Forest Insect and Disease Conditions Nelson Forest Region - 1994

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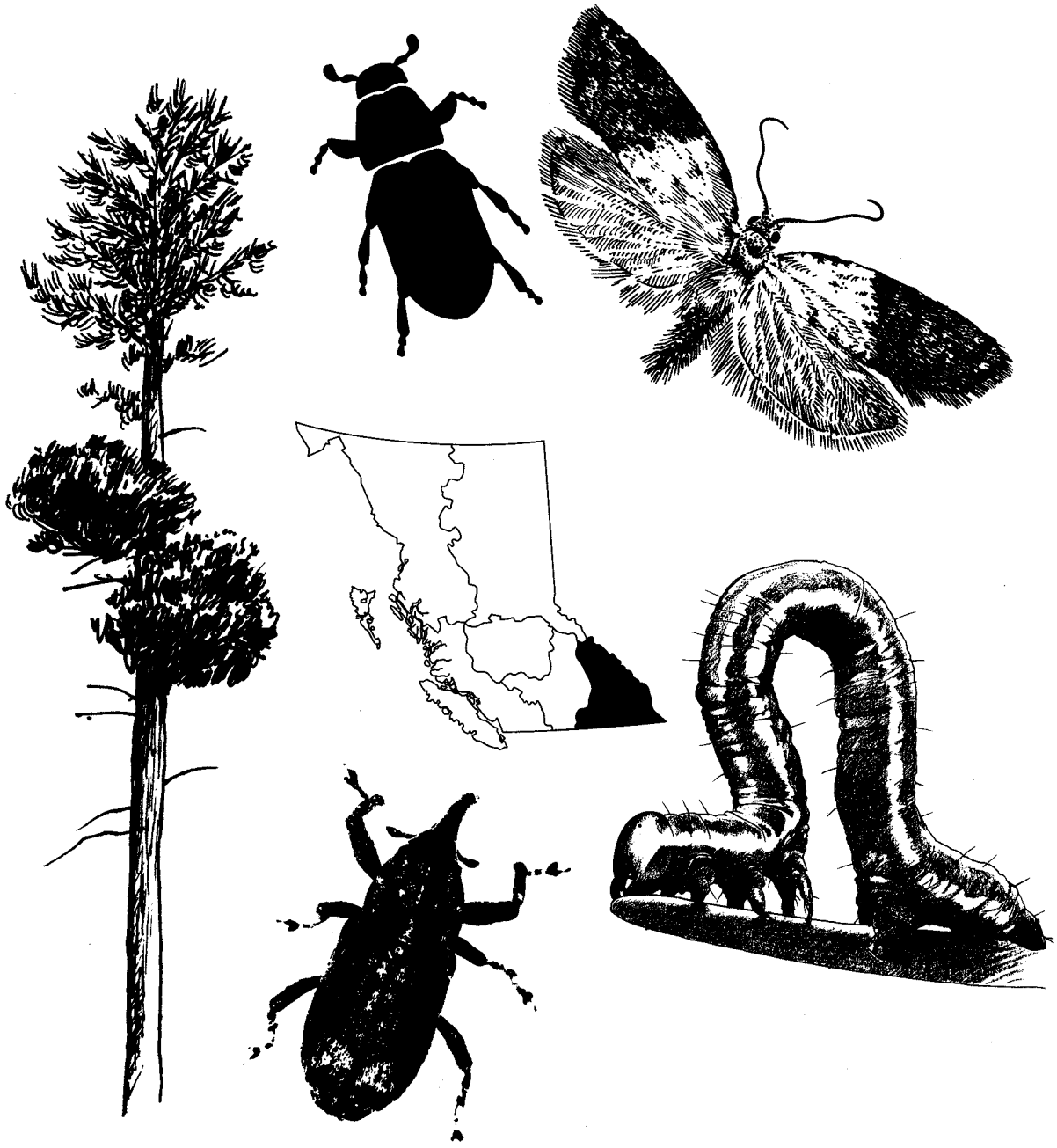
Canadian Forest Service - Pacific and Yukon Region



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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 independant 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 late May to early 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
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New Denver, B.C.
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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.

Contents

Introduction

This report outlines forest insect and disease conditions in the Nelson Forest Region and Kootenay, Yoho, Glacier, and Mt. Revelstoke national parks in 1994, highlighting those that cause forest management problems and forecasting trends. Agents are discussed by host in order of importance, often in the context of a local management unit such as a forest district or national park.

The 1994 field season extended from June to September with about 160 insect and disease collections sent to the Pacific Forestry Centre. About 100 contacts and on-site examinations were made with a wide range of groups and individuals, including the B.C. Forest Service, industry, parks, and general public. New slides of many pest concerns were collected to update existing files. Fixed-wing aerial survey time (± 39 hours), 8 hours of helicopter time, and assistance with preliminary sketch maps was provided by the B.C. Forest Service.

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, 1994.
* Summary of pest problems in provincial parks, Nelson Forest Region, 1994.
* Summary of pest problems in young stands, Nelson Forest Region, 1994.
* Pest reports mailed out during the year:

  - Mountain pine beetle population forecast Nelson Forest Region spring 1994. FIDS Pest Report 94-8.
  - Preliminary summary of forest pest conditions in the Nelson Forest Region, 1994. FIDS Pest Report 94-22.
  - Forest insect and disease conditions in the West Arm Demonstration Forest 1994. FIDS Pest Report 94-25.
  - Forest insect and disease conditions in the MacPherson Demonstration Forest 1994. FIDS Pest Report 94-26.
  - Tree mortality and defoliation caused by western hemlock looper in British Columbia in 1994 and defoliation forecast for 1995. FIDS Pest Report 94-29.
  - Forest insect and disease conditions in Ecological Reserves of the Nelson Forest Region 1994. FIDS Pest Report 94-31.
  - Forest insect and disease conditions in Mt. Revelstoke and Glacier National Parks 1994. FIDS Pest Report 94-32.
  - Forest insect and disease conditions in Kootenay National Park 1994. FIDS Pest Report 94-33.
  - Forest insect and disease conditions in Yoho National Park 1994. FIDS Pest Report 94-34.

Summary

In this summary pests are grouped by host(s), generally in order of importance.

Mountain pine beetle infestations declined to about 331 000 pine killed over 2750 ha. Several **bark beetles** again killed patches of ±5 ponderosa pine in the southwest; near Cranbrook 57% of fire-damaged trees were attacked. **White pine blister rust** infected 41% of white pine in pruned stands. Mostly severe discoloration by **pine needle cast** was mapped over 227 000 ha in the southern two-thirds of the region. **Whitebark pine decline** was again assessed.

Defoliation by the **western hemlock looper** declined to 3020 ha; 6.6 million m3 of mainly western hemlock were killed over 5 years. The **western blackheaded budworm** lightly defoliated hemlock over 4600 ha. Hemlock mortality after a **gray spruce looper** outbreak accumulated to 40% of stand volume. A **hemlock needleminer** was recorded for the first time in the Interior.

Douglas-fir beetle outbreaks increased to 237 ha in the region. High levels of **Douglas-fir needlecast** again reduced growth in young stands over 20 000 ha. Defoliation by **western spruce budworm** declined to trace levels and the **Douglas-fir tussock moth** remained endemic in the southwest.

The **spruce beetle** killed trees on 292 ha in the Golden, Kootenay Lake, Cranbrook and Invermere districts. **Spruce weevil** attacks increased slightly overall. Defoliation by **two-year-cycle spruce budworm** decreased to 282 ha in the Monashee Mountains; moderate defoliation is predicted at Bugaboo and Vowell creeks. Chronic **western balsam bark beetle** activity continued through the host range.

Larch budmoth moderately to severely defoliated western larch near Fernie and occasionally alpine larch in the Rocky and Purcell mountains. A **larch shoot moth** killed 12% of terminals in spaced stands near Windermere Lake. Discoloration by **larch needle blight** decreased to trace levels in most of the host range. The **larch casebearer** remained near-endemic.

Armillaria root disease was present in 62% of young stands surveyed; incidence increased with partial logging, spacing, and drought stress. **Mammals** damaged 29% of young stands surveyed. The **black army cutworm** defoliated several cutblocks north of Golden, but should decline in 1995. **Rhizina root disease** was found in 11 of 20 burned clearcuts with seedling mortality up to 45%. A July to September **drought** killed trees in the southeast. No **gypsy moth** were trapped at 33 sites.

Defoliation of aspen by the **satin moth** increased near Golden to 4580 ha and declined in the southwest to 80 ha. **Leafminers** discolored birch throughout the the region. **Aspen leafrollers** defoliated 300 ha in the northeast.

Pests of young stands surveys in 45 managed stands found 7% of trees with pests leading to mortality and lost growth in 9%. A study to exempt western hemlock from **pinewood nematode** export restrictions continued. No symptoms were recorded at 3 **Acid Rain National Early Warning System (ARNEWS)** and **biomonitoring** plots. A biodiversity study of **earthworms** in forested areas continued.

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

Pine Pests

Mountain pine beetle
Dendroctonus ponderosae

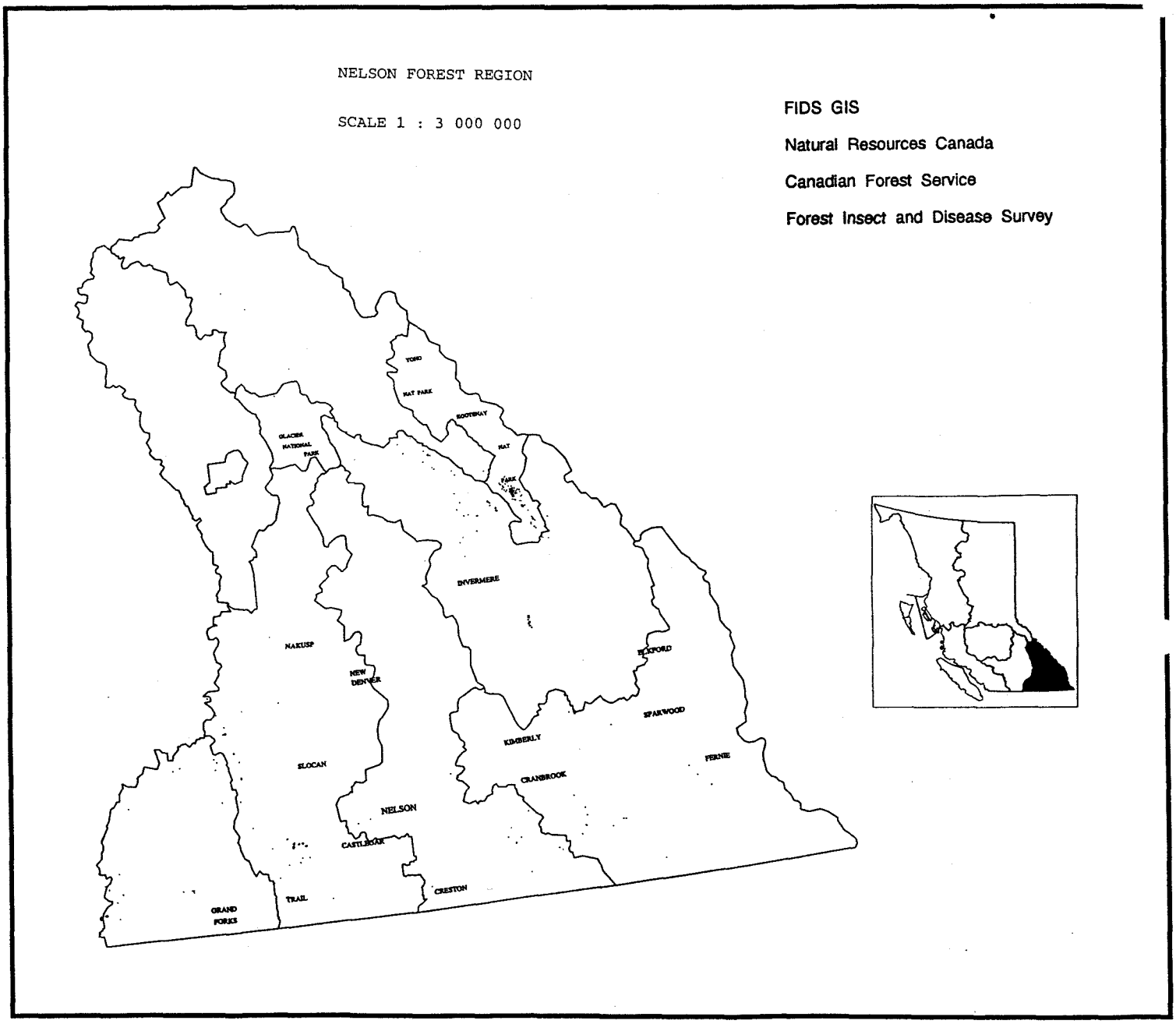
Mountain pine beetle killed mainly lodgepole pine and occasionally western white and ponderosa pines on 2750 ha region-wide (Table 1, Map 1), down for the fifth year and 64% less than in 1993 (Chart 1). A decline occurred in all management units except Kootenay National Park. Some factors leading to the reduction were cool moist weather during the 1993 flight, host depletion, predation, and more attacks on younger, less favorable trees.

Table 1. Annual occurrence and impact of the mountain pine beetle. FIDS, Nelson Forest Region 1994.

Management unit	Number of infestations	Area (ha)	Trees killed (faders)[1]	
			Number	Vol. (m^3)
Forest Districts				
Arrow	695	637	70 800	28 300
Invermere	559	484	68 000	24 600
Boundary	556	386	53 600	19 300
Cranbrook	404	157	29 000	10 500
Golden	213	57	9 400	3 400
Kootenay Lake	203	91	11 640	4 650
Revelstoke	4	1	50	20
National Parks				
Kootenay	611	897	86 600	31 200
Glacier	33	25	1 375	1 360
Yoho	39	15	520	260
Mt. Revelstoke	3	1	15	10
Regional Total	3320	2750	331 000	123 600

[1] Trees attacked in 1993, discolored in 1994.

The area of red trees mapped in the **Arrow District** decreased to 637 ha, after increasing to 3800 ha in 1993. Most of the decline was due to depletion of susceptible hosts in the larger areas that were previously mapped in the southern half of the district. However, new spot outbreaks of up to 25 trees increased to the west of lower Arrow Lake north to the Inonoaklin River drainage, in the Blueberry Creek area, and east of upper Arrow Lake. Most of the current area mapped consisted of spot outbreaks.



Map 1. Areas with pine recently killed by the mountain pine beetle as determined by ground and aerial surveys in 1994.

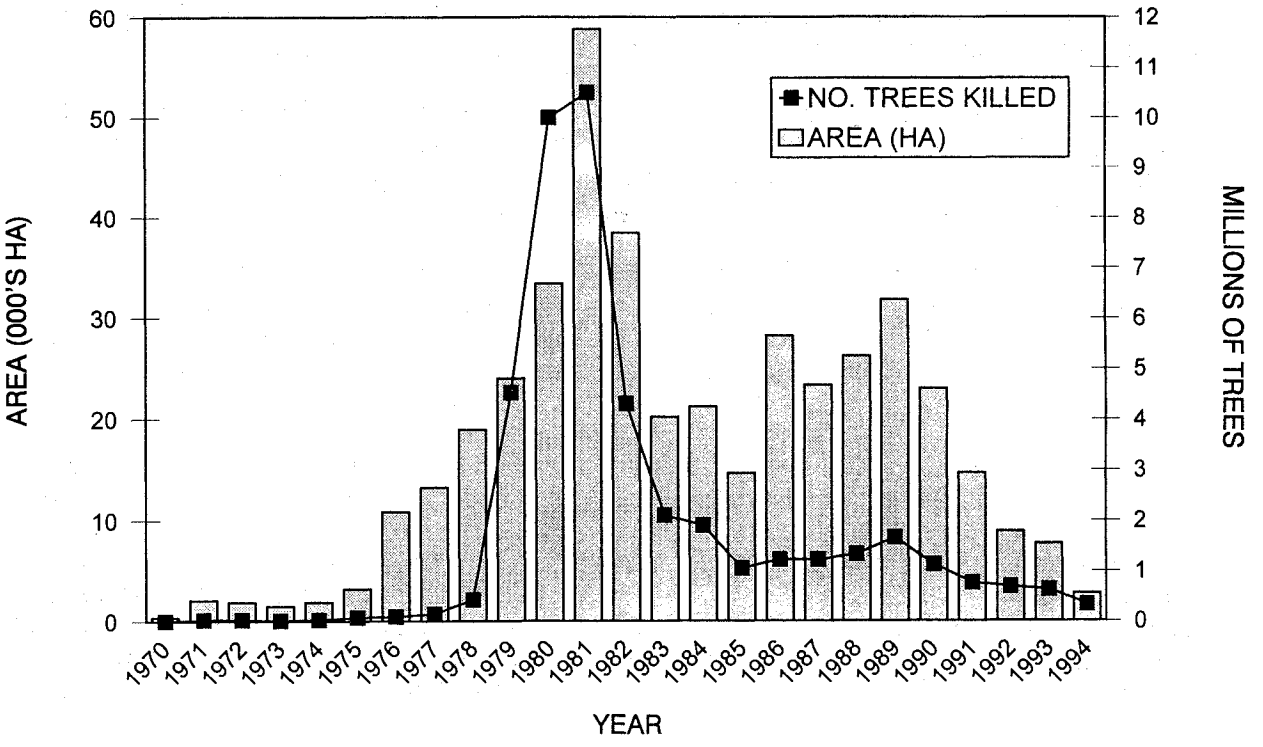


Chart 1. Area and impact of mountain pine beetle infestations in the Nelson Region from 1970 to 1994. FIDS, Nelson Forest Region 1994.

In the **Invermere District,** the area with recent tree mortality decreased to 484 ha from 1376 in 1993. The decrease occurred mainly in the southern part of the district, including Swansea and Steamboat mountains, Whitetail Lake, and along Frances, Pinnacle and Horsethief creeks. Infestations remained relatively stable at Forster Creek and in small patches along the Columbia River north of Steamboat Mountain to the district boundary. The number of ±5 tree patches increased along Cross Creek as beetles disperse from large infestations in Kootenay National Park.

The area of red trees mapped in the **Boundary District** declined to 386 ha from 960 ha in 1993, again attributed to host depletion in chronic outbreaks and low brood survival in remaining smaller trees due to overwintering mortality (Table 2). Current infestations were mostly spot outbreaks of up to 25 trees most common in drainages west of the Kettle River towards the regional boundary, and the Boundary Creek area.

The area of infestation declined throughout the **Cranbrook District** to 157 ha from 436 ha in 1993 and 2200 ha in 1992. Infestations in the Moyie Lake area and along Wildhorse Creek remained active with only a minor decline from 1993. Scattered, small infestations were also mapped along the lower Elk and Bull rivers, Morrissey, Teepee and Gold creeks, and St. Mary and Wasa lakes.

In the **Golden District,** the number of recently-killed lodgepole and white pine increased to 9400 from 7000 in 1993. The total area decreased while the number of infestations increased, reflecting beetle movement in mixed stands and dispersion from larger infestations outside the district. The main increase was in small spot infestations in the upper Kootenay

River drainage. Spot outbreaks remained relatively stable through the rest of the district, including along the Columbia, Beaver and Blaeberry rivers, Blackwater Ridge, Glenogle and Lyell creeks, and scattered along McNaughton Lake north of Bush Harbor.

The area of red trees mapped in the **Kootenay Lake District** declined to 91 ha of mostly spot outbreaks, after increasing for two years to reach 290 ha in 1993. Most of the decrease was in the southeast, offsetting an increase in scattered spot outbreaks in the West Arm to Kootenay River area.

Infestations remained at the low levels of recent years in the **Revelstoke District** with only 3 spot outbreaks on south-facing slopes along the lower Illecillewaet River and 1 along upper Arrow Lake. Most of these lingering spot outbreaks are in or near mixed stands with few lodgepole or white pine to spread to. Scattered, usually single, infested white pine were usually weakened by white pine blister rust and were not quantified.

The infestation in **Kootenay National Park** continued to increase to 897 ha from 715 in 1993. Lack of suitable host at the original focal point near Daer Mountain has led to a large increase in the number of faders up to and beyond the northern and southern park boundaries. Scattered single tree attacks were noted as far north as Numa Creek along the Vermilion River. In **Yoho National Park**, the 520 trees mapped in 1994 was down only slightly from 1993. The main infestation remained in the Field area, but there was an increase in the number of spot infestations along the Beaverfoot River. In **Glacier National Park**, the number of trees mapped increased to 1375, mostly along Mountain Creek with the infestation near the mouth dispersing westward up the creek. Populations remained low in **Mt. Revelstoke National Park** with occasional spot outbreaks of up to 5 trees observed on south-facing slopes above the Illecillewaet River in lodgepole pine and blister rust-infected white pine.

Forecasts

In the East Kootenay the 1994 beetle flight was generally smaller than in 1993, but continued to indicate an increasing population in the north and decreasing in the south (Table 2). Some of the reduced flight was due to the cool, damp summer in 1993, which resulted in small broods in more dense stands, especially in cooler higher elevation side drainages. The largest broods occurred on the south sides of open-growing stands and fringe trees. Many infestations are becoming smaller and more manageable as a result. Even when broods indicate an increasing population, the actual area of new attack is often reduced due to a strong management program.

Cranbrook and southern Invermere Forest Districts

Populations were generally stable to decreasing in this area, as indicated by spring brood sampling (Table 2). Current attack levels continued to decline in older portions of infestations, with increased attack present only in small new infestations with large trees, notably in the Moyie Lake area.

Table 2. Overwintering survival and population status of mountain pine beetle. FIDS, Nelson Forest Region 1994.

Location	"R" value[1]	Population status[2]	Location	"R" value	Population status
Boundary District			**Cranbrook District**		
Bitter Cr.	3.9	Static	Moyie Lk	5.8	Increasing
Mitchener Cr.	2.1	Decreasing	Teepee Cr.	3.8	Static
Mt. Baldy Rd	1.6	Decreasing	Bull R	3.7	Static
Boundary Cr.	1.2	Decreasing	Fernie	1.7	Decreasing
Beaverdell	0.9	Decreasing			
			Invermere District		
Arrow District			Mitchell Cr.	8.6	Increasing
Nancy Greene Lk	6.1	Increasing	Cartwright Lk	6.5	Increasing
Deer Cr.	4.2	Increasing	Frances Cr.	5.9	Increasing
			Pinnacle Cr.	5.6	Increasing
Golden District			Parson	3.9	Static
12 Mile Cr.	8.3	Increasing			
Waitabit Cr.	6.6	Increasing	**Kootenay National Park**		
Blackwater Ridge	3.8	Static	Kootenay Crossing	12.5	Increasing
			Dog Lk Trail	4.5	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.

Northern Invermere and Golden Forest Districts

Spring assessments of broods indicated static to increasing populations in this zone. Although woodpecker predation destroyed up to 70% of the broods in some of the older infestations near Steamboat Mountain, the remaining broods were large and current- to red-attack ratios were close to 3:1 in leave strips in the area. Small infestations to the north along the Columbia River should remain relatively static. Infestations along Waitabit Creek, the upper Kootenay and Beaverfoot rivers, and Cross Creek had an increase in beetle flight with a general current- to red-attack ratio of 2:1, that ranged up to 8:1 along the northern boundary of Kootenay National Park. The current attack in these small infestations was often widely dispersed from the 1994 faders.

Boundary and southern Arrow Forest Districts

Spring assessments of overwintering survival again revealed a population decline at western locations in this outbreak zone, and static to increasing populations to the east in areas of the Blueberry-Paulson Plateau where susceptible trees remain. Western declines were attributed to winter brood mortality in smaller trees attacked due to depletion of larger hosts, a trend that may not last with remaining mature stands aging to become more susceptible. Fall cruises (Table 3) confirmed that the outbreak declined slightly after the 1994 beetle flight with ratios of current to red attack averaging 0.9:1.

Table 3. Status of lodgepole and white pine in stands infested by mountain pine beetle, from fall prism cruises. FIDS, Nelson Forest Region 1994.

Location	Percent of pine attacked[1]				Percent healthy
	Current (1994)	Partial (1994)[2]	Red (1993)	Grey (pre-1993)	
Arrow District					
Nancy Greene Lk. east	15	0	24	19	42
Nancy Greene Lk. north	23	3	31	0	39
Gem Hill	36	0	25	3	36
Blueberry Cr.	12	0	25	8	55
Cranbrook District					
Moyie Lk.	24	0	21	2	52
Invermere District					
Frances Cr.	30	1	12	3	47
Golden District					
12 Mile Cr.	26	4	19	8	36
National Parks					
Dog Lake	34	0	11	0	51
Kootenay Crossing	29	0	12	1	58
Field	39	6	10	1	40
Regional Average	**27**	**1**	**19**	**4**	**46**

[1] Totals may not equal 100% due to mortality from other causes.
[2] The partial attacks include pitchouts.

Revelstoke, Kootenay Lake, and northern Arrow Forest Districts

Spot infestations are expected to remain at low levels in large areas of this zone where pine is a relatively minor component. However, there is potential for expansion where significant pine stocking is reaching a susceptible age, a risk increased by conservation and fire suppression which preserve aging stands. Numerous increasingly-susceptible stands originated from the widespread burning and logging that accompanied the large wave of settlement a century ago. Examples include parts of the West Arm, Kootenay River, and Arrow Lake drainages where spot beetle outbreaks in aging pine are increasing. In addition, scattered infestation of white pine weakened by blister rust will continue throughout the host range, though spill-over into healthy trees is rare.

National Parks

In Kootenay National Park populations are continuing to increase as indicated by brood size and cruise data (Table 3). Most suitable host trees have been killed in the Daer Mountain

area and further expansion can be expected to the north in the Kootenay Crossing area and south along the Kootenay River to the park boundary. Scattered spot infestations are expected to increase along the Vermilion River as beetles disperse from the main infestation area. Local populations in the Vermilion River drainage are still too small to allow for population buildup. In the infestation near Field, in Yoho National Park, current attack levels increased over three-fold from 1993. The number of spot infestations near the mouth of the Beaverfoot River is expected to continue to increase slightly, largely due to migrating beetles. In Glacier National Park, the infestation near the mouth of Mountain Creek should decline, while the infestation upstream is expected to remain at similar levels in 1995. Populations are expected to linger at low levels in Mt. Revelstoke National Park in limited patches of aging lodgepole pine and blister rust-infected white pine.

Bark beetles in ponderosa pine

Boundary and Arrow Forest Districts

For the third year patches of usually about 5 ponderosa pine of varying ages were killed by bark beetles throughout the host range in the southern Boundary and Arrow districts. There were 45 patches of dying (red stage) trees mapped, down from 170 and 140 in 1993 and 1992, respectively. Mortality was again most frequent in the Bridesville to Greenwood, Rock Creek to Westbridge, and lower Arrow Lake areas. Initial attacks were in the first meter of bole by the red turpentine beetle, *Dendroctonus valens*, and higher by the mountain pine beetle. These were followed by the western pine beetle, *D. brevicomis*; Ips beetles, *Ips pini* and *I. emarginatus*; and a secondary bark beetle, *Hylurgops porosus*.

Additional infestation is likely considering the scattered nature of attacks, potential host trees remaining, and dry weather in 1994. Brood survival is 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 fungus, *Ceratocystis* sp., introduced by the bark beetles was detected.

Cranbrook Forest District

In an experimental burn in a ponderosa pine/Douglas-fir stand near Fort Steele, 57% of the scorched ponderosa pine were attacked by the red turpentine beetle. Generally, mortality due to this beetle was less then 5%, but ranged up to 45% in $\pm$0.5 ha patches. Tree mortality from this beetle requires attacks to be approximately 15 cm apart or less. However, attacked trees will often become attractive to other beetles such as mountain pine beetle, western pine beetle and Ips, which will kill trees that survive the turpentine beetle attacks. An additional 2% of the scorched trees were killed by mountain pine beetle.

White pine blister rust
Cronartium ribicola

This non-native disease continues to kill trees in high numbers, decreasing the occurrence of white, limber and whitebark pines throughout their ranges. The scattered occurrence of infections, discoloration for several years before mortality, and occasional secondary infestation by bark beetles prevent an accurate regional determination of annual impact. Surveys of accumulated impact in 1993 revealed that infection rates averaged 85%, including 31% mortality, in representative natural stands. The following bark beetles have been collected mass attacking rust-infected white pine: mountain pine beetle, red turpentine beetle, Ips beetles, and *Pityogenes fossifrons*.

Table 4. Occurrence of white pine blister rust in spaced and pruned stands. FIDS, Nelson Forest Region 1994.

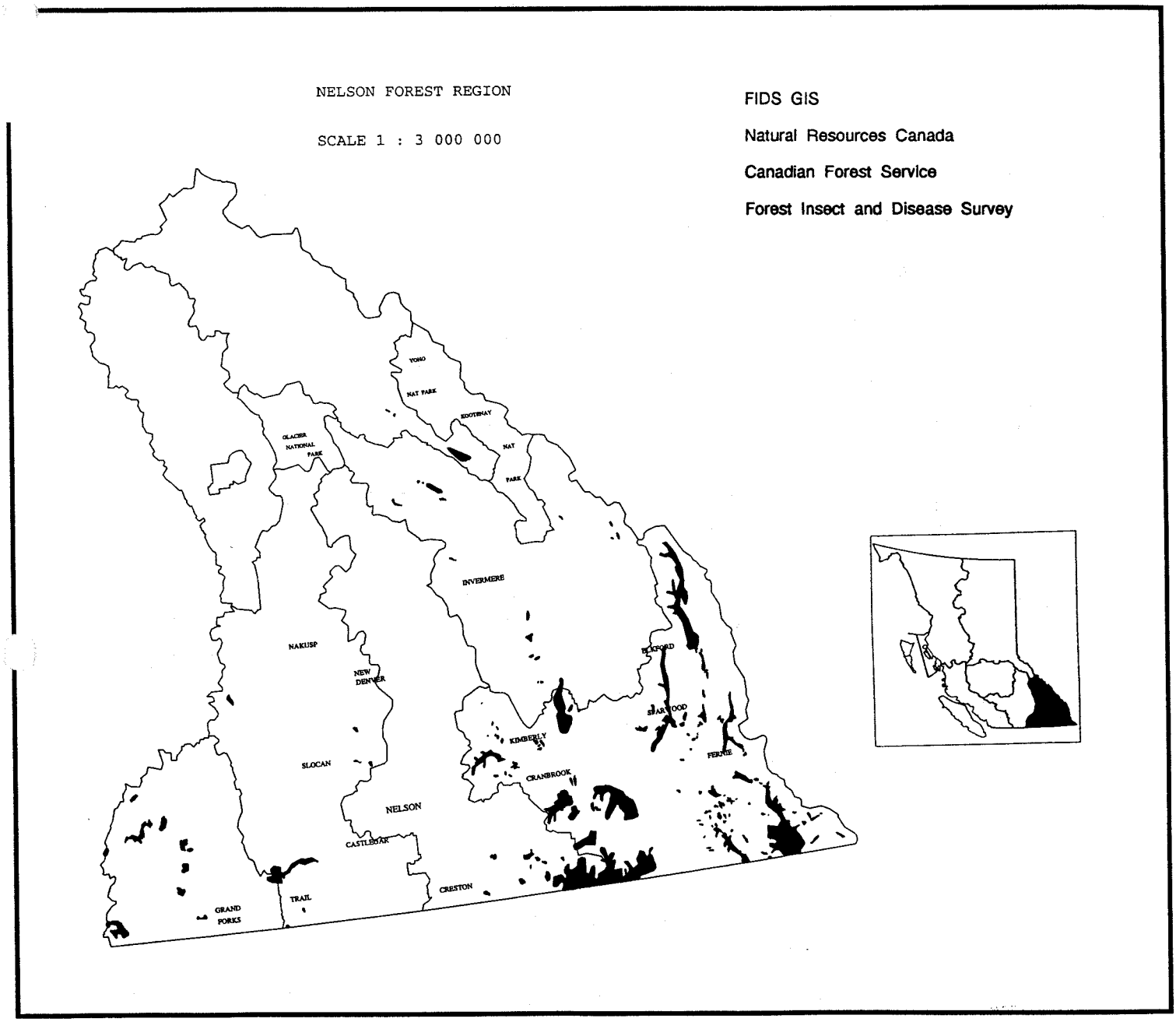
Location	Age	% wwP in stand	Percent of western white pine infected				Years since treatment
			Branch-cankers	Stem-cankers	Dead	Total	
Hamilton Ck.	12	51	2	7	7	16	1
Meadow Ridge	23	14	8	43	0	51	2
Halfway R.	19	87	0	15	10	25	2
Wilson Creek	28	10	8	33	0	42	3
Cranberry Ck.	25	68	5	18	3	26	4
Lardeau R.	20	24	21	58	0	79	4
Matt Creek	25	7	0	14	29	43	5
Meadow Ck.	24	10	18	27	9	55	6
Sale Mtn.	25	39	8	35	9	52	6
Montana Ck.	40	27	14	18	4	36	6
Martha Ck.	22	18	10	20	5	35	7
Kuskanax Ck.	30	64	4	19	13	37	8
Average			8	26	7	41	

Young stands with a white pine component can be pruned to stop the progression of branch infections into the stem. However, follow-up surveys of treated stands (Table 4) reveal variable but usually high levels of mortality and imminent mortality from stem cankers. The dead and dying trees were usually affected by cankers in the lowest 2 m of bole, indicating that improvements could be achieved by pruning earlier, before infections had progressed into the stem.

Researchers at the Pacific Forestry Centre continue to study genetic variations in the fungus in several general infection areas in the region. Collections were submitted from white pine at Idaho Peak and whitebark pine in the Galton Range.

Pine needle cast
Lophodermella concolor

For the fourth consecutive year, year-old lodgepole pine needles were killed by *L. concolor* at moderate to high levels through much of the southern two-thirds of the region. Conspicuous areas of mostly severe discoloration were mapped over 227 000 ha (Map 2) compared to 71 000 ha in 1993. These are conservative figures since discoloration was masked by new foliage in many areas when mapped in late July and August. Some of the larger areas mapped were 81 000 ha south of Cranbrook (Gold Mtn. to Yahk), 31 000 ha in the Elk River/Michel Creek area, 43 000 ha in the Flathead-Wigwam river areas, 13 000 ha in the Lost Dog-Mather creeks area, 10 000 ha along Bull River, and 7 000 ha in the St. Mary River drainage.



Map 2. Areas where year-old lodgepole pine foliage was moderately to severely discolored by pine needle cast. FIDS, Nelson Forest Region 1994.

Understory and sapling to pole-sized stands were the most severely affected. Many young stands have little foliage left after consecutive years of severe needlecasting and there may be scattered mortality in addition to the usual impact of 50 to 70 percent annual growth loss. A secondary fungus, *Hendersonia pinicola*, was present in most collections of *L. concolor*, causing further blighting of infected needles.

As in previous years, foliar infection by this fungus was favored by wet weather early in the growing season and continued discoloration is forecast for 1995. At Castlegar and Cranbrook, April to June rainfall was 24% above normal. Conversely, the last half of the field season was very dry and the loss of infected older foliage should have slowed water loss through evapotranspiration, reducing the impact of drought.

Trees chronically discolored by needle cast sustained greater damage by Armillaria root disease (Table 5). Plots were established in 1990 in 3 pole- sized stands and monitored annually. At each site, 10 trees consistantly in each category of foliar discoloration were excavated for root examination. Armillaria was identified by mycelial growth and/or fruiting bodies. Of the 20 severely-discolored trees with root disease one had recently died, four had advanced decay on a main root, and the rest had bark lesions and dead minor roots. The lightly-discolored trees had only bark lesions or infected minor roots.

Table 5. Infection of lodgepole pine by *Armillaria ostoyae* at two levels of *Lophodermella concolor* discoloration. FIDS, Nelson Forest Region, 1994.

Location	Percent of trees with Armillaria root disease	
	Severe foliar discoloration	Light foliar discoloration
Lodgepole Creek	70	40
Bull River	60	0
Bloom Creek	70	10
Average	**67**	**17**

A pine needle blight
Leptomelanconium cinereum

Most of the 1993 and older ponderosa pine foliage was killed by this needle blight over 3120 ha in the southern Rocky Mountain Trench. The area and intensity may be conservative since new growth masked the diseased foliage when mapped at the end of July. The most severe and extensive blighting was recorded in the Tobacco Plains area along the United States Border, with gradually diminishing intensity north of Jaffray, but common as far north as the junction of the St. Mary and Kootenay rivers area.

This fungus is most commonly seen on older foliage but in favorable conditions is capable of infecting all ages of needles. With one year of severe blighting radial growth may be reduced by 40%. In drought years, such as 1994, the early foliage loss may reduce water loss due to evapotranspiration.

Whitebark pine decline

In a continuing assessment of whitebark pine decline in the Galton range, 20 recently cut stumps were examined for the presence of root disease. Seven (35%) were infected by *Inonotus tomentosus*, one (5%) was infected by *Armillaria ostoyae*, and two (10%) had both of these root diseases. The site was basically an overmature stand with both whitebark and lodgepole pine declining. Root disease was the major mortality factor for both species, although white pine blister rust was present on mature whitebark pine, it was not severe enough to predispose trees to more rapid development of root pathogens through the root system. A major impact of white pine blister rust on whitebark pine is its threat to the survival of struggling regeneration, 61% of which had stem or major branch cankers.

Hemlock Pests

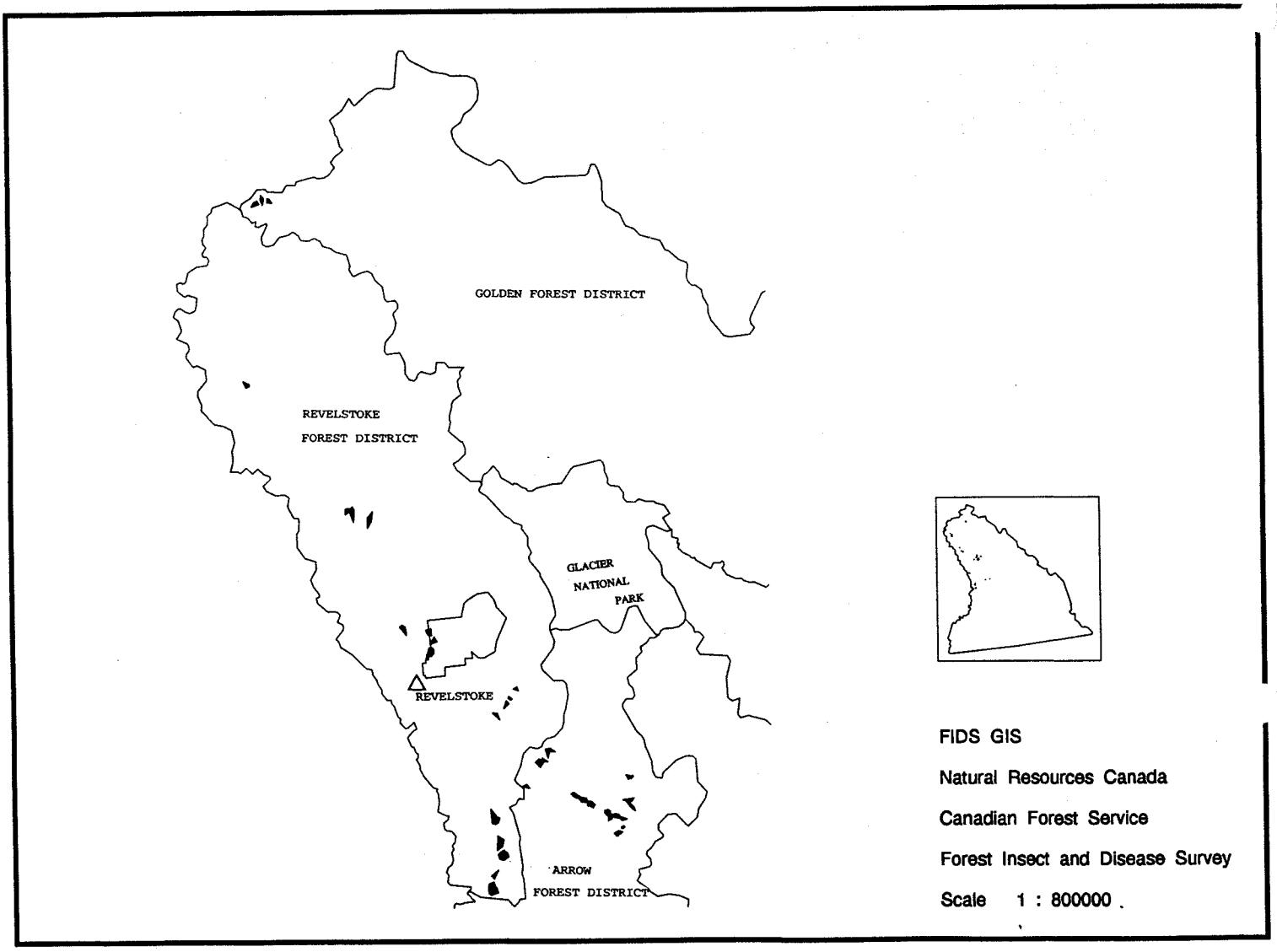
Western hemlock looper
Lambdina fiscellaria lugubrosa

In the fifth year of a multi-regional outbreak, defoliation of mature to overmature western hemlock-western red cedar stands declined by 94% to 3020 ha, at mostly light intensity (Table 6). Current defoliation was mapped at mid-elevations along the Revelstoke Lake Reservoir, upper Arrow Lake, and east to Trout Lake (Map 3). Defoliation also declined in the Prince George Forest Region and collapsed in the Kamloops and Cariboo regions.

Table 6. Defoliation in the current outbreak of the western hemlock looper. FIDS, Nelson Forest Region 1990-94.

Year	Number of Infestations	Area defoliated (ha)			
		Light	Moderate	Severe	Total
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
1994	**39**	**2 370**	**650**	**-**	**3 020**

Five outbreaks have been recorded in the Nelson region with an average of 11 intervening years (range 5-24). Until this outbreak, defoliation occurred for 2 or 3 years, causing scattered top-kill and mortality. In the Nelson region and B.C. Interior the extent, duration, intensity, and impact of the current outbreak are the greatest recorded.



Map 3. Areas where current defoliation caused by the western hemlock looper was detected during aerial and ground surveys in 1994. FIDS, Nelson Forest Region 1994.

Impact

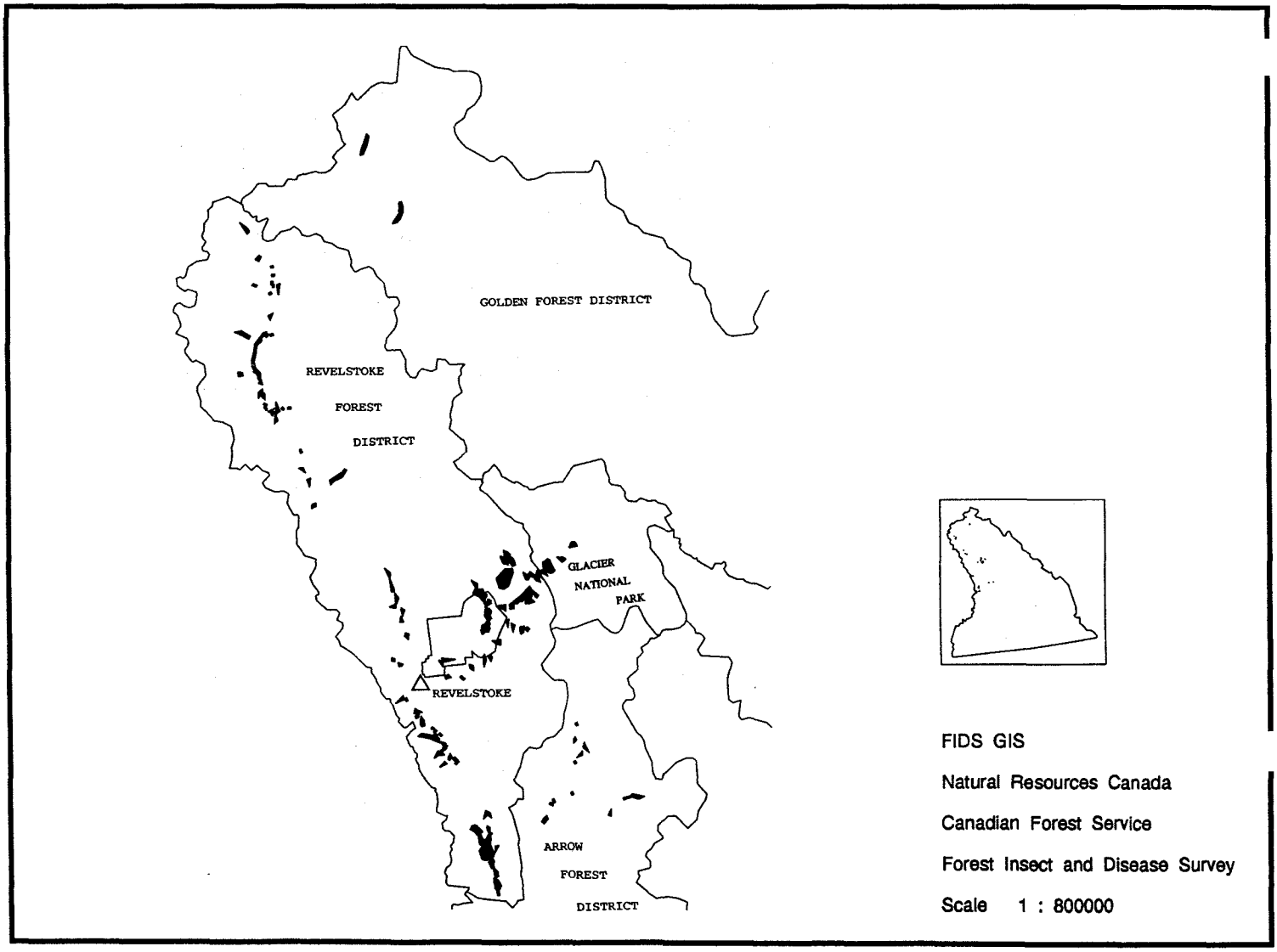
Current impact data is available from plots in representative stands (Table 7), though mortality is expected to continue for several years after the outbreak and will be monitored annually. Mortality to date region-wide totals 4.6 million trees or 6.6 million m^3 over an accumulated total of 89 800 ha. Stands with severe impact, significant mortality visible from the air, were mapped over 9150 ha and sustained mortality of 1.6 million trees or 5.3 million m^3 to date. The remaining 80 650 ha defoliated were designated as lightly impacted with mortality of 3.0 million trees or 1.3 million m^3 to date, usually smaller understory trees. Most mortality occurred near the upper Arrow and Revelstoke lakes; Jumping, Woolsey, Lardeau and Pingston creeks; and the Illecillewaet and Tangier rivers (Map 4).

Table 7. Impact of the current outbreak of the western hemlock looper to date as determined from fixed radius plots in representative stands of severe and light impact. FIDS, Nelson Forest Region 1994.

Impact category[1], location, host	Stand composition m^3/ha	Stand composition No.trees/ha	Percent mortality Volume	Percent mortality No.trees	Crown dieback[2] (%)
Severe impact					
Downie Creek					
western hemlock	836	314	40	47	32
w. red cedar	249	47	86	67	27
w. white pine	41	4	0	0	0
Total/average	Total: 1127	365	Avg: 48	48	Avg: 32
Bigmouth Creek					
western hemlock	886	414	47	35	35
w. red cedar	217	32	86	50	1
alpine fir	2	14	100	100	-
Total/average	1104	460	55	38	33
Average	**1116**	**413**	**52**	**43**	**33**
Light impact					
Downie Creek					
western hemlock	471	372	<1	3	8
w. red cedar	194	159	2	3	21
Engelmann spruce	27	16	0	0	3
Total/average	693	547	1	3	9
Tangier River					
western hemlock	891	356	1	6	13
w. red cedar	209	44	0	0	4
Total/average	1100	400	1	5	12
Redrock Peninsula					
western hemlock	668	442	4	18	3
w. red cedar	25	18	0	0	40
Total/average	693	460	4	17	5
Average	**829**	**469**	**2**	**8**	**9**

1 **Severe impact** = stands with enough mortality at the end of the outbreak to map from the air; **light impact** = remaining stands with mortality of mostly understory trees not obvious from the air.

2 Crown dieback includes topkill, most common in severely-impacted stands, and lower crown branch mortality, common in all looper-defoliated stands.



Map 4. Areas where severe impact, including significant tree mortality, resulting from the 1990 to 1994 outbreak of the western hemlock looper was detected during aerial and ground surveys. FIDS, Nelson Forest Region 1994.

In remaining live trees, crown dieback averaged 33% (hemlock 34%, cedar 14%) in areas of severe impact and 9% (hemlock 8%, cedar 22%) in remaining stands (Table 7). Volume losses from reduced growth in surviving trees are expected to be significant and will be quantified about 5 years after the outbreak when the full extent of mortality and recovery becomes evident.

Both impact categories occurred in over-mature stands but representative severely-impacted sites had an average of 12% less stocking and 26% more volume compared to areas of light impact. This quantifies a generally accepted observation that the greatest looper activity occurs in the oldest stands with the largest, though fewest, trees. The volume and stocking values representative of these impact categories have potential application to a region-specific risk rating system for outbreak susceptibility in over-mature stands.

As expected, the impact of defoliation varied widely in the understory due to variable growth and stocking under over-mature stands (Table 8). An average of 46% hemlock and 6% cedar regeneration were killed to date in areas of severe impact, while mortality averaged 5% of each in areas of lighter impact. Most of the regeneration was less than 3 m tall.

In previous outbreaks, trees that were 100% defoliated were usually killed directly. Top-kill started with only 40% defoliation, some tree mortality followed 60% defoliation, and those 80% or more defoliated usually died within 3 to 5 years from secondary causes. Post-outbreak mortality will be monitored by FIDS after the current infestation.

Table 8. Mortality of understory regeneration to date due to the current outbreak of the western hemlock looper as determined from fixed-radius plots in representative stands of severe and light impact. FIDS, Nelson Forest Region 1994.

Impact category, Location	Regeneration stocking (trees/ha)			% Regeneration mortality		
	W. hemlock	W. red cedar	Total	W. hemlock	W. red cedar	Stand
Severe impact						
Downie Creek	450	140	590	66	11	53
Bigmouth Creek	80	100	180	25	0	11
Average	265	120	385	46	6	32
Light impact						
Downie Creek	280	47	327	10	14	10
Tangier River	130	50	180	0	0	0
Redrock Peninsula	340	220	560	6	0	4
Average	250	106	356	5	5	5

Forecast

Larval sampling, egg counts and pheromone trapping confirmed the near-collapse of the population and defoliation is expected to decrease again in 1995 (Table 9, Map 5). Sampling was done at 9 sites (Map 6) in a continuing project to calibrate a new pheromone by relating moth catches to subsequent defoliation. Moth catches reflect the current year's activity and the use of threshold values for forecasting depends on the context: between outbreaks an increase in moths caught should indicate an expanding population, while late in an outbreak a similar catch as a decrease from the previous year would mean less activity expected the next year. In the current collapsing outbreak moth catches declined an average 90% from 1993, indicating that populations should decrease again next year. This trend is supported by lower larval and egg counts at the monitoring sites and no significant current defoliation.

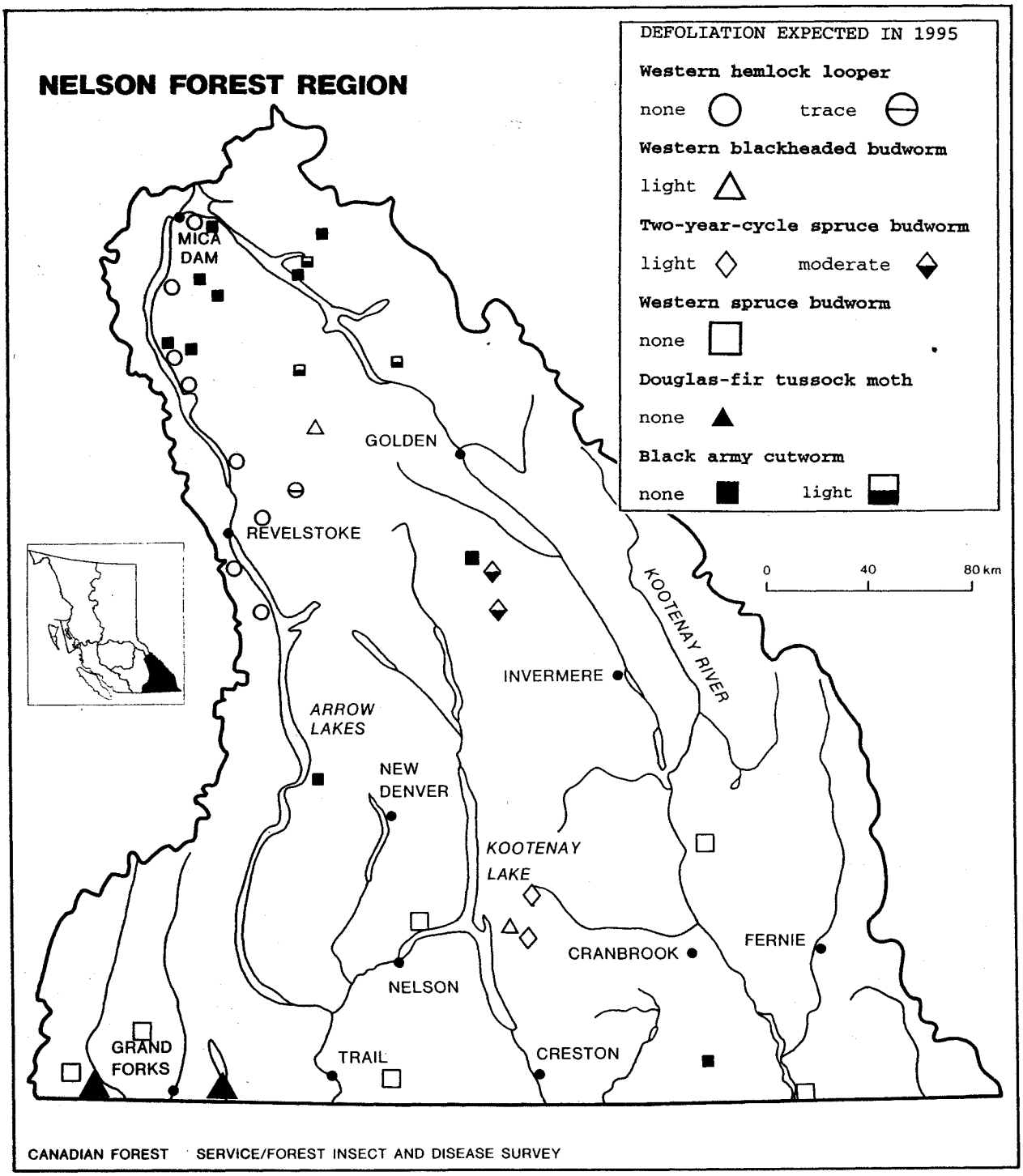
Table 9. Trends in larval counts, moth catches and egg sampling at population monitoring sites used to forecast decreasing defoliation by the western hemlock looper in 1995. FIDS, Nelson Forest Region 1994.

Location	Current Defol.	No. larvae[1]		No. moths trapped[2]		No. eggs[3]	
		1994	% change	1994	% change	1994	% change
Tangier River	trace	23	-85	489	-89	25	-86
Illecillewaet R.	trace	11	-91	384	-96	6	-90
Begbie Creek	none	0	-100	762	-50	5	-76
Shelter Bay	none	4	+33	289	-92	3	-63
Martha Creek	none	6	-77	79	-98	7	-83
Downie Creek	none	0	-100	77	-95	3	-88
Goldstream R.	none	0	-100	40	-97	2	-80
Redrock Penin.	none	0	-100	13	-95	0	-100
Bigmouth Ck.	none	0	-100	5	-99	8	+100
Average		**5**	**-80**	**238**	**-90**	**7**	**-63**

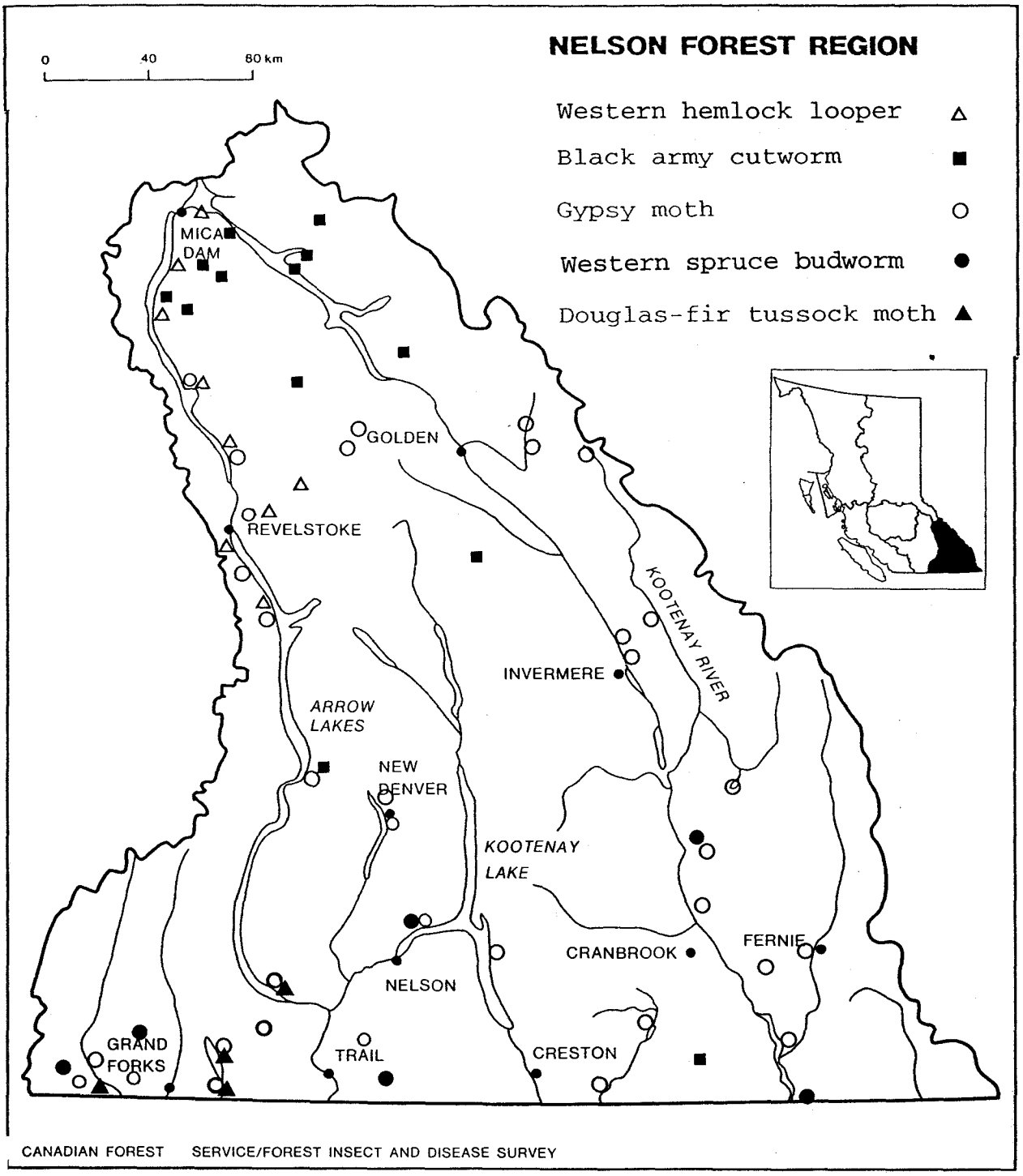
1 No. of larvae per standard 3-tree beating sample, % change from 1993.

2 Avg. of 2 Universal pheromone traps per site, 10 ug bait, % change from 1993

3 Average no. healthy eggs per 100 g lichen, extracted by hot water filtration.



Map 5. Forecasts of defoliation in 1995 by six insects in the Nelson Forest Region.



Map 6. Locations where one or more pheromone-baited traps were deployed in 1994.

Western blackheaded budworm
Acleris gloverana

Budworm populations increased to defoliate 4626 ha of mainly western hemlock; 40 ha was mapped along Gray Creek and the rest in Glacier National Park. In Glacier Park, trace to light defoliation occurred along the Illecillewaet River from the Bostock-Flat creeks area, east to Cougar Creek and Loop Brook, and along Beaver River near Avalanche Creek. Additional trace defoliation was noted during ground surveys over about 100 ha in the Crawford Creek drainage and in patches in the Wilson Lake to Halfway River and Trout Lake areas. Both the Gray and Crawford creek infestations were on north aspects at 1200 m elevation. Larval counts along the west side of the Columbia Reach remained from 300 to 400 in standard beating samples, causing only trace to very light defoliation. From Gold River north along McNaughton Lake populations declined to endemic levels, averaging less than 20 larvae in beatings.

In the Beaver River area, increasing numbers of hemlock sawfly, *Neodiprion tsugae,* compounded the impact of blackheaded budworm defoliation by eating older foliage.

Defoliation is expected to decline in 1995 (Map 5). Branch samples from Bostock Creek had an average of six eggs per 45 cm branch, indicating potential for trace to light defoliation only. At Gray Creek, egg counts were down to two eggs, with no significant defoliation expected in 1995. The decline in population between larval and egg sampling appears to be a result of disease. Mass larval collections from Bostock Creek had only 2% emergence, with 74% diseased and 16% parasitized, mainly by Hymenoptera. At Gray Creek 34% emerged, 35% were diseased and 2% parasitized.

Gray spruce looper
Caripeta divisata

Populations of this insect remained endemic after an intense two year, 4000 ha outbreak subsided in 1992. However, new mortality continues to be recorded due to secondary insects, root disease and climate in trees with significant crown dieback in all severely defoliated stands. In an unsalvaged stand near Wragge Point, accumulated mortality of western hemlock has reached an average of 500 trees/ha which is 46% of the hemlock component or 40% of the stand; in terms of volume the losses to date totalled 171 m^3/ha of hemlock which is 43% of the hemlock volume or 40% of stand volume. Crown dieback still averaged 41% (range 0-95%) in remaining live hemlock compared to 53% in 1992, so additional mortality is possible.

Other hosts were relatively lightly damaged. Mortality of cedar was 8% of trees or 6% of volume with an average of 1% crown dieback in remaining live trees. Minor components of larch and Douglas-fir, less than 1% each, did not sustain mortality and averaged 4 and 5 percent crown dieback, respectively.

A hemlock needle miner
Epinotia sp.?

A hemlock needle miner lightly defoliated mature and immature hemlock over 0.25 ha just north of Smith Creek along McNaughton Lake. Historically, no needle miners have been collected from hemlock in the Interior. No insects were present when damage was first noted in mid-July, but the damage was typical of *Epinotia tsugana* which occasionally has caused extensive defoliation of coastal western hemlock. Feeding occurs during early spring and moths fly during June and early July.

Douglas-fir Pests

Douglas-fir beetle
Dendroctonus pseudotsugae

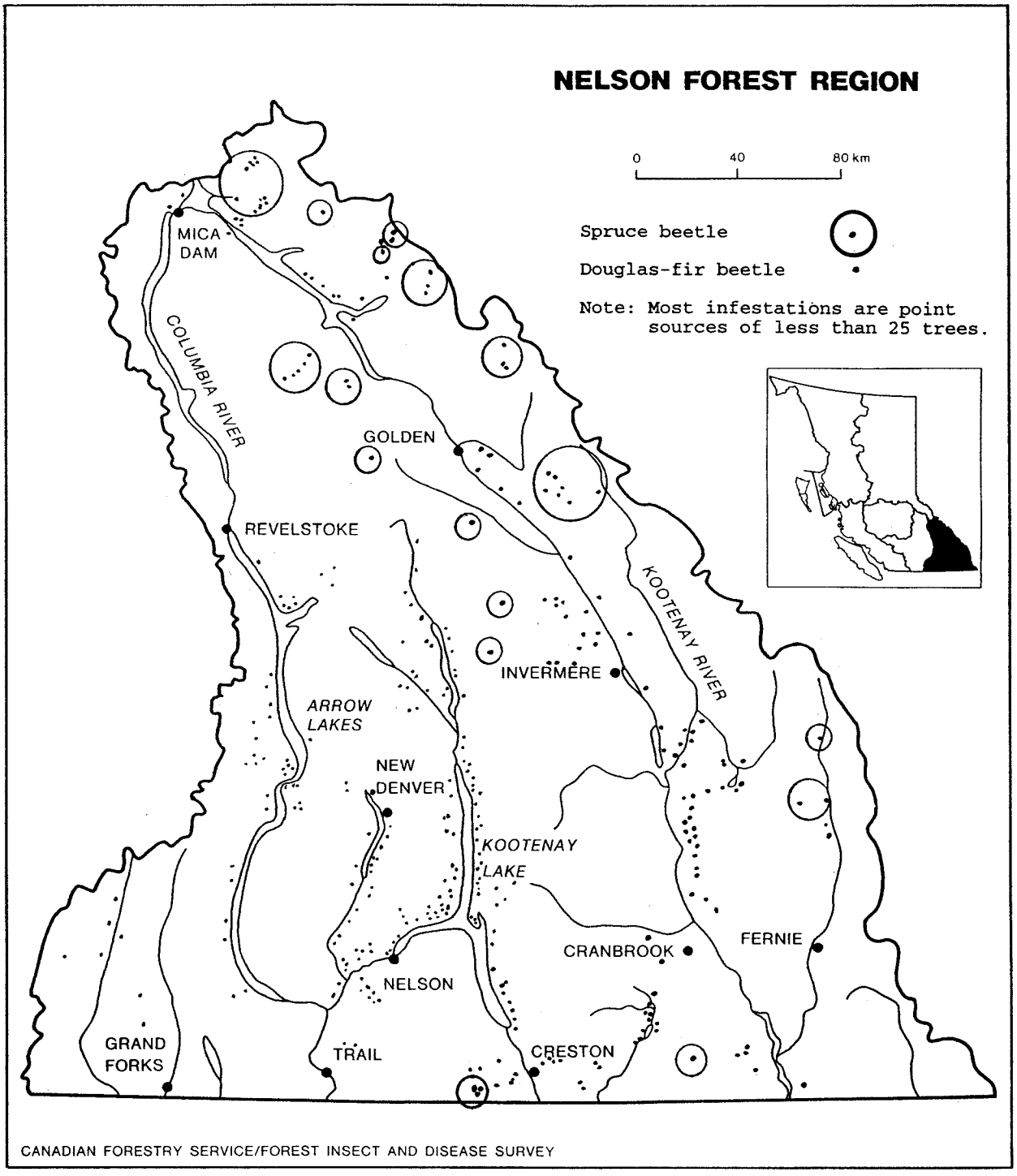
A total of 585 Douglas-fir beetle infestations were mapped over 237 ha in the region, up from 22 ha in 1993 (Map 7, Table 10). Concentrated increased beetle activity occurred along Steamboat Mountain and Premier Lake in the East Kootenay while scattered new spot outbreaks of up to 25 trees were mapped mainly in the Kootenay Lake and Arrow districts of the West Kootenays.

Table 10. Location, number, and area of Douglas-fir recently killed by the Douglas-fir beetle. FIDS, Nelson Forest Region 1994.

District	Area	No. infestations	No. trees
Kootenay Lake	118	268	3000
Invermere	53	102	2300
Arrow	24	96	960
Cranbrook	20	67	820
Golden	15	31	600
Revelstoke	3	11	110
Boundary	2	8	80
Kootenay National Park	2	2	30
Total	**237**	**585**	**7900**

In the **Kootenay Lake District,** new small patches of recently-killed Douglas-fir were most common along the West Arm of Kootenay Lake, the east side of Kootenay Lake, south aspect slopes along the lower Goat River, and the Corn Creek and Little Moyie River drainages. Scattered windthrow from the fall of 1991 and numerous patches of root disease may have contributed to the population increase in these aging, increasingly-susceptible stands.

In the **Invermere District,** there was a four-fold increase in the number of recently-killed trees. The most active populations remained in the Lower Lussier River area, especially in the Premier to Lazy lakes area, but with small groups of recently killed trees extending up the Lussier River drainage to Whiteswan Lake and south to Wildhorse Creek in the Cranbrook District. Additional concentrations of the recently killed trees occurred in the Steamboat Mountain area where windthrown trees from the fall of 1991 were attacked in 1992, emerged in 1993 to attack standing trees, which turned color in 1994. Scattered pockets of beetle activity declined along the Columbia River from Canal Flats to Invermere, but increased north of Invermere to the district boundary.



Map 7. Areas with Douglas-fir and Engelmann spruce recently killed by the Douglas-fir and spruce beetles, respectively, as determined by aerial and ground surveys. FIDS, Nelson Forest Region 1994.

Scattered spot outbreaks also increased in the **Arrow District** but to a lesser extent than the adjacent Kootenay Lake District. Outbreaks were mapped near several side drainages of the Slocan and Kootenay River drainages, Arrow Park, and occasionally near upper Arrow and Slocan Lakes. As in other districts, scattered windthrow from the fall of 1991 and numerous patches of root disease may have contributed to the population increase in these aging, increasingly-susceptible stands.

In the **Cranbrook District,** there was a nine-fold increase in the number of recently-killed trees. Much of the activity was in small scattered groups of trees along the east side of the Rocky Mountain Trench, especially between Wildhorse Creek and the Lewis Creek-Lazy Lake area. New pockets of beetle activity were mapped along the Elk River Valley, primarily to south of Elkford near Weigert Creek, along Moyie River from north of Lumberton, south to the Kootenay Lake District boundary. Scattered tree mortality occurred along the lower St. Mary River. The infestation in the Wickman Creek area continued at reduced levels. Many of the new infestations resulted from beetles emerging from windthrown trees from the fall of 1991.

In the **Golden District,** there was five-fold increase in the number of scattered small patches of recent mortality. Recent tree mortality was noted along the east side of McNaughton Lake, north of Bush Harbor, with the the most active populations in the Cummins River area. The infestation near Rice Brook, along Bush River continued to expand. New areas with groups of recent mortality were recorded along the Kicking Horse River, east of Golden. Most of the increase continued to be associated with recent logging activity, blowdown, or off-site Douglas-fir stands, with populations expanding to adjacent root-diseased trees.

Populations in the **Revelstoke District** increased slightly in the Arrowhead area with only single spot outbreaks mapped elsewhere, including Drimmie Creek where a localized infestation was logged out in 1993. Similarly, few spot outbreaks in the **Boundary District** were mapped in the Kettle River and Boundary Creek areas. In **Kootenay National Park,** scattered groups of less than five recently killed trees were mapped along the south aspect slopes along Sinclair Creek.

Forecast

Although there was a significant increase in the number of small groups of recently-killed Douglas-fir, many of these stemmed from blowdown in 1991 and populations were decreasing in 1994. However, factors such as additional blowdown, root disease, and the July to September 1994 drought may reverse this trend given that most of the affected stands are increasingly susceptible due to their age.

Populations in the Premier Lake to Wildhorse Creek area are expected to continue to increase in 1995, based on brood sampling in the Premier Lake area. Current attacks were three times greater than in 1993, and the "R" value was 4.7, (1.4+ = increasing population) indicating increased attack for 1995. At Steamboat Mountain and Moyie Lake the current attack was less than one tenth the 1993 level due to the immaturity of many of the stands and resulting poor brood development.

Concentrated recent blowdown in the Kicking Horse-Beaverfoot rivers area, and scattered blowdown extending along both drainages contained a limited amount of Douglas-fir which may lead to some standing attack in 1995.

Douglas-fir needlecast
Rhabdocline pseudotsugae

Douglas-fir needlecast continued to impact Douglas-fir over about 20 000 ha, mainly in side drainages of the Rocky Mountain Trench and Kootenay Lake. In Christmas tree growing areas between Canal Flats and Edgewater the incidence increased from an average of 9% in 1993 to 34% of the trees in 1994. Correspondingly, intensity increased to 40% of foliage from 9% in 1993.

Douglas-fir stands in narrow east-west valleys and at the fringe of their range are highly susceptible to foliage diseases, and chronic needle cast at varying annual intensities can limit the success of Douglas-fir as a regeneration species. Several such stands examined along the Bull and Elk rivers, and along Summit and Sinclair creeks had 50 to 70% of the foliage killed. In addition, the bud necrosis fungus, *Dichomera gemmicola,* killed up to 65% of the 1994 buds. The combination of these two diseases over several successive years has limited the growth of young Douglas-fir in parts of these areas, severely deformed from 5 to 20%, and killed up to 10% of regeneration in small patches.

Western spruce budworm
Choristoneura occidentalis

The budworm population continued to decline in the southwest quadrant of the region. For the second year no current defoliation was observed during aerial surveys, though lower crown foliage and understory trees were occasionally defoliated at trace levels. Spring counts of infested buds averaged 1% at the Phoenix and Conkle Lake Road pheromone calibration sites, down from 5% in 1993 and 21% in 1992. There was only 1 larva at each site in standard 3-tree beatings, while new calibration sites near Kokanee Creek, Waneta, Phillips Creek, and Premier Ridge were negative. Current moth catches (Map 6) were the same as 1993 at Phoenix (average 1 moth) and Conkle Lake Road (7), and were also low near Kokanee Creek (2), Waneta (4), Phillipps Creek (2) and Premier Ridge (15). No current defoliation was observed at the calibration sites, and none is forecast for 1995 (Map 5).

Douglas-fir tussock moth
Orgyia pseudotsugata

The tussock moth population remained low with no significant defoliation recorded since 1983 except an isolated case of moderate defoliation of several urban spruce trees in Montrose. Current moth catches (Map 6) remained low with only a single moth in each set of 5 pheromone-baited traps at calibration sites (Table 11) and negative in single traps at distribution study sites near Texas and Syringa creeks. Populations are expected to remain low in 1995 (Map 5).

Table 11. Catches of the Douglas-fir tussock moth in a calibration study of pheromone-baited sticky traps. FIDS, Nelson Forest Region 1994.

Location	Average moth catch per trap						
	1988	1989	1990	1991	1992	1993	1994
Cascade	0	2	19	63	5	0	0
Rock Creek	1	1	8	11	9	0	0

Catches of other moths attracted to the same pheromone were: the pine tussock moth, *Dasychira grisefacta*, remaining low averaging 7 moths per trap at Rock Creek, 1 at Texas Creek, and none at Cascade and Syringa Creek; and the rusty tussock moth, *Orgyia antiqua badia*, not caught for the second year.

Spruce Pests

Spruce beetle
Dendroctonus rufipennis

The area in which trees were killed by the spruce beetle more than doubled to 292 ha mapped in the region (Table 12, Map 7). Most activity remains scattered through the Golden District, but new small infestations were noted in most districts, especially the Kootenay Lake District where the B.C. Ministry of Forests reported several infestations.

Table 12. Annual occurrence and impact of the spruce beetle. FIDS, Nelson Forest Region 1994.

Management unit	Number of infestations	Area (ha)	Trees killed (faders)[1]	
			Number	Vol. (m^3)
Forest Districts				
Golden	75	136	5800	8 800
Kootenay Lake	13	138	±1000	±1 500
Cranbrook	5	2	175	270
Invermere	4	3	60	90
District Total	**97**	**279**	**7035**	**10 660**
National Parks				
Kootenay	3	5	200	300
Yoho	5	7	500	800
Glacier	2	1	20	30
National Parks Total	**10**	**13**	**720**	**1 130**
Regional Total	**107**	**292**	**7755**	**11 790**

[1] Trees attacked in 1993, discolored in 1994.

In the **Golden District**, the area mapped increased by 30% to 136 ha, while the number of small infestations increased by 70%. The main infestations in the Bachelor Creek drainage have been logged, but active pockets remain in leave strips and riparian reserves. Some of the larger, increasing infestations occur along the Bush River near Rice Brook, at the top end of Rice Brook and along Gorman Creek. Scattered small, new infestations were mapped along Ensign Creek and the upper Blaeberry River, the Valenciennes River and Icefall Brook area, and the Fraser and Moose creek areas. Several small, older infestations persisted in the Sullivan and Beaverfoot river, and Cupola Creek drainages. Patches of dead spruce were also noted along Cummins and Wood rivers, and Windy Creek, in areas severely defoliated by western hemlock looper during 1992 and 1993. These sites were not ground checked, but with the general increase in spruce beetle, the stressed trees would be highly susceptible to attack.

In the **Invermere District**, small infestations with less than 30 trees were mapped along McMurdo, Bugaboo and Bobbie Burns creeks. Spruce beetle-infested blowdown along the Middle Fork of the White River continued to harbour large broods.

Small infestation of up to 50 trees were mapped in the **Cranbrook District** along the upper Elk and Bull rivers, and near Cherry Lake along Gilnockie Creek. The areas checked at Lowe and Gilnockie creeks stemmed from 1991 blowdown with most of the attack occurring in 1993.

The main infestation in the **Kootenay Lake District** was mapped in the upper Corn Creek area. Occasional small groups of recent dead spruce were also mapped in the Goat River-Skelly Creek area and along Irishman, Sanca, and Howser creeks. Aerial surveys in the District were done by the B.C. Ministry of Forests.

In **Yoho National Park**, several infestations were mapped along the Ice River. No ground surveys were conducted, but populations appeared to have built up in slide and flood damaged trees. In **Kootenay National Park** a small infestation developed adjacent to a snowslide near the mouth of Numa Creek, along with widely scattered trees along Vermilion River. In **Glacier National Park** spot infestations occurred along Mountain and Connaught creeks.

Forecasts

Broods were generally developing in a two year cycle, except for the southern infestations, where a one year cycle was common. Although the population status in Table 13 may indicate an increasing population based on brood flying the following year, beetle populations normally decline when depending entirely upon standing trees, due to high levels of unsuccessful attack. This is especially evident in relatively isolated small infestations.

Table 13. Overwinter survival and population status of the spruce beetle. FIDS, Nelson Forest Region 1994.

Location	"R" value[1]	Population status[2]	Location	"R" value	Population status
Golden District			**Cranbrook TSA**		
Bush River	7.1	Increasing	St. Mary R.	2.7	Increasing
Blaeberry R.	2.1	Increasing	Lowe Cr.	1.0	Static
Gorman Cr.	2.0	Increasing	Gilnockie Cr.	0.6	Decreasing
Bachelor Cr.	1.7	Increasing			
Sullivan R.	0.6	Decreasing	**Invermere TSA**		
Beaverfoot R.	0.5	Decreasing	McMurdo Cr.	3.7	Increasing
			White R.	2.5	Increasing

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

[2] Interpretation of "R" values: <0.7 = decreasing population; 0.7-1.3 = static population; >1.3 = increasing population.

In most areas the main beetle flight will be in the spring of 1995, as reflected in low ratios of current to red attack (Table 14). However, in larger, older infestations there will be less annual variation.

In the **Golden District**, large flights are expected in 1995 at Camp David along the Bush River, where there are extensive areas of overmature and root-diseased trees. Populations in the Bachelor Creek drainage have started to decline following an extensive control program, but susceptible mature stands remain, along with infested trees in leave and reserve strips which may prolong the infestation. In the Gorman Creek area an expected large 1995 flight threatens much of the remaining spruce in this small drainage. Along the Blaeberry River several small new infestations are expected to expand in the Ensign and Wildcat creek areas, and maturing broods in blowdown at the lower end of the drainage could infest standing trees. Broods in the Sullivan River drainage were generally small and continuation of a beetle control program should contain the infestations. Scattered blowdown patches of up to 20 trees throughout the Beaverfoot River area absorbed beetles in 1994, leading to potential small infestations when beetles emerge in 1996.

In the **Invermere District**, large broods in a small McMurdo Creek infestation will spread to mature leave trees along the creek if left unchecked, however prompt action should prevent any significant spread. Blowdown along the middle fork of the White River remains a beetle sink, with a substantial flight expected to move into standing trees in leave blocks in 1995.

In the **Cranbrook District**, the small infestations along the Elk and Bull rivers, and near Cherry Lake are expected to decline, with only light attack in 1995. In-stand blowdown along the St. Mary River harboured moderate-sized broods which pose a threat to standing trees.

Table 14. Status of spruce in stands infested by spruce beetle. FIDS, Nelson Forest Region 1994.

Location	Percent of spruce attacked					Percent healthy
	Current (1994)	Partial (1994)	Pitchout (1994)	Red (1993)	Grey (pre-1993)	
Golden District						
Bachelor Cr.	3	5	1	18	12	61
Beaverfoot R.	7	6	3	11	4	69
Bush R.	0	1	1	51	0	47
Gorman Cr.	6	8	9	25	0	52
Cranbrook District						
Lowe Cr.	5	3	15	27	0	50
Gilnockie Cr.	11	6	4	34	1	44
Average	**5**	**5**	**5**	**28**	**3**	**54**

The infestation in **Kootenay National Park** had largely collapsed, with minimal 1994 attack and no significant activity expected in 1995. The **Yoho National Park** infestations in the Ice River area were not examined but the infestation in the upper drainage is expected to continue while downstream infestations are expected to decline, based on historic infestation patterns.

Spruce weevil
Pissodes strobi

Populations were static to increasing in four monitoring sites in the northern part of the region (Table 15). In the north, stands at lower elevations have shown a steady increase in attack levels once they reach susceptible age, however as elevations increase brood survival becomes more dependent upon local weather resulting in greater attack fluctuation.

Table 15. Spruce weevil damage trends. FIDS, Nelson Forest Region 1994.

Location	Percent of leaders attacked						Remarks
	1989	1990	1991	1992	1993	1994	
Beaverfoot R.	6	9	9	14	16	21	open valley bottom
Blackwater Cr.	4	5	5	12	19	18	spaced, valley bottom
Quartz Cr.	32	18	21	26	15	17	mixed stand
McLeod Meadows	-	-	4	9	4	8	dense natural stand
Average	**14**	**11**	**10**	**15**	**13**	**16**	

In young stand surveys 6 of 15 stands in the region in which spruce was a significant species had an average of 12% current attack, ranging up to 29% mainly in lower elevation stands in the Golden District. Significant attack levels were conspicuously absent from low elevation stands in most of the Kootenay Lake and Arrow districts. However, more attack was noted in regeneration at mid to higher elevations, such as the Barnes to Holding creeks and upper Blueberry Creek - Paulson Plateau areas.

True Fir Pests

Two-year-cycle spruce budworm
Choristoneura biennis

In the Monashee Range the area of alpine fir and spruce defoliated by this budworm declined to 282 ha at light intensity, at mid-elevations south of Plant and Cusson Creeks and east of the Whatshan River. This was down from 4300 ha of mostly severe defoliation in 1993 and reflected the shift in population from mostly maturing larvae to smaller, earlier instars. Immature larvae also lightly defoliated 40 ha in the upper parts of the Bugaboo Creek drainage. Bud counts at Bugaboo and Vowell creeks indicate a potential for severe defoliation, but egg mass counts in 1993 suggested only light defoliation in 1995, so the prediction for Bugaboo Creek has been adjusted to moderate (Table 16).

Table 16. Forecast of defoliation in 1995 by two-year-cycle spruce budworm. FIDS, Nelson Forest Region 1994.

Location	Percent of buds infested	Predicted defoliation
Bugaboo Creek	68	moderate - 1995
Vowell Creek	38	moderate - 1995
Baker Creek	20	light - 1995
St. Mary River	14	light - 1995

A project to calibrate number of moths caught in pheromone-baited traps to defoliation expected was discontinued due to limited resources and very inconsistent results. Efforts are being focused on insects for which pheromones have shown more promise and those causing the greatest damage.

Western balsam bark beetle
Dryocoetes confusus

Recent alpine fir mortality was mapped over 3300 ha, down slightly from 1993. Most of the mortality was in scattered groups of up to 50 trees in mature stands throughout the region. Some of the larger concentrations were mapped in the upper St. Mary River drainage which increased to 1900 ha, 500 ha along Bugaboo and Vowell creeks, 100 ha in the Goodfellow-Hope creeks area, and infested areas in the Spillimacheen River drainage remained

close to 300 ha. At a monitoring site in the Spillimacheen drainage current attack of standing trees continued to decline with a 1994 to 1993 attack ratio of 1:1.5.

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

Larch Pests

Larch budmoth
Zeiraphera improbana

Budmoths moderately to severely defoliated 678 ha of alpine and western larch, mainly along the Elk River near Fernie. Other widely scattered patches were mapped on alpine larch along the St. Mary River, at Whitetail Creek in the upper Kootenay River drainage, and in the Perry Creek drainage. This is the first significant infestation of larch budmoth recorded in the Rocky Mountain Range; minor defoliation occurred along the White River in 1983. Outbreaks have occurred at about 10 year intervals in the region since the only major outbreak recorded in 1965, when over 70 000 ha were defoliated.

A larch shoot moth
Argyresthia columbiana

Terminal mortality by this insect increased to 12% in spaced western larch stands in the Columbia-Windermere lakes area, after declining from 40% in 1991 to 5% in 1993. Follow-up surveys of trees with terminal mortality in 1991 found that 15% had two or more codominant leaders in 1994.

Larch needle blight
Hypodermella laricis

Discoloration of foliage by this blight fell to trace levels over the host range from the moderate to severe discoloration common in 1993 and mapped over 6400 ha. Annual variation is related to weather with a wet spring favoring successful infection. A second flush of foliage usually occurs during the summer.

Larch casebearer
Coleophora laricella

Populations remained near-endemic throughout the region for the second year. Outbreaks of this introduced insect have been minimized in recent years by foreign parasites released by FIDS in 1969, 1974-77, and 1982-84. Of 15 long-term sampling points between Anarchist Mountain and Jaffray, trace defoliation, about 1%, was recorded only at the Castlegar Pulp Mill and Cranbrook sites, all others were not defoliated. Pupal parasitism was not quantified in 1994 since most adult emergence occurred before the field season. Light to moderate defoliation by the casebearer did occur in the Kamloops Region in 1994; populations will again be monitored by FIDS in 1995.

Multiple Host Pests

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 incites 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, mostly treated under FRDA agreements. Of 45 stands assessed in 1994 and treated in the last few years, usually by spacing, 28 (62%) already had some of the remaining trees killed by Armillaria root disease (Table 19). This includes stands where the incidence was low and only recorded between plots. In stands where the disease was detected within plots an average of 4% (range 1-18%) of trees had symptoms. The incidence is expected to increase considerably within a few years as the root disease flourishes due to the partial cutting.

The development of Armillaria root disease was evaluated in three mixed species stands of Douglas-fir and pine, where the pine was removed for mountain pine beetle management (Table 17). At least three 100 m continuous strips were surveyed in pine-removal portions of each stand and adjacent undisturbed areas. The Bloom Creek and Steamboat Mountain sites had few above ground symptoms in undisturbed stands and a two- to three-fold increase in root disease 5+ years after partial cutting. The site on the Golden bench had a major root rot pocket in the partial cut area which killed 80% of the remaining Douglas-fir, and suggested an association between root-diseased pine and bark beetle attack.

Table 17. Effect on the incidence of Armillaria root disease of removing pine from mixed Douglas-fir stands. FIDS, Nelson Forest Region, 1994.

Location	Stand age	% of stand removed	Pine-removed stand		Adjacent undisturbed stand	
			% infected	No. centers	% infected	No. centers
Bloom Cr.	mix	15	8	8	4	5
Steamboat	80	65	6	5	2	2
Golden	70	50	23	7	1	2
Average			**12**	**7**	**2**	**3**

Five fixed-radius plots established to follow the progress of Armillaria root disease in a young mountain pine beetle-infested stand in the Flathead River darinage indicated a steady 1.9% mortality per year. The stand was approximately 50 years old when scattered beetle infestations in 1979 reduced the stocking to 1125 trees per hectare. Subsequent expansion of the root disease, centered around beetle-killed trees, reduced stocking to 895 trees per hectare by 1991 and 812 by 1994. Most mortality occurring immediately after the beetle infestation was independant of tree size, but later mortality occurred in mainly smaller, less vigorous trees with an average diameter of 8 cm, half that of the healthy trees of the same age.

Armillaria root disease killed almost four times as many trees in a spaced young lodgepole pine stand than in an adjacent unspaced stand; 10 infection centers were monitored at each site in the Beaverfoot River drainage. The infection centers in the stand spaced in 1990, had an average of 4.6 trees killed or symptomatic of root disease since spacing. An adjacent unspaced stand averaged 1.2 additional trees per center since 1989.

The incidence of Armillaria increased to 14%, and stocking has been reduced to 510 trees per hectare from 590, in a 20-year-old spruce plantation in the upper St. Mary River drainage. Ten plots were established in 1988 when the infection level was 8%. The increase was due to expansion of existing centers.

Drought accelerated the mortality of trees infected by *A. ostoyae* in the Rocky Mountain Trench. In a Christmas tree growing area near Edgewater, five root disease centers had an average of 1.2 recently-dead trees with an additional 3.6 drought stressed, root-diseased trees killed in each center in 1994. The reduced root function of diseased trees was unable to withstand the drought stress from 80% below-normal precipitation during the summer months.

Mammal damage

Mammal damage occurs in most stands and when populations are high the impact can be significant. Of 45 young stands recently treated, usually by spacing, 13 had an average of 2% (range 1-8%) of remaining trees damaged by mammals (Table 19). Different mammals prefer certain hosts, as indicated in a five year summary of damage in pests of young stand surveys (Table 18).

Table 18. Host preferences of several mammals accumulated from 5 years of surveys of managed young stands, usually recently spaced. FIDS, Nelson Forest Region 1994.

	Host preference (percent)				
	Lodgepole pine	Western larch	Spruce	Douglas-fir	Alpine fir
Mammal					
Hare	100	0	0	0	0
Squirrel	63	37	0	0	0
Bear	30	42	12	16	0
Porcupine	47	20	4	7	22
Ungulates	10	16	22	14	38
No. of stands: (with damage)	**76**	**34**	**59**	**64**	**21**

Black army cutworm
Actebia fennica

Black army cutworm killed 10% of the spruce seedlings in a mixed-species, 10 ha plantation, and severely defoliated herbaceous vegetation over approximately 130 ha in an unplanted cutblock near Cariboo Creek along McNaughton Lake. Large populations followed high moth catches in 1993. No damage was found at 7 sites re-checked in the West Kootenay, as forecast.

Moth catches remained low on 15 sites trapped in the region (Maps 5,6). In the East Kootenay, a low potential for light defoliation was present at three of 8 sites trapped: Bachelor (339 moths), Bluewater (340) and Sullivan (326) rivers. In the West Kootenay, catches at 7 recently-burned sites averaged 34 moths (range 10-87), well below the 600 moth threshold of potential significant infestation.

Rhizina root disease
Rhizina undulata

The occurrence of Rhizina root disease remained patchy in the region with significant seedling mortality still occurring in northwestern areas. The variable occurrence of the fungus is expected to continue as new burns provide the necessary environment. Most impact, including seedling mortality if the site was planted, occurs in the first year after burning. Seedling mortality has consistantly been less than 5% in the second year, mostly those infected but not killed the first year.

Fruiting bodies were observed at 10 of 11 recently-burned and planted clearcuts assessed in the **Revelstoke, Arrow, and Kootenay Lake districts.** Approximate seedling mortalities were: less than 10% at sites near Asher (2), Keen, Baerg, and Bigmouth creeks; 10 to 20% near Spikers, Keystone, Bigmouth and Louis Lee creeks; and 45% at a site near the Goldstream River.

In the **East Kootenay**, Rhizina fruiting bodies were found in one of nine sites examined. This may have been conservative because the sites were checked before significant fall rainfall and after a late-summer drought. In an unplanted cutblock near Cherry Lake, south of Cranbrook, large numbers of fruiting bodies were evident in several small concentrated patches, but single and small clumps of fruiting bodies were scattered throughout most of the cutblock.

Drought

Weather early in the field season was wetter and warmer than normal, however July to September rainfall at Castlegar and Cranbrook was 61 and 80 percent below normal and temperatures 9 and 15 percent warmer, respectively. Drought affected trees at low elevations, especially in the southern Rocky Mountain Trench and the Moyie Lake and Creston areas. Up to ten-year-old Douglas-fir, lodgepole pine, and to a lesser degree western larch regeneration were killed on vulnerable sites (rocky slopes and thin soils) from the United States border to Fairmont and less often north to Parson. Notable areas included patches of 10 to 20% lodgepole pine mortality over 75 ha along lower Lussier River, 0.5 ha patches of 80% mortality in the Moyie Lake area, and small patches of up to 24% current mortality in Christmas tree plantations near Edgewater. The impact was greatest in more open sites and stand fringes where periodic drought may have limited tree establishment. Factors reducing the survival of drought-stressed trees included Armillaria root disease, small mammal damage, root collar weevil, and stem cankers.

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 6). 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. Four moths of the potentially more damaging Asian strain were trapped in the Lower Mainland.

Deciduous Tree Pests

Satin Moth
Leucoma salicis

Satin moth populations increased near Golden, but decreased in southern areas of the Boundary District with current defoliation of mostly trembling aspen mapped over a regional total of 4660 ha, up from 2940 ha in 1993. This insect was accidentally introduced to B.C. from Europe in 1920 and first collected in the Nelson Region at Needles in 1963. Six outbreaks have since occurred in the region with host mortality recorded for the first time in the current outbreak.

Golden Forest District

Defoliation by satin moth increased to 4580 ha from 2700 ha in 1993. The main area of infestation remains on the bench to the west of Golden, but defoliation increased in the Blaeberry River area and to the east along the Kicking Horse River. Large moth flights were observed in the Golden area, with fewer moths observed as far south as Cranbrook.

Boundary Forest District

Defoliation of aspen and willow continued for the third year but in smaller patches at much lower intensity in the Anarchist Mountain to Grand Forks area. Mostly light current defoliation was mapped over 80 ha, down from 240 and 500 ha of mostly moderate to severe in 1993 and 1992, respectively. There was very little refoliation and mortality of severely defoliated stands was mapped over 360 ha, up from 172 ha in 1992. In previous outbreaks most trees recovered with a second flush of foliage later in the season.

Introduced parasites, a native bacterium, and a fungus have helped reduce previous satin moth outbreaks. However, current larval health remained quite good, with 54 and 48% of mass collections from near Bridesville and Golden, respectively, emerging after rearing. All but 1% of the mortality was caused by a pathogenic fungus, *Paecilomyces* sp. Mortality and dieback of host trees in the Boundary District may continue to limit populations by starvation in 1995.

Leafminers

Discoloration of birch and black cottonwood foliage by leafminers continued for the third year in the northwest quadrant of the region, but at lower levels in most areas. Discoloration of birch by *Lyonetia speculella* was again severe in the upper Illecillewaet River drainage, most conspicuous along slide paths and in relatively pure stands, but decreased to light levels elsewhere. The ambermarked birch leafminer, *Profenusa thomsonii*, was collected at low levels in the Goldstream River area. Scattered light discoloration of black cottonwood by *Phyllocnistis populiella* continued.

In the southern two-thirds of the Arrow and Kootenay Lake districts populations of *L. speculella* increased with patches of severe birch discoloration common throughout the host range, particularly conspicuous in the Castlegar and Procter to Harrop areas (2600 ha) and Arrow Park to Fauquier, Slocan Valley and Kaslo to Lardeau areas. Previous severe outbreaks of leafminers have not caused significant tree mortality in the region.

Aspen leafrollers

Leafroller activity continued over 300 ha along the Kicking Horse River, but at reduced levels with most of the defoliation caused by satin moth. Between Invermere and Fairmont, small patches of aspen were moderately to severely defoliated by an unknown leafroller.

Special Surveys

Pests of young stands

Forty-five young, recently-treated stands were examined for pest and abiotic problems in 1994 (Table 19). Tree removal during treatments, most often spacing, affected the occurrence of most pests. Sites were selected from lists stratified by district, biogeoclimatic zone, and treatment. The incidence of some pests, especially root disease, at this early stage after treatment suggests that pre-treatment surveys were inadequate in several areas and that long term impacts may be severe.

Life-threatening pest problems were recorded in 82% of stands surveyed. Root diseases, stem cankers, and mammal damage were the most frequent problems. Of 5477 trees examined, 59% were pest-free, 7% were either dead or had pests that often lead to tree mortality, and 9% had pests that cause significant growth loss. Several of the pests in Table 19 are discussed in more detail elsewhere in this report.

Table 19. Summary of pests when hosts were a significant stand component in 45 young, recently treated (usually spaced) stands. FIDS, Nelson Forest Region 1994.

Host/Pest	Most frequent severity index[1]	No. affected (suscept.) Stands		Trees		% of trees affected[2] Avg.	Range
Lodgepole pine - 1878 trees in 44 stands, significant in 12 stands							
Warren's root collar weevil	6	2	(7)	12	(694)	4	1-8
Ips bark beetle	6	2	(5)	2	(771)	1	1-1
Armillaria root disease	5	8	(12)	26	(1325)	4	1-14
Tomentosus root disease	5	1	(7)	3	(916)	4	-
Comandra blister rust	5	4	(12)	11	(1325)	2	1-3
Western gall rust	5	4	(12)	34	(1325)	9	1-21
Stalactiform blister rust	5	3	(12)	6	(1325)	2	1-3
Rhizina root disease	5	1	(1)	10	(14)	71	
Bear	5	3	(8)	11	(1082)	3	1-5
Porcupine	5	5	(8)	9	(1082)	2	1-4
Squirrel	5	5	(8)	8	(1082)	1	1-2
Ice/snow/wind	4	3	(12)	5	(1325)	1	1-2
Deer	4	1	(7)	6	(694)	4	-
Terminal weevil	4	2	(6)	3	(554)	1	1-2
Unknown (fork)	4	3	(12)	3	(1325)	1	1-1
Pine needle cast	3	10	(12)	811	(1325)	73	4-97
Pest-free	1	10	(12)	444	(1325)	34	1-97
Engelmann spruce - 1224 trees in 30 stands, significant in 15 stands							
Tomentosus root disease	5	3	(12)	5	(934)	2	1-3
Armillaria root disease	5	3	(12)	5	(934)	2	1-2
Rhizina root disease	5	1	(1)	18	(39)	46	-
Spruce weevil	4	6	(15)	57	(1121)	13	1-29
Bear	3	1	(15)	1	(1121)	1	-
Frost	3	3	(15)	172	(1121)	55	10-100
Mechanical	3	1	(15)	2	(1121)	6	-
Adelges	2	15	(15)	900	(1121)	74	13-100
Chrysomyxa sp.	2	1	(15)	3	(1121)	3	-
Zeiraphera sp.	2	1	(15)	45	(1121)	45	-
Pest-free	1	7	(15)	163	(1121)	48	1-84
Douglas-fir - 1251 trees in 35 stands, significant in 15 stands							
Mammal	6	1	(15)	1	(1087)	1	-
Armillaria root disease	5	12	(15)	76	(1087)	9	1-29
Rhizina root disease	5	1	(1)	23	(46)	50	-
Snow/wind	4	3	(15)	12	(1087)	4	2-7
Stem/branch diseases	4	1	(15)	1	(1087)	1	
Sirococcus	4	1	(15)	5	(1087)	4	
Rhabdocline needle disease	3	1	(15)	7	(1087)	9	-
Mechanical	3	2	(15)	7	(1087)	3	2-5
Unknown (multi-top/lean)	3	3	(15)	5	(1087)	1	1-2
Adelges	2	1	(15)	2	(1087)	1	-
Pest-free	1	15	(15)	961	(1087)	87	53-100

Table 19. (Cont'd)

Host/Pest	Most frequent severity index[1]	No. affected (suscept.) Stands	Trees	% of trees affected[2] Avg.	Range
Alpine fir - 257 trees in 13 stands, significant in 3 stands					
Armillaria root disease	5	1 (3)	4 (172)	5	-
Pest-free	1	3 (3)	168 (172)	98	95-100
Western larch - 237 trees in 17 stands, significant in 3 stands					
Armillaria root disease	6	2 (3)	3 (144)	3	2-4
Bear	5	2 (3)	4 (144)	7	3-11
Squirrel	4	2 (3)	4 (144)	7	4-11
Deer	4	1 (3)	2 (144)	2	-
Hypodermella sp.	2	1 (3)	6 (144)	18	-
Pest-free	1	3 (3)	128 (144)	88	79-93
Western white pine - 437 trees in 15 stands, significant in 5 stands					
Cronartium ribicola	5	5 (5)	82 (339)	21	3-37
Drought	5	1 (5)	8 (339)	25	-
Pest free	1	5 (5)	249 (339)	72	63-84
Ponderosa pine - 45 trees in 3 stands, significant in 1 stand					
Armillaria root disease	5	1 (1)	1 (29)	3	-
Pest free	1	1 (1)	28 (29)	97	-
Western red cedar - 244 trees in 22 stands, significant in 3 stands					
Pest-free	1	3 (3)	97 (97)	100	
Western hemlock - 379 trees in 16 stands, significant in 5 stands					
Pest-free	1	5 (5)	310 (310)	100	

[1] 1 - pest free
2 - minor damage, minimal impact
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.

The frequency of different pests by host in recently-treated young stands was compiled for the last five years (Chart 2). These do not necessarily reflect the overall health of young stands due to the effect of the treatment, especially spacing when most unhealthy or dead trees are removed. Only pests which affected over 1% of the trees are identified.

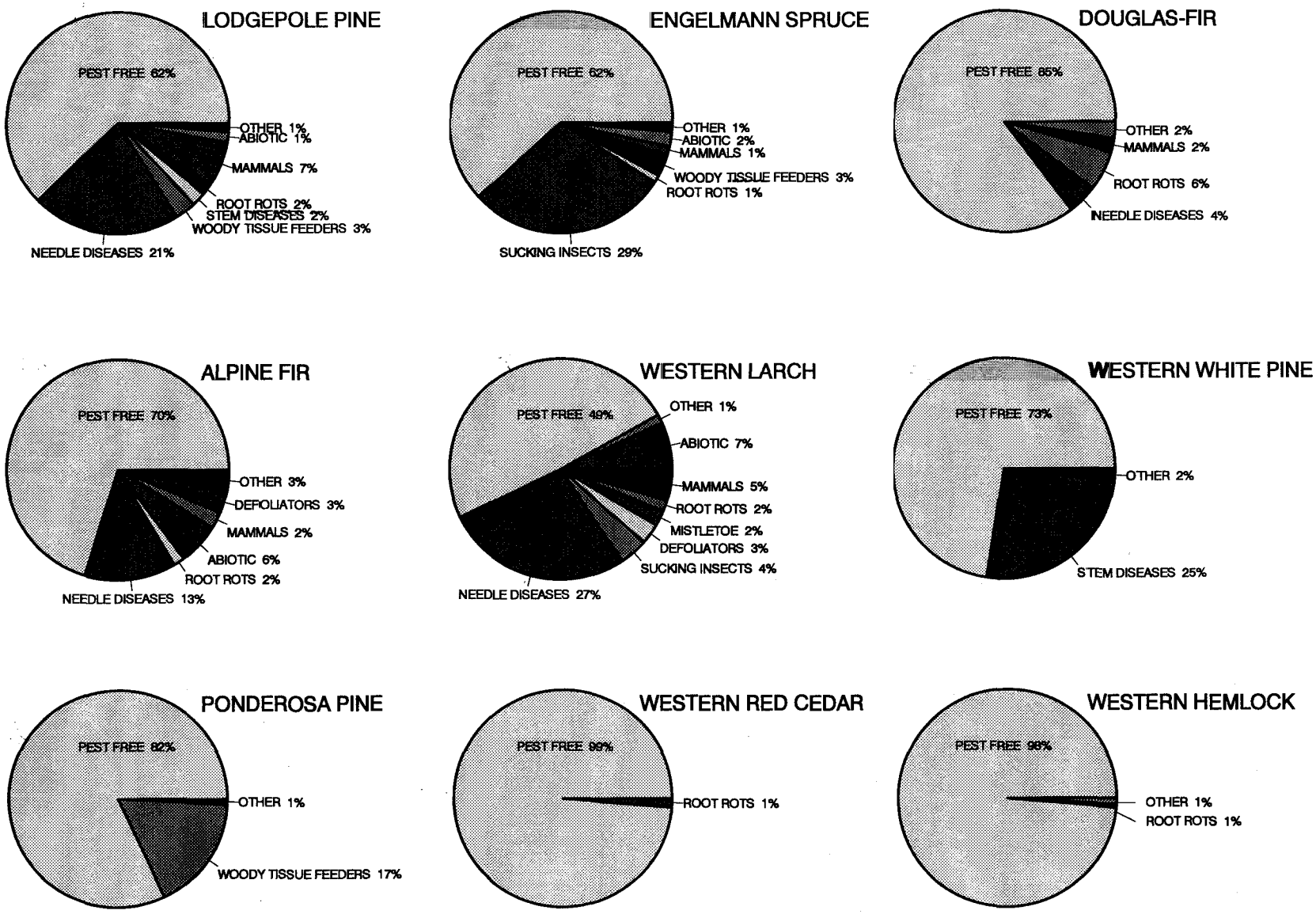


Chart 2. Five-year summary of pest occurrence by host in managed, mostly recently-spaced, young stands. FIDS, Nelson Forest Region 1990-1994.

Pinewood nematode

Bursaphelenchus xylophilus

As of January 1993 most lumber shipped to Europe has to be heat-treated to a core temperature of 56°C for 30 minutes to prevent the introduction of this nematode. Lumber also must be free of woodborer holes to show that no vectoring of the nematode into the wood occurred. Western red cedar is exempt from the heat treatment 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 1994 at three sites in the province, including a site near Canal Flats. In 1993 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 to overwinter and retrieved in 1994, but insect emergence is not yet complete. Western hemlock logs were attacked by *Monochamus* spp. when they were close to the favored lodgepole pine. Samples are being processed for completion of their life cycle in hemlock and tested for the presence of pinewood nematode.

Acid Rain National Early Warning System (ARNEWS)

As part of a national network, 10 x 40 m plots are being biomonitored to detect any impact of air- and rain-borne pollution on native trees and indicator plants. Three plots in the Nelson 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. Only the same insects and diseases were found, at low levels, as in previous years. No damage from acid rain was found.

Earthworms

As part of a biodiversity study, surveys were initiated in 1991 to record earthworm species and their distribution in British Columbia. In the Nelson Region seven European species have been collected from 18 forested sites. The most common were *Aporrectoda tuberculata* (10 sites), *A. trapezoides* (5), *Lumbricus rubellus* (3), *L. terrestris* and *Octolasion tyrtaeum* (2), and single collections of *A. turgida* and *O. cyaneum.*

Other Noteworthy Pests

Agents that are currently relatively minor, or cause significant chronic damage that varies little and is not quantified, are tabulated by host. Some of the entries were collections from research projects or special surveys which contribute to the overall record of biodiversity.

Host/Pest	Location	Remarks
PINE		
Arceuthobium americanum Lodgepole pine dwarf mistletoe	host range	occasional chronic patches, locally severe impact
Atropellis piniphila Atropellis canker	host range	occasional stem cankering of lodgepole pine, locally severe impact
Cinara sp. Giant conifer aphid	East Kootenay	common in young stands
Coleosporium asterum Foliage rust	Brewer Cr.	common in lodgepole pine seedlings
Endocronartium harknessii Western gall rust	host ranges	widespread, relatively minor impact
Endothiella aggregata A foliar fungus	Gray Creek	fruiting on winter-killed whitebark pine needles
Eucosma sonomana Western pineshoot borer	Cascade	low levels on shoots of open growing ponderosa pine
Eurytoma sp. A parasite	Moyie River	parasitizing an unknown borer in spaced lodgepole pine
Hendersonia pinicola A needle blight fungus	Syringa Creek	moderate levels in ponderosa pine, common in host range
Lachnellula agassizii A branch canker fungus	Galton Range	light levels on understory white pine
Pithyophthorus sp. A secondary bark beetle	Wasa Lake	killing branches of ponderosa pine
Rhizosphaera pini A needle blight fungus	Kane Creek	common on white pine at low levels, most of host range

Host/Pest	Location	Remarks
Scirrhia pini Red band needle disease	Kane Creek Blueberry Creek	common on white pine at low levels, most of host range locally common on lodgepole pine
WESTERN HEMLOCK		
Echinodontium tinctorium Yellow stringy heart rot	host range	significant decay common in old growth stands
Nematocampa limbata Filament bearer	host range	remaining endemic
Pucciniastrum vaccinii Hemlock-blueberry rust	Martha Creek	common at trace levels
DOUGLAS-FIR		
Arceuthobium douglasii Douglas-fir dwarf mistletoe	SW quarter of region	occasional chronic patches, locally severe impact
Contarinia pseudotsugae A needle midge	Rocky Mtn. southern Arrow and Boundary districts	10% infection on 15% of in Christmas trees scattered conspicuous infestion. of current growth in dry areas for third year
Dioryctria sp. A shoot and bud miner	Sand Creek	lightly infesting shoots
Melampsora medusae Conifer-aspen rust	Crawford Bay	localized severe patches
Nepytia freemani W. false hemlock looper	Rock Creek	occasional trace to light understory defoliation
Ophiostoma europhioides and *O. pseudotsugae* Sap staining fungi	Wildhorse Creek	associated with Douglas-fir beetle
Phaeocryptopus gaeumannii Swiss needle cast	Edgewater	branch dieback, Christmas tree area
Sirococcus conigenus A tip dieback fungus	Wilson Creek	occasional leader and lateral dieback in 6 year old stand
Xenomeris abietis A tip dieback fungus	Arrow Park	low levels of top kill in young stand

Host/Pest	Location	Remarks
SPRUCE		
Adelges cooleyi Cooley spruce gall adelgid	host range	generally light to moderate intensity
Badhamia sp. A slime mould	Wilson Creek	trace on seedlings, no impact
Ceratocystis coerulescens A sap stain fungus	Caribou Creek	associated with spruce beetle
Chrysomyxa weirii Weir's spruce cushion rust	Summs Creek	trace levels on year-old foliage
Leptographium abietinum A sap stain fungus	Caribou Creek	associated with spruce beetle
Ophiostoma europhioides A sap stain fungus	Caribou Creek	associated with spruce beetle
Pikonema alaskensis Yellowheaded spruce sawfly	Castlegar	mostly moderate defoliation for ± 20 km radius, some severe in urban areas
	Slocan Valley	new feeding north to Slocan Park
Sunscald/exposure	Holding Creek	occasional discoloration of new foliage in higher elevation stand
TRUE FIRS		
Adelges piceae Balsam woolly adelgid	U.S. border areas	several assessments negative, threat of spread from Idaho
Cinara sp. Giant conifer aphid	Pend' Oreille R.	trace damage on new growth of grand fir
Lirula abietis-concoloris A fir needle blight	host range	chronic trace damage common in higher elevation stands
Pleroneura sp. A shoot-boring sawfly	host ranges	chronic low numbers on grand and alpine firs
Potebniamyces balsamicola var. *boycei* A tip dieback fungus	Nine Mile Creek	at low levels on grand fir

Host/Pest	Location	Remarks
Pucciniastrum epilobii Fir-fireweed rust	host range	light dieback of current growth common, occas. moderate
WESTERN LARCH		
Arceuthobium laricis Larch dwarf mistletoe	host range west of Rocky Mtns.	occasional chronic patches, locally severe impact
Semiothisa sexmaculata Green larch looper	host range	remaining endemic after 1990 outbreak
JUNIPER		
Gymnosporangium clavariiforme Clavariform juniper rust	host range	high incidence of branch swellings
Gymnosporangium nelsonii Nelson's juniper rust	host range	occasional galls
Gymnosporangium tremelloides Common juniper gall rust	Castlegar	occasional tip and branch mortality
MULTIPLE HOSTS		
Gnathotrichus retusus An ambrosia beetle	host ranges	chronic pest degrading softwood lumber
Leptoglossus occidentalis Western conifer seed bug	host ranges	common, occasionally numerous overwintering in houses
Leptographium wageneri Black stain root disease	portions of host ranges	infection centers most often in pine and Douglas-fir
Trypodendron lineatum Striped ambrosia beetle	host ranges	chronic pest degrading softwood lumber
DECIDUOUS HOSTS		
Cryptorhynchus lapathi Poplar and willow borer	host range	scattered attacks chronic and widespread, common
Exobasidium sp. A leaf spot fungus (immature)	Martha Creek	trace damage to huckleberries *Vaccinium ovalifolium* and *V. membranaceum*
E. cordilleranum var. *minor* A leaf spot fungus	Summs Creek	light damage to *Vaccinium membranaceum*

Host/Pest	Location	Remarks
E. vaccinii var. *arctostaphyli* A leaf spot fungus	Martha Creek	light damage to kinnikinnick
Fomes fomentarius Birch trunk rot	host range	common stem decay of birch, conspicuous in drier areas
Hyphantria cunea Fall webworm	southern Arrow, Boundary and Cranbrook districts	low levels in roadside trees and shrubs in drier areas
Kabatia periclymeni A leaf spot fungus	Martha Creek	light damage to red twinberry
Malacosoma disstria Forest tent caterpillar	Golden	collapsed after peaking in 1989 on 9900 ha
Melampsora occidentalis Conifer-cottonwood rust	host range	chronic light to moderate leaf blotching of black cottonwood
Mycosphaerella chimaphilina A leaf spot fungus	Martha Creek	occas. leaf spotting and "shot hole" damage to prince's pine
Mycosphaerella populicola Septoria leaf spot	host range	chronic low levels on black cottonwood
Mycovellosiella sp. A leaf spot fungus	Lardeau River	first record in B.C.; low levels on red osier dogwood
Phellinus tremulae White trunk rot of aspen	host range	causing extensive decay and wood stain
Phyllosticta pachystimae A leaf spot fungus	Martha Creek	damage to false box at low levels, new record
Profenusa thomsoni A leafminer	Goldstream River	light infestation of hazelnut foliage
Saperda populnea A twig borer	Fairmont	common at low levels on aspen
Septoria sp. A leaf spot fungus	Goldstream River	low levels on birch, possibly *S. weirii*
Smerinthus cerisyi Willow sphinx moth	New Denver	moths common but larval impact minor on poplar and willow
Spilosoma virginica Yellow woollybear	Cascade	low levels on weeds and shrubs