. confusus* through field and laboratory trials. Controlled temperature rearing will be conducted (completed), coupled with field observations. A microclimate station will be set-up in the field to record weather variables. Periodic field sampling will correlate flight times, attack and insect development to the weather variables. This will be integrated into the overall hazard & risk model being developed (in-progress).

8. Produce a hazard and risk model for *D. confusus* and sub-alpine fir forests (in-progress).

Drought Survey and Assessment

Drought caused mortality, resulting from extremely dry weather conditions in the summer of 1998, caused widespread mortality throughout the region (>10,035 ha mapped from the air). In early spring 1999, trees and stands began fading as a result of the drought stress. In July 1999, a project was initiated to assess and quantify the effects of the 1998 drought. The project entailed quantifying the drought impact at different scales. Using the 1999 aerial overview surveys maps as a base, detailed rotary wing flights were conducted to map and photograph the areas affected (Fig. 7). Polygons were then identified for ground assessment to determine: 1) the affected area within the stand; 2) the incidence and impact of secondary or other pests; and, 3) the impact of the drought throughout the sample area. Ground surveys were conducted July – October 1999 in the following Districts (number of stands assessed shown in brackets): Vernon (19); Salmon Arm (21); Clearwater (5); Kamloops (5); and, Merritt (1). Seventeen young stands and 29 mature stands, totalling over 1,000 ha, were assessed for drought effects (Tables 12, 13). Mortality in mature stands, from various damaging agents (Table 14), ranged from 5% to 73%, averaging 21.2% overall (Table 12). Young stands in the ICH were most severely impacted with about 50% stand area affected and on average 26% stems dead (Table 13). Lodgepole pine and Douglas-fir were the most commonly affected species.

Development of a Hazard & Risk model for western spruce budworm

A project to develop a hazard and risk model for the western spruce budworm is nearing completion. Data being incorporated into the model comes from various sources and past research projects. JCH Forest Pest Management has compiled all the historic budworm defoliation from 1909-1999 (Fig. 8) into ArcView format and is conducting an analysis linking forest cover, stand age, management history and ecosystem. Astudy investigating stand structure and budworm damage (EntoPath Management) is also being incorporated into the model. This project should be completed by summer 2000 at which time maps and a report will be made available from the Kamloops Regional office.

Table 12. Total number of mature stands visited in 1999 drought assessment, by Districts and ecosystem, showing total area surveyed and average mortality.

District	No. sites	Total area surveyed (ha)	Average % mortality	Ecosystem
Salmon Arm	2	22.8	13.3	IDFmw1
Salmon Arm	2	50.8	46.5	ICH mw2
Salmon Arm	4	91.3	25.0	ICH mw3
Salmon Arm	2	45.5	35.0	IDF mw1
Salmon Arm	9	210.5	31.3	IDF mw2
Salmon Arm	1	23.6	5.0	MS dm2
Salmon Arm	1	120.0	30.0	MS dm2, IDF mw2
Salmon Arm	1	9.0	10.0	ESSF dc2, MS dm2
Salmon Arm	1	9.0	15.0	ESSF wc2
Salmon Arm	1	4.8	15.0	ICH m1
Vernon	1	12.5	5.0	ICH mk1
Vernon	1	51.0	35.0	IDF mw1
Vernon	3	12.3	10.0	MS dm1
Total	29	640.2	21.2	

Figure 7. Aerial photograph of drought caused mortality in the Aberdeen Plateau area, Vernon District.

Table 13. Total number of young stands visited in 1999 drought assessment, by District and ecosystem. Table shows total area surveyed, affected, and average mortality encountered.

		Area (ha)		Average	
District	No. sites	Total	Affected	% mortality	Ecosystem
Salmon Arm	2	72.5	41.5	25.0	ICH mw2
Kamloops	1	37.0	37.0	40.0	ICH mw3
Vernon	3	50.7	18.7	13.3	ICH mk1
Vernon	2	62.6	15.3	22.5	IDF mw1
Vernon	1	18.5	12.2	20.0	IDF xh1, MS dm1
Vernon	8	166.2	71.1	36.9	MS dm1
Summary	17	407.5	195.7	26.3	

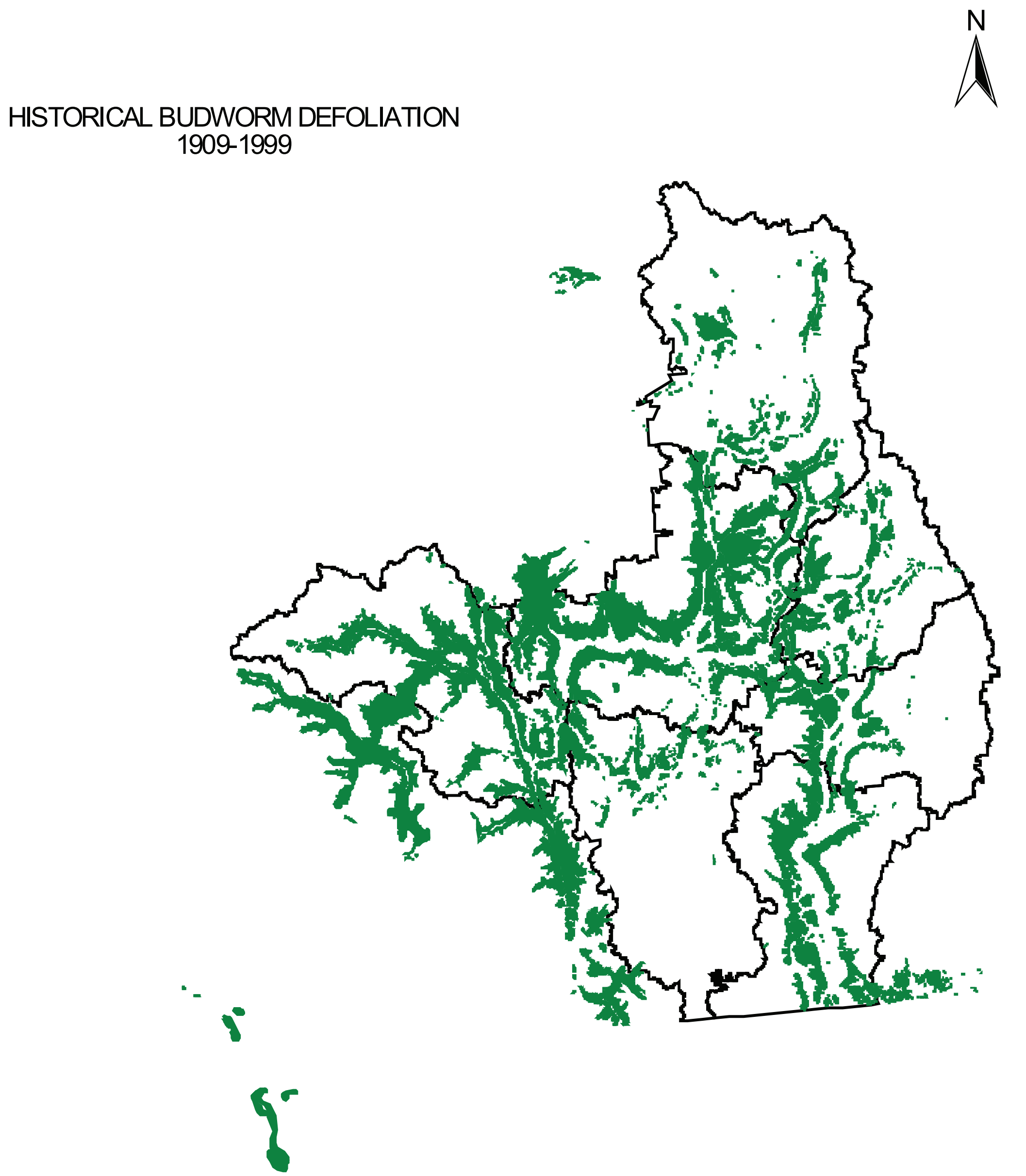

Figure 8. Area of historic western spruce budworm defoliation in south central British Columbia (1909-1999).

Table 14. List of insects, diseases and other damaging agents identified in drought affected trees.

Common Name	Latin Name
Bark Beetles	
Red turpentine beetle	*Dendroctonus valens*
Twig beetle	*Pityophthorus spp.*
Twig beetle	*Pityogenes spp.*
Hylastes species	*Hylastes sp.*
Hylurgops species	*Hylurgops sp.*
Ambrosia beetles	*Gnathotrichus and Trypodendron*
Engraver beetles	*Scolytus sp.*
Pine engraver beetle	*Ips pini*
Twig Beetle	*Magdalis gentilis*
Silver Fir Beetle	*Pseudohylesinus spp*
	Pityokteines minutus
Shoot Borers	
Northern Pitch Moth	*Petrova albicapitana*
Root and Terminal Weevils	
Root collar weevil	*Hylobius warreni*
Yosemite bark weevil	*Pissodes schwarzi*
Lodgepole terminal weevil	*Pissodes terminalis*
Root Disease	
Armillaria root disease	*Armillaria ostoyae*
Black stain root disease	*Leptographium wagneri*
Stem Disease	
White pine blister rust	*Cronartium ribicola*
Western gall rust	*Endocronartium harknessii*
Comandra blister rust	*Cronartium comandrae*
Stalactiform blister rust	*Cronartium coleosporioides*
Foliage Disease	
Lophodermella needle cast	*Lophodermella concolor*
Larch Blight	*Hypodermella laricis*
Larch Needle Cast	*Meria laricis*
Animal Damage	
Bear	
Deer	
Squirrel	
Hare	
cattle	

Status of Whitebark Pine

Hadrian Merler and Stefan Zeglen, the Regional Pathologists in Kamloops and Vancouver Forest Regions, respectively, have been looking at white pine blister rust on whitebark pine. Stefan and Hadrian have been conducting surveys in Merritt and Penticton Districts to assess the incidence and impact of blister rust on white bark pine. The objectives of the project are to measure current levels of blister rust infection, mortality, and identify potential parent trees for use in a breeding program. Survey results are summarized in Table 15.

Table 15. Levels of white pine blister rust infection and mortality in whitebark pine in the Merritt and Penticton Districts.

	no. trees	Percent trees	Status	
District	assessed	infected	Live/dead	Blister rust
Merritt	600 trees	44%	live	uninfected
		30%	live	infected
		15%	dead	infected
		10%	dead	other
Penticton	100 trees	56%	live	uninfected
		34%	live	infected
		5%	dead	infected
		5%	dead	other

For more information, and copies of 1999 aerial overview maps, please contact:

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Pat Byrne - Merritt

Ed Senger, R.P. Bio. - Lillooet