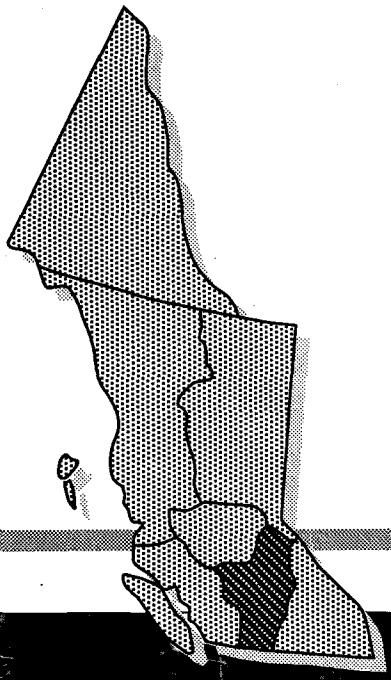
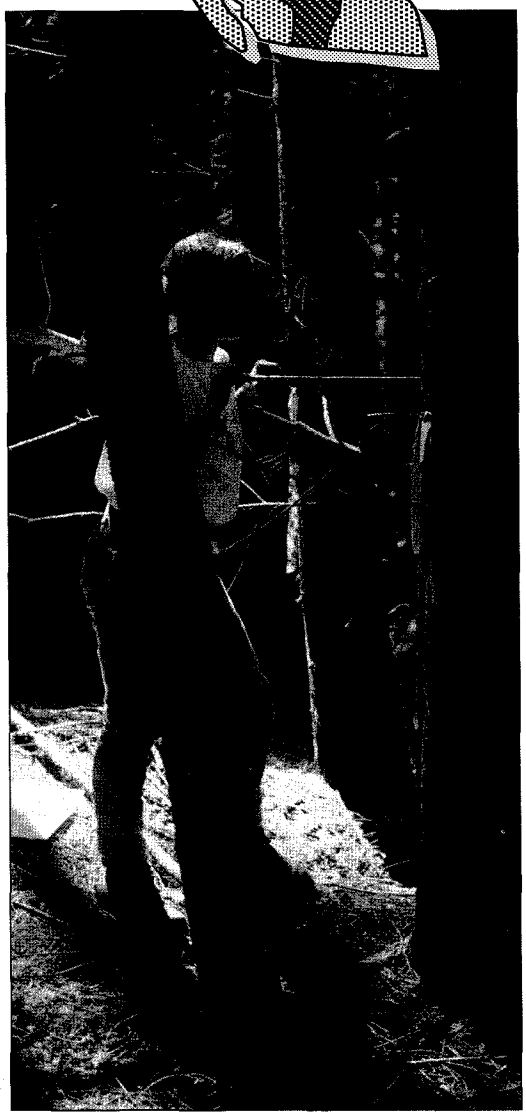
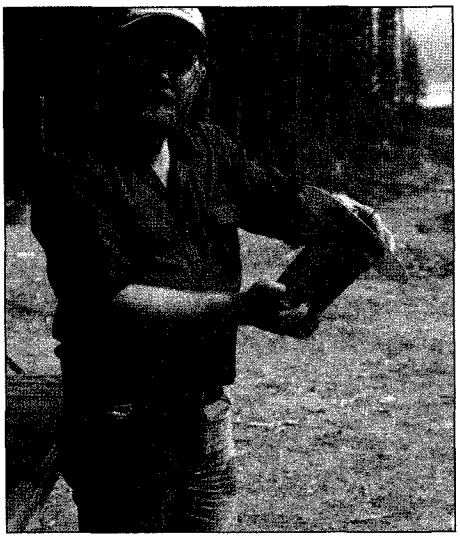


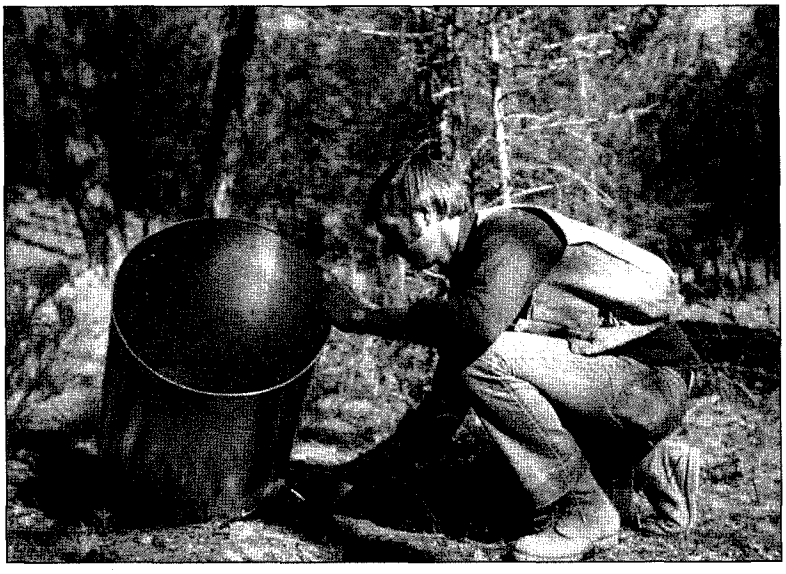
Forest Insect and Disease Conditions

Kamloops Forest Region • 1993

Peter Koot and Janice Hodge







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Contents

Foreword

This annual report describes and summarizes the status of forest pests and the effects of environmental factors on forests in the Kamloops Forest Region in 1993, and attempts to forecast population trends and highlight pests that are capable of sudden damaging outbreaks with forest management implications. Pests are mentioned by host, in order of importance, and occasionally within the context of a management unit or Timber Supply Area (TSA).

The Forest Insect and Disease Survey (FIDS) group is the national network within the Canadian Forest Service responsible for:

(1) producing an overview of forest pest conditions and their implications;

(2) maintaining records and surveys to support quarantines and facilitate predictions;

(3) supporting forestry research, and herbaria, insect collections and records;

(4) providing advice on forest insect and disease conditions; and,

(5) developing and testing survey techniques and conducting related biological studies.

Introduction

This report was compiled mostly from information derived from field observations and records collected during the field season (Figure 1), which extended from late May to early October. A total of 220 insect and disease collections were submitted for identification and verification to the Pacific Forestry Centre (PFC). Some of these specimens were added to the extensive permanent collections in the PFC Insectary and Herbarium. Provincial government agencies, industry, and private sources submitted additional insect and disease collections. Approximately 450 contacts and on-site pest examinations were made personally and with personnel from the British Columbia Forest Service (BCFS), other government agencies, the forest industry, educational institutions and private individuals. Their cooperation is essential to effectively fulfill these responsibilities and is greatly appreciated. Special thanks are extended to the BCFS for their participation in a cooperative survey and for the provision of 91 hours of fixed-wing and 2 hours of helicopter aerial survey time and assistance in producing preliminary regional sketch maps. The area covered by the aerial survey is shown on Figure 1.

Definitions:

Throughout this report, defoliation intensity is defined as follows:

light - discolored foliage barely visible from the air, some upper crown and branch tip defoliation;

moderate - pronounced discoloration and noticeably thin foliage; top third of many trees severely defoliated, some completed stripped;

severe - top, plus many branches completely defoliated, most trees more than 50% defoliated.

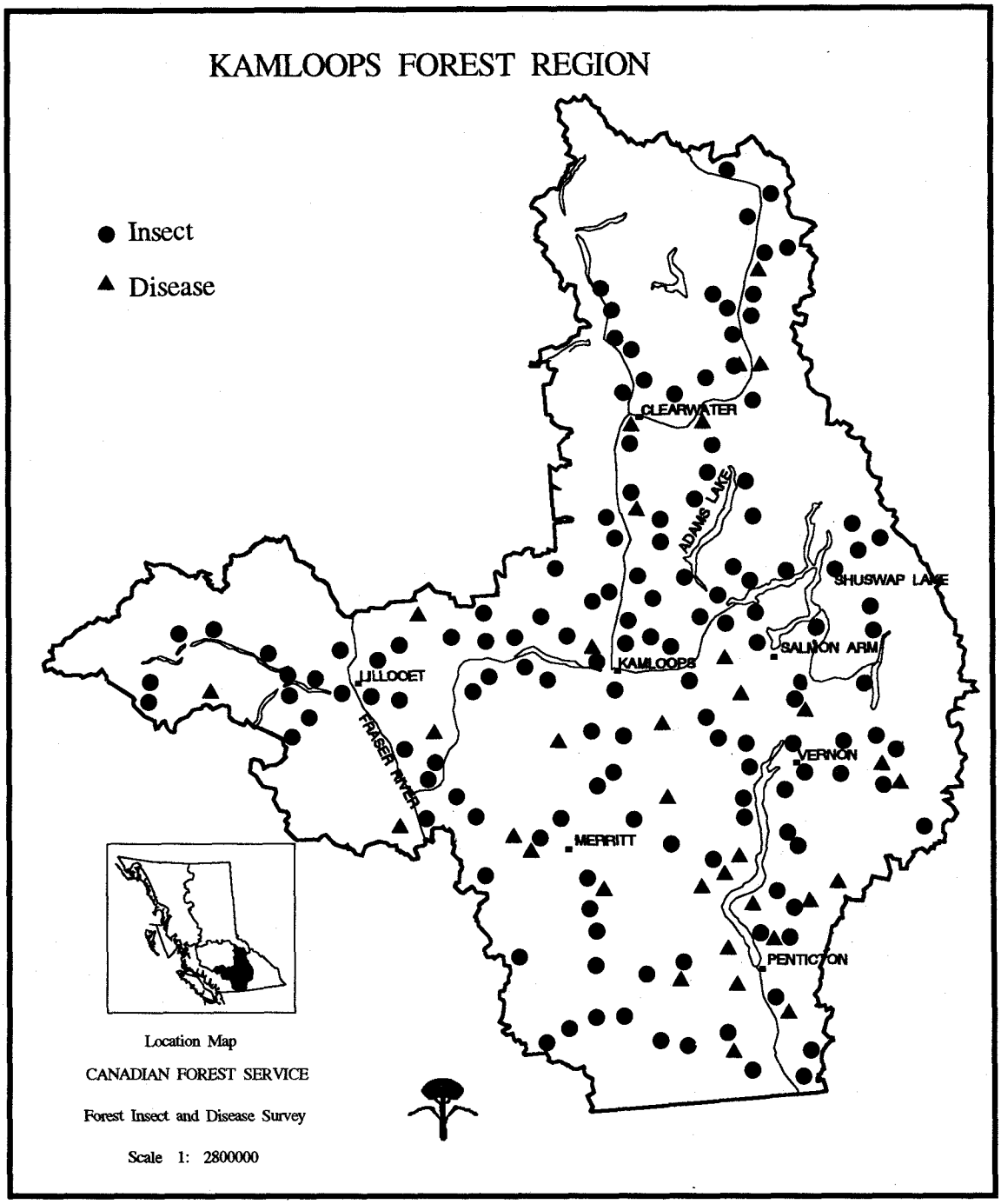

Figure 1. Location where one or more forest insect and disease samples were collected in 1993.

Summary

Mountain pine beetle continued as the most destructive forest insect in the Kamloops Forest Region, killing 3.5 million lodgepole pine and western white pine on 20 000 ha, similar to 1992. The bulk of the infestation (83%) occurred in the Okanagan TSA. Recent mortality of ponderosa pine, attributed to **western pine beetle**, increased to nearly 300 ha, from 67 ha in 1992, the majority of which was in the Okanagan Valley. Infestation by a number of pests, has caused **Ponderosa pine decline** resulting in reduced growth, vigor and occasional tree mortality in the South Okanagan Valley. The **pine needle diseases**, including **pine needle cast**, and **Elytroderma needle disease**, were again prominent over widespread areas throughout their respective host ranges.

Based on aerial surveys, the area of **western spruce budworm** defoliation declined nearly 90% to 39 000 ha. The majority of feeding damage was in the Okanagan, Merritt and Lillooet TSA's. Trace levels of defoliation were present throughout many stands previously infested. Further reductions are expected in 1994. **Douglas-fir beetle** infestations totalled 1175 ha in 970 pockets, more than three times the area attacked in 1992. The main outbreak was in the Kamloops District, where pockets generally contained from 5 to 30 trees each. **Douglas-fir tussock moth** infestations collapsed in most previously defoliated Douglas-fir stands west of Kamloops and near Hedley, but expanded east of Kamloops to Chase and north to Vinsulla. A further overall decline is expected in 1994. **Western false hemlock looper** together with Douglas-fir tussock moth caused some light defoliation of Douglas-fir on 40 ha at Mara Hill near Kamloops.

Spruce beetle killed mature spruce over 2040 ha, mostly in the Lillooet and Merritt TSA's, an increase from 1655 ha in 1992. Notable expansions occurred south of Merritt from Brook Lake to the Tulameen Valley. **Two-year cycle spruce budworm** caused light to moderate defoliation of 10 150 ha of alpine fir-spruce in 23 areas in the Keefer Lake-Sugar Lake area in Vernon Forest District. Increased defoliation is expected in 1994, particularly north of Clearwater.

Infestations of **western balsam bark beetle** as determined by aerial surveys, increased to 5200 ha from 1720 ha previously. Small pockets of attack were common throughout the host range in the Region.

Western hemlock looper defoliated mostly old growth hemlock and cedar over only 1150 ha, down from 88 000 ha in 1992. Infestations collapsed in the North Thompson Valley, Wells Grey Park and upper Adams River Valley, but continued in parts of Salmon Arm District. Some increases leading to defoliation are expected northeast of Vernon in 1994.

Premature needle discoloration of western larch stands by **larch needle blight** declined to 420 ha from 1540 ha in 1992, mostly in areas north and east of Lumby. **Larch casebearer** populations continued to decline, with only light defoliation near Vernon.

For the fifth consecutive year there were no reports or observations of **black army cutworm** larvae or damage anywhere in the region. Adult trapping indicates a potential for some light defoliation of ground cover at one location near Clearwater in 1994.

Pests of Young Stands surveys were completed for forty-one Forest Resource Development Agreement-2 (FRDA-2) treatments, totalling 448 plots and 5128 trees. These were surveyed for pest occurrence and damage. Less than 5% of trees were killed or sustained

life threatening injuries by pests such as white pine blister rust, root diseases, western gall rust, Warren's root collar weevil, mammals or other problems such as mechanical damage, or injuries due to abiotic agents. **Pinewood nematode** bait-log trials continued in the region to determine nematode survival under field conditions and their distribution within logs of various tree species. Results are pending. Two biomonitoring plots established in 1992 and a third **acid rain monitoring** plot established in 1986 were examined. Preliminary observations show no damage associated with acid rain.

Trembling aspen and black cottonwood were lightly to moderately defoliated by **satin moth** on 240 ha, a reduction from 960 ha previously. No male **gypsy moths** were caught in any of the 42 pheromone-baited traps distributed in provincial parks in the Kamloops Forest Region.

Other noteworthy pests mentioned near the end of this report are those that have the potential for causing significant damage, but are presently at low levels or causing damage in small localized areas.

Pine Pests

Mountain pine beetle
Dendroctonus ponderosae

Mountain pine beetle continued to be the most destructive forest insect in the Kamloops Forest Region, having a major impact on harvesting schedules of lodgepole pine and on watershed, recreational, and other resource values. In 1993, beetle infestations declined slightly in area to 19 920 ha, from 21 000 ha in 1992, killing an estimated 3.5 million lodgepole pine and white pine (Figure 2, Table 1), similar to 1992. Pine volume losses totalled 1 781 870 m^3 in 1993. As shown by Figure 3, the amount of area infested on a regional basis has remained relatively static over the past three years. However, it is expected that continued management action, lower green attack levels, and poorer brood development in 1993, particularly in the Okanagan Valley, will likely result in a reduction in infested areas in 1994.

The bulk of the outbreak continued to be in the Okanagan TSA, which accounts for 83% of the infestation area, followed by Merritt, Kamloops, and Lillooet TSAs respectively (Table 2).

Table 1. Recent pine mortality (red attack) caused by mountain pine beetle as determined from aerial and ground surveys, Kamloops Forest Region, 1993.

TSA	Host[1]	Number of infestations	Area (ha)	Number of trees killed	Volume of trees killed (m^3)
Kamloops	lP,wP	287	555	22 240	23 170
Lillooet	lP	2	2	160	200
Okanagan	lP,pP	1 954	16 549	3 001 000	1 515 000
Merritt	lP	2 205	2 814	487 100	243 500
Totals		4 448	19 920	3 510 500	1 781 870

[1] lP - lodgepole pine; wP - white pine ; pP - ponderosa pine

Kamloops TSA

Beetles killed an estimated 22 240 western white pine and lodgepole pine over 550 ha in 1993, approximately one-third of the total area infested in 1992. This reduction reflected primarily the decline of several of the larger infestations in stands containing white pine at Murtle Lake, along Mad River, Hole-in-the-Wall Pass and to a lesser extent in the upper Adams Lake area. Most of this decline was the result of host depletion, and control initiatives. There were also fewer spot infestations containing 5 to 20 trees each along the North Thompson Valley and adjacent drainages between Vavenby and Albreda. Similarly, fewer scattered infestation pockets were noted in parts of the Barriere lakes area. Localized outbreaks elsewhere, mostly in lodgepole pine stands, north of Paxton Valley, and in the Tranquille Valley-Red Lake area did not change substantially from 1992. However, some expansion was evident in TFL 16 near Georges Creek, where infestations have been on-going for a number of years. Scattered infestations have also expanded to the west from Momich Lake, where there is concern for additional spread in susceptible white pine stands.

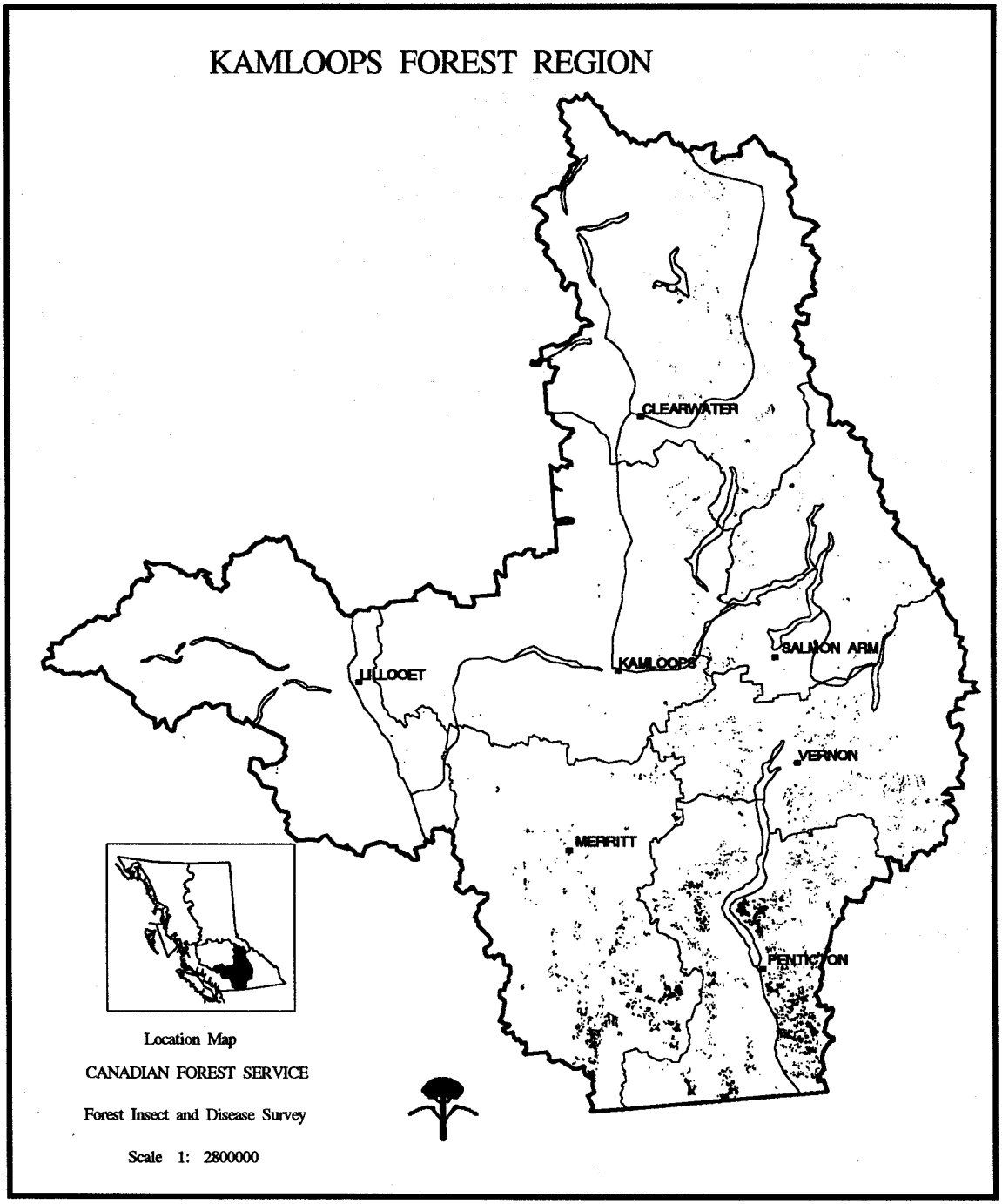

Figure 2. Areas of pine recently killed by mountain pine beetle as determined by aerial and ground surveys, 1993.

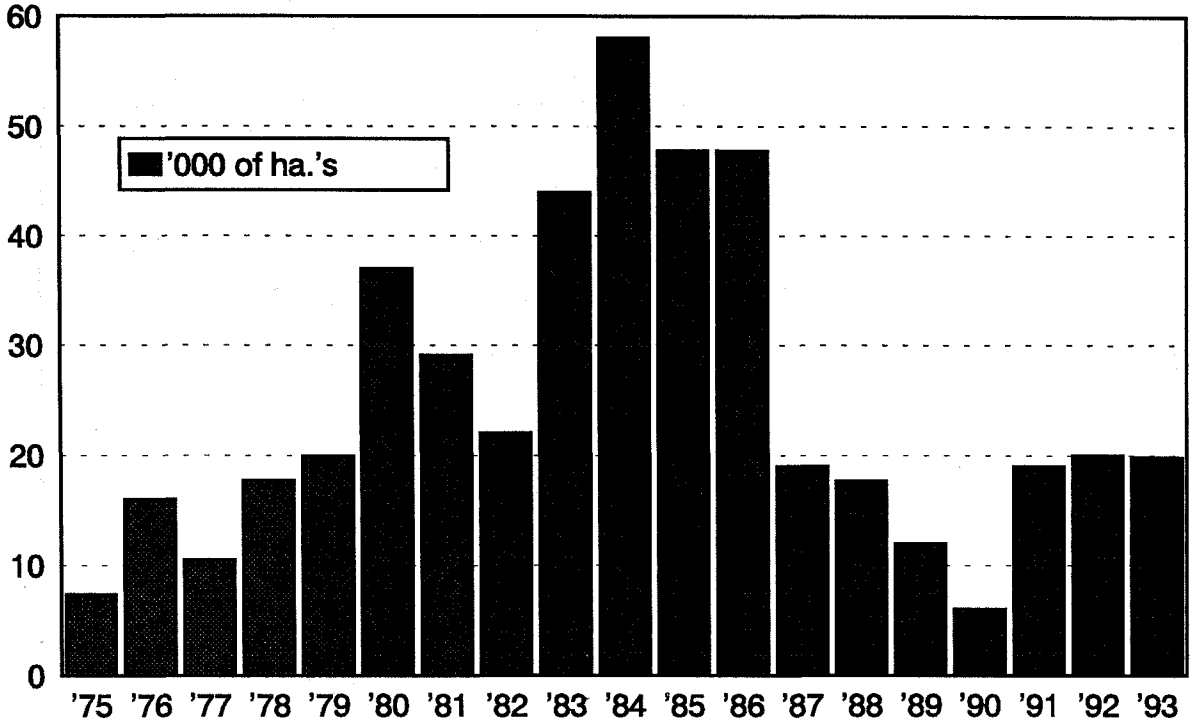

Figure 3. Area (ha) of mountain pine beetle infestation, 1975-1993, Kamloops Region.

Table 2. Major mountain pine beetle infestations, Kamloops Forest Region, 1993.

TSA and Location	Red 1993[1] (ha)	Red 1992 (ha)	Change1992-93(ha)
Kamloops TSA			
Barriere Lakes-Fennel Creek	70	134	- 64
Vavenby-Albreda	120	1 087	- 967
Mahood Lake	0	1	- 1
Adams Lake-Adams River	331	456	- 125
Kamloops-Barriere	3	13	- 10
Paxton Valley-Chase	31	27	+ 4
Subtotal	555	1 718	- 1 162
Okanagan TSA			
Humamilt Lake-Seymour Arm	125	75	+ 50
Three Valley-Mabel Lake	35	-	+ 35
Yard Creek	12	7	+ 5
Shorts Creek-Falkland	340	194	+ 146
Coldstream	113	96	+ 17
Lumby-Ferry Cr-Sugar Lake	328	508	- 180
Upper Kettle River	78	333	- 255
Mission-Belgo-Daves Creek	156	334	- 178

Table 2. (Cont'd)

TSA and Location	Red 1993[1] (ha)	Red 1992 (ha)	Change1992-93(ha)
Okanagan TSA			
Ideal Lake-Vernon	168	31	+ 137
Dale Creek-Campbell Creek	230	1 231	- 1 001
Penticton Creek-Chute Lake	1 510	740	+ 770
Hydraulic Lake-Lebanon Lake	710	1 582	- 872
Lambly Lake-Brenda Lake Mine	250	512	- 262
Okanagan Mountain Park	1 788	2 280	- 492
Trout Creek-Summerland	1 700	1 165	+ 535
Vaseux Creek-Saunier Creek	5 589	6 619	- 1 030
Inkaneep Creek	1 019	1 263	- 244
Shoudy Creek-Ollala	1 138	806	+ 332
Yellow Lake-Fairleigh Lake	694	400	+ 294
Cathedral Park-Ewart Creek	566	324	+ 242
Subtotal	16 549	18 500	- 1 951
Merritt TSA (breakdown for 1992 not available)			
Merritt	30		
Douglas Lake-Sawmill Lake	148		
Spences Bridge	30		
Jellicoe-Princeton	189		
Princeton-Merritt	128		
Hedley-Princeton	1 549		
Coalmont-Manning Park	740		
Subtotal	2 814	880	+ 1 934
Lillooet TSA			
Duffey Lake - Cayoosh Creek	2	2	
Subtotal	2	2	
TOTAL	**19 920**	**21 100**	**- 1 180**

[1] Trees attacked in 1992, discolored in 1993

Okanagan TSA

The area of mountain pine beetle-infested stands decreased 11% to 16 550 ha, with losses totalling 1 515 000 m^3 in 4 448 separate infestations. Aggressive management strategies, in some cases combined with lack of suitable material, were responsible for the decrease. The majority of the decrease occurred on the east side of the Okanagan Valley, from Osoyoos north to Vernon, where beetles have been active for many years.

In the south Okanagan Valley, host depletions due to prolonged beetle activity resulted in a 26% reduction in infested area in the Dale, Stirling, Vaseux, Saunier, and Inkaneep creek drainages on the east side of Okanagan Lake. In areas of limited access, such as Shoudy Creek-Catherdral Park, red tree counts increased from levels recorded last year. On the west side of Okanagan Lake beetles have dispersed from spot infestations into susceptible stands, causing increases along the Trout Creek drainage as far as Summerland. Where current attacks outnumbered reds as determined by 1992 fall surveys, infestations escalated. This was true in the Naramata Creek area and between Chute Lake and Penticton Creek.

In the central Okanagan, minor increases in the number of spot infestations occurred between Ideal Lake and Vernon, and on the west side of the Okanagan Lake between Shorts Creek and Falkland, while decreases occurred between Mission and Daves Creek, northwest of Kelowna.

Slight increases occurred in the northern part of the TSA in previously infested areas near Humamilt Lake and Yard Creek. New spot infestations of 3-5 trees were also recorded between Cherryville and Three Valley Gap. Aggressive management tactics, including felling and burning, have helped reduce beetle populations in the Upper Kettle River-Sugar Lake-Lumby area following a significant increase in the Sugar Lake-Lumby area in 1992.

Merritt TSA

The area of infestation increased to 2814 ha from 880 ha recorded in 1992 with an estimated mortality of 487 100 trees totalling 243 500 m^3 in volume losses. Large homogeneous stands of susceptible lodgepole pine have led to expansion of existing beetle populations in many areas throughout the TSA. The majority of the infestation, (55%) occurred between Princeton and Hedley. Small spot infestations were most common, but numerous large areas of up to 200 ha of red trees were recorded in the McNulty-Hedley Creek drainages. This has occurred despite aggressive management tactics, involving an extensive semio-chemical program including areas south of Princeton as far as Manning Park. Small spot infestations of 5-10 trees each were also recorded near Merritt and Spences Bridge, and between Douglas Lake and Sawmill Lake.

Lillooet TSA

Beetle activity in the Lillooet TSA was limited to a few spot infestations in white pine and lodgepole pine near Duffey Lake and along Cayoosh Creek, similar to 1992. Due to the steep terrain in these areas, control options are limited. Several other localized outbreaks included a few small patches along North Laluwissin Creek and one expanding infestation of approximately 50 lodgepole pine near Pasulko Lake.

Forecast

Two types of surveys are conducted annually to determine beetle population trends in areas of infestations. Overwintering brood assessments to determine "R" values are conducted

in the spring to estimate infestation trend, brood mortality and health and vigor of progeny (Table 3). This information is supplemented with fall cruises to determine levels of current attack and also help estimate volume losses and infestation trends. A cursory survey based on overwintering brood assessments and fall surveys at 10 locations in the Okanagan TSA, indicated some decline in populations for 1994. While this prediction can be used as a general guide, deviations can be expected due to variations in slope, aspect, stand composition, management strategies etc., throughout the Region. Local climate also strongly influences beetle populations. Cool, wet summers for instance (such as occurred in 1993) retard brood development and reduces survival and subsequent green (current) attacks.

Table 3. Mountain pine beetle reproductive ratios and overwintering survival, Kamloops Forest Region, spring 1993.

TSA	Location	"R" value[1]	Pop. status[2]	Overwinter survival
Okanagan	Allendale Lake	2.7	static	72%
	Ellis Creek	4.2	increasing	76%
	Naramata Creek	2.7	static	76%
	Mission Creek	6.3	increasing	78%
	West Kettle	4.9	increasing	96%
	Goudie	1.7	decreasing	77%
	Peachland Lake	3.7	static	73%
	Rill Creek	2.8	static	54%
	Mount Randolph	0.3	decreasing	30%
	Heckman Creek	0.8	decreasing	83%

[1] "R" $\frac{\text{sum of (a+b/c)}}{\text{no. of trees examined}}$

a = number of eggs and larvae
b = number of pupae and adults
c = number of galleries originating within sample area

[2] Interpretation of "R" values to determine the population status:

- ≤ 2.5 -decreasing population
- 2.6-4.0 -static population
- ≥ 4.1 -increasing population

In spring 1993, the average "R" value increased to 3.0 from 1.1 in 1992 and overwinter survival rates were normal, averaging 72%. However, a cooler wetter summer helped reduce beetle populations. These adverse weather conditions led to delayed beetle flights, in some cases late into September, lower attack densities and reduced flight dispersal. Surveys conducted in mid-late September revealed late attacks and short parent galleries with eggs or early instar larvae present in all areas surveyed in the Okanagan and Merritt TSA's (Table 4). These results coincide with those from a special survey conducted by BCFS-Penticton to determine the effect of the abnormal summer season and aggressive management tactics on beetle populations within the district. In addition this survey found that some adults and late instar larvae were remaining in 1992 red attacked trees. Given this, several factors could lead to reduced beetle populations over the next few years, including; higher susceptibility to predators, parasites and disease of progeny in 1992 attacked trees, increased overwinter

mortality of early instar larvae or adults present in 1993 attacked trees, due to cold temperatures; lack of sufficient numbers of adults to successfully attack a tree and thereby establish broods; reduced dispersal due to reduced numbers of adults. Although fall surveys indicate the potential for increased attacks in areas near Peachland Lake in the Okanagan TSA and Rattler/Stemwinder Creek in the Merritt TSA, the hazard may be reduced due to the aforementioned reasons.

Table 4. Mountain pine beetle cruise data, Kamloops Forest Region, 1993.

	Percent of pine attacked						
Location/TSA	Healthy	Current attack (1993)	Partial attack (1993)	Red (1992)	Grey (pre-1991)	Total	Total pine volume (m^3/ha)
Okanagan TSA							
Peachland Lake	89	10	-	-	1	100	295
Elinor Lake	34	15	1	31	19	100	346
Swalwell Lake	94	2	-	4	-	100	395
Merritt TSA							
Sunday Creek	86	5	-	6	3	100	304
Rattler/Stemwinder	69	27	-	4	-	100	280

Western pine beetle
Dendroctonus brevicomis

Areas of recent ponderosa pine mortality attributed to western pine beetle increased to nearly 300 ha in 1993, from 67 ha in 1992. Of the 354 infestations recorded during aerial surveys, 332 occurred in the Okanagan TSA, along both sides of the Okanagan Valley, mostly between Oyama and Osoyoos. The majority of infestations occurred as small pockets of 5 to 20 trees each. Areas of discolored ponderosa pine were most pronounced at or near areas infested in 1992 including Oyama, Lambly Creek, Trepanier Creek, Okanagan Mountain Park, Naramata, Summerland to Kaleden, Ellis Creek, Okanagan Falls to Oliver and Osoyoos. At the lower elevations, western pine beetle was frequently associated with red turpentine beetle and at higher elevations in the Ponderosa Pine and Interior Douglas-fir Biogeoclimatic Zones with both turpentine beetle and mountain pine beetle. Occasionally, all three bark beetles could be found in the same tree. Elsewhere, attacks to small groups of pine were common near Kamloops, Heffley Creek, Fountain, Hat Creek, Chase, and Ashnola River.

The present outbreak was probably precipitated by drought conditions in the late 1980's, but overmaturity and root rot may also have played a significant role. Some of the attack also occurred in healthy trees, which happens when epidemics cause beetles to become aggressive and kill apparently vigorous trees of all ages. Sanitation-salvage logging is the generally accepted method used to minimize losses. Due to scattered high populations, additional losses can be expected in the vicinity of present infestations in 1994.

Ponderosa pine decline

A number of pests continue to reduce ponderosa pine vigor in the South Okanagan, particularly in the Bunchgrass Biogeoclimatic Zone. Scattered mortality of both mature and semi-mature ponderosa pine were recorded between Oliver and Osoyoos, at levels similar to those recorded in 1992. Living affected trees appear unhealthy, with reduced growth, scorched/drooping needles, branch dieback, broken branches, brooms and chlorosis.

Populations of scale insects, black pineleaf scale, **Nuculaspis californica**, and pine needle scale, **Chionaspis pinifoliae**, decreased from levels recorded in 1992. Scattered ponderosa pine mortality throughout the Okanagan caused by drought and scale insects has occurred sporadically since 1972. Elytroderma needle disease, caused by **Elytroderma deformans**, Sequoia pitch moth, **Synanthedon sequoiae**, a web-spinning sawfly, **Cephalcia sp.**, and western gall rust, **Endocronartium harknessii**, western pine moth, **Dioryctria cambiicola**, and a midge, **Cecidomyia sp.** were also found in low levels. In some cases either one or a combination of these pests weakened the trees, predisposing them to western pine beetle, **Dendroctonus brevicomis** attack.

Pine needle diseases
Lophodermella concolor,
Hendersonia pinicola,
Elytroderma deformans

Foliage discoloration resulting from infections by native pathogens, continued over widespread areas throughout the host range of lodgepole pine and to a lesser extent ponderosa pine in the Kamloops Forest Region.

Similar to 1992, extensive areas of lodgepole pine discoloration and premature needle cast in both planted and natural stands was caused by *L. concolor*, frequently in association with the hyperparasite, *H. pinicola.* Large areas of severe discoloration of year-old foliage were prominent in the Kamloops TSA along the Bonaparte Hills, Tranquille and Thompson plateaus, and included managed stands that were spaced, thinned, pruned or fertilized. Discoloration in the North Thompson Valley north of Clearwater was generally less pronounced than in 1992. Large patches were also noted during aerial surveys in Merritt TSA near Douglas Lake, south of Merritt along Voght, McCullough and Otter creeks and the Wilbert Hills and Manning Park area. In the Okanagan TSA discoloration was common in the Barton Hills, Wilkinson-Stirling-Big White area, Ellis Creek, Railroad Creek and near Monte Lake. In Lillooet TSA there was a high incidence of infection on more than 1000 ha along Hurley River between Gwyneth Creek and Lone Goat Creek, similar to 1992.

Before the 1993 growth had fully flushed in the Brigade Lake area in Kamloops Forest District, it was not uncommon to find that previous needle loss had resulted in only 1992 needle retention, with up to 100% of those needles being discolored. These stands typified the "lion's tail" effect which describes the appearance of trees when only the current growth remains. Throughout the Region, intensities of needle discoloration ranged from 20 to 100% on roadside regeneration, along fringes of mature stands, and in immature natural and planted stands.

Increment losses can be expected in stands with chronic foliage loss due to successive years of infection. New infections occur on current-year needles in early summer by wind-borne and rain-splashed spores, with discoloration appearing the following year. Spread and successive invasion of the needles by the spores is greatly favored by moist conditions such as

occurred in 1993 in late spring and early summer. Consequently, a continuation of widespread foliage discoloration is likely in the Kamloops Forest Region in 1994.

Elytroderma needle disease, *Elytroderma deformans* continued to cause widespread disease of ponderosa pine, adversely affecting its growth throughout the Ponderosa Pine and Bunchgrass biogeoclimatic zones in the Region. Trees so affected usually display prominent witches' brooms and needle discoloration and make little perceptible growth. Severely diseased pine are susceptible to attacks by red turpentine beetle. While this disease can be found throughout the host range of ponderosa pine, some noteworthy occurrences include Voght Valley, south of Merritt, where up to 100% of pines suffered 80% foliage infection in localized areas. Along Okanagan Mountain Park Road and at Venables Valley, brooms were common on 50% of trees and foliage discoloration affected up to 70% of the individual crowns.

Practical control is limited to silvicultural manipulations such as removing severely infected trees and thinning stands to promote vigorous growth.

Douglas-fir Pests

Western spruce budworm
Choristoneura occidentalis

Based on aerial surveys, the area of western spruce budworm defoliation declined nearly 90% to 39 000 ha from the 320 100 ha in 1992 and from a peak of 820 000 ha in 1987 (Fig.4, Fig.5). Defoliation intensities as forecasted, were also reduced. More than 37 000 ha of Douglas-fir in 217 mixed-age class stands were lightly defoliated, and 1900 moderately defoliated. The majority of feeding was in the Okanagan, Merritt and Lillooet TSA's (Table 5). Trace levels of defoliation not visible during aerial surveys were present in many stands previously infested.

Table 5. Area of Douglas-fir defoliated by western spruce budworm, by TSA, as determined from aerial and ground surveys, Kamloops Forest Region, 1992 and **1993.**

TSA	Area of defoliation (ha)						
	Light		Moderate		Severe		Total
	1992	**1993**	1992	**1993**	1992	**1993**	**1993**
Okanagan	111 800	16 100	42 200	50	200	0	16 150
Merritt	13 000	12 600	3 800	0	50	0	12 600
Lillooet	57 600	4 900	24 800	1600	1 000	0	6 500
Kamloops	42 250	3 500	16 400	250	1 000	0	3 750
Totals	230 650	37 100	87 200	1900	2 250	0	39 000

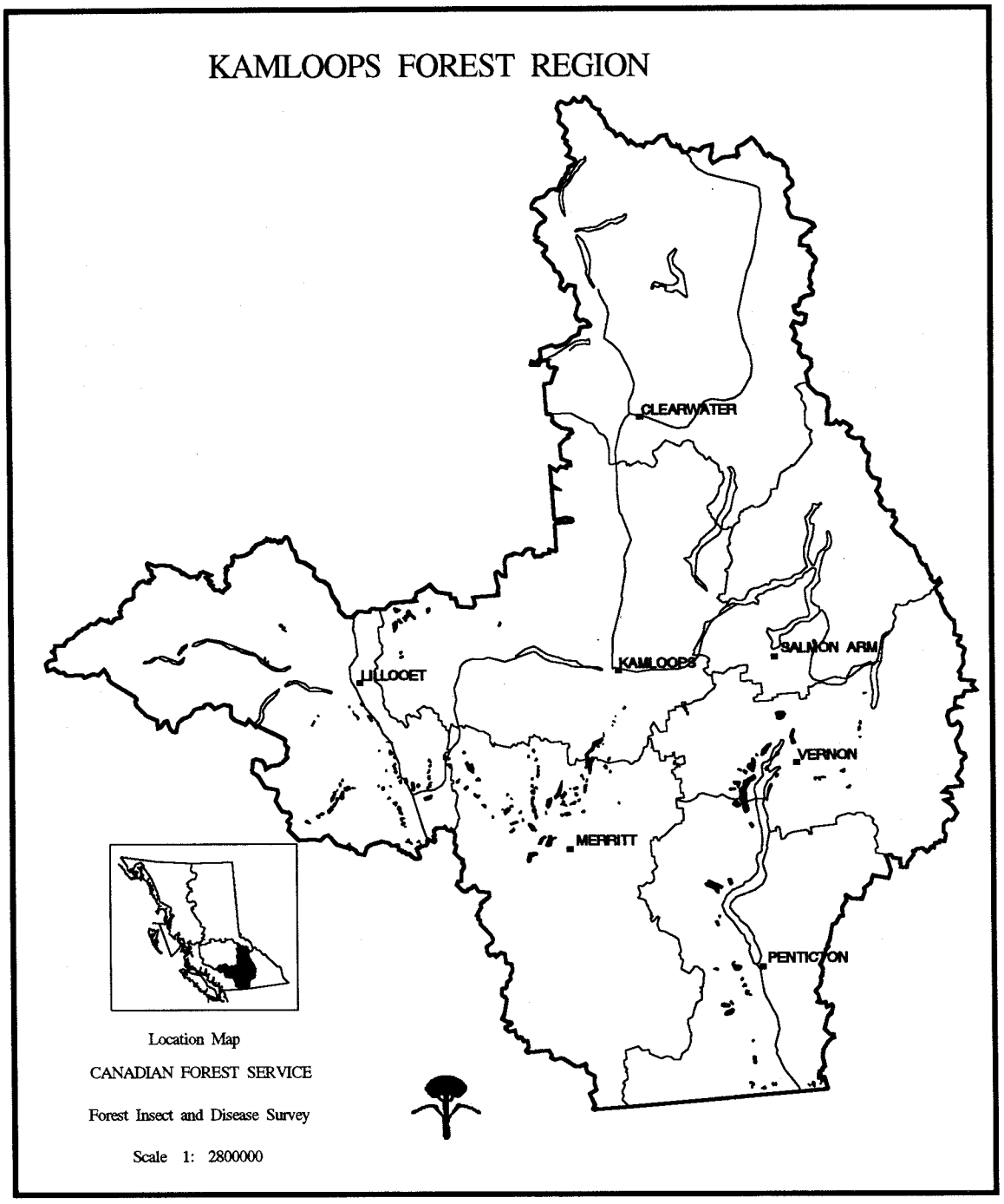

Figure 4. Areas where Douglas-fir was defoliated by western spruce budworm as detected by ground and aerial surveys, 1993.

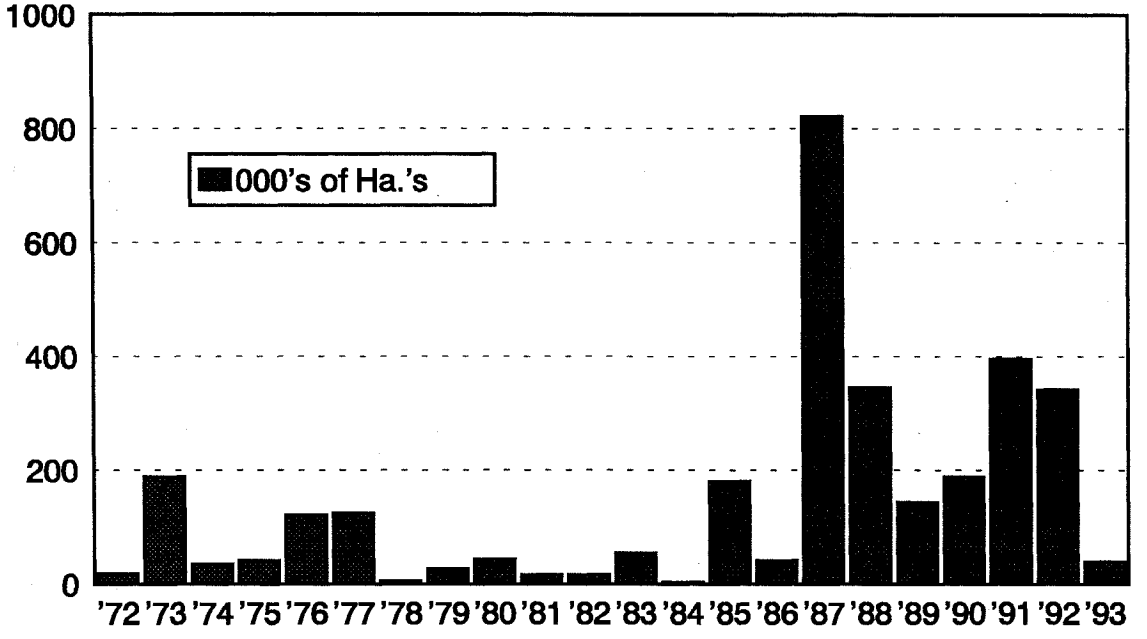

Figure 5. Area (ha) of western spruce budworm infestation, 1975-1993, Kamloops Region.

Damage

In the Okanagan TSA, mostly light defoliation extended south from Armstrong to Osoyoos in many areas previously infested. The area of infestation declined to 16 150 ha, from 154 200 ha in 1992. No severe defoliation was recorded this year and moderate defoliation occurred on only 50 ha near Shorts Creek on Okanagan Lake. Successive years of defoliation however, have led to scattered tree mortality and top-kill in the Salmon River Valley-Monte Hills area, Postill Lake, Glenrosa, Peachland Main, Darke Lake, Chute Lake Rd, Apex-Yellow Lake area, Mount Kobau, Blue Lake and Anarchist Mountain.

Infestations in the Merritt TSA continued at reduced intensity levels from Mamit Lake south to Merritt, along Nicola River Valley and at Nicola Lake. The total area of 12 600 ha was lower than 1992, but there was some expansion at Iron Mountain to the south of Merritt and in the Promontory Hills to the west of Merritt. With the exception of areas south of Spences Bridge, infestations in the Merritt TSA are relatively recent, and have not caused any of the top-kill and tree mortality which often results from several successive years of severe defoliation.

In the Lillooet TSA, light and moderate defoliation declined to 6500 ha from 83 400 ha in 1992. Yalakom River and Cayoosh Creek were the only two areas west of Lillooet of repeat infestation. Defoliation declined to light intensity along the Thompson River and south of Lillooet to Kwoiek Creek, including the Stein Valley. Of the total 1600 ha of moderate defoliation, 1350 occurred along the Stein River, and the remainder in scattered pockets between Lytton and Laluwissin Creek. Chronic infestations in Fountain Valley, where defoliation was trace to light in 1993, have resulted in branch dieback, top-kill and mortality of Douglas-fir, particularly in dense immature stands.

Infestations in the Kamloops TSA declined to 3750 ha, their lowest level since 1978, compared to 65 650 ha in 1992. Light discoloration was recorded on only 3500 ha in the Maiden Creek-Hat Creek area, Criss Creek and south of Kamloops between Stump and Shumway lakes. Moderate defoliation totalled 250 ha at Scottie Creek and Shumway Hill. Scattered tree mortality, top-kill and deformity of immature and mature Douglas-fir were evident in many stands severely defoliated for successive years. Douglas-fir beetle attacks were also common in chronically defoliated stands along Tranquille River, areas north and south of Kamloops Lake and near Monte Lake.

Sampling Surveys

Bud sampling

A bud sampling survey, repeated annually since 1987, continued in late May at 44 locations to assist in predicting defoliation for the current (1993) year. A total of 100 buds were examined from five trees at each location. Severe defoliation was predicted at 3 sites, moderate at 14 and trace or light at 27 sites. The low feeding damage intensities predicted at the majority of sites, suggested a continued downward trend at many of the same locations sampled in 1992. Subsequent aerial surveys and ground assessments found predictions to be correct at 50% of stands sampled, similar to accuracies obtained between 1987 and 1992, which ranged from 40-65%. In areas where the predicted and actual values were dissimilar, the difference was usually not more than one defoliation category. The exception occurred near Merritt, where populations at two newer infestations predicted severe defoliation, but actual defoliation was light. Bud sampling provides a useful tool for predicting defoliation, allowing enough time for decision making during epidemic conditions where a control option may be required.

Larval and moth sampling

Consistent with decreased defoliation intensities, larval populations were lower than 1992. Standard beating collections, mostly from the Interior Douglas-fir (IDF) Biogeoclimatic Zone averaged 25 larvae per sample, compared to 31 in 1992 and 48 in 1991. Higher disease and parasite incidence in the population contributed to the reduction.

Adult males were monitored for the seventh consecutive year at four locations with low populations, but with a history of outbreaks. Moths were caught in pheromone-baited "Multipher" traps as part of a study to correlate trap catches with subsequent defoliation. Counts averaged 358 moths (range 11-691) per trap, down from 476 moths in 1992. The high count of 691 moths/trap at Adams River indicates the potential for some light defoliation in 1994, but none at Stump, Darke and Sugar lakes. Only trace amounts of defoliation occurred at Stump Lake and none at the other three sites in 1993.

Forecasts

The average number of egg masses obtained per $10m^2$ of foliage at each site was nearly 40% lower than 1992 at 22 of 24 locations sampled for two consecutive years (Table 6, Figure 6). While a continued overall population decline is indicated, egg mass counts in parts of the Kamloops and Merritt TSA's were up from 1992. Severe defoliation at Stephens and Kirby creeks near Merritt prompted egg mass sampling there for the first time. Severe defoliation is again predicted at these two locations in 1994 and at Shumway Lake south of Kamloops. Moderate defoliation is forecast at four locations in previously infested areas. Trace to light defoliation is predicted at 12 locations and no defoliation is predicted in five areas sampled. A

Table 6. Average number of western spruce budworm egg masses on Douglas-fir from 1990-1993, and predicted defoliation in Kamloops Region in 1994.

	Predicted Defoliation	No. of Egg Masses Per 10m2 Foliage [1] 1993	1992	1991	1990
Kamloops TSA					
Pemberton Hill	trace	10	46	827	960
Niskonlith Lake	moderate	90	32	184	-
Shumway Lake	severe	340	208	818	
McQueen Lake	nil	0	104	345	
Criss Creek	moderate	100	115	185	111
Cherry Creek	light	20	112	596	105
Average		**93**	**72**		
Okanagan TSA					
Equesis Creek	nil	0	77	233	
Postill Lake	moderate	73	41	447	43
Glenrosa	trace	7	8	370	357
Darke Lake	light	29	74	218	74
Peachland Main	trace	8	33	306	336
Apex-Yellow Lakes	trace	7	50	264	222
Blind Creek	nil	0	20	183	77
Mount Kobau	nil	0	35	454	521
Anarchist Mountain	light	17	92	256	-
Blue Lake	trace	8	12	74	143
Average		**15**	**53**		
Lillooet TSA					
Cayoosh Creek	light	30	32	-	
Yalakom River	moderate	60	135	146	348
Fountain Valley	light	20	37	407	109
Gun Lake	nil	0	32	98	-
Botanie Creek	light	30	54	74	0
Average		**28**	**62**		
Merritt TSA					
Stephens Creek	severe	379	-	-	
Kirby Creek	severe	190	-	-	
Peter Hope Lake	light	20	89	505	
Average		**196**	**89**		

1 1 - 10 eggs/10m2 - trace defoliation
11 - 50 eggs/10m2 - light defoliation
51 - 150 eggs/10m2 - moderate defoliation
151+ eggs/10m2 - severe defoliation

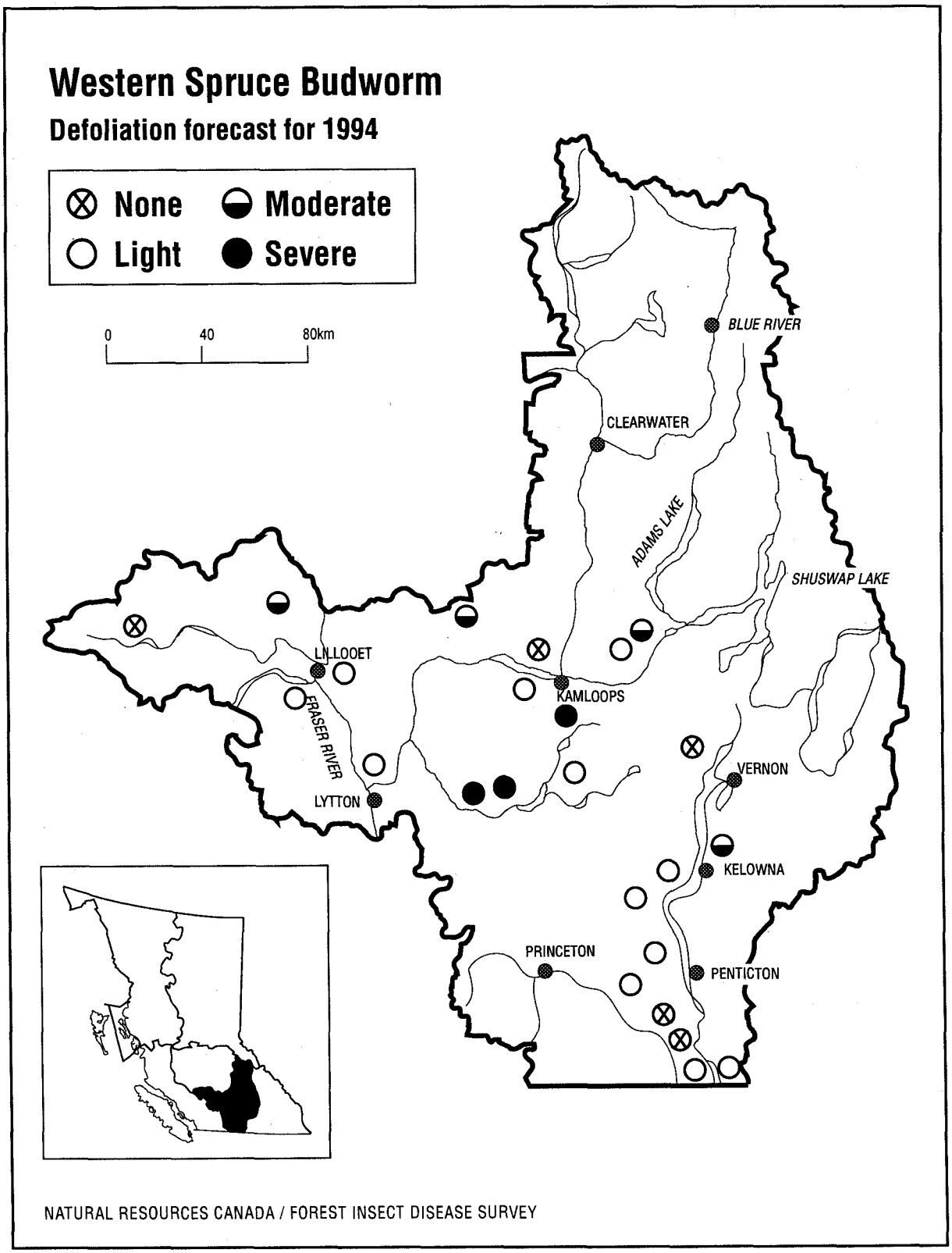

Figure 6. Defoliation by western spruce budworm forecast for 1994, based on 1993 egg surveys.

more extensive survey by the B.C. Forest Service has found similar results, but with additional predictions of severe defoliation in 1994 at Arrowstone and Maiden creeks in Kamloops TSA and in the Tom Cole area, Tiffin, Laluwissin and Cayoosh creeks and Pasulko Lake areas in Lillooet TSA.

Egg mass samples consisted of collecting two 45-cm branch tips from each of ten trees per location. The number of egg masses were counted on each branch and extrapolated to 10 m^2 of foliage. These figures were then used to determine defoliation severity for 1994. Predictions preclude adverse weather conditions, which would decrease overwintering survival of larvae.

Biological Control

Disease incidence and larval and pupal parasitism were determined from rearings of late-instar larvae collected at 9 locations within the infested areas. Incidence of entomopathogens in samples averaged 48% (range 0 to 88%), up from 38% in 1992. The most common entomopathogens were bacteria and viruses, but a fungus, **Entomophthora** sp. was also present in 4% of samples. Parasitism averaged 9% (range 2 to 17%), mostly by dipterans and hymenopterans, similar to 1992.

The highest levels of disease occurred at upper Dairy Creek, Skimikin Lake, Stump Lake, and Cinquefoil Creek, indicating that disease was widely distributed throughout the population. The trend towards an increase in disease incidence reflected in the lower egg counts over the past several years, points to a further reduction in budworm defoliation next year. Parasites appear to have less impact. Studies have shown parasites to be affective at controlling low populations of budworm, but have minimal influence at epidemic levels.

Aerial applications of the biological insecticide *Bacillus thuringiensis* (Bt) were made on 34 000 ha of budworm-infested stands in five forest districts. This followed successful applications on 36 000 ha of managed stands in 1992, on which the objective was to reduce feeding damage in priority areas.

Impact

Due to successive years of severe defoliation, tree mortality, top-kill increment loss, and tree deformity were common in many parts of the IDF zone in the Kamloops Region. Monitoring of defoliation impact continued in 64 young stands of Douglas-fir in the region, and resulted in an additional 1% tree mortality. Cumulative tree mortality since 1986 is now 11%.

Due to the exclusion of fire and the use of selective harvesting methods, many stands are uneven-aged with a dense understory of Douglas-fir, which favors budworm feeding and population buildup. In areas where budworm has been historically active and where even-aged stand management is an option, this silvicultural method should be encouraged.

Douglas-fir beetle
Dendroctonus pseudotsugae

Douglas-fir beetle infestations totalled 1175 ha in 970 pockets, more than three times the area attacked in 1992. Individual outbreaks were generally small, from 5 to 30 tree each.

In Kamloops Forest District, virtually every pocket of infestation was photographed and sketch-mapped during aerial surveys.

The majority of infestations continued to be along the Thompson River Valley and adjacent drainages between Kamloops and Spences Bridge, and north and west of Cache Creek to Scottie Creek, Hat Creek and Pavilion Lake. Notable increases occurred north of Kamloops Lake along Tranquille River where up to 10% of Douglas-fir were attacked in five patches of 40 to 80 ha each. Similarly, up to 20% of trees were killed in three areas ranging in size from 40 to 100 ha along the Carabine and Eagle hills. Infestations also expanded along the east side of Adams Lake opposite Skwaam Bay, where more than 300 new trees were discolored in 10 pockets of 10 to 100 trees each. In Salmon Arm Forest District, scattered small groups increased in number along Salmon River Valley, along Shuswap River south of Sugar Lake, and Mabel Lake in Vernon Forest District. In the Merritt Forest District noticeable increases occurred in small pockets dispersed along Pimainus Creek near Spences Bridge.

Lighter beetle concentrations were noted in several stands near Helmcken Falls in Wells Gray Provincial Park containing both beetle and root rot-killed trees. In Kamloops Forest District groups of 2 to 10 trees each were common along the North Thompson River, between Little Fort and Kamloops, including Paul Lake, Barriere River, Louis Creek, Durand Creek, Deadman River, Pass Valley, Cache Creek area and Barnes Lake to Spences Bridge including Venables Valley. In Lillooet Forest District small pockets were scattered along the Thompson and Fraser River valleys, including the Stein River and Kwoiek Creek, and west of Lillooet along the Yalakom River, Cayoosh Creek and at Seton Portage. Attacks to single trees and occasional small groups continued throughout the host range of Douglas-fir in the Okanagan and Similkameen valleys and south of Merritt. Scattered beetle-killed trees along roadsides between Manning Park and Keremeos were likely predisposed by salt and winter injury.

Timely harvest of recently killed trees combined with the judicious use of trap trees associated with pheromone baiting, should help to reduce the impact of expanding infestations and help keep them in check. Those stands with recent windthrow containing mature and overmature Douglas-fir and those suffering the cumulative effects of spruce budworm defoliation, will require extra vigilance.

Douglas-fir tussock moth
Orgyia pseudotsugata

Douglas-fir tussock moth defoliated 1150 ha in 64 patches between Chase and Ashcroft, and north of Kamloops to Vinsulla, down from 1875 ha in 1992. Most of the decline occurred in previously defoliated Douglas-fir stands west of Kamloops, and near Hedley. Infestations however, expanded east of Kamloops towards Chase and north to Vinsulla. The areas most severely affected were primarily on ranch and other private properties in the Ponderosa Pine and Bunchgrass biogeoclimatic zones. Single Douglas-fir and ornamental spruce were occasionally defoliated in Kamloops and in the Okanagan Valley.

The largest infestation, at Battle Creek east of Cache Creek, expanded to nearly 400 ha of light to severe defoliation. Areas of severe defoliation may sustain up to 50% tree mortality and top-kill. Elsewhere, tree mortality can be expected in up to 40 ha patches on the east side of the North Thompson River from Kamloops to Vinsulla, and in several locations near Monte Creek. Most areas of light and moderate defoliation above Westsyde and Batchelor Hills near Kamloops, at Barnhartvale and near Pritchard, should recover, although occasional tree mortality and top-kill may occur. Up to 80% tree mortality and top-kill was evident in scattered pockets in stands severely defoliated in 1992 at Indian Gardens near Savona. Light tree

mortality was noted in several stands near Oregon Jack Creek, along Venables Valley, Sabiston Creek, and Six Mile Ranch area.

Male moth captures in pheromone-baited sticky traps at **monitoring** sites decreased for the first time in eight years in Douglas-fir stands selected for the greatest historical frequency of outbreaks (Table 7). Counts at 17 sites in the Kamloops Forest Region averaged 27 moths per trap (6 traps per location), down from 40 in 1992. Counts in single traps located at 1-2 kilometer intervals in the Thompson and Okanagan valleys were also down, averaging 43 moths per site compared to 56 previously. These traps were placed to determine population **distribution** and to help locate epidemic centers. Similar results were obtained by the B.C. Forest Service whose traps at 152 sites averaged 14 moths per trap, down from 30 in 1992.

Egg mass surveys were conducted at 15 sites where high moth counts indicated the potential for defoliation in 1994 and also in or near areas recently defoliated. No defoliation is forecast at 14 sites and only trace levels are forecast at Battle Creek. Egg mass surveys and observations by Dr. I. Otvos of the Canadian Forest Service resulted in similar findings. Egg mass frequency was determined using a sequential sampling survey, which required the inspection of a minimum of 20 trees per site.

There is continued evidence of the disease caused by the naturally occurring nucleopolyhedrosis virus (NPV) in many areas of the outbreak. At Monte Creek where the population collapsed after causing severe defoliation, 98% of larvae died of disease; half from fungus infection (*Beauveria* sp.)and the remainder from virus infection. At Heffley Creek 33% of larvae died, presumably from virus infection. The collapse of populations in many areas west of Kamloops in 1992 was also the result of NPV infection. Rearings of 1993 egg masses from Oregon Jack, Battle, and Monte creeks, and Rayleigh, found evidence of virus, but results were not yet available at the time of this writing. Parasitism of larvae was only 2% at each of two areas assessed, but general observations indicate a more pronounced impact in the late larval and pupal stages.

An overall reduction in numbers of trapped moths, increased NPV, fungus infection, and pupal parasitism and a reduction in egg masses all point to a further reduction in populations, and possibly a total collapse.

Aerial application of virus was completed by the B.C. Forest Service on six blocks varying in size from 20 to 120 ha each. Approximately 610 ha were successfully treated. Much of the area treated was on private land, but directly adjacent to crown forested land.

Research trials conducted in 1993 by the Canadian Forest Service and B.C. Ministry of Forests, Kamloops, showed great promise in the use of pheromone for detracting males from females as a means of controlling Douglas-fir tussock moth populations. A test at Mara Hill, near Kamloops involved the aerial application of four different concentrations of pheromone on 12 two-hectare plots with an additional 4 two-hectare plots as controls. Preliminary results indicate that the pheromone concentration can be reduced and still maintain confusion of the males and block mating. A test at Wallachin to determine sources of secondary attraction in baited traps was inconclusive, and may be repeated in 1994. A test in the Similkameen Valley to determine the efficacy of two concentrations of pheromone over time, found some disruption two years after treatment.

Table 7. Summary of sequential Douglas-fir tussock moth egg mass surveys, and pheromone trapping, 1993 and predicted defoliation for 1994, Kamloops Forest Region.

Location	Avg. No. moths/trap	Avg. No. egg masses/tree	1993 defoliation	Predicted 1994[1] defoliation
MONITORING TRAPS				
Pavilion	10	-	Nil	-
Veasy L	16	-	Nil	-
Barnes L	21	-	Nil	-
Battle Creek	96	0.3	Severe	Trace
Six Mile Ranch	45	-	Nil	
Cherry Creek	49		Nil	
Stump L	1	-	Nil	-
Heffley Creek	96	0.1	Moderate	Nil
Kaneta	26	-	Nil	-
Monte Creek	75	0.05	Nil	Nil
Chase	3	-	Nil	
North Okanagan				
Winfield	1		Nil	
Armstrong	<1		Nil	
South Okanagan				
Darke L	0	-	Nil	-
Blue L	4	-	Nil	-
Kaleden	11	-	Nil	-
Similkameen Valley				
Stemwinder Park	1		Nil	
DISTRIBUTION TRAPS				
Ashcroft-Spences Bridge				
Oregon Jack Creek		0.1	Moderate	Nil
Deadman River				
Km 16	84		Nil	
Km 1.8	53	-	Nil	-
Sabiston Creek-5Km	58	0.0	Nil	Nil
Indian Gardens				
Km 42-07 Guichon Rd	0 (down)	0.0	Trace	Nil
Km 1-W of Guichon Rd	71	-	Nil	-
Km 2-W of Guichon Rd	64		Nil	-
Indian Grdns-L2 plot	1		Nil	-
1.3 km E of Guichon	43		Nil	-
2.7 km E of Guichon	7		Nil	-

Table 7. (Cont'd)

Location	Avg. No. moths/trap	Avg. No. egg masses/tree	1993 defoliation	Predicted 1994[1] defoliation
Six Mile Ranch				
Pat L	53	-	Nil	-
Bull Pen Rifle Range	39	-	Nil	-
Six Mile L/O	12	-	Nil	-
6 Mi Ranch Rd- 1km	50	-	Nil	-
1.2km E.of previous	80	-	Nil	-
1.6km E.of previous	37	-	Nil	-
3km E.of previous	6	-	Nil	-
1.3km E.of previous	57	-	Nil	-
Dominic Lake Rd.				
Km 1	14	-	Nil	-
Km 2	48	-	Nil	-
Beaton Lake-Kamloops				
Beaton Rd - Km2.4	52		Nil	
Beaton Rd - Km5.1	63		Nil	
Kamloops-North				
Westsyde	-	0.0	Moderate	Nil
Rayleigh	-	0.1	Moderate	Nil
Palmer-Forsythe Rd.	-	0.0	Moderate	Nil
Robbins Creek	-	0.0	Light	Nil
Duck Range Rd.				
Km 0.8	69	-	Nil	-
Km 3.2	42	-	Nil	-
Km 5.4	63	-	Nil	-
Pritchard				
5.1 km W. Pritchard	65	0.0	Trace	Nil
3.4 km E. Pritchard	30	-	Nil	-
Barnhartvale-Chase				
Buse Lake	-	0.0	Moderate	Nil
Bostock Rd	-	0.1	Mod-Sev	Nil
Lions Head	-	0.0	Mod-Sev	Nil
Willow Rd	-	0.05	Moderate	Nil
Central Okanagan Valley				
O.K. Mountain Park-O.K. Mission	<1	-	Nil	-
Winfield-Kelowna	<1	-	Nil	-

[1] <0.7 egg masses/tree (3 branches) = nil to light defoliation
0.7 - 2.0 egg masses/tree (3 branches) = moderate defoliation
>2.0 egg masses/tree (3 branches) = severe defoliation

Western false hemlock looper
Nepytia freemani

Western false hemlock looper in association with Douglas-fir tussock moth and western spruce budworm caused some light defoliation of Douglas-fir on 40 ha in the Mara Hill area near Kamloops. Some minor feeding damage was also observed south of Wallachin. Elsewhere, the highest populations were found in the IDF and PP biogeoclimatic zones between Kamloops and Barriere, and north of the Thompson River from Savona to Cache Creek, but there was no defoliation. Sampling will continue in 1994, with emphasis in historically active areas between Chase and Salmon Arm, from Monte Lake to Falkland and near Barriere.

Spruce Pests

Spruce beetle
Dendroctonus rufipennis

The area of mature spruce recently killed by spruce beetle increased for the second year, to 2040 ha in 49 separate infestations, from 1655 ha in 1992. As in previous years the majority of infestations occurred in the Lillooet Forest District, and were generally continuations of past outbreaks. Nearly 1500 ha were infested along McGillivray, Connel and Noel creeks, where recent tree mortality ranged from 5 to 30% of stems in 30 pockets of infestation. In spite of ongoing harvesting, infestations in these long standing outbreaks in mature spruce may continue at varying rates of intensity until natural control factors prevail or the host is depleted.

In the Merritt Forest District infestations expanded to 500 ha south of Merritt from Brook Lake to the Tulameen Valley including Lawless, Skwum, Holm, Champion, Slade and Arrastra creeks. Increases occurred as a result of consecutive years of blowdown along valley bottoms, adjacent slopes and the fringes of clearcut blocks. Populations were able to build up in this material and this led to attack in standing timber. Subsequent to aerial surveys, ground probing by affected licensees to identify management priorities, has discovered an additional 700 ha of current attack. Removal of infested material was in progress, but is not likely to be completed prior to beetle flight in spring 1994, due to early snowfall and a late spring in many high elevation areas.

Elsewhere, spruce beetle was found in blowdown south of Vernon at Swalwell Lake and in standing trees at Yeoward Creek, Torrent Creek and Holstein Lake. Harvesting of infested and susceptible spruce is helping keep these pockets of infestation in check. Other infestations in historically active areas include pockets of 0.5 to to 30 ha each along the upper drainages of Chu Chua Creek and Nikwikwaia Creek in Kamloops Forest District, and Van Horlick Creek in Lillooet Forest District.

Spruce beetle infestations most frequently result from populations building in windthrow and slash, including high stumps. This is typically followed by attacks to standing mature spruce. Beetle control is usually achieved by one or a combination of management practices such as slash reduction, sanitation logging, the use of trap trees, or pheromone baiting. Natural population control can also occur as a result of host depletion and extended low winter temperatures. Identification of infested trees and windfall and monitoring of cutblock boundaries for blowdown is key to preventative maintenance in keeping spruce beetle activity to a minimum.

Two-year cycle spruce budworm
Choristoneura biennis

The area of spruce and alpine fir forests defoliated by two-year cycle spruce budworm totalled 10 150 ha in 23 areas, all in the Vernon Forest District. Moderate defoliation on 5100 ha occurred mainly east of Lumby in the Sugar Lake area. Light defoliation on 5050 ha was concentrated in the Upper Kettle River Valley near Keefer Lake and south to Winnifred Creek. Similar damage intensity was mapped on more than 11 000 ha in the same area in 1992. The Keefer Lake-Sugar Lake area has experienced seven consecutive years of light to moderate defoliation ranging from 2000 ha to 11 000 ha annually. Supported by 1992 egg samples, which indicated continued light defoliation in 1994, and 1993 egg samples which indicated light defoliation in 1995, there appears to be two distinct two-year cycle budworm populations in this area maturing in alternate years. Pheromone trapping and larval sampling for several years should help to determine the behavioral patterns in this area.

No defoliation occurred elsewhere in the district, but egg samples taken in 1992 forecasted light to moderate defoliation in 1994 throughout many of the stands previously defoliated in the Clearwater Forest District, including Wells Gray Provincial Park.

The impact of budworm defoliation upon spruce and alpine fir has not been well researched. Observations in areas of chronic infestation in the upper North Thompson Valley determined bud mortality, occasional branch dieback, and some top-kill to have resulted directly as a result of budworm feeding. Stress from chronic foliage loss may also be a factor in the incidence of Armillaria root disease and attacks by secondary agents in infested stands.

Alpine Fir Pests

Western balsam bark beetle
Dryocoetes confusus

The area of recent alpine fir mortality as determined by aerial surveys increased to 5200 ha from 1720 ha recorded in 1992. However, this increase is partially due to increased aerial surveillance in remote high elevation areas. One of the largest and most chronic infestations continued on 1230 ha near Taweel Lake in the Kamloops Forest District. Host mortality of 1 to 5% has occurred annually in this area for at least the past five years. Similar long standing epidemics in the Wentworth Creek-Tranquille Lake area and near Fadear Lake, continued unchanged. More recent infestations comprising small pockets of attack were common over 3250 ha in Salmon Arm Forest District south of Humamilt Lake, upper Scotch Creek, and Ratchford Creek. Recent attacks rarely affected more than 5% of the stands in these areas. Infestations at Blanc Creek have declined, partly due to host depletion and some harvesting. Up to 5% of trees were recently infested on 50 ha south of Mara Lake. In the Vernon Forest District, infestations were generally in small pockets of 5 to 30 trees each, including the east side of Mabel Lake, Harris Creek, McGregor Creek, Salmon River, and Chaperon Mountain. Spot infestations were also common in the Penticton Forest District along Trout Creek and at Eneas Lakes and in the Lillooet Forest District along Hurley River, North Kwoiek Creek, and near Kanaka Mountain.

Once established, beetles continue to selectively attack small groups of trees, killing an average of 1-5% annually. While the area and intensity of attack do not fluctuate dramatically from year to year, consistent and accurate mapping is difficult due to retention of red foliage for

up to five years. Extensive mortality caused by other agents, including root rots, and the inconsistency of aerial surveys in remote subalpine drainages will result in additional work to interpret accumulated data.

Western Hemlock Pests

Western hemlock looper
Lambdina fiscellaria lugubrosa

Western hemlock looper defoliated approximately 1150 ha of old growth western hemlock and red cedar, down from 88 000 ha in 1992. Infestations collapsed in the North Thompson Valley, Wells Gray Provincial Park and upper Adams River Valley in the Clearwater Forest District. Infestations continued in previously infested areas in the Salmon Arm Forest District and at one location in the Kamloops Forest District. Moderate defoliation occurred on only 100 ha near East Barriere Lake. Light defoliation was prominent on 1050 ha in the Salmon Arm District, mainly along Perry River where several small blocks were successfully sprayed by the B.C. Forest Service. Several pockets of light defoliation also occurred along Ratchford Creek, Scotch Creek and near Malakwa.

The general decline in populations appeared largely to be the result of high parasitism, which averaged 40% in 1992. This was followed in 1993 by unseasonably cool weather during larval development and the spread of disease through the infestations. Larval starvation was also a factor in previously severely defoliated stands.

After two years of severe defoliation, extensive top-kill and tree mortality was evident in many hemlock-cedar stands in the North Thompson Valley near Blue River, in Wells Gray Park along Clearwater and Hobson Lakes and to a lesser extent in the Upper Adams River drainage. Preliminary data from damage appraisal plots established in three stands near Blue River to monitor the impact of defoliation on tree growth and survival, indicated probable mortality of more than 50% of western hemlock in many stands severely defoliated for two consecutive years. Tree mortality is expected to be greatest in the intermediate and suppressed crown classes at this point. However, increased mortality of larger overmature stems may occur from attack by secondary insects such as bark beetles and woodborers after the outbreak has subsided. Presently, the impact of severe defoliation on understory hemlock and cedar is less severe, resulting in 15% and 1% tree mortality respectively. Extensive heartrot by the Indian paint fungus, *Echinodontium tinctorium*, as evidenced by their conks, was found on up to 25% of hemlock examined. The merchantability of many of these infected trees is doubtful.

Based on egg samples from 9 areas in the Kamloops Region, defoliation is forecast to be severe, north of Sugar Lake, and light in one location along Perry River. No defoliation is predicted in 7 other locations sampled in previously infested stands (Table 8) in the North Thompson Valley and Wells Gray Provincial Park.

Table 8. Location, average number, and viability of western hemlock looper eggs and subsequent defoliation predicted for 1994, Kamloops Forest Region, 1993.

Location	Avg. no eggs (per 100 g lichen)				Predicted 1994[1] defoliation
	Healthy	Parasitized	Infertile	Old	
Vernon Forest District					
Sugar Lake	75	30	3	2	Severe
Salmon Arm District					
Perry River	23	4	2	19	Light
Clearwater Forest District					
Murtle Lake Road	1	1	0	97	None
Mud Lake	3	1	0	3	None
Peddie Mtn. Road	2	4	1	17	None
Finn Creek	0	2	0	11	None
Avola Mtn.	1	0	0	2	None
Helmcken Falls	0	0	0	3	None
Clearwater Lake	2	2	1	33	None

[1] Light - 5-26 eggs; moderate - 27-60; severe - 61+ eggs

A cooperative study initiated in 1992 by Simon Fraser University and the Canadian Forest Service to develop a pheromone trapping and forecasting system, continued in 1993. In the Kamloops Region, assessments were completed at 7 of 27 sites in B.C. with a history of looper activity. Looper population assessments were made incorporating the FIDS three-tree beating method for larvae, burlap sacking traps for pupae, pheromone trapping for adults, and overwintering egg extraction from lichen samples for forecasting 1994 defoliation levels. One more year of testing and evaluation will be required for pheromone calibration and placement timing before this system becomes available as a monitoring and forecasting tool.

A small experimental control operation was initiated by the B.C. Ministry of Forests along Perry River. Two formulations (Foray® and Dipel®) of *Bacillus thuringiensis* (Bt.) were tested on 100 ha comprised of 6 blocks of 5 to 20 ha each. Generally, good efficacy was seen in each of the treatment blocks and subsequent aerial surveys showed only light feeding damage in the area.

Western Larch Pests

Larch needle blight
Hypodermella laricis

Premature discoloration of larch stands by larch needle blight, declined for the second year to 420 ha from 1540 ha in 1992 in the Okanagan TSA. Moderate foliar browning was detected during aerial surveys near Mabel Lake at Wap River, Hunters Creek, Hidden Lake and Kingfisher. Pockets of moderate discoloration, ranging from 5 to 20 ha were also common on the south side of the highway, from Lumby east to Cherryville.

No foliar browning was noted at previously infected areas at Cosens Creek, King Edward Main, Trinity Valley, Ashton Creek and at Sugar Lake. A needle cast, *Meria laricis*, common in many of the same areas previously, did not reoccur.

Larch casebearer
Coleophora laricella

Larch casebearer populations continued to decline from previous levels, with only light defoliation of western larch observed along King Edward Main. No feeding damage was observed in larch stands lightly defoliated in 1992 between Sicamous and Canoe, along the Silver Star Mountain Road, and Shuttleworth Creek. There has been no recorded permanent damage caused by this pest on western larch in the TSA. Both introduced and natural parasites appear to have been successful in limiting casebearer populations.

Multiple Host Pests

Black army cutworm
Actebia fennica

Black army cutworm populations increased, but remained relatively low in 1993. There have been no reports or observations of cutworm larvae or damage in the region for the past five years. However, numbers of male moths caught in pheromone-baited Multipher®traps, increased for the third consecutive year, to 147 per trap from 80 in 1992 (Table 9). Low populations are predicted to continue for 1994 in areas where traps were deployed in 1992 broadcast burns between Clearwater and Blue River and along upper Adams River and Lake. There is a low to moderate potential for an infestation to develop and cause damage to herbaceous ground cover at one site near Martin Mountain, east of Clearwater, where 384 moths were captured. However, no significant outbreaks have developed where fewer than 600 moths per trap were caught the previous year.

Table 9. Predicted 1994 potential for black army cutworm infestations to develop and cause damage, Clearwater Forest District, Kamloops Forest Region, 1993.

Location	No. Adults	Damage potential
McCorvie Lake	193	None
18 km Chuck Creek/Gollen Creek	127	None
Mud Lake	113	None
Storm Creek (Upper Adams R)	83	None
Upper Adams River	0 (damaged trap)	None
Bear Spur (Upper Adams R)	67	None
Avola Mtn	143	None
Salt Creek (Otter Creek)	123	None
Martin Mtn	384	Low-Moderate
Rock Creek Rd - Adams Lake	90	None
Average	147	

damage potential - 350-600 adults - low to moderate for infestations to develop.
- 600+ adults - moderate to high for infestations to develop.

Special Surveys

Pests of Young Stands

The health of 41 young stands treated under FRDA II was assessed in 1993. A total of 448 plots and 5128 trees, were surveyed for pest occurrence and damage during mid to late summer. Stand openings were randomly selected by biogeoclimatic zone from the BCFS silvicultural database. The majority of the stands examined occurred in the Montane Spruce (MS) and Interior Cedar Hemlock (ICH) zones with the most common stand treatment being spacing. The survey methodology consisted of identifying and quantifying pests by assigning them a field code based on level of defoliation etc. The field codes varied with pest type. A minimum of 100 trees were assessed in 10 or more fixed-radius plots located between fixed intervals along transect lines in each location. In stands greater than 10 years of age, strip surveys (5M) were conducted between plots to quantify root diseases.

Fifty percent of the trees examined were pest free (Severity Index 1 or SI 1), a notable decrease from an average of 61% over the last 3 years. This decrease was in part due to the high incidence of needle infections of *Lophodermella concolor* on lodgepole pine (SI 2). An average of 4.5% of trees of all species were either recently killed (SI 6) or affected by life threatening agents (SI 5), such as white pine blister rust, root diseases, western gall rust, Warren's root collar weevil, mechanical damage and injuries due to abiotic agents and animals. Damage causing significant growth reduction or volume loss (SI 4) affected 2.3% of the trees, resulting from mechanical damage, lodgepole pine terminal weevil, white pine weevil, lodgepole pine dwarf mistletoe, animals, abiotic agents, atropellis canker and western gall rust. Significant loss of current growth potential (SI 3) due mostly to pine needle cast and Adelgids

will occur on 8% of the stems surveyed. Minor damage (SI 2) will occur on 35% of the trees from needle diseases, defoliators, Adelgids, abiotic agents and animals (Figure 7).

Overall, needle diseases represented 30% of the pests found, followed by sucking insects (6%), defoliators (4%), stem cankers (3%), mechanical damage (3%) and woody tissue feeders, animal injuries, abiotic agents, stem and branch diseases and root diseases accounting for the remaining 4%. Table 10 summarizes specific pests according to host and provides a minimum and maximum range of intensity levels recorded.

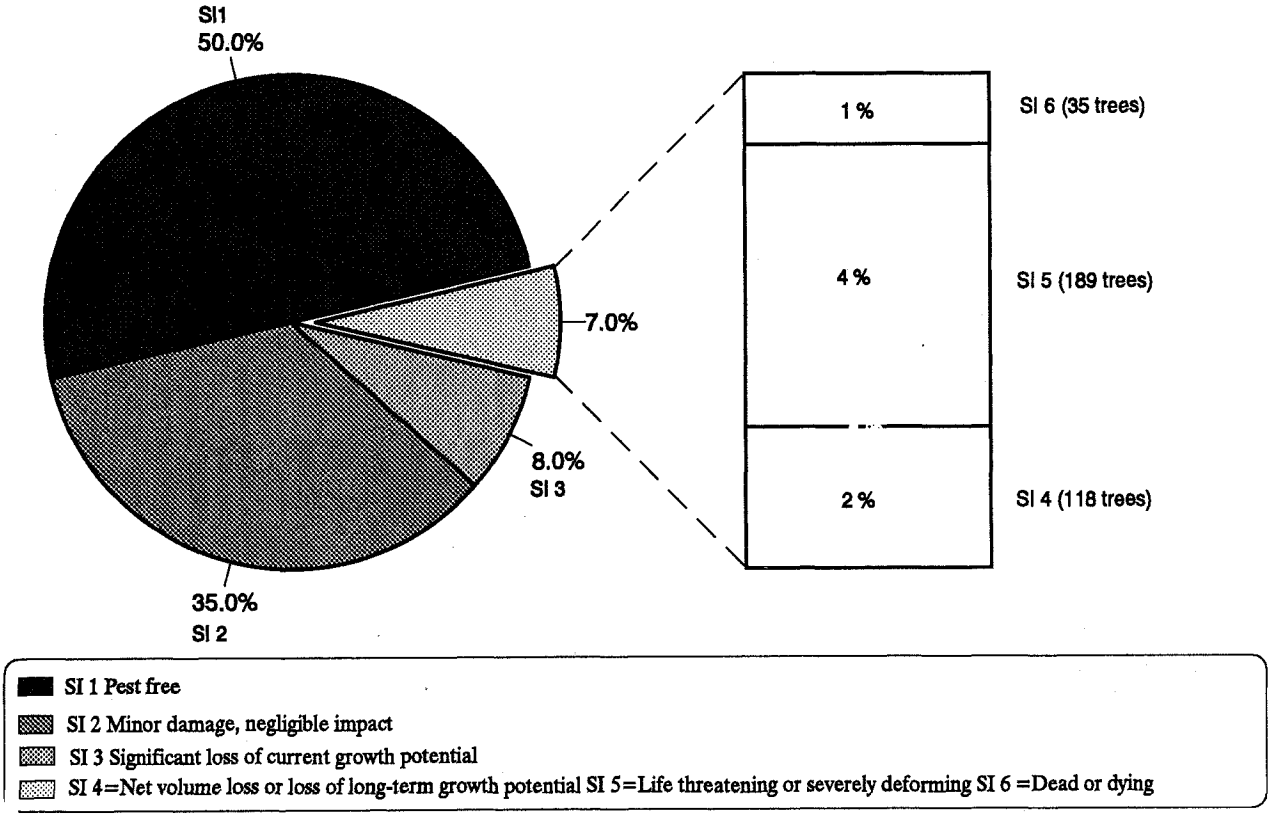

Figure 7. Summary of pests of young stands surveys, by severity index, Kamloops Forest Region, 1993.

Table 10. Summary of pests of young stands surveys, by host, Kamloops Forest Region, 1993.

Host/Pest [1]	No. stands affected	% of trees affected [2] Avg	Min	Max	Severity [3] Index
Lodgepole pine - 2815 trees in 35 stands, 1089 trees were pest free					
Armillaria root disease	2	13	6	21	6,5,2
Animal damage	10	5	1	25	6,5,4,3,2
Mechanical damage	18	4	1	15	6,5,4,3,2
Western gall rust	20	4	1	14	5,4,3
Warren's root collar weevil	5	1	1	2	5
Abiotic	1	1	1	1	5
Pine terminal weevil	9	2	1	5	4
Dwarf mistletoe	2	1	1	1	4
Atropellis canker	1	1	1	1	4
Gouty pitch midge	4	1	1	2	3,2
Pine needle cast	21	40	3	85	3,2
Pine needle sheathminer	3	17	4	41	2
Giant conifer aphids	3	13	1	6	2
Douglas-fir - 628 trees in 25 stands, 322 trees were pest free					
Armillaria root disease	3	4	1	10	6,5
Mechanical damage	12	4	1	19	6,5,4,3,2
Animal damage	4	3	1	11	5,4,3,2
Adelgids	6	3	1	8	4,3,2
Abiotic damage	2	3	2	4	4,3
Needle diseases	1	36	36	36	3,2
Western spruce budworm	2	67	66	67	2
Spruce - 588 trees in 33 stands, 297 trees were pest free					
Armillaria root disease	2	3	2	4	6,5
Spruce weevil	2	9	4	12	4
Mechanical damage	5	2	1	3	4,3
Adelgids	23	9	1	63	3,2
Abiotic damage	1	3	3	3	2
Animal damage	1	7	7	7	2
Alpine fir - 507 trees in 26 stands, 305 trees were pest free					
Armillaria root disease	1	1	1	1	6
Abiotic damage	6	7	1	18	5,4,3,2
Mechanical damage	5	2	1	7	4,3
Animal damage	3	2	1	5	4,3

cont'd

Host/Pest [1]	No. stands affected	% of trees affected [2] Avg	Min	Max	Severity Index [3]
Western red cedar - 221 trees in 13 stands, 201 trees were pest free					
Armillaria root disease	2	1	1	1	6
Mechanical damage	1	1	1	1	4
Abiotic damage	1	1	1	1	3
Western white pine - 117 trees in 11stands, 69 trees were pest free					
Armillaria root disease	1	1	1	1	5
White pine blister rust	4	6	1	9	5,4,3
Mechanical damage	3	4	1	9	5,4,3

1 Other species examined which were pest free; western and mountain hemlock, western larch, aspen, cottonwood and willow.

2 Percent of trees affected includes only trees from stands in which pest occurred, and reflects % of all species in stand.

3 Severity Index:

1. pest free
2. minor damage, minimal impact
3. significant loss of current growth potential
4. net volume loss or significant long-term loss of growth potential
5. life-threatening or severely deforming
6. dead or dying

Pinewood nematode
Bursaphelenchus xylophilus

Pinewood nematode bait log trials continued in the Region in cooperation with the Council of Forest Industries (COFI) to obtain data to support an exemption for western hemlock from the ban on non-kiln dried or -heat treated softwood exports from Canada to the European Community (EC).

In the Kamloops Forest Region, a follow-up study continued to determine the survivability of pinewood nematodes under field conditions and their distribution within logs of various tree species. At Summerland, freshly cut 12 metre-long bolts of each of western hemlock, Douglas-fir and lodgepole pine were placed on the ground and inoculated with pinewood nematodes. The ends of the bolts were waxed to preserve moisture. Although the study is not fully completed, initial observations indicate that pinewood nematodes can survive through several stages within western hemlock, in the bark and cambium, but not in the xylem. If such findings are conclusive, manufactured products such as lumber would be nematode-free.

A lumber product survey for pinewood nematode incidence was also initiated as part of a provincial study. No pinewood nematodes were found in any of 578 samples collected and examined between July and September from 50 mills in the Pacific and Yukon Region. Only 6 samples contained nematodes, but none were *B. xylophilus*. The survey also found that, irrespective of lumber grade or intended markets, sap stain was found in 6% of samples, bark on 5%, and grub holes in 3% of samples. Samples included 177 western hemlock. 163 spruce, 118 true fir, and 113 Douglas-fir.

Another survey to obtain exemption of yellow cedar from the ban on non-kiln dried softwood exports was conducted primarily in the Vancouver Forest Region. None of the 31 extracted samples contained pinewood nematodes. Conclusion of several studies is expected in 1994.

Acid rain monitoring

In order to identify changes in forest vegetation and tree vigor related to air pollutants or acid rain, 15 Acid Rain National Early Warning System (ARNEWS) plots were established in British Columbia between 1984 and 1986. Baseline data was obtained for analysis of a number of parameters including conifer foliar chemistry, soils, ground cover species including lichens and mosses, natural regeneration and forest pests. In 1992 an additional 12 Biomonitoring plots were established throughout the province to better represent the biodiversity of the various biogeoclimatic zones and some of the tree species underrepresented in existing plots. In Kamloops Forest Region two new plots were established, one representing the driest forested zone (Ponderosa Pine) in B.C., located near Monte Creek. The other represented a deciduous forest and was located in a trembling aspen stand at Lambly Creek.

Visual assessments of plot trees and ground cover and foliage analysis were made at both newly established plots and the previously established Twin Lakes plot. No symptoms of acid or toxic rain or other air pollutants were found at any of the sites. Some minor feeding damage on Douglas-fir foliage by spruce budworm was noted at Twin Lakes and some needle feeding by a weevil, *Scythropus californicus*, occurred on ponderosa pine at the Monte Creek site. Monitoring at all three sites will continue in 1994.

Deciduous Pests

Satin moth
Leucoma salicis

Trembling aspen and black cottonwood were lightly to moderately defoliated on 240 ha, a reduction from 960 ha defoliated in 1992. The largest area was comprised of four patches of moderate defoliation near Mt. Tod along Louis and McGillivray creeks. Many of the aspen in these stands were totally stripped, but had partially refoliated by mid-August. Previous defoliation has resulted in some minor branch dieback in this area. Two infestations were comprised of 70 ha of moderate defoliation near Mabel Lake, down from 100 ha in 1992. Pockets of infestation of up to 25 ha each continued for the second year west of Lillooet along Hurley River and at Bralorne, and near Keremeos on 10 ha at Larcan Creek. Elsewhere, occasional single trees and small groups of trees were severely defoliated along Carpenter

Lake, near Anarchist Mountain, and along Fadear Creek. No defoliation was observed in previously infested stands near Peachland or along Lambly Creek in the Okanagan Valley.

No identified tree mortality has resulted from recent satin moth feeding, but continued infestation of stands severely defoliated for two consecutive years, may result in branch dieback and occasional tree mortality.

Gypsy moth
Lymantria dispar

No male gypsy moth adults were caught in any of 42 pheromone-baited traps distributed in provincial parks throughout the Kamloops Forest Region by FIDS staff. The total number of moths trapped in British Columbia in 1993 declined to 141, from 166 in 1992, and included two of the Asian biotype not found since first identified in 1991.

The capture of 61 moths of the European strain in Richmond in 1992, prompted aerial and ground applications of *Bacillus thuringiensis* var. *kurstaki* on 710 ha in April and May, 1993. This eradication effort appeared successful. Some additional ground treatments and intensified trapping were implemented in areas where high trap numbers were recorded in 1992 at Hope, east of Parksville and Salt Spring Island.

Other Noteworthy Pests Currently Active in the Kamloops Forest Region, 1993

Host and Pest	Location	Remarks
Douglas-fir		
A Douglas-fir needle midge *Contarinia pseudotsugae*	Little Fort - Clearwater	Extensive discoloration and subsequent needle drop on roadside and undergrown regeneration.
A rust hyperparasite *Sphaerellopsis filum*	Voght Valley	A hyperparasite of *M. medusae*. A new host record.
Conifer-aspen rust *Melampsora medusae*	Voght Valley	Up to 70% foliage infection on 50% of trees in young stands.
Green-striped forest looper *Melanolophia imitata*	widespread	Common in collections; avg. 4 larvae/beating sample.
Laminated root rot *Phellinus weirii*	Whistle Creek	Pockets of 4-5 trees scattered throughout 30 to 80 year old stands.

Host and Pest	Location	Remarks
Lodgepole Pine		
A gall mining Dioryctria *Dioryctria* sp.	Stirling Creek	Common in western gall rust galls.
Pine needle sheathminer *Zelleria haimbachi*	widespread	Decline. Only very light discoloration in small widely scattered stands.
Warren's root collar weevil *Hylobius warreni*	Bigg Creek, Stirling Creek	Less than 5% tree mortality; common elsewhere in young plantations.
Western pine-aster rust, *Coleosporium asterum*	Georges Creek	Average 25% of needles infected on 80% of young pine in several stands.
Winter damage	Coquihalla Hwy	Foliage desiccation on young fringe growing trees between Coldwater R. and Toll Booth. < 5% tree mortality.
Salt damage	Hwy 97C (Connector)	Scattered tree mortality and foliage discoloration; mostly on lodgepole pine below road grade.
Ponderosa pine		
Annosus root disease *Heterobasidion annosum*	Naramata	New host record.
A pine needle blight *Lophodermium* sp.	Voght Valley	Severe foliage discoloration on mature pines in area.
Armillaria root disease *Armillaria ostoyae*	Shingle Creek, Summerland McPhail Creek	Scattered mortality of young trees on 20 ha in each area.
A twig beetle, *Pityophthorus* sp.	Okanagan Mtn Park	Severe localized tip flagging on open growing trees.
Pine needle scale *Chionaspis pinifoliae*	Monte Creek, Winfield to Kelowna	Causing stunted deformed tops; up to 60% foliage infested on 30% of multi-aged pines.
Porcupine	Guichon Creek Blue Lake	Top-kill on scattered immature trees.
Red turpentine beetle *Dendroctonus valens*	Okanagan Valley	Scattered mortality in young pines; often associated with western pine beetle infestations.

Host and Pest	Location	Remarks
Western pine moth *Dioryctria cambiicola*	McIntyre Bluff	Up to 30% shoots infested on young pines in two localized stands.
Whitebark pine A pine needle blight *Leptomelanconium allescheri*	Mt. Riordan	Causing needle dieback on 50% of pines.
Squirrels	Mt. Riordan	Shoot and bud removal; dead tips common.
White pine blister rust, *Cronartium ribicola*	Mt. Riordan	Branch and stem cankers on 10% of pines in scattered areas; occasional top-kill.
Spruce white pine weevil *Pissodes strobi*	Juliet Creek	Old and new attack on 50% of planted spruce on 60 ha. Current attack 5%.
Alpine fir An alpine fir bark beetle *Pityokteines sp*	McPhail Creek	Associated with 10% mortality of young stands.
Fir-blueberry rust *Pucciniastrum goeppertianum*	Hurley River, Duffey Lake	Moderate foliage discoloration on 30% of mixed-age trees.
Fir-fireweed rust *Pucciniastrum epilobii*	North Thompson Valley, Winnifred Creek	Up to 50% foliage discoloration on 30-60% of regeneration in localized areas.
Balsam woolly adelgid *Adelges piceae*	Manning Park (3), Thynne Mtn., Hurley River	NEGATIVE - 5 areas examined.
Western hemlock Western blackheaded budworm *Acleris gloverana*	Wells Gray Park, Adams Lake, Mission Pass, Sugar Lake	Increase. Common, avg. 5 larvae per sample.
Western yew Yew big bud mite *Cecidophyopsis psilaspis*	Moonbeam, Storm, Yard creeks, Perry River	NEGATIVE - 4 areas examined.
Poplars A leaf beetle *Chrysomela* sp.	Inkaneep	Light defoliation of black cottonwood in park.

Host and Pest	Location	Remarks
Poplar borer *Saperda calcarata*	Lambly Creek Cayoosh Creek	Attacks to 5% of trembling aspen. Attacks to 20% of black cottonwood.
Birch		
A birch leafminer *Lyonetia speculella*	Adams Lake, Rock Cr. Rd.	Up to 25% foliage discoloration in scattered birch stands.
Willow		
European leafroller *Archips rosana*	Carpenter Lake	Moderate defoliation on roadside willow.
Elm		
Elm leaf beetle *Pyrrhalta luteola*	Vaseux Lake, Okanagan Falls	Light to moderate defoliation in parks.
Other deciduous hosts		
Fall webworm *Hyphantria cunea*	widespread	Scattered light to moderate and occasional severe defoliation on deciduous roadside trees and shrubs.
Uglynest caterpillar *Archips cerasivorana*	Adams River	Light defoliation of chokecherry along lower Adams River.
Sapsuckers	Clearwater	Typical horizontal hole drilling damage common in area on mountain ash.

Appendices

The following appendices are available upon request from the Forest Insect and Disease Survey, Pacific Forestry Centre, Natural Resources Canada, 506 West Burnside Road, Victoria B.C. V8Z 1M5.

I. Maps of major 1993 beetle and defoliator infestations in Kamloops Forest Region.

II. Summary of pest problems in provincial parks within the Kamloops Forest Region, 1993.

III. Details of pheromone trap programs, Kamloops Forest Region, 1993.

IV. Pest Reports:

- Pine Needle Cast, *Lophodermella concolor* in the Kamloops Forest Region, July 1993. H.P. Koot.
- Douglas-fir tussock moth in Kamloops Forest District, July 1993. H.P. Koot.
- Summary of forest pest conditions in the Kamloops Forest Region, August 1993. Janice Hodge.
- Western spruce budworm in British Columbia, 1993 and forecast for 1994. November 1993. P. Koot, J. Hodge, R. Turnquist, E. Erickson, and A. Stewart.
- Western hemlock looper in British Columbia, 1993 and forecast for 1994. A. Stewart, N. Humphreys, P. Koot, R. Erickson. December 1993.

During the FIDS field season from May to October, correspondence can be directed to:

Forest Insect and Disease Survey
Natural Resources Canada
1379 Dominion Crescent
Kamloops, B.C.
V2C 2X2 Ph. 372-1241

Forest Insect and Disease Survey
Natural Resources Canada
R.R.#4, Site 92
Summerland, B.C.
V0H 1Z0 Ph. 494-8742

or, throughout the year to:

Forest Insect and Disease Survey
Natural Resources Canada,
Pacific Forestry Centre
506 West Burnside Rd.
Victoria, B.C.
V8Z 1M5 Ph.363-0600

Additional copies of this report or related publications such as provincial and national pest survey overviews, forest pest leaflets, and regional forest pest histories, can be obtained from FIDS at the above address.