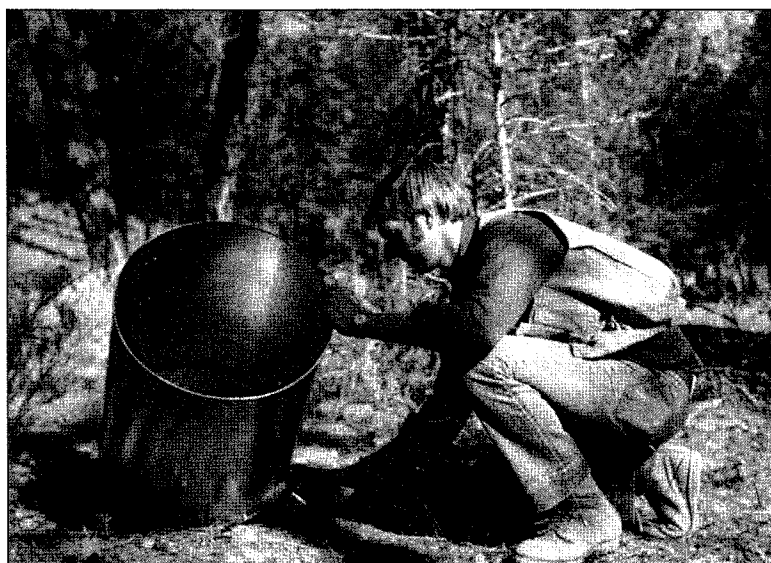
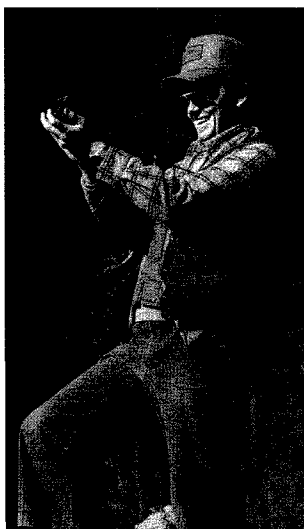


Forest Insect and Disease Conditions

Nelson Forest Region • 1993

Leo Unger and Alan Stewart



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Foreword

The Forest Insect and Disease Survey (FIDS) is a national unit in the Canadian Forest Service responsible for:

- (1) an overview of forest insect and disease conditions and their implications, including forecasts when possible;
- (2) records and surveys to support quarantines;
- (3) supporting forestry research, herbaria and insect collections;
- (4) providing independent advice, extension, and technology transfer;
- (5) developing and testing survey techniques;
- (6) related biological and impact studies.

The cooperation of federal, provincial and local government agencies, industry, and academic establishments is essential to effectively fulfill these mandates and is greatly appreciated.

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

Forest Insect and Disease Survey
Canadian Forest Service
Box 120
Wasa, B.C.
V0B 2K0 Ph. 422-3465

Forest Insect and Disease Survey
Canadian Forest Service
Box 7
New Denver, B.C.
V0G 1S0 Ph. 358-2264

or throughout the year to:

Forest Insect and Disease Survey
Canadian Forest Service
506 West Burnside Road
Victoria, B.C. V8Z 1M5 Ph. 363-0673

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

Introduction

This report outlines forest insect and disease conditions in the Nelson Forest Region and Kootenay, Yoho, Glacier, and Mt. Revelstoke National parks in 1993, highlighting those that cause forest management problems and forecasting population trends. Agents are discussed by host, in order of importance, often within the context of a management unit or Timber Supply Area (TSA).

The 1993 field season extended from mid-May to mid-October with about 120 insect and disease collections submitted to the Pacific Forestry Centre. About 400 contacts and on-site pest examinations were made with a wide range of groups and individuals, including the B.C. Forest Service, industry, parks, and general public. New slide documentation of numerous pest concerns was collected to update existing files. Fixed-wing aerial survey time (\pm 36 hours) and assistance in producing preliminary sketch maps was provided by the B.C. Forest Service; 5 hours of helicopter time was provided by Pope and Talbot Ltd. for a more detailed survey of the northern half of TFL 23.

Incidences of trees killed by bark beetles are defined as: **light**= <10% of a stand; **moderate**= 10 to 30%; **severe**= >30%. Defoliation is defined by intensity as: **light**= <25% of foliage gone, usually limited to the upper crown; **moderate**= 25 to 65% defoliation, usually extending down into the mid-crown; **severe**= >65% defoliation, usually throughout the crown.

The following current information and recent reports are available upon request:

- * Maps of major beetle and defoliator outbreaks, Nelson Forest Region, 1993.
- * Summary of pest problems in provincial parks, Nelson Forest Region, 1993.
- * Summary of pest problems in young stands, Nelson Forest Region, 1993.
- * A new regional pest history:
 - Graphs of recorded forest insect outbreaks up to 1992 in the Nelson Forest Region. FIDS Report 93-9.
- * Pest reports mailed out during the year:
 - Mountain pine beetle status in the East Kootenay spring 1993. FIDS Pest Report 93-4.
 - Second year of defoliation by the satin moth in the Boundary Forest District. FIDS Pest Report 93-10.
 - Mountain pine beetle outbreaks in the West Kootenay: an early season update. FIDS Pest Report 93-11.
 - Bark beetle infestation of ponderosa pine in the West Kootenay. FIDS Pest Report 93-12.
 - Foliar diseases of pine and larch in the West Kootenay. FIDS Pest Report 93-13.
 - Summary of forest pest conditions in the Nelson Forest Region 1993. FIDS Pest Report 93-26.
 - Western spruce budworm in British Columbia 1993 and forecast for 1994. FIDS Pest Report 93-28.
 - Western hemlock looper in British Columbia 1993 and forecast for 1994. FIDS Pest Report 93-29.
 - Forest insect and disease conditions in the West Arm Demonstration Forest 1993. FIDS Pest Report 93-30.

- Forest insect and disease conditions in Mt. Revelstoke and Glacier National Parks 1993. FIDS Pest Report 93-31.
- Forest insect and disease conditions in Kootenay National Park 1993. FIDS Pest Report 93-32.
- Forest insect and disease conditions in Yoho National Park 1993. FIDS Pest Report 93-33.
- Forest insect and disease conditions in Ecological Reserves of the Nelson Forest Region 1993. FIDS Pest Report 93-34.

Summary

In this summary pests are grouped by host(s), generally in order of importance. The field season was wetter and cooler than normal; total April - September **precipitation** at Castlegar and Cranbrook was 17 and 67 percent above normal, respectively, and mean **temperatures** were cooler by 1 and 4 percent each.

Mountain pine beetle populations declined 13% overall, killing an estimated 631 500 trees over 7724 ha. The **red turpentine beetle** and other **bark beetles** killed patches of up to 30 ponderosa pine in the Boundary TSA for the second year. The accumulated impact of chronic **white pine blister rust** infections was assessed. Moderate to severe discoloration by **pine needle cast** was common in the southern half of the region, 71 000 ha were mapped. A **Dioryctria borer** girdled young trees in part of the Kootenay River drainage. A preliminary assessment of **whitebark pine decline** was done.

Defoliation by the **western hemlock looper** expanded to 48 500 ha in the fourth year of an outbreak expected to decline in 1994. Defoliation by the **western blackheaded budworm** remained light near Kootenay Lake and west of Donald. The **gray spruce looper** remained endemic, continuing host mortality was assessed.

Douglas-fir beetle outbreaks were stable over about 22 ha, mainly in the Rocky Mountain Trench. High levels of **Douglas-fir needlecast** reduced growth in young stands over 19 000 ha. Defoliation by **western spruce budworm** was trace in the southwest and expected to remain minor in 1994. The **Douglas-fir tussock moth** remained endemic.

Mortality due to the **spruce beetle** again increased north of Golden with 105 ha mapped. **Spruce weevil** attacks were relatively stable overall.

Defoliation by **two-year-cycle spruce budworm** increased overall due to an outbreak in the Monashee Mountains. Chronic **western balsam bark beetle** outbreaks continued through the host range.

Patches of moderate to severe discoloration by **larch needle blight** occurred in most of the host range. **Larch casebearer** declined to near-endemic levels. A **larch shoot moth** killed 5% of terminals in spaced stands near Windermere Lake.

Tomentosus root disease was detected in about 40% of Engelmann spruce and lodgepole pine in 4 East Kootenay drainages. **Armillaria root disease** remained the most important cause of mortality in regeneration and existing stands. **Rhizina root disease** remained patchy, detected in 10 of 13 burned clearcuts with seedling mortality up to 30%. An average of 4% of trees in 26 of 50 young stands surveyed were damaged by **mammals**. Low levels of **black army cutworm** are not expected to rise in 1994. No **gypsy moth** were caught at 33 sites trapped.

Defoliation of aspen by the **satin moth** increased near Golden to 2700 ha and declined in the Boundary TSA to 240 ha. **Leafminers** infested birch, alder and black cottonwood in the northern half of the region. **Aspen leafrollers** moderately defoliated 300 ha along the Kicking Horse River. The **alder woolly sawfly** was collected near Revelstoke, the first time in the Interior.

Pests of young stands surveys were done in 50 stands established or treated under Canada-B.C. Forest Resource Development Agreements; of all trees surveyed 6% had pests leading to mortality and 9% causing growth loss. A FIDS-Council of Forest Industries study to exempt western hemlock from **pinewood nematode** export restrictions continued. No significant damage was recorded at 3 **Acid Rain National Early Warning System (ARNEWS)** and **biomonitoring** plots.

Other noteworthy pests not surveyed annually or currently at low levels are tabulated.

Pine Pests

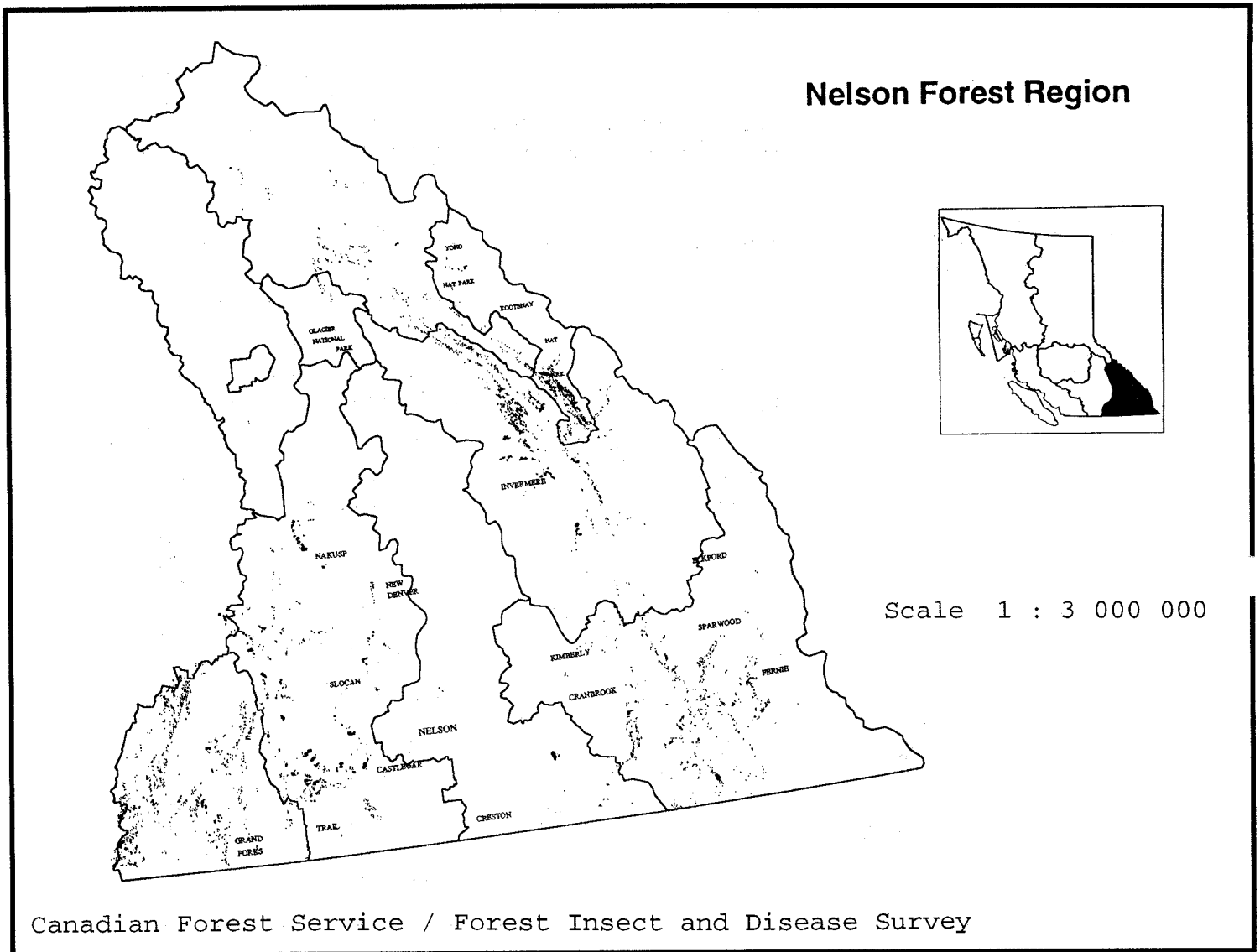
Mountain pine beetle *Dendroctonus ponderosae*

Mountain pine beetle killed mainly lodgepole pine and occasionally western white and ponderosa pines on 7724 ha region-wide (Table 1, Map 1), down for the fourth year and 13% less than in 1992 (Chart 1). The decline was mainly in the Cranbrook and Boundary TSAs, overshadowing increases in the Arrow, Kootenay Lake and Golden TSAs.

Table 1. Annual occurrence and impact of the mountain pine beetle. FIDS, Nelson Forest Region 1993.

Management unit	Number of infestations	Area (ha)	Trees killed (faders) ¹	
			Number	Vol. (m ³)
Boundary TSA	1 062	960	81 800	29 500
Arrow TSA	608	3 800	252 500	101 000
Revelstoke TSA	7	2	30	30
Kootenay Lake TSA	39	290	2 500	10 000
Cranbrook TSA	903	436	71 000	25 500
Invermere TSA	905	1 376	137 000	49 400
Golden TSA	199	95	7 000	3 000
TSA Total	3 723	6 959	551 830	218 430
Kootenay National Park	589	715	77 900	28 050
Glacier National Park	21	30	1 140	1 140
Yoho National Park	33	20	600	300
Mt. Revelstoke Nat. Park	0	0	0	0
National Parks Total	643	765	79 640	29 490
Regional Total	4 366	7 724	631 470	247 920

¹ Trees attacked in 1992, discolored in 1993.



Map 1. Areas with pine recently killed by mountain pine beetle as determined by ground and aerial surveys in 1993.

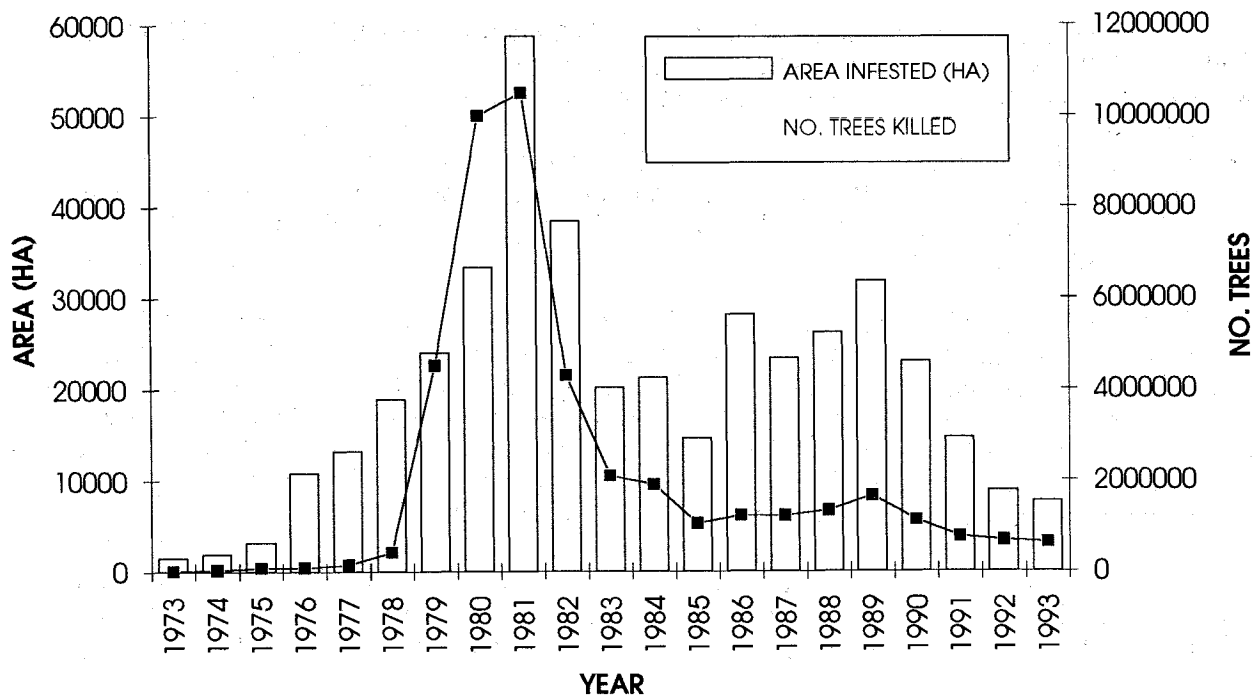


Chart 1. Mountain pine beetle infestations from 1973 to 1993 in the Nelson Forest Region. FIDS, Nelson Forest Region 1993.

Following a slight increase in 1992, the area of red trees mapped in the **Boundary TSA** declined 69% to 960 ha in 1993. The decline was attributed to host depletion in chronic outbreak areas and low brood survival in remaining smaller trees due to overwintering mortality and predation. Significant new outbreaks occasionally still occur in previously uninfested stands, often at higher elevations such as the upper Boundary Creek area. Severe infestations, mainly spot outbreaks of up to 25 trees each, are currently 19% of the area mapped, 59% was of moderate incidence, and 22% was light.

The area of red trees mapped in the **Arrow TSA** increased for the second year, reaching 3800 ha compared to 1390 ha in 1992. Most of the increase was in and near existing outbreaks in the southern half of the TSA, though significant new outbreaks again occurred in drainages east of Upper Arrow Lake and at higher elevations near the Slocan Valley. Severe infestations, mainly spot outbreaks, were 12% of the area mapped, 51% was of moderate incidence, and 37% was light.

Infestations remained at the low levels of recent years in the **Revelstoke TSA**, consisting of 7 spot outbreaks along the east shore of Upper Arrow Lake and in the Illecillewaet River valley. Most of these lingering spot outbreaks are in or near mixed stands with relatively few lodgepole or white pine to spread to. Scattered infested white pine had usually been weakened by white pine blister rust.

The area of red trees mapped in the **Kootenay Lake TSA** increased for the second year, tripling to 290 ha in 1993. Most of the increase was near the Goat River at Bohan Creek, with few scattered spot outbreaks remaining fairly constant near Hawkins and Freeman creeks and Kitchener and Moyie rivers. Severe infestations (spot outbreaks) were 4% of the area mapped with the rest at moderate incidence.

The area of infestation in the **Cranbrook TSA** decreased to 436 ha from 2200 ha in 1992 and 8580 ha in 1991. The number of faders declined throughout the TSA except for Moyie Lake and Wildhorse Creek where slight increases occurred. Minor infestations continued along the Elk River near Fernie, south of Cranbrook along Teepee, Gold and Caven creeks, and along the Bull and St. Mary rivers. Reductions were attributed to several factors: low spring brood survival in 1992 as trees dried out before larvae matured, leading to a small flight; brood mortality due to high predator levels after major beetle populations; and high numbers of attacks pitched out in 1992.

There was a 55% increase in the number of trees mapped in the **Invermere TSA** despite relatively little change in the area of infestations. Outbreaks continued to expand along the Columbia River and lower portions of side drainages north of Radium Hot Springs, Forester Creek, and at Whitetail Lake. Infestations remained relatively stable in the Toby and Horsethief creek drainages. Large older infestation areas along the east side of Columbia and Windermere lakes continued to decline. Previously increasing populations to the west of Steamboat Mountain, along Frances Creek and in the Cartwright lakes area started to decline.

There was close to a three-fold increase in the number of recently killed lodgepole and white pine in the **Golden TSA**. Increasing infestations were recorded along the Columbia River south of Golden, at Waitabit Creek, and in small groups of trees in the upper Kootenay River drainage north of Kootenay National Park. Small populations persist along Blackwater Ridge, Glenogle Creek, Beaver River, lower Columbia Reach, near Lyell Creek, at Split Creek in the Blaeberry River drainage, and scattered north of Bush Harbor along McNaughton Lake.

The main infestations in **Kootenay National Park** remain in the Daer to Pitts creeks area, with dispersing beetles increasing the size and number of outbreaks to the north and south park boundaries. Infestations are subsiding in younger stands along Sinclair Creek. In **Yoho National Park** the number of faders mapped and the area with beetle mortality doubled. The main infestation remained along the Kicking Horse River across from Field, with an increase in the number of spot infestations of ± 5 trees to the southwest and into the Beaverfoot River drainage. Populations in **Glacier National Park** remained relatively stable in chronically infested white pine at the Beaver River and Mountain Creek junction, and there was little change in the number of small groups of recently killed white pine nearby. Although no spot outbreaks were mapped during aerial surveys of **Mt. Revelstoke National Park**, scattered white pine infected by white pine blister rust were occasionally infested.

Forecasts

Overall, the number of trees discoloring in 1994 should increase in the East Kootenay and decrease in most of the West Kootenay. Brood sampling indicated an increased flight at 13 of 31 sites while decreasing at seven (Table 2). Current attack levels from fall cruise data (Table 3) generally agreed with spring "R" value forecasts. Forecasts are grouped according to distinct outbreak areas with some overlap between TSAs where outbreaks are continuous.

Boundary and southern Arrow TSAs

Spring assessments of overwintering survival (Table 2) revealed a population decline at most locations in this outbreak zone. This was attributed to winter brood mortality in smaller trees attacked due to depletion of larger hosts, and predation by woodpeckers. Fall cruises (Table 3) confirmed that the outbreak declined after the 1993 beetle flight with ratios of current to red attack averaging 0.8:1, 57% of the 1992 level.

Table 2. Overwinter survival and population status of the mountain pine beetle. FIDS, Nelson Forest Region 1993.

Location	"R" value ¹	Population status ²	Location	"R" value	Population status
<u>Boundary TSA</u>			<u>Cranbrook TSA</u>		
u. Boundary Ck.	6.2	Increasing	Barkshanty Cr.	5.6	Increasing
Mt. Baldy	3.1	Static	Caven Creek	4.4	Increasing
l. Boundary Ck.	2.8	Static	Teepee Creek	4.2	Increasing
Phoenix Mtn.	2.2	Decreasing	Etna Creek	3.4	Static
Beaverdell	2.0	Decreasing	Bull River	2.8	Static
Carmi	1.5	Decreasing	Fernie	2.7	Static
Grano Creek	1.5	Decreasing	<u>Invermere TSA</u>		
Burrell Creek	0.8	Decreasing	Cartwright lks	11.0	Increasing
State Creek	0.7	Decreasing	Pinnacle Cr	10.7	Increasing
<u>Arrow TSA</u>			Hurst Creek	5.1	Increasing
Nancy Greene Lk	5.6	Increasing	Mitchell Cr	3.6	Static
Cayuse Creek	4.4	Increasing	Horsethief Cr	3.6	Static
Deer Creek	3.9	Static	<u>National Parks</u>		
Blueberry Creek	1.8	Decreasing	Field	4.9	Increasing
<u>Kootenay Lake TSA</u>			Mountain Creek	11.4	Increasing
Yahk	3.7	Static	Kootenay Xing	3.8	Static
<u>Golden TSA</u>					
Waitabit Creek	9.2	Increasing			
12 Mile Creek	6.4	Increasing			

¹ "R" value = an average population trend, derived in spring from the number of insects relative to the number of entrance holes in representative bark samples at DBH.

² Interpretation of "R" values: <2.5 = decreasing population; 2.5-4.0 = static population; >4.0 = increasing population.

Revelstoke, Kootenay Lake, and northern Arrow TSAs

Spot infestations are expected to remain at relatively low levels, as they have for several years, with expansion in some areas as fire-regenerated pine stands age to favor successful brood production. Scattered infestation of white pine weakened by blister rust will continue.

Cranbrook and southern Invermere TSAs

Populations were relatively stable in this area as forecast by spring brood sampling. Current attacks increased marginally to the south of Cranbrook along Teepee, Caven, and Gold creek drainages. There was a minor decline in the Moyie Lake area as infestations moved into younger stands and a large decrease in the Elk and Bull river drainages. Cool weather extended the beetle flight causing variable development with late broods vulnerable to overwintering mortality.

Table 3. Status of lodgepole and white pine in stands infested by mountain pine beetle, from fall prism cruises. FIDS, Nelson Forest Region 1993.

Location	Percent of pine attacked				Percent healthy
	Current (1993)	Partial ¹ (1993)	Red (1992)	Grey (pre-1992)	
<u>Boundary TSA</u>					
Boundary Creek	14	8	21	15	42
Beaverdell Creek	13	3	19	10	55
Mt. Baldy Road	11	6	19	13	51
Walker Creek	11	5	12	3	70
<u>Arrow TSA</u>					
Nancy Greene Lake	28	2	18	10	43
Gem Hill	12	0	26	3	59
Cayuse Creek	6	14	18	30	31
<u>Cranbrook TSA</u>					
Moyie Lake	39	6	16	4	35
Teepee Creek	27	2	22	9	40
Caven Creek	13	12	10	10	55
Fernie	4	9	17	5	65
<u>Invermere TSA</u>					
Pinnacle Creek	32	3	14	4	47
Frances Creek	27	1	18	1	53
Parson	22	9	11	1	57
<u>Golden TSA</u>					
12 Mile Creek	30	7	6	4	53
Waitabit Creek	26	7	12	3	52
<u>National Parks</u>					
Dog Lake	39	9	13	3	36
Kootenay Crossing	23	9	19	3	46
Field	3	18	27	6	46
Regional Average	20	7	17	7	49

¹ The partial attacks include pitchouts.

Golden and northern Invermere TSAs

With spring brood "R" values averaging 7.7 followed by 27% current attack, populations again expanded in existing and scattered new pockets. Leave strips in the general Steamboat Mountain--Frances Creek area remain highly vulnerable. Just north of this area large trees are producing good broods with wide dispersal and scattered attack in mixed stands complicating control programs.

Most infestations north of Golden are still quite focused but beginning to disperse and require more management. More spot outbreaks can be expected in the TSA portion of the Beaverfoot--Kootenay river drainages as large populations in Kootenay National Park disperse after host depletion. The control program should reverse this trend, especially in newer and smaller infestations north of Steamboat Mountain, including Golden TSA.

National Parks

In **Kootenay National Park** brood and cruise data indicate that populations will increase again. While older infestations between Daer and Pitts creeks decline due to host depletion, outbreaks both south and north along the Kootenay River will grow in size and number. Infestations along Sinclair Creek are expected to continue declining as mature pine are depleted. The outbreak near Field in **Yoho National Park** is expected to decline after late spring brood mortality when the trees dried out before beetle maturation. Smaller pockets of beetle-caused mortality should continue increasing to the south along the Kicking Horse and Beaverfoot rivers. In **Glacier National Park** the main infestation at Mountain Creek is expected to continue to spread in adjacent white pine stands after exceptionally large brood production in 1992 - 1993. Populations are expected to remain low in **Mt. Revelstoke National Park**.

Red turpentine beetle *Dendroctonus valens*

For the second year patches of usually about 5, but occasionally up to 30, ponderosa pine were killed by bark beetles throughout the host range in southern areas of the Boundary and Arrow TSAs. Patches of currently-dying (red stage) trees numbered 170, up from 140 in 1992, again most frequent in the Bridesville to Greenwood and Rock Creek to Beaverdell areas. Most initial attacks were again by the red turpentine beetle, in the first meter of bole, followed by the mountain pine beetle, western pine beetle, *D. brevicornis*, and Ips beetles, *Ips pini* and *I. emarginatus* throughout the bole. In the larger patches trees of all sizes were infested.

Additional infestation is likely considering the scattered and intense nature of these outbreaks and potential host trees remaining. Brood survival has been good in these thick-barked trees with less than 5% overwintering mortality observed. Limited sampling to determine if blackstain root disease, *Leptographium wageneri*, was a pre-disposing agent was negative. Only a sapstaining fungi, *Ceratocystis* sp., introduced by the bark beetles was detected.

White pine blister rust *Cronartium ribicola*

This introduced disease continues to kill trees in high numbers, decreasing the biodiversity of stands within the range of white, limber and whitebark pines. The scattered occurrence of infections, discoloration for several years before mortality, and occasional secondary infestation by bark beetles preclude an accurate regional determination of annual impact. The following bark beetles have been collected mass attacking rust-infected white pine: mountain pine beetle, red turpentine beetle, Ips beetles, and, from 1993 collections at Enterprise and Apex creeks, *Pityogenes fossifrons*.

Accumulated impact was assessed in 12 representative natural stands in 1993 (Table 4). Cumulative mortality of the white pine component averaged 31%, with an additional 42% stem-cankered but still alive, 12% branch-infected, and 15% healthy. Living stem-cankered trees were either top-killed only, from high stem cankers, or were in the process of dying from lower cankers. Variation within infection categories should decline as the stands age and infections progress. Variable spread within stands and individual trees is expected due to local factors such as alternate host availability, site index, and so on.

Table 4. Accumulated impact of white pine blister rust in representative natural stands. FIDS, Nelson Forest Region 1993.

Location	Stand age	Percent of western white pine			
		Healthy	Branch-infected	Stem-cankered	Dead
Dry Creek	17	36	20	30	14
Fosthall Creek	18	30	10	36	24
Lardeau River	20	24	8	36	32
Summit Lake	29	16	10	41	33
Lardeau River	32	4	12	42	42
Kaslo River	35	3	10	49	38
Enterprise Creek	37	12	12	56	20
Mars Creek	44	18	14	48	20
Kokanee Creek	46	8	10	32	50
Carnes Creek	47	14	14	32	40
Three Forks	60	9	19	41	31
LaForme Creek	65	6	10	60	24
Average		15	12	42	31

Researchers at the Pacific Forestry Centre continue to study genetic variations in several general infection areas in the region. Collections were submitted from white pine at Enterprise Creek, limber pine near Golden, and whitebark pine in the Galton Range.

Pine needle cast *Lophodermella concolor*

For the third year, year-old lodgepole pine needles were killed by *L. concolor* at moderate to high levels through much of the southern half of the region and trace to light levels in the north. Understory and young open-grown trees were again the most severely affected. Over 71 000 ha of discolored mature stands were mapped compared to 33 000 ha in 1992, conservative figures since discoloration was masked by new foliage in many areas when mapped. Some of the larger areas were 18 000 ha in the Flathead-Wigwam river areas, 32 000 ha in the Bloom - Yahk - Hawkins creeks area, 4500 ha in the Bull River drainage, 5500 ha along the Elk River, 2000 ha along Teepee Creek, and an undetermined area across the Blueberry - Paulson summit plateau.

Many young stands of regeneration have little foliage left after two years of severe needlecasting and there is the possibility of scattered mortality in addition to the usual impact of 50 to 70 percent annual growth loss. Moist June weather favored infection of 1993 foliage and continued discoloration is forecast for 1994. A secondary fungus, *Hendersonia pinicola*, was present in most collections of *L. concolor*, causing further blighting of infected needles.

A Dioryctria sp. borer

This versatile insect caused occasional stem girdling of young lodgepole pine, mainly in the Kootenay River drainage from Whiteswan Lake north to Kootenay National Park. Activity was initiated by either chainsaw nicks or rust galls. Girdling averaged 72% (range 40 to 100%) when initiated by minor chainsaw injury and less than 25% near *Endocronartium harknessii* galls since the insects stayed near the galls.

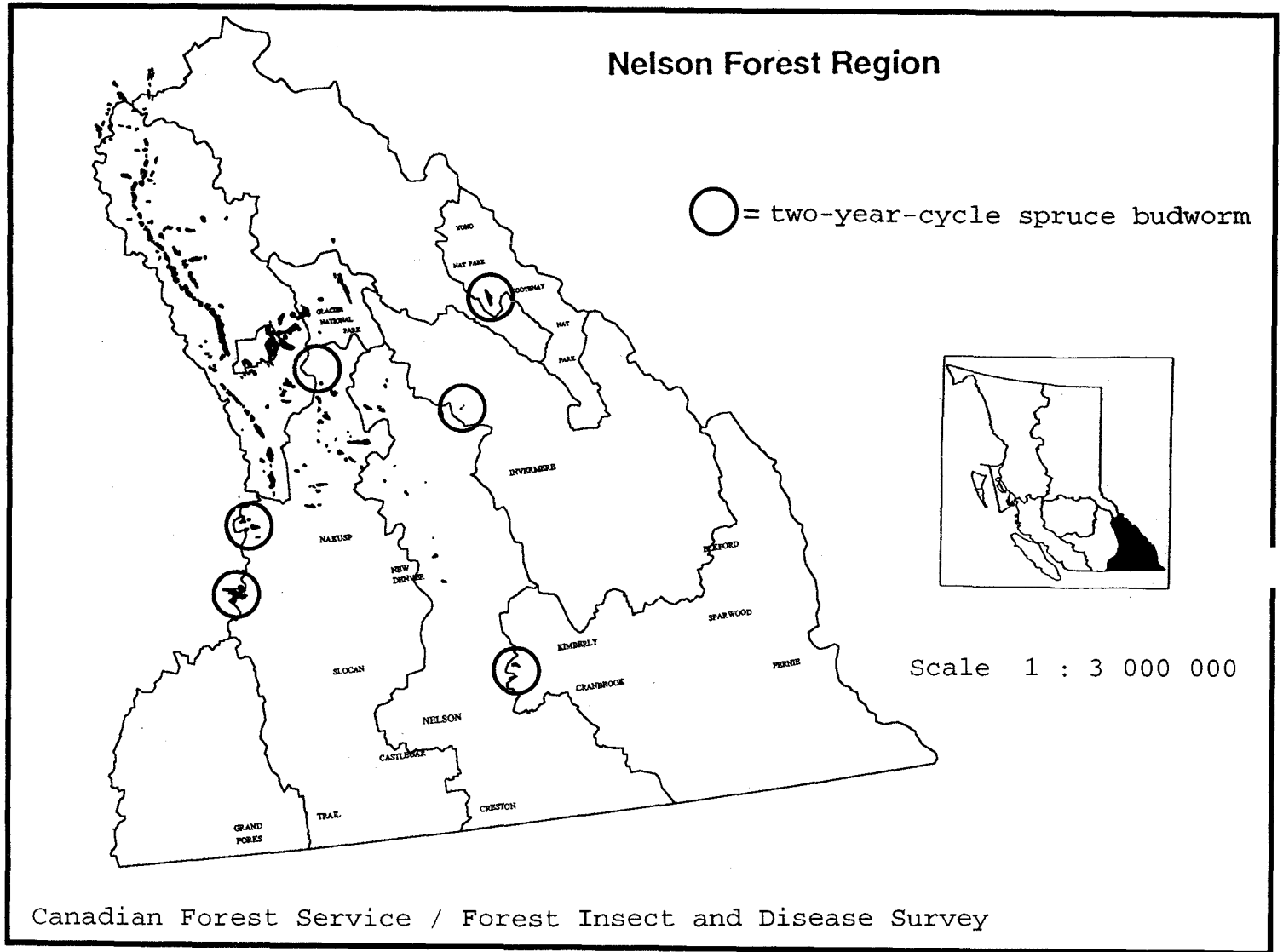
Whitebark pine decline

A preliminary assessment of this decline/dieback involved a strip of 50 host trees in the Galton Range of which 78% were recently dead or severely declining. The stand was 17% whitebark pine, 30% lodgepole pine, 38% Engelmann spruce and 15% alpine fir. Detailed examination of 5 severely declining whitebark pine found advanced decay caused by *Inonotus* root disease, *Inonotus* sp., extending up the stem for 1 to 2 m. White pine blister rust was also present on each tree but was of minor consequence except one tree with 2 m of top-kill. A similar decline on 62% of the lodgepole pine was less severe and mortality was below 5%.

Hemlock Pests

Western hemlock looper *Lambdina fiscellaria lugubrosa*

Defoliation of mature to overmature western hemlock-western red cedar stands by the western hemlock looper increased by 3% to 48 500 ha in the fourth year of an outbreak (Table 5, Map 2). However, feeding intensity declined with 59% of current defoliation moderate to severe compared to 92% in 1992. Defoliation also continues in portions of the Prince George, Kamloops, and Cariboo forest regions, totalling 92 750 ha provincially.



Map 2. Areas where current defoliation by the western hemlock looper and two-year-cycle spruce budworm was detected during aerial and ground surveys in 1993.

Table 5. Defoliation in the current outbreak of the western hemlock looper. FIDS, Nelson Forest Region 1993.

Year	Number of Infestations	Area defoliated (ha)			Total (ha)
		Light	Moderate	Severe	
1990	7	915	-	-	915
1991	143	3 701	3 455	1 069	8 225
1992	302	3 989	23 838	19 385	47 212
1993	216	19 900	16 350	12 250	48 500

Areas defoliated since the start of the outbreak, north of Revelstoke, continued to decline with most remaining feeding at light to moderate intensity in higher elevation stands. These included adjacent spruce and fir stands in the ESSF biogeoclimatic zone.

Farther south, in side drainages to Arrow, Trout and upper Kootenay lakes and the Illecillewaet River, moderate to severe defoliation continued with expansion in some areas. Extensive severe defoliation was particularly conspicuous along the Trans-Canada Highway from the Tangier River into Glacier National Park; stands of Douglas-fir and spruce were also occasionally defoliated. The southern extent of the outbreak reached St. Leon Creek in the Arrow drainage and Schroeder Creek west of Kootenay Lake.

Six outbreaks have been recorded in the Interior at intervals of about 8 to 9 years. These have usually caused defoliation for 2 to 3 years before collapsing, leaving extensive top-kill and scattered mortality. Regionally (Chart 2) and provincially the extent, duration, and intensity of the current outbreak are the greatest recorded in the Interior.

Forecast

Based on fall egg sampling the total area defoliated is forecast to decrease in 1994 with most declines expected in areas infested the longest (Table 6, Map 3). However, defoliation is expected to continue, with some expansion possible, in southern areas relatively recently infested. Larval disease and parasitism were low in areas of recent expansion; populations mass sampled at the Tangier and Illecillewaet Rivers averaging only 6% and 3% mortality during rearing.

Egg parasitism averaged 28% over the 15 locations sampled, approaching the 30% threshold preceding the collapse of previous outbreaks. In general, higher parasitism in areas defoliated longer is coinciding with expected population declines while egg parasitism in areas of recent expansion remains low.

In a co-operative Simon Fraser University - FIDS study, a pheromone identified in 1991 is being calibrated by relating moth catches to subsequent defoliation. This should result in an additional monitoring method to predict outbreaks and compliment forecasts based on egg sampling during outbreaks.

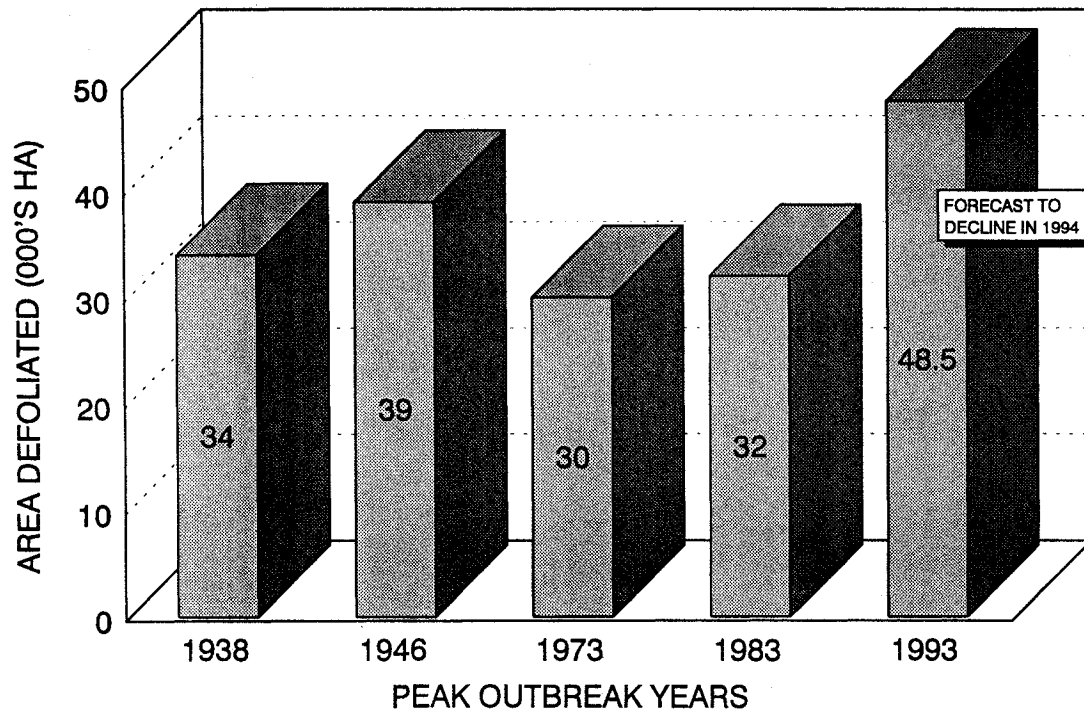
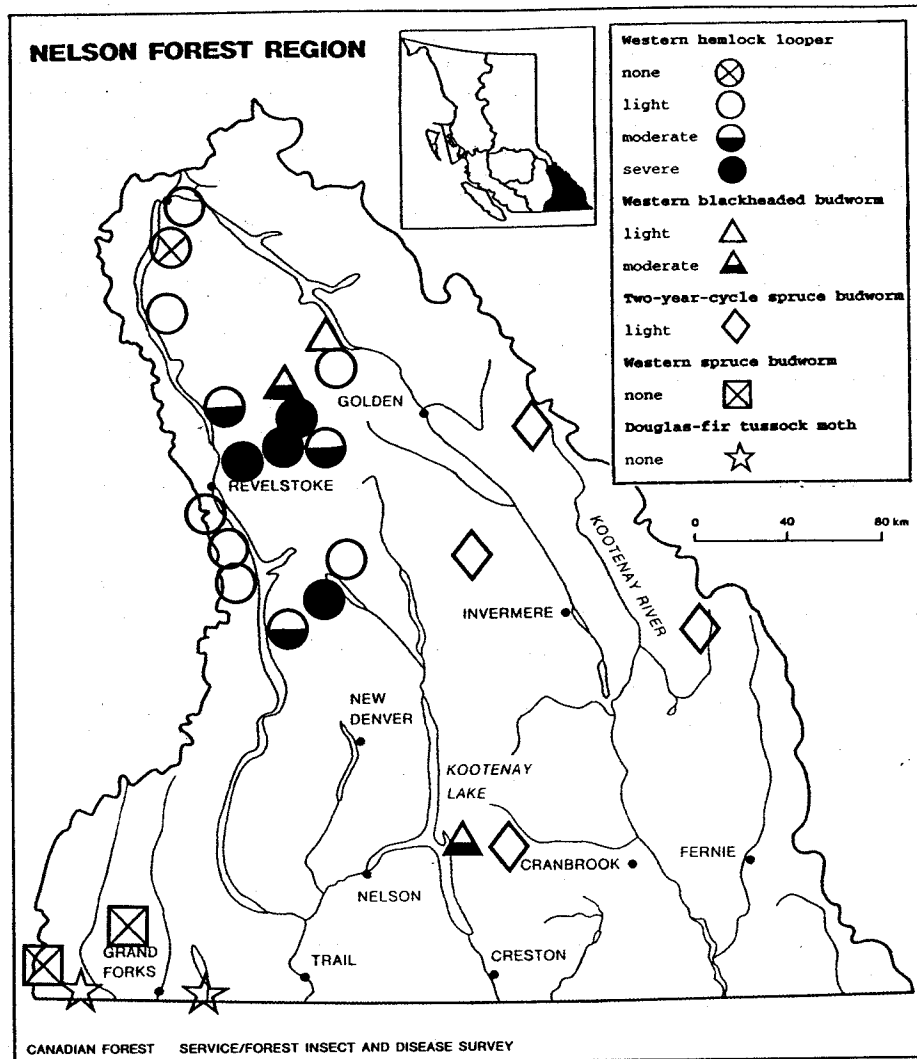


Chart 2. Maximum extent of annual defoliation during recorded outbreaks of the western hemlock looper. FIDS, Nelson Forest Region 1993.

Table 6. Results of fall egg sampling to forecast defoliation by the western hemlock looper. FIDS, Nelson Forest Region 1993.

Location	Average number eggs per 100 g lichen				Percent parasitism	Predicted 1994 defol ¹
	Healthy	Parasitized ¹	Infertile	Old		
Bigmouth Creek	0	9	5	126	64	None
Shelter Bay	8	4	0	7	33	Light
Beaver River	9	1	1	36	8	Light
Goldstream River	10	15	7	21	47	Light
Redrock Peninsula	11	11	7	41	38	Light
Lardeau Creek	16	20	4	54	49	Light
Pingston Creek	21	12	2	2	34	Light
Begbie Creek	21	17	3	19	41	Light
Jumping Creek	31	5	6	17	12	Moderate
St. Leon Creek	35	3	1	8	8	Moderate
Martha Creek	42	28	10	39	35	Moderate
Bostock Creek	58	8	7	30	11	Mod.-Sev.
Illecillewaet River	62	8	1	13	11	Severe
Asher Creek	96	20	22	130	14	Severe
Tangier River	148	32	3	26	18	Severe

¹ Defoliation prediction thresholds: none = <5 healthy eggs
light = 5-26 healthy eggs
moderate = 27-60 healthy eggs
severe = >60 healthy eggs



Map 3. Forecasts of defoliation in 1994 by five defoliating insects.

Impact

Limited patches of greater than 40% tree mortality have occurred near Downie, Bigmouth, Lardeau, and Pingston creeks, and Goldstream and Illecillewaet rivers. However, the area of significant mortality is currently estimated at less than 5% of the area defoliated. A more accurate determination will be possible after the outbreak subsides and accumulated mortality, top dieback, and recovery can be determined at representative locations.

Previous infestations have caused extensive top-kill and scattered mortality. In older stands trees that are 100% defoliated are usually killed directly while those 80% or more defoliated usually die within 3 to 5 years from secondary causes. Salvage is limited by wildlife and watershed concerns in the numerous areas where leave strips from previous harvesting are currently defoliated.

Western blackheaded budworm
Acleris gloverana

Feeding by the blackheaded budworm remained light on 45 ha along Gray Creek and contributed to defoliation in several western hemlock looper infestations west of Golden. At Gray Creek 50% of current foliage was fed on, with over 1000 larvae in three-tree beating samples. Larval counts were also high at Bostock Creek (900) in association with a larger western hemlock looper population. Larval numbers doubled along the west side of Columbia Reach (181) causing trace to light defoliation, especially at the mouths of creeks.

Defoliation is expected to continue in 1994 (Map 3). At Gray Creek an average of 50 eggs per 45 cm branch indicate potential moderate defoliation. At Beaver River (18 eggs) and Bostock Creek (35) light and moderate defoliation, respectively, is expected. Only 4% of laboratory-reared larvae were parasitised, currently a minor factor in the population.

Gray spruce looper
Caripeta divisata

Populations of this insect were endemic after an intense two year, 4000 ha outbreak subsided in 1992. Additional mortality by secondary insects and climate was expected due to crown dieback in all severely defoliated stands and was assessed in an unsalvaged stand near Wragge Point. Currently 31% of mature hemlock were dead compared to 14% in 1992. Crown dieback still averages 41% (range 0-90%) in remaining live trees compared to 53% in 1992, so more secondary mortality is possible. Mortality of hemlock severely defoliated by the western hemlock looper can continue up to 5 years after an outbreak.

Douglas-fir Pests

Douglas-fir beetle
Dendroctonus pseudotsugae

Douglas-fir beetle infestations remained relatively stable in 1993 at 22 ha, mainly along the east side of the Rocky Mountain Trench (Table 7). In the **Golden TSA** there were 50% fewer recently killed trees mapped during aerial surveys. Scattered activity continued along the east side of McNaughton Lake north of Bush Harbor and near Rice Brook along Bush River. While there are several patches of 50 to 80 trees, most are in groups of 5 to 20. Localized infestations start in blowdown and logging slash and expand in root diseased trees for several years before collapsing.

In the **Invermere TSA**, there was close to a three-fold increase in the number of recently killed trees. Most were in the Premier Lake area with smaller groups extending north along the Lussier River to Ram Creek and south to Wildhorse Creek in Cranbrook TSA. Small groups persisted along the south side of Whiteswan Lake, near Canal Flats, and in the Fairmont-Madias Creek area. Scattered attack was also noted along the the Columbia River below Steamboat Mountain and along the east side of the Rocky Mountain Trench from Radium Hot Springs to Brisco.

Table 7. Location, number, and area of Douglas-fir recently killed by Douglas-fir beetle. FIDS, Nelson Forest Region 1993.

TSA	Area	No. infestations	No. trees
Cranbrook	2	9	90
Invermere	14	38	570
Golden	4	12	300
Revelstoke	2	6	40
Total	22	65	1000

In the **Cranbrook TSA** infestations remained stable with a few scattered spot infestations in chronic areas at Wickman-Gold creeks and in the Wildhorse Creek drainage. Several small groups of recently killed Douglas-fir were also noted along the lower Hellroaring Creek but were not ground checked for beetle.

Scattered current attacks occurred in the Drimmie Creek area of the **Revelstoke TSA** after populations built up in windthrow. Prompt sanitation logging in the area is being directed by the B.C. Forest Service. Increasing populations in the Rover Creek area of the **Kootenay Lake TSA** are being monitored by the B.C. Forest Service with pheromone traps; no standing timber has yet been infested.

Forecast

Beetle broods were examined only at Premier Lake, where current attack was up 50% from 1992. An overall "R" value of 2.6, based on adults and late instar larvae only, indicates that the population will again increase in 1994. Cool summer weather delayed adult re-emergence, almost half the 1993 attack, so no broods had developed beyond the not winter hardy egg stage by early October.

Douglas-fir needlecast *Rhabdocline pseudotsugae*

Douglas-fir needlecast continued to impact close growing Douglas-fir over approximately 19 000 ha in the Rocky Mountain Trench and side drainages of Kootenay Lake. Spot checks of Christmas trees in growing areas between Dutch and Horsethief creeks found an average of 30% with moderate to severe needlecasting when growing at less than four foot spacing. Adjacent open growing sites had 16% with trace to light levels. Sites along the east side of the Rocky Mountain Trench between Canal Flats and Edgewater had only trace levels. Needlecasting was more severe in side drainages, such as Harvey Creek where 90% of the 1992 foliage was killed in a 20 ha plantation.

Severe needlecasting reduces height growth by about 25% (Nelson Region Annual Report 1991) and, based on defoliation impact studies, diameter losses are usually greater. This should be considered in planting plans for chronic infection areas such as narrow east-west valley bottoms, lower passes, some north aspect slopes, etc.

Cool and wet weather in 1993 favored extensive infection. During limited fall inspections early symptoms of infection, yellow blotching, were present on 20 to 100% of the trees at all sites from Golden south to the USA border. This is considerably more intense and widespread than in recent years and included traditional non-infection areas in the driest part of the district.

Western spruce budworm
Choristoneura occidentalis

The budworm population continued to decline in the southwest corner of the region. For the second year no current defoliation was observed during aerial surveys, though trace defoliation of understory foliage was occasionally seen during ground surveys. Spring counts of infested buds averaged 6% (range 3 to 8%) at 4 locations in the Boundary TSA, compared to the 1992 average of 27% at the same locations. Current moth catches at two pheromone calibration sites (Map 4) were 1 and 10 percent of 1992 levels, further quantifying the population decline and indicating that numbers should remain low in 1994 (Map 3).

Populations declined to endemic levels in a minor, though unprecedented, 1992 outbreak of mostly understory feeding in the Premier Ridge area of the Invermere TSA. Also, a large 1993 moth flight was reported in the Kootenay River valley west of Nelson. Although no current defoliation was detected there are susceptible stands that will be monitored in 1994.

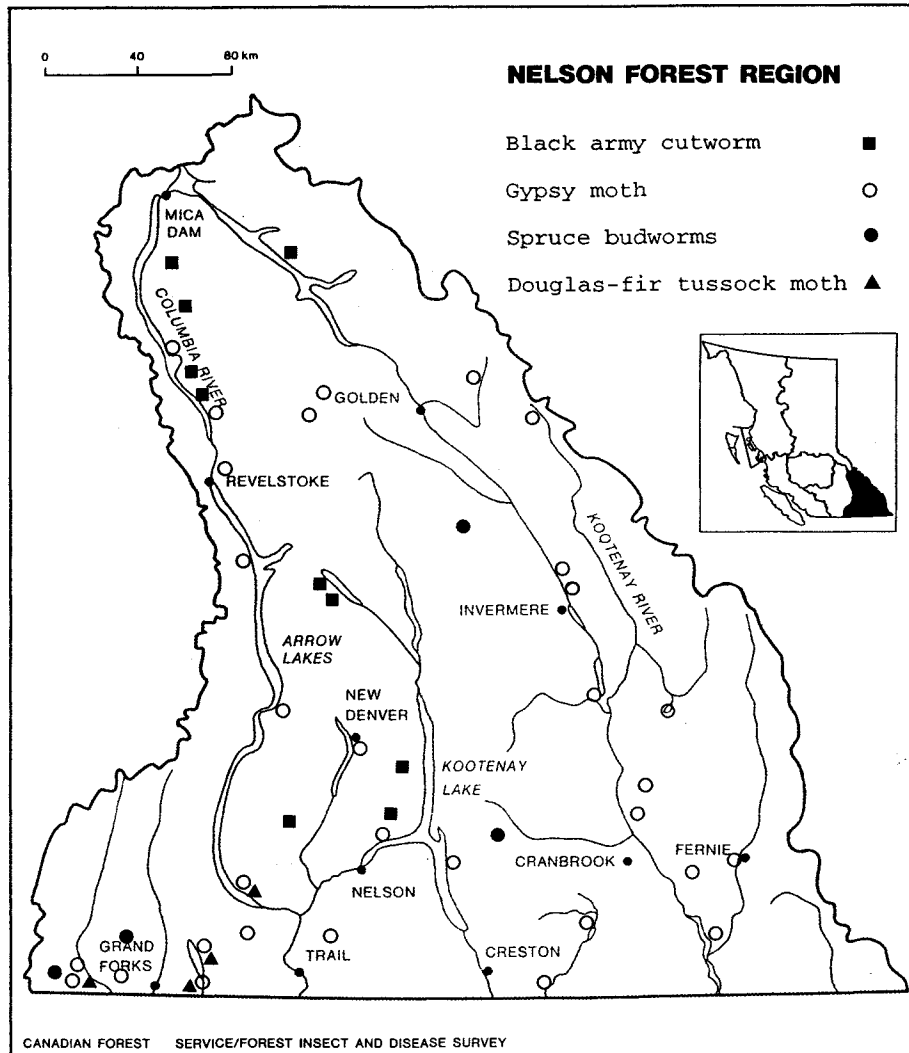
Douglas-fir tussock moth
Orgyia pseudotsugata

The tussock moth population remained low in 1993 with no defoliation recorded except a continuing isolated case of moderate defoliation of several urban spruce trees in Montrose. Few moths were caught in pheromone-baited sticky traps at calibration study sites in Cascade and Rock Creek (Table 8, Map 4). Populations are expected to remain low in 1994 (Map 3).

Table 8. Catches of the Douglas-fir tussock moth in a calibration study of pheromone-baited sticky traps. FIDS, Nelson Forest Region 1993.

Location	Average moth catch per trap					
	1988	1989	1990	1991	1992	1993
Cascade	0	2	19	63	5	0.2
Rock Creek	1	1	8	11	9	0.4

Two additional traps deployed in a distribution study at Texas and Syringa creeks were negative for Douglas-fir tussock moth. Of other moths attracted to the same pheromone, the rusty tussock moth, *Orgyia antiqua badia*, continued to decline with no moths caught and the pine tussock moth, *Dasychira griseifacta*, remained low averaging 3 moths per trap at the Rock Creek calibration site only.



Map 4. Locations where one or more pheromone-baited traps were deployed.

Spruce Pests

Spruce beetle *Dendroctonus rufipennis*

Spruce beetle populations continued to increase in the **Golden TSA** with 44 infestations mapped over 105 ha in 1993. An estimated 3000 1992-attacked trees were mapped during aerial surveys. The main infestation areas continue in Bachelor, Cupola, Sullivan and Ensign creeks, with spot outbreaks observed in the Bush River-Rice Brook area, Chatter Creek, Valenciennes River, Smith and Ventego creeks, Wood Arm and Beaverfoot River. Early detection is variable due to slow tree discoloration and by the time detected infestations are often two to five times larger than aerially observed. Scheduled monitoring of blowdown

and beetle populations and preventive measures should follow any logging activities in mature spruce stands.

Several potential outbreaks should be monitored in the **Invermere** and **Cranbrook TSAs**. Along the middle fork of the White River 1991 blowdown was only lightly attacked in 1992 but there were large broods which will fly in 1994. Later blowdown and hinge-rooted 1991 blowdown had moderate to high levels of 1993 attack providing the potential for a large 1995 flight and local infestation. Such partially blown-down stands with above-normal levels of annual blowdown maintain high beetle numbers responsive to infestation-inducing environmental conditions. Along Bugaboo Creek isolated groups of less than five recently attacked trees were noted but limited current attack indicates populations are declining. Along the west fork of the St. Mary River summer blowdown of mature spruce will be vulnerable to beetle attack in 1994.

Broods are generally developing in a normal two year cycle. The brood size of beetles flying in 1994 indicates an increasing population at Cupola Creek ("R" value = 7.0), the only area examined where the main flight will be in 1994. At the other sites adult beetles dropped to the duff earlier than normal and "R" values were only obtained at Bachelor Creek (1.4 = static population). Control programs should further reduce the population. In a non-control area 59% of 1993 attacks were unsuccessful, indicating a declining population in this main flight year. A trap tree program absorbed most of the current flight in the Sullivan River area. The most successful 1993 flight was along Ensign Creek where, without a control program, current attack remained at 19% despite smaller and younger trees (Table 9).

Table 9. Status of spruce in stands infested by spruce beetle. FIDS, Nelson Forest Region 1993.

Location	Percent of spruce attacked					Percent healthy
	Current (1993)	Partial (1993)	Pitchout (1993)	Red (1992)	Grey (pre-1992)	
Bachelor Creek	6	1	10	8	13	62
Cupola Creek	10	7	22	25	14	22
Sullivan River	12	5	0	5	20	58
Ensign Creek	19	9	1	7	20	44
Average	12	5	8	11	17	47

Spruce weevil
Pissodes strobi

Populations are increasing throughout the region where extensive spruce regeneration has reached susceptible age classes. In young open-growing stands in the Golden TSA (Table 10) damage increased when oviposition occurred during unseasonally warm May weather but decreased if it occurred during inclement June weather. At Quartz Creek an almost 50% reduction in attack was largely attributed to high predation of late instar larvae in 1992.

Table 10. Spruce weevil damage trends. FIDS, Nelson Forest Region 1993.

Location	Percent of leaders attacked					Remarks
	1989	1990	1991	1992	1993	
Beaverfoot R.	6	9	9	14	16	open valley bottom.
Blackwater Cr.	4	5	5	12	19	spaced, valley bottom.
Quartz Cr.	32	18	21	26	15	mixed stand
McLeod Meadows	-	-	4	9	4	dense natural stand.
Average	14	11	10	15	13	

True Fir Pests

Two-year-cycle spruce budworm *Choristoneura biennis*

Moderate to severe defoliation of alpine fir and spruce by mature larvae occurred on 4300 ha in the Monashee Range, mostly in the upper Barnes Creek drainage and on ridges above Plant and South Fosthall creeks (Map 2). Mature larvae also defoliated 50% of current foliage over 300 ha in the Baribeau and Baker creeks area, and over 30 ha in the upper Bugaboo area. This was less than anticipated from egg surveys in 1992 and early bud counts in 1993 due to unseasonal cold, wet weather in June and a high incidence of disease.

Immature budworm larvae lightly defoliated trees over 750 ha along Ice River in Yoho National Park, the only area with enough mature larval feeding in 1992 to cause aerially observable defoliation in 1993. At Marble Canyon and White River 5 and 17%, respectively, of buds were mined in the spring indicating trace to light defoliation by mature larvae in 1994.

Impact

Short strips were run in chronic budworm areas at Baker Creek and St. Mary River. Dominant trees were 77% spruce and 23% alpine fir; the intermediate and understory were 92% alpine fir of which 51% had dead tops and 40% were dead. Although not all the impact can be attributed to the budworm, it is much higher than non-infested stands at 4 to 13% top-kill only. Armillaria root disease was found on only one of 15 recent dead or top-killed trees examined.

Forecasts

Egg mass counts indicate that budworm populations should increase at Baker and Bugaboo creeks, but with defoliation in 1995 remaining light (Table 11). In recent years, similar numbers of eggs have resulted in light defoliation from immature larvae. However, the populations were highly diseased with mortality of 27 and 44% in two collections from the St. Mary River drainage. Incidence was highest in the largest populations and may indicate further reductions in 1994/95. An additional 10% died due to parasitism.

Bud counts in the Rocky Mountain Range, where larvae will mature in 1994, indicate declining defoliation in areas ground surveyed (Table 11). However, light defoliation along the Ice River, and in other unsurveyed drainages, by immature larvae suggests that feeding could intensify in 1994 similar to 1992.

Table 11. Forecast of defoliation in 1993 and 1994 by two-year-cycle spruce budworm. FIDS, Nelson Forest Region 1993.

Location	Percent of buds infested	No. of egg masses	Predicted defoliation
Bugaboo Cr.	-	77	light - 1995
Baker Cr.	-	60	light - 1995
White R.	17		light - 1994
Vermilion R.	5		light - 1994

A project to calibrate number of moths caught in pheromone-baited traps to defoliation expected continued at Redding and Bugaboo creeks (Table 12, Maps 3 and 4). Several more generations have to be monitored at numerous locations and population levels before threshold values can be determined.

Table 12. Number of adults and defoliation at two-year-cycle spruce budworm pheromone calibration plots. FIDS, Nelson Forest Region 1993.

Location	Avg. no. of adults/trap			Defoliation		
	1989	1991	1993	1989	1991	1993
Redding Creek	56	211	37	Nil	Nil	Nil
Bugaboo Creek	179	1320	667	Trace	Light	Light

Western balsam bark beetle *Dryocoetes confusus*

Recent alpine fir mortality was mapped over close to 4000 ha, relatively unchanged from 1992, with scattered groups of up to 50 recently killed trees in mature stands throughout the region. Increasing mortality was mapped over 1200 ha in the St. Mary River drainage. In the Spillimacheen River and Bobby Burns Creek systems the area of tree mortality was halved after several years of decreasing attack, leaving small groups of recently killed trees near older larger infestations. At a monitoring plot in the Spillimacheen River drainage current attack of standing trees continued to decline, reaching only half the 1992 level. Drainages with a concentration of current spot infestations include headwaters of creeks in the White River system, Bruce and Bugaboo creeks, Beaver River in Glacier National Park, the Dogtooth

Range and adjoining Quartz Creek, the Esplanade Range along Columbia Reach and side creeks along Bush River.

Once established, the beetles continue to selectively kill small groups of trees at a fairly constant level, about 1-3% annually. Following blowdown there will often be a temporary increase in tree mortality as beetle populations increase after emergence from the blowdown. Ground surveys indicate that in most cases 50 to 65% of the mortality is due to balsam bark beetle, often in association with root rot and/or blowdown.

Larch Pests

Larch needle blight *Hypodermella laricis*

The incidence of needle blight, identified as *H. laricis* during field surveys, increased in the Boundary, Arrow and Kootenay Lake TSAs with various levels in most western larch stands. Current levels were greater than 1992 (trace to light) and comparable to 1991. Annual variation is related to spring moisture, with wet weather favoring successful infection. A second flush of foliage usually occurs during the summer.

Some of the more conspicuous severely-blighted stands were mapped over 6400 ha. Severe patches up to about 300 ha were mapped along: Kianuko and Irishman creeks and Salmo and Kaslo rivers in the Kootenay Lake TSA; Whatshan River and Carpenter Creek in the Arrow TSA; and Twin and July creeks in the Boundary TSA. Light to moderate levels were noted from roadside observations along the Goat River (600 ha), Yahk to Creston (1500 ha), and in 50 to 100 ha patches north of Yahk and along East Arrow and Summit creeks. In the East Kootenay, levels were generally trace to light with increases noted only in the Whiteswan Lake area.

A preliminary impact assessment in a severely blighted 50 year old stand along the Goat River involved comparing height and radial increments from 1992 to 1993 in 10 healthy and 10 infected trees (Table 13). The net impact on height was an average decrease of 11% while diameter increments declined by an average of 18%. Cool and wet summer weather may have influenced the impact of foliar infection.

Table 13. Preliminary assessment of growth reduction in western larch with severe needle blighting. FIDS, Nelson Forest Region 1993.

	Height Increment (%) ¹	Diameter Increment (%) ¹
Infected	89	64
Healthy	100	82
Net Impact	-11	-18

¹ All figures represent 1993 growth as a percent of the pre-infection increment.

Larch casebearer
Coleophora laricella

Populations declined to near endemic levels throughout the region. Outbreaks of this introduced insect have been regulated by foreign parasites released in 1969, 1974-77, and 1982-84. At 15 long-term sampling points between Anarchist Mountain and Jaffray, minor defoliation, about 1%, was recorded at the Castlegar Pulp Mill and Cranbrook sites, all others were at trace (<1%) levels. Pupal parasitism was not quantified in 1993 due to adult emergence during warm weather before the field season.

A larch shoot moth
Argyresthia columbiana

Terminal damage by this shoot moth continued to decline in 1993 in western larch in the Columbia--Windermere lakes area. Terminal shoots were killed on 5% of the crop trees in a 1990-spaced stand, initially surveyed before spacing when less than 1% of the terminals were affected. After spacing the incidence increased to 40% but declined to 18% in 1992.

Multiple Host Pests

Tomentosus root disease
Inonotus tomentosus

Tomentosus root disease occurred on approximately 40% of mature to overmature Engelmann spruce and lodgepole pine in stands surveyed in the Horsethief, Sanca, Teepee, and Quartz creek drainages. It was the main pathogen, with *Phaeolus schweinitzii* and *Armillaria ostoyae* encountered at lower frequencies, less than 5%. *Phaeolus schweinitzii* was as prevalent (5%) as *I. tomentosus* of the spruce in older stands along Horsethief Creek.

Incidence was determined in continuous strips 5 m wide for 300 to 1000 m (Table 14). All trees were tallied as with or without symptoms and some recently dead or symptomatic trees sampled to determine the cause. Since *I. tomentosus* must be well established before visible symptoms are evident, up to two root cross sections were examined on each of 15 to 20 randomly-selected apparently healthy trees to determine the extent of non-symptomatic trees infected. The percent of area diseased was based on trees with visible symptoms only.

Of interest is the high incidence of pine infection in the two lodgepole pine - spruce stands at Teepee Creek. Both stands are in rapid successional transition from overmature pine to spruce. In previously surveyed stands a high incidence of pine infection led to high spruce infection as the stands aged.

Table 14. Occurrence of *Inonotus tomentosus* in representative stands. FIDS, Nelson Forest Region 1993.

Location	Tree spp. ¹	% trees healthy	Percent of trees infected			% of area diseased	No.centers per ha
			no symptoms	symptoms	dead		
Horsethief Creek drainage							
McDonald Cr.	eS(alf)	17	29	19	35	83	10
Horsethief Cr.	eS(alf)	67	29	0	4	12	2
Sanca Creek drainage							
Sanca Cr.	eS(alf)	61	28	8	3	17	2
South Fork	eS(alf)	51	39	7	2	22	4
East Fork	eS(alf)	98	0	1	1	5	1
Teepee Creek drainage							
Jake Cr.	eS(IP)	75	25	0	0	7	2
	eS(IP)	0	78	5	17	7	2
Beatie Cr.	IP(eS)	26	62	8	4	18	6
	IP(eS)	80	20	0	0	18	6
u. Teepee Cr.	eS(alf)	90	8	2	0	2	1
Quartz Creek drainage							
u. Quartz Cr.	eS(alf)	42	32	12	14	40	8
l. Quartz Cr.	eS(alf)	64	27	9	0	17	4
Average							
		60	31	6	7	22	4

¹ eS=Engelmann spruce,alf=alpine fir,IP=lodgepole pine;()=lesser stand component

Armillaria root disease *Armillaria ostoyae*

Armillaria root disease remains the main detriment to restocking logged areas in southeastern British Columbia and causes scattered mortality in most existing stands. Infection of regeneration, mainly by rhizomorphs the first few years after logging and later by root contact, commonly results in unsatisfactory restocking. Partial cutting results in the greatest increase in root disease and is not sustainable in most areas due to mortality of both regeneration and remaining trees.

Due to the chronic, variable, and widespread nature of the disease, and limited resources, no annual surveys were conducted beyond specific programs such as surveys of young stands treated under FRDA agreements. Of 50 stands assessed in 1993 and treated in the last few years, usually by spacing, 30 already had some of the trees left killed by *Armillaria*. This includes stands where the incidence was low and only recorded between plots. An average of 4% (range 1-22) of trees left had symptoms in stands where the disease occurred within plots.

Rhizina root disease
Rhizina undulata

Rhizina root disease remained patchy in the region with significant seedling mortality still occurring in some areas. There was no evidence of the disease in five areas examined in the eastern part of the region.

Fruiting bodies were observed at 10 of 13 recently-burned clearcuts assessed in the Revelstoke, Arrow, and Kootenay Lake TSAs. Approximate seedling mortalities were: less than 5% at Asher Creek (2 sites) and Dry Creek; 5 to 10% at Spikers Creek (2 sites), Cusson Creek, and Keystone Creek; 15% at Redfish Creek; and 30% at the Tangier River. A site with sporulation common, at the Goldstream River, had not been planted. Scattered infections are expected to continue as new burns provide the necessary environment.

Mammal damage

Mammal damage is a natural component of all stands, however in areas of high populations the impact can be significant. Of 50 young stands recently treated, usually by spacing, 26 had an average of 4% (range 1-16%) of trees left damaged by mammals (Table 15). The most frequent damage, but at low intensity, was caused by large ungulates in 26% of stands, usually Douglas-fir. Patches of damage, usually in lodgepole pine stands, were caused by bear (16% of stands), porcupine (8%), hare (6%), and vole (4%).

Black army cutworm
Actebia fennica

Black army cutworm populations remained low in 1993. Light ground cover damage was recorded in a site at Cariboo Creek along McNaughton Lake. No damage was found at 2 other sites checked in the East Kootenay and 10 in the West Kootenay.

Moth catches at 9 sites in the West Kootenay were all below the threshold of potential infestation in 1994 (Map 4). In the East Kootenay, 688 moths caught in a reburned cutblock at Cariboo Creek indicate moderate potential for an infestation to develop. The site should be checked for cutworm feeding in the spring before planting and shortly after the ground vegetation flush.

Gypsy moth
Lymantria dispar

A total of 34 pheromone-baited traps were deployed at 33 forested provincial and national park campgrounds in the region as part of an ongoing co-operative program to detect any introduction of this pest into the region (Map 4). No moths were caught in the region; traps placed by Agriculture Canada and the B.C. Forest Service were also negative. However the threat of introduction remains. Moths were caught in south coastal areas of British Columbia and northern Washington and Idaho States.

Deciduous Tree Pests

Satin Moth *Leucoma salicis*

Satin moth populations increased in the Golden area and remained high in southwestern areas of the Boundary TSA with current defoliation mapped over a total of 2940 ha. This defoliator was accidentally introduced to B.C. from Europe in 1920 and first collected in the Nelson Forest Region at Needles in 1963. Several outbreaks have since occurred in the region with host mortality now recorded for the first time.

Golden TSA

Defoliation by satin moth occurred over 2700 ha of mainly aspen near Golden. Stands on the bench west of town have had moderate to severe defoliation by several defoliators since 1989 with different species dominant almost annually. Smaller patches of light to moderate defoliation extended into the lower Blaeberry River area and south to Horse Creek. Trace defoliation was noted as far south as Parson.

The first record of satin moth near Golden was in 1989 in forest tent caterpillar infestations and populations have gradually grown to current levels. Early indications of tree mortality average 12%, ranging up to 45% in small patches; the full impact will not be evident until the infestation subsides.

Boundary TSA

Defoliation of trembling aspen and willow continued for the second year in the Anarchist Mountain to Bridesville area and expanded to the Rock Creek, Midway, Greenwood and, to a lesser extent, Grand Forks areas. Current defoliation was mapped over 240 ha, half of which was severe, down from 500 ha in 1992 partly due to host depletion.

In previous outbreaks most trees recovered with a second flush of foliage later in the season. However, in this outbreak there was very little refoliation and mortality of stands severely defoliated in 1992 was mapped over 172 ha. The impact of 1993 defoliation will be assessed after the 1994 flush.

Introduced parasites, a native bacterium, and a fungus have helped reduce previous satin moth outbreaks. Current larval health was quite good, with 69% of a mass collection at Johnstone Creek emerging after rearing, only 2% parasitized and 29% dead from disease (NPV) or rearing mortality. Mortality and dieback of host trees may limit populations by starvation in 1994.

Leafminers

Increased leafminer activity caused varying discoloration of birch, alder, and black cottonwood through the northern half of the region. Most prominent was, for the second year, extensive moderate to severe discoloration of birch by *Lyonetia speculella* and *Profenusa thomsoni*. Damage was most conspicuous along slide paths and in relatively pure stands to the west and south of Roger's Pass, extending as far south as the Kaslo River. Conspicuous

patches were mapped over a total of 12 000 ha during aerial surveys. Previous outbreaks of severe discoloration by leafminers have not caused significant tree mortality.

In the same areas scattered moderate to severe discoloration of alder was caused by *Fenusa dohrni* and light to moderate discoloration of black cottonwood by *Phyllocnistis populiella*.

Aspen leafrollers

A variety of leafrollers moderately defoliated trembling aspen over 300 ha along the Kicking Horse River, just west of Yoho National Park. The main defoliator was the aspen leafroller, *Pseudexentera oregonana*, with lower numbers of the paleheaded aspen leafroller, *Anacampsis niveopulvella*, and an *Epinotia* sp.. Leafrollers, mainly *Epinotia* sp., have moderately to severely defoliated stands in the area since 1991, causing dieback of about 30% of trees. Along the lower Bull River *Epinotia* sp. continue to cause trace to light defoliation over 50 ha.

Alder woolly sawfly *Eriocampa ovata*

This introduced European insect was collected at Montana Creek, near Revelstoke, moderately defoliating understory alder. Though well established along the B.C. coast this is the first collection from the Interior. Coastal infestations usually cause scattered 1 to 2 ha patches of moderate to severe defoliation.

Special Surveys

Pests of young stands

Fifty young stands planted or treated under the Canada-B.C. FRDA agreements were examined for pest problems in 1993 (Table 15). Tree removal during treatments affected the occurrence of some pests. Sites were selected from lists stratified by district, biogeoclimatic zone, and treatment. The incidence of some pests, especially root rots, at this early stage after treatment suggests that pre-treatment surveys were inadequate in some areas and that long term impact may be severe.

Life-threatening pest problems were recorded in 88% of stands surveyed. Root rots and mammal damage were the most frequent problems, each in over half the stands (Chart 3). Of 5827 trees examined, 71% were pest-free, 6% had pests that often lead to tree mortality, and 9% had pests that cause growth loss. Several of the pests in Table 15 are discussed in more detail elsewhere in the report.

Table 15. Summary of pests when hosts were a significant stand component in 50 young stands treated under the Canada-B.C. FRDA agreements. FIDS, Nelson Forest Region 1993.

Host/Pest	Most frequent severity index ¹	No. affected (suscept.)		% of trees affected ²	
		stands	trees	avg.	range
Lodgepole pine - 2264 trees in 31 stands, significant in 24 stands					
Warren's root collar weevil	6	9 (21)	29 (1550)	3	1-5
Bear	6	6 (19)	28 (1572)	5	1-44
Armillaria root disease	6	13 (24)	20 (2078)	1	1-7
Tomentosus root disease	6	1 (19)	1 (1572)	1	-
Porcupine	5	5 (12)	24 (1021)	6	2-33
Commandra blister rust	5	2 (24)	34 (2078)	12	1-22
Western gall rust	5	7 (24)	37 (2078)	1	1-14
Stalactiform blister rust	5	1 (24)	1 (2078)	1	-
Ice/snow	5	10 (24)	29 (2078)	2	1-6
Hare	4	4 (21)	19 (1550)	6	1-24
Squirrel	4	6 (24)	30 (2078)	7	1-14
Deer	4	3 (21)	3 (1550)	1	1
Terminal weevil	4	9 (20)	24 (1734)	3	1-9
Pithyophthorus	4	1 (20)	5 (1734)	5	-
Mechanical	4	3 (24)	6 (2078)	2	1-3
Pine needle cast	3	15 (24)	547 (2078)	31	2-91
Sequoia pitch moth	3	2 (24)	38 (2078)	20	1-34
Dioryctria (stem)	3	7 (20)	26 (1734)	2	1-3
Pest-free	1	22 (24)	1177 (2078)	57	23-100
Engelmann spruce - 803 trees in 35 stands, significant in 13 stands					
Armillaria root disease	5	1 (13)	1 (733)	1	-
Inonotus root disease	5	1 (8)	1 (406)	5	-
Bear	5	1 (11)	2 (593)	4	-
Spruce weevil	4	1 (10)	2 (450)	7	-
Foliage rust	3	1 (13)	10 (733)	18	-
Pest-free	1	12 (13)	574 (733)	75	21-94
Douglas-fir - 1042 trees in 32 stands, significant in 16 stands					
Vole	6	1 (3)	22 (255)	48	-
Armillaria root disease	5	7 (16)	59 (945)	12	1-37
Bear	4	2 (11)	2 (628)	1	-
Deer	3	4 (14)	23 (883)	7	1-13
Pest-free	1	16 (16)	738 (985)	75	4-100
Alpine fir - 300 trees in 18 stands, significant in 6 stands					
Armillaria root disease	5	1 (6)	2 (255)	2	-
Needle disease	3	3 (6)	54 (255)	45	29-68
Pest-free	1	6 (6)	199 (255)	78	27-100

Table 15. (Cont'd)

Host/Pest	Most frequent severity index ¹	No. affected (suscept.)		% of trees affected ²	
		stands	trees	avg.	range
Western larch - 414 trees in 19 stands, significant in 5 stands					
Armillaria root disease	5	1 (5)	2 (347)	2	-
Bear	5	2 (5)	3 (332)	7	6-8
Squirrel	5	3 (5)	10 (347)	4	2-6
Deer	4	3 (5)	3 (332)	4	4-4
Snow press	4	3 (5)	3 (347)	1	1-1
Stem canker	4	1 (5)	5 (347)	5	
Mistletoe	4	1 (5)	11 (347)	12	-
Needle diseases	3	6 (5)	95 (347)	27	16-88
Competition	3	1 (5)	28 (347)	21	-
Pest-free	1	5 (5)	184 (347)	53	6-92
Western red cedar - 270 trees in 24 stands, significant in 7 stands					
Armillaria root disease	5	1 (7)	1 (142)	2	
Snow press	5	1 (7)	1 (197)	5	-
Pest-free	1	7 (7)	187 (197)	95	50-100
Western white pine - 354 trees in 16 stands, significant in 11 stands					
White pine blister rust	5	10 (11)	91 (340)	32	2-100
Bear	5	1 (8)	3 (227)	11	-
Vole	5	1 (2)	2 (101)	5	-
Pest-free	1	10 (11)	244 (340)	72	23-100
Western hemlock - 240 trees in 13 stands, significant in 5 stands					
Armillaria root disease	5	1 (5)	1 (220)	2	
Pest-free	1	5 (5)	219 (220)	99	
Ponderosa pine - 125 trees in 2 stands, significant in both					
Red turpentine beetle	5	2 (2)	5 (125)	7	3-11
Ips beetle	5	2 (2)	10 (125)	13	6-21
Pest-free	1	2 (2)	109 (125)	77	63-92

¹ 1 - pest free
2 - minor damage, minimal impact (not tabulated)
3 - significant loss of current growth potential
4 - loss of net volume or significant long-term growth potential
5 - life-threatening or severely deforming
6 - recently dead

² Percent of trees affected only in stands with the pest.

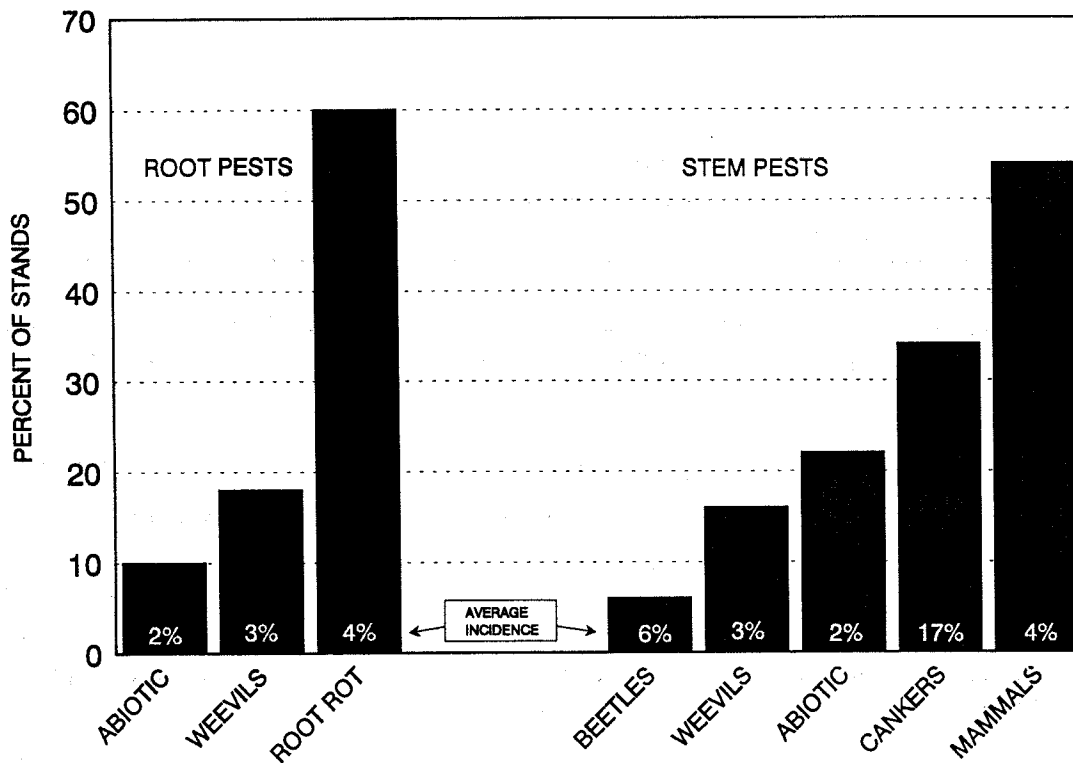


Chart 3. Proportion of 50 FRDA-treated young stands afflicted by significant root and stem pests and their average incidence. FIDS, Nelson Forest Region 1993.

Pinewood nematode *Bursaphelenchus xylophilus*

As of January 1993 most lumber shipped to Europe has to be kiln dried, with a core temperature of 56°C for 30 minutes, to prevent the introduction of this nematode. Lumber also has to be free of woodborer holes to show that no vectoring of the nematode into the wood occurred. Western red cedar is exempt from the drying since it does not host the *Monochamus* spp. woodborers which vector the nematode in British Columbia.

A FIDS-COFI project to extend the exemption to western hemlock continued in 1993. Studies in 1992 found that hemlock logs did host *Monochamus* spp. when close to favored hosts such as lodgepole pine, but no nematodes were found despite high counts in the pine. The project was continued at the four places in the province with the highest nematode counts in 1992, one near Canal Flats. Fresh 1 m trap logs were set in two arrangements 50 m apart: six hemlock logs evenly interspersed with 12 pine logs, and 12 hemlock logs only. The logs were left on-site to overwinter so results will not be available until later in 1994.

Acid rain national early warning system (ARNEWS)

As part of a national network, 10 x 40 m plots are being biomonitoring to detect any impact of air- and rain-borne pollution on native trees and indicator plants. Three plots in the Nelson Forest Region are located near Summs Creek (since 1985), Martha Creek and Wasa

(1992). Visual assessments of plot vegetation and pest conditions are done annually with more detailed measurements such as foliar analysis every five years. Currently only the same insects and diseases were found, at low levels, as in previous years. No damage from acid rain was found.

Other Noteworthy Pests

Other agents that are currently relatively minor or not surveyed are tabulated, including those capable of causing prominent damage or which to date have caused only minor damage in the region.

Host/Pest	Location	Remarks
Pine		
<i>Arceuthobium americanum</i> lodgepole pine dwarf mistletoe	host range locally severe impact	occasional chronic patches,
<i>Atropellis piniphila</i> Atropellis canker	host range	occasional stem cankering, locally severe impact
<i>Cinara</i> sp. giant conifer aphid	Cranbrook TSA	common in young stands
<i>Dioryctria</i> sp. a bud miner	Sand Creek	lightly infesting buds
<i>Endocronartium harknessii</i> western gall rust	host ranges	widespread, relatively minor impact
<i>Endothiella aggregata</i> a foliar fungus	Gray Creek	fruiting on winter-killed white bark pine; host record
<i>Hendersonia pinicola</i> a needle blight	Syringa Creek	moderate levels in ponderosa pine
<i>Leptomelanconium pinicola</i> a needle disease	S.E. of part of region	low levels common on ponderosa pine
<i>Lophodermium pinastri</i> a needle disease	Martha Creek	trace levels on w. white pine
<i>Lophodermium nitens</i> a needle disease	Enterprise Ck.	light levels on w. white pine
<i>Seythropus elegans</i> a weevil	Martha Creek	trace feeding on w. white pine

Host/Pest	Location	Remarks
Western Hemlock		
<i>Adelges tsugae</i> hemlock woolly adelgid	Beaver R.	range extension, cecidomyiid predators common
<i>Echinodontium tinctorium</i> yellow stringy heart rot	host range	significant decay common in old growth stands
<i>Nematocampa filamentaria</i> filament bearer	host range	remaining endemic
<i>Neodiprion</i> sp. a conifer sawfly	Beaver R.	increasing numbers within w. hemlock looper outbreak
Douglas-fir		
<i>Arceuthobium douglasii</i> Douglas-fir dwarf mistletoe	SW quarter of region	occasional chronic patches, locally severe impact
<i>Contarinia pseudotsugae</i> a needle midge	Rocky Mtn. southern Arrow & Boundary TSAs	trace levels on 48% of hosts in Christmas tree areas scattered conspicuous infestn. of current growth in dry areas for second year
<i>Erwinia</i> sp. (=Agrobacterium pseudotsugae) bacterial gall	Twin Creek	locally common branch galling
<i>Phaeocryptopus gaeumannii</i> Swiss needle cast	Edgewater	branch dieback, Christmas tree area
Spruce		
<i>Adelges cooleyi</i> Cooley spruce gall adelgid	throughout host range	generally light to moderate intensity
<i>Pikonema alaskensis</i> yellowheaded spruce sawfly	Castlegar Slocan Valley	mostly moderate defoliation for \pm 20 km radius new feeding north to Slocan Park
True Fir		
<i>Herpotrichia juniperi</i> a snow mold	high elevations	common this year, occasional lower branch or seedling mort.
<i>Lirula abietis-concoloris</i> a fir needle blight	host range	trace damage common in higher elevation stands

Host/Pest	Location	Remarks
<i>Pleuroneura</i> sp. a shoot-boring sawfly	host ranges	low number on grand and alpine firs
<i>Pucciniastrum epilobii</i> fir-fireweed rust	host range	light dieback of current growth common
Western Larch		
<i>Adelges oregonensis</i> w. larch woolly adelgid	Rossland	collected at trace level
<i>Anoplonyx laricivorus</i> twolined larch sawfly	Rossland	collected at trace level
<i>Arceuthobium laricis</i> larch dwarf mistletoe	host range west of Rocky Mtns.	occasional chronic patches, locally severe impact
<i>Semiothisa sexmaculata</i> green larch looper	host range	remaining endemic after 1990 outbreak
Western Yew		
<i>Cecidophyopsis psilaspis</i> a bud mite	host range	all foliar collections negative so far
<i>Discochora philoprina</i> a needle/shoot blight	Castlegar	minor needle and shoot dieback
<i>Glomerella cingulata</i> a needle blight	Castlegar	trace levels
<i>Phacidium</i> sp. a needle blight	Boundary Creek	light levels
Juniper		
<i>Gymnosporangium clavariiforme</i> clavariiform juniper rust	host range	high incidence of branch swellings
<i>Gymnosporangium nelsonii</i> Nelson's juniper rust	host range	occasional galls
<i>Gymnosporangium tremelloides</i> common juniper gall rust	Castlegar	occasional tip and branch mortality

Host/Pest	Location	Remarks
Multiple Hosts		
<i>Gnathotrichus retusus</i> an ambrosia beetle	host ranges	chronic pest degrading softwood lumber
<i>Leptoglossus occidentalis</i> western conifer seed bug	host ranges	common, occasionally numerous overwintering in houses
<i>Leptographium wageneri</i> black stain root disease	portions of host ranges	infection centers most often in pine and Douglas-fir
<i>Sydowia polyspora</i> Sydowia tip dieback	Palliser River	pine seedlings, 40% top-kill
<i>Trypodendron lineatum</i> striped ambrosia beetle	host ranges	chronic pest degrading softwood lumber
Deciduous Hosts		
<i>Aristastoma</i> sp. a leaf spot fungus	Summs Creek	common on <u>Bromus</u> sp. shoots
<i>Asphondylia shepherdiae</i> a flower gall	Horsethief Cr.	killed 60% of male <u>Shepherdia</u> sp. flowers
<i>Botrytis cinerea</i> gray mold	Lardeau River	secondary infection after frost damage
<i>Cryptorhynchus lapathi</i> poplar and willow borer	host range	scattered attacks chronic and widespread
<i>Fomes fomentarius</i> white mottled heart rot	host range	common stem decay of birch, conspicuous in drier areas
<i>Gnomonia setacea</i> a foliar disease	Mause Creek	infecting older foliage of alder
<i>Hyphantria cunea</i> fall webworm	southern Arrow, Boundary and Cranbrook TSAs	declined to low levels in roadside trees and shrubs in drier areas
<i>Linospora tetraspora</i> cottonwood leaf blight	Lardeau River	moderate leaf blotching of black cottonwood
<i>Malacosoma disstria</i> forest tent caterpillar	Golden	collapsed after peaking in 1989 on 9900 ha

Host/Pest	Location	Remarks
<i>Melampsora occidentalis</i> conifer-cottonwood rust	Goldstream River Lardeau River	moderate leaf blotching of black cottonwood
<i>Mycosphaerella</i> sp. a foliar disease	Mause Creek	infecting older foliage of alder
<i>Mycosphaerella populicola</i> a leaf spot fungus	Goldstream R.	low levels on black cottonwood
<i>Phaeoramularia maculicola</i> a leaf spot fungus	Illecillewaet R.	moderate levels in black cottonwood
<i>Phellinus tremulae</i> white trunk rot of aspen	host range	causing extensive decay and wood stain
<i>Pyrrhalta decora carbo</i> Pacific willow leaf beetle	Columbia River north of Radium	light to moderate defoliation of willow
<i>Septoria rubi</i> a leaf spot	Lardeau River	light foliar blotching of thimbleberry