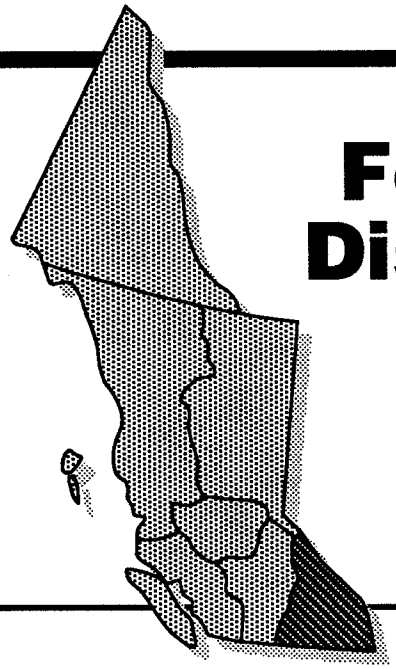
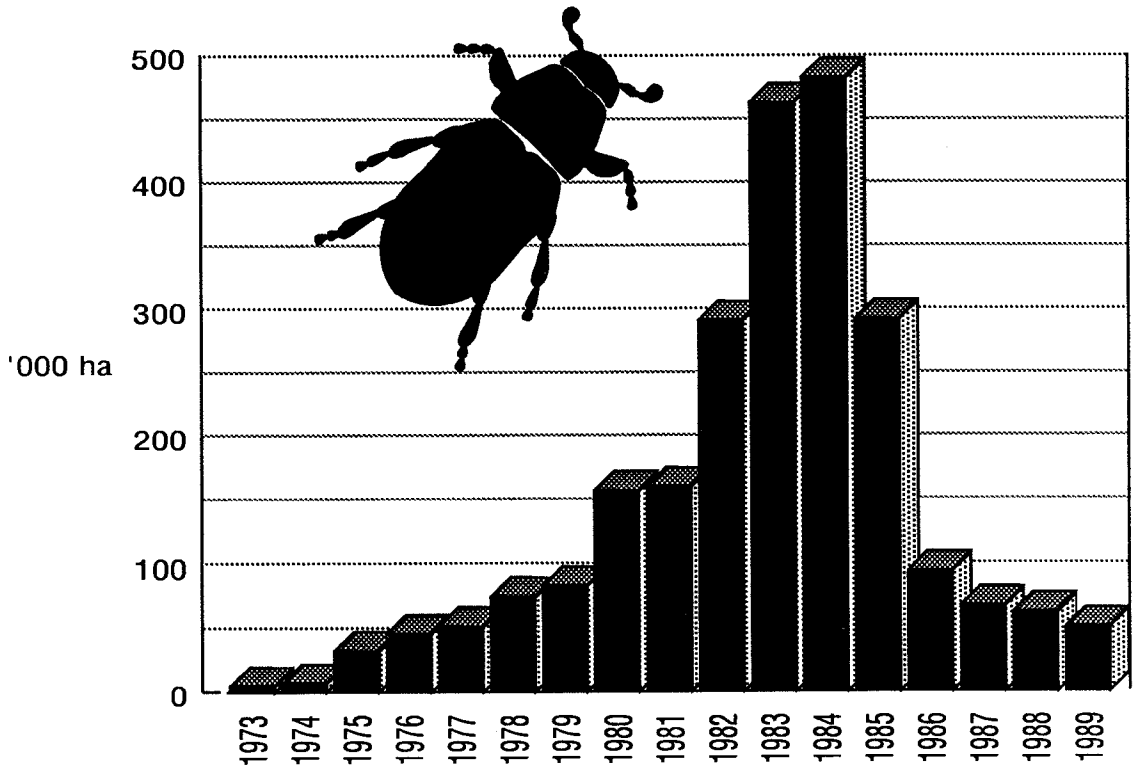


Forest Insect and Disease Conditions

Nelson Forest Region
1989

L. Unger & J. Vallentgoed



Mountain Pine Beetle in British Columbia

Forestry Canada Forêts Canada

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APPENDICES

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

I Location, area and number of pine trees killed by mountain pine beetle in the Nelson Forest Region, 1989.

II Maps of major beetle and defoliator infestations in the Nelson Forest Region, 1989.

III Summaries of pest problems in provincial and national parks in and adjacent to the Nelson Forest Region, 1989.

IV Summary of pheromone trap programs, Nelson Forest Region, 1989.

V Summary of pest problems in young stands, Nelson Forest Region, 1989.

VI Special report - Glacier National Park, root rot survey, May 1989.

VII Summary of mountain pine beetle activity along the Alberta border in 1989.

INTRODUCTION

This report outlines the status of forest insect and disease conditions in the Nelson Forest Region including Mt. Revelstoke and Glacier national parks in 1989, and attempts to forecast population trends and highlight pests that are capable of sudden damaging outbreaks resulting in forest management problems. Pests are discussed by host, in order of importance, and occasionally within the context of a management unit or Timber Supply Area (TSA).

The Forest Insect and Disease Survey (FIDS) group is the national network within Forestry Canada (ForCan) responsible for:

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

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

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

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

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

Close liaison with federal, provincial and local government agencies and industry is essential for effective fulfillment of these responsibilities.

The 1989 field season extended from mid-May to mid-October during which a total of 308 insect and disease collections were submitted to the Pacific Forestry Centre (Map 1). Approximately 220 contacts and on-site pest examinations were made with British Columbia Forest Service (BCFS), other government agencies, forest industry personnel and private individuals.

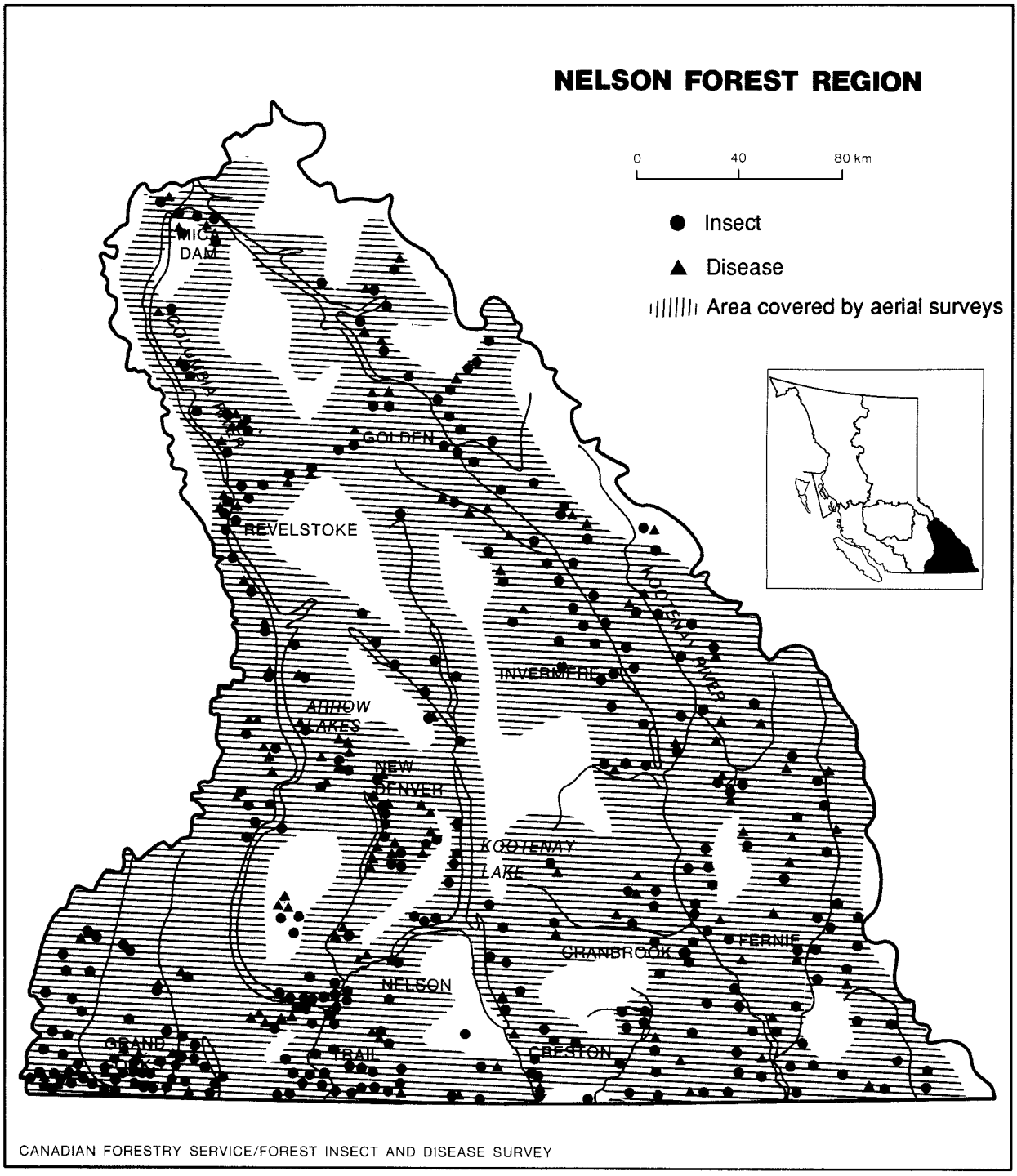
Special thanks are extended to the BCFS for the provision of 51 hours of fixed-wing aerial survey time and assistance in producing preliminary regional sketch maps. The area covered by aerial surveys is shown on Map 1.

During the Forest Insect and Disease Survey field season from May to October, correspondence can be directed to:

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

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

or, throughout the entire year to: Forest Insect and Disease Survey
Forestry Canada,
Pacific Forestry Centre,
506 West Burnside Road,
Victoria, B.C. V8Z 1M5
Ph. 388-0600



Map 1. Location where one or more forest insect and disease samples were collected and areas covered by aerial surveys to map bark beetle and defoliator infestations in 1989.

SUMMARY

The following summary of pest conditions in the Nelson Forest Region groups pests by host(s), generally in order of importance.

Mountain pine beetle populations increased and continued to be the most damaging pest in the region, killing more than 1.6 million lodgepole, western white and ponderosa pines over 31 785 ha, compared to 1.3 million trees on 25 575 ha in 1988. An additional 20 000 pines were killed over 704 ha in Kootenay, Glacier and Mt. Revelstoke national parks. **Pine needle sheathminer** populations on lodgepole pine increased in the West Kootenay where moderate defoliation occurred over 416 ha near Grand Forks. **Pine needle diseases** were more widespread on lodgepole pine in the southern part of the region and on western white pine in the Revelstoke area. **White pine blister rust** infected an average of 22% of the western white and whitebark pines in seven of eight young stands surveyed.

Increased numbers of **Douglas-fir beetle**-killed trees were mapped over 292 ha throughout the East Kootenay and the Boundary TSA. **Western spruce budworm** defoliation of Douglas-fir increased in area and intensity covering 17 608 ha in the Boundary TSA, up from 3275 ha in 1988; moderate to severe defoliation is predicted in most areas for 1990. **Douglas-fir tussock moth** populations predominantely remained at endemic levels; however, two ornamental trees were lightly defoliated at Christina Lake, and pheromone-baited traps indicated continuing endemic levels for 1990.

Pests of young stands which included root rots, stem cankers or bear damage, killed an average of 8% of the trees in 27 of 35 young stands examined throughout the region. **Rhizina root disease** killed an estimated 82 000 seedlings in 12 of 44 cut blocks, primarily in the Interior Cedar-Hemlock (ICH) biogeoclimatic zone. **Black army cutworm** populations decreased with light feeding recorded in only three cut blocks at Vowell Creek, Donald and Bush River; pheromone trapping indicated a high potential for infestations in the northern part of the Golden and Revelstoke TSAs in 1990. In mature stands, 80% of the lodgepole pine and 59% of the Engelmann spruce were infected by **root diseases**, primarily tomentosus root rot but also Armillaria and blackstain root diseases. Severe **climatic injury** led to bud kill and up to 35% tree mortality over 1500 ha in the southeast portion of the region. **Animal damage** was recorded in five young lodgepole pine stands; tree mortality by bears ranged up to 12% and stem scarring primarily by squirrels to 61%. **Roadside tree damage** possibly due to winter salt application and drought was primarily light but of a chronic nature with small patches of tree decline and mortality in run-off gullies in the southern portion of the region. In an **acid rain** monitoring plot in the Blueberry-Paulson summit area west of Castlegar, there was no evidence of atmospheric pollution effects.

Two-year-cycle spruce budworm populations increased in fir-spruce stands in the Barnes and Plant creeks areas covering 5892 ha but decreased in the St. Mary River drainage to only 40 ha; pheromone trapping and fall egg mass surveys indicated potential moderate to severe defoliation in 1991 at Plant, Barnes and Bugaboo creeks. **Western balsam bark beetle** populations increased slightly, killing mature alpine fir over 1600 ha, primarily in the Spillimacheen River drainage. **Fir engraver beetle** populations increased and killed grand fir over

237 ha in the Pend-d' Oreille River and Creston areas. **Foliar diseases** continued to infect true firs throughout their range but generally caused only minor discoloration.

Larch casebearer defoliation of western larch decreased with only light to moderate discoloration of regeneration near Castlegar and Kimberley. **Larch sawfly** populations collapsed in the Elk River Valley and caused only trace defoliation in a 1988 infestation area at Miller Creek. The incidence of **larch needle diseases** increased, with varying levels of intensity recorded in most western larch stands in the Invermere, Cranbrook to Yahk areas and in much of the Boundary TSA. **Larch budmoth** populations increased slightly in the Anarchist Mountain area but remained at endemic levels. At Bauer and Myers creeks in the Boundary TSA, **woodborers** killed scattered groups of larch over areas up to 5 ha. **Spike-top of larch** was present on western larch seed trees and affected 5% of the regeneration along the Lussier River.

Spruce beetle populations were generally at low levels and primarily in blowdown in the East Kootenay; however, broods indicate potential for small local infestations at Redding Creek and the Vermilion and Spillimacheen rivers drainages. **Spruce weevil** levels increased by up to fourfold in 15-to 20-year-old stands but terminal mortality remained at 5% in 10-to 13-year-old stands in widely separated plantations in the East Kootenay.

Forest tent caterpillar populations increased, defoliating 9900 ha of trembling aspen primarily in the Golden to Blaeberry River and the Fort Steele to Wasa Lake areas; severe defoliation is again predicted in these areas for 1990. No **gypsy moth** adults were caught at 35 locations where pheromone-baited traps were deployed. Activity by the **Pacific willow leaf beetle** decreased in the Revelstoke to Mica Dam area. **Birch leafminer** activity continued in the West Kootenay but collapsed early in the summer in the East Kootenay. The **apple and thorn skeletonizer** caused intermittent light to severe damage to apple trees in the West Kootenay.

Western hemlock looper populations increased in western hemlock stands in the Revelstoke TSA.

Throughout the text reference to "light", "moderate" and "severe" defoliation by larval defoliators may be assumed to mean 1-25%, 26-65% and 66+% defoliation, respectively.

PINE PESTS

Mountain pine beetle
Dendroctonus ponderosae

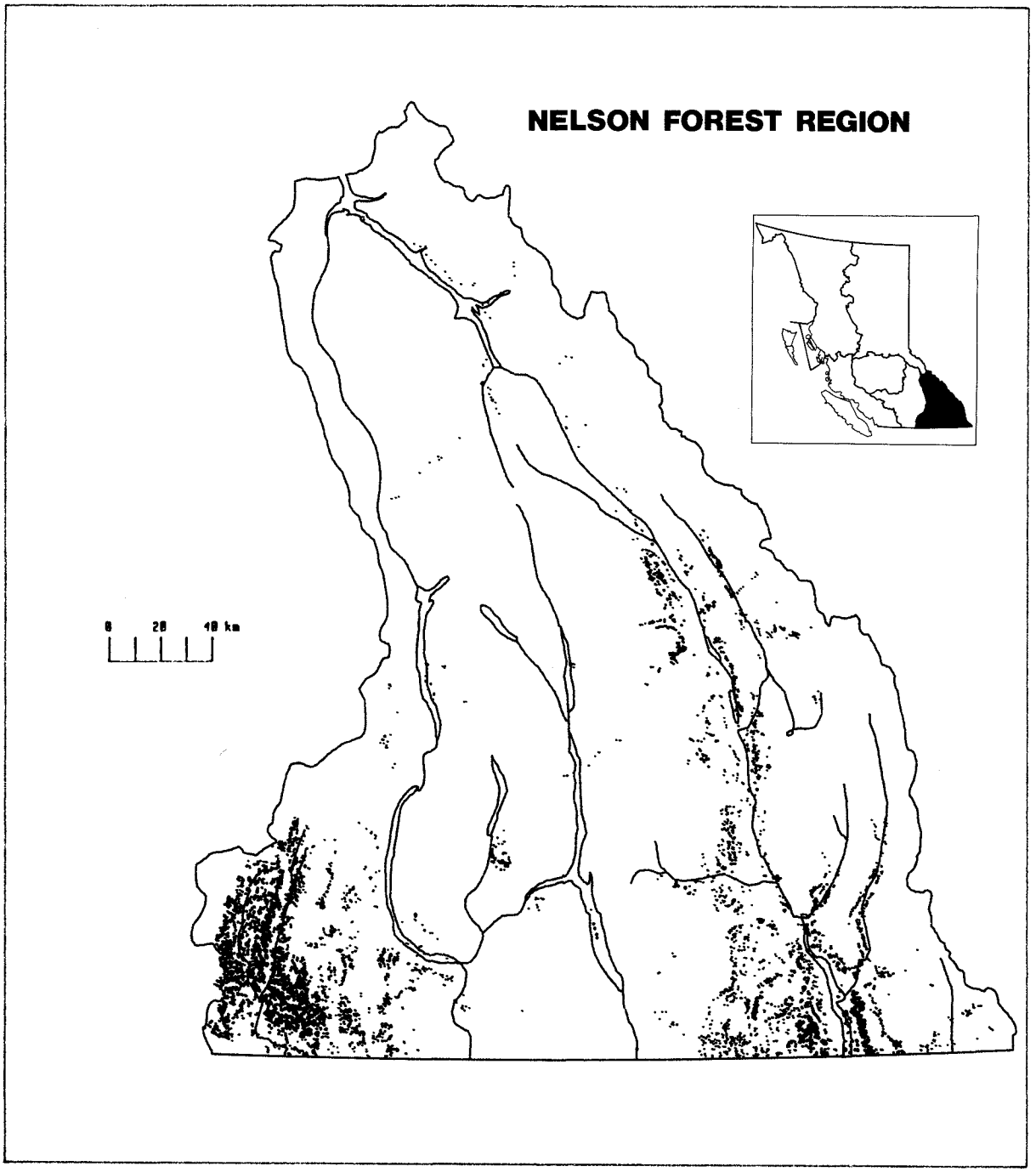
Mountain pine beetle killed more than 1.6 million lodgepole, western white and ponderosa pines over 31 082 ha in 5201 infestations in the region, with an additional 20,000 trees over 704 ha in Kootenay, Glacier and Mt. Revelstoke national parks (Table 1, Map 2). This is a continued increase from 1987 and 1988 with 22 310 ha and 25 575 ha affected, respectively.

Table 1. Location, number, area and volume of pine recently killed by mountain pine beetle as determined from aerial and ground surveys, Nelson Forest Region and National Parks, 1989.

TSA or Park	Tree species[1]	No. of infestations	Area (ha)	Trees killed (faders)[2] No.	Vol.(m^3)
Boundary	lP,pP	2351	19 566	990 800	356 700
Arrow	lP,wwP,pP	269	906	33 200	13 900
Revelstoke	wwP	14	5	200	200
Kootenay L.	lP,wwP	206	205	15 000	5 400
Cranbrook	lP,wwP,pP	1665	7 965	524 100	188 700
Invermere	lP,wwP	666	2 427	76 100	27 400
Golden	lP,wwP	30	8	200	100
Subtotal		5201	31 082	1 639 600	592 400
Kootenay N.P.	lP	99	616	19 700	7 100
Glacier N.P.	wwP	11	87	300	300
Mt. Revelstoke N.P.	wwP	4	1	(20)	(20)
Subtotal		114	704	20 000	7 400
Total		5315	31 786	1 659 600	599 800

[1] lP - lodgepole pine; wwP - western white pine; pP - ponderosa pine
[2] Trees attacked in 1988, discolored in 1989

The main activity occurred again in the Boundary TSA where 19 566 ha were infested, up from 15 461 ha in 1988. This is the sixth consecutive expansion in the TSA and counts for over half the area infested in the region. Major increases also occurred in the Cranbrook TSA where 7965 ha were affected compared to 5250 ha in 1988. The Invermere TSA had a significant decline in activity while only minor changes occurred in Arrow, Revelstoke, Kootenay Lake and Golden TSAs. For 1990 the current population trends are forecast to



Map 2. Areas of pine recently killed by mountain pine beetle determined by aerial and ground surveys in 1989.

continue; a localized exception is the southeast portion of the region where overwintering brood mortality temporarily decreased beetle populations. Harvesting, host availability, infestation age, immigrating populations, climatic conditions, accessibility, management philosophy, and implementation are all influential in the changing situations within the region and from district to district.

Boundary TSA

In the eastern part of the TSA, activity decreased somewhat in most areas including Sutherland Creek and drainages feeding into Christina Lake. Similar reduced activity was noted along the Granby River where current attack indicated static to decreasing populations in parts of the Sand, Volcanic, Toronto, Pass and Rock Candy creek drainages (Table 2) though plenty of host remains available. North of Mt. Burns, the infestation area has increased. In the Boundary Creek drainages, infestations continue very active throughout with some expanded activity noted in the upper reaches of the drainages. Host availability such as at Wallace Creek (19% healthy) will reduce the activity in some areas. Along the Kettle River the beetle remains very active from Westbridge north with some expanding infestations from Steeves Creek north. High current to red ratios and good host availability were noted at Grano-Hellroarer creeks with expanding infestations there and in drainages north including Rendell Creek. Areas between Kettle and West Kettle rivers were very active with expansion in the east, especially in the Beaverdell area and in the Big Goat Creek to Kelly River drainages adjacent to the Kamloops Region. In the south, activity was highly variable in the Rock Creek area with several age class and type mixes present; the Ingram Creek infestations appear to be declining with reduced host availability and after extensive logging, while activity expanded in the Twin, Lind, and Eholt creeks areas where future host availability is becoming scattered.

Arrow TSA

In the Arrow TSA, a total of 269 infestations covered 906 ha, a reduction from 1298 ha mapped in 1988. Infestations continued in the Dog Creek and associated drainages. In the Lemon-Chapleau creeks area the beetle also remained active, although fewer infestations were noted in the Dayton Creek area. While light to severe attack continued in the Nancy Greene Lake area, a decrease in activity was noted in the Shields-Moberly creeks area.

Revelstoke TSA

In the Revelstoke TSA, only 14 infestations totalling 5 ha were mapped, a continued decrease of beetle activity in western white pine. Occasional scattered attack occurred mainly along the Illecillewaet River but was again greatly reduced along the Arrow Lakes and associated drainages.

Kootenay Lake TSA

In the Kootenay Lake TSA, infestations covered 205 ha, a continuing increase from 147 ha in 1988. The main area of beetle activity remains in the lodgepole pine stands in the Hawkins-Freeman creeks area where widespread small spot infestations continue to appear almost randomly throughout the valleys as the beetles disperse widely, searching for susceptible host in a drainage

composed of large areas of trees under 60 years. In the pockets of mature pine, expansion continues at a rapid rate. Small groups of western white pine continue to be attacked annually in the Goat River drainage near Kitchener and along Skelly Creek.

Cranbrook TSA

In the Cranbrook TSA, infestations increased to 7965 ha, up from 5250 ha in 1988 and 3450 ha in 1987. Drainages with recent large increases in the number of spot infestations of 2-50 trees included the Elk River Valley from Fernie to just north of Sparwood, the Moyie Lake-Lumberton area, along Lost Dog Creek, portions of the St. Mary River, lower Perry Creek, Couldrey and Sage creeks in the Flathead River drainage, in the upper Yahk River area, and several pockets in the Peavine and upper Gold creeks area.

In other areas small spot infestations have rapidly expanded and coalesced. These were particularly evident in the lower Bull River area, along the lower Elk River between Elko and Fernie, and in the Galton Range including the Wigwam Creek area.

Older infestation areas are continuing to expand especially into the higher-elevation stands above the main logging areas near Gold Mountain, Linklater and Bloom creeks. Similar increases were evident to the north in the Rocky and Chipka creeks area and on the plateau north of Mt. Baker. In the southern Rocky Mountain Trench there was an increase in beetle activity in ponderosa pine and continued in the smaller lodgepole pine through to the Wildhorse Creek and the Wasa Lake area.

Invermere TSA

Infestations in the Invermere TSA declined to 2427 ha from 3400 ha in 1988 and 6800 in 1987. The main areas of continuing beetle activity included the high-elevation pine stands on the east side of the Rocky Mountain Trench from the Columbia Lake area to Radium. Similar expansion was recorded in the Toby and Horsethief creeks areas. In the Frances Creek to Spillimacheen River area, small spot infestations continue to spread northward while the larger infestations are being logged. In the major drainages along the Kootenay River, beetles remained relatively inactive with several patches remaining along the Palliser River while most of the Cross River infestations have been logged.

In nearby Kootenay National Park, the area of mapped recent beetle activity remained similar to 1988 at just over 600 ha, but with fewer faders present. In the Redstreak Creek area beetle activity has spread into the nearby Kimpton and John McKay creeks. The main Kootenay River infestation area remains centered around Mt. Daer. Several new pockets of the infestation extended toward the south park boundary and only occasional groups of 1-5 fading trees were noted north to Kootenay Crossing.

Golden TSA

The mountain pine beetle remained relatively inactive in the Golden TSA, although several small patches of new attack on lodgepole pine showed up near Golden. Along the Blaeberry River small groups of lodgepole pine faders continue near Split Creek. Similarly small groups of western white pine were

mapped along McNaughton Lake with the largest group of 30 trees near the mouth of the Beaver River. In Glacier National Park, expansion of previous beetle infestations in western white pine along the Beaver River totalled 87 ha.

Influencing factors in population dynamics

With an apparent return to more normal climatic conditions, as witnessed by increased pitch flow and more moisture retained under the bark during spring assessments, such influences were less pronounced in the character of populations. A major exception was the southeast portion of the region where overwintering brood mortality caused a significant set-back to local increasing populations. Stand composition, host availability and proximity to major and long-running infestations appeared important in shaping conditions.

In the Sand-Snowball creeks area and other drainages associated with the Granby River, the beetle is at relatively static to decreasing levels. This relatively low level of activity may have been influenced by harvesting, however, infestations were relatively recent, host remains abundant and roads were unavailable to address initially expanding populations. The area did lack immigration pressure from other immediately proximate major outbreaks and many stands are mixed to scattered in nature. In the west and northwest, a great deal of northward movement of beetle populations appeared to occur from the major long-running infestations such as the area bounded by Ingram, Blythe and Windfall creeks. Overwintering brood numbers were high and larvae healthy but host availability has now been drastically reduced, forcing the beetle to emigrate into newer areas such as Grano-Hellroarer creeks and north where plentiful host is available and expansions are continuing for the fourth consecutive year. Pressure is also coming from the long-running Kamloops Region outbreaks and from the Trapping Creek area drainages, influencing those drainages flowing east and those areas between the Kettle and West Kettle rivers. Relatively milder winter conditions also assisted in good survival and continued high levels of activity in the west.

Overwintering brood mortality was high in the southeast portion of the region due to low temperatures combined with strong winds in February. In the Flathead River drainage and in the higher-elevation (1400 m) infestations in the Gold Mountain area, all beetles above the snow line were killed with most of the remaining beetles destroyed by woodpeckers. Beetle brood mortality was less severe in higher-elevation stands throughout the Bloom Creek to Yahk River area but current attack was greatly reduced from that of 1988. In the Elk River Valley north of Fernie, brood mortality was variable; close to 80% on the smaller-diameter trees, but insignificant on trees over 25 cm. Overwintering brood mortality was generally minor in other areas and beetles in the lower valleys and slopes produced large broods.

The late cool spring and relatively cool summer initially delayed brood maturation and consequently the 1989 beetle flight. Although this will have little impact on the broods at low elevations, some beetle populations in higher-elevation side drainages and slopes entered the winter months in the less hardy early-instar larval stage.

Table 2. Status of lodgepole pine in stands affected by mountain pine beetle, Nelson Forest Region, 1989.

Location	Percent of pine attacked[1]				Percent healthy
	Current(1989)	Partial(1989)	Red(1988)	Grey(pre 1988)	
Kelly R.	17	3	17	3	59
Wallace Cr.	18	4	14	45	19
Rock Cr.	6	3	10	16	66
Hellroarer Cr.	23	7	4	3	61
Cup L.	16	9	4	10	61
Ingram Cr.	9	2	18	22	49
W. Boundary Cr.	11	9	22	33	25
Phoenix Mtn.	16	5	11	12	56
Pass Cr.	6	4	10	8	73
Sand Cr.	11	2	15	19	53
Frances Cr.	35	3	18	12	32
Morrissey	32	0	5	4	57
Fernie	13	4	16	8	59
Baynes L.	42	2	18	8	30
Horsethief Cr.	39	4	13	7	37
Phillips Cr.	29	2	7	10	51
Moyie L.	38	3	2	8	49
Tepee Cr.	25	4	13	7	51
Freeman Cr.	4	1	11	2	82
Hawkins Cr.	22	3	7	3	65
Redstreak Cr.	48	1	2	17	32
Bull R.	53	4	5	0	38
Average %	23	4	11	12	50

[1]Totals may not equal 100% due to mortality from other causes.

Forecasts

Overall in 1990 the number of discolored trees should be similar to, or higher than in 1989, as indicated from "R" value (ratio of overwintering larvae to parent adults) assessments and aerial surveys combined with fall cruising results. Spring "R" values ranged from 0.4 to 14.3 averaging 6.4, indicating expanding populations (Table 3). Cruise results indicated expanding activity in 14 of 22 areas, with decreasing red to current ratios in six areas.

In the West Kootenay, in areas such as Sand Creek, spring, summer and fall assessments all seem to confirm continued static to declining populations despite the continued presence of host material. Evidence from aerial surveys implies some northward movement into the upper Granby and Burrel creeks areas. If host is available, these currently inaccessible areas may become problem zones. In the Boundary Creek drainage, ratios suggest expansion in the south, which host depletion should negate, while in the north where the current to red ratio is low, the "R" value was very high and mature adjacent stands may absorb

large populations of beetles. There is little host remaining in the Eholt north-facing slope but in the Twin-Lind creeks area, activity may continue to expand. The main area of expansion is expected north from Grano-Hellroarer creeks along the Kettle River Valley drainages where aerial surveys show expanding and new infestations, "R" values are high, current to red ratios indicate expansions and host material is plentiful, and many fairly pure pine areas are available. Similar scenarios are applicable to the far west such as Kelly River and Big Goat Creek if sufficient mature pine is available. Areas between the Kettle and West Kettle rivers indicated expansion during aerial surveys as well as in the current to red ratio assessments, but in many areas such as Crouse Creek and Collier Lakes, infestations have been long running and many areas are harvested.

In the East Kootenay, the population trends indicate a high variability in the number of trees currently attacked and due to discolor in 1990. Observations of broods and current attack indicate general static to increasing numbers of faders in the Rocky Mountain Trench and the lower portions of the side valleys especially the Elk and Bull rivers, and Horsethief Creek. Increases were also evident in the Moyie Lake area. The average "R" values in these areas were 9.0. Static to decreasing populations were indicated for the general area south of Cranbrook to the USA border, the Flathead River drainage, the upper Elk River, Findlay Creek, Cross River, Palliser River and the Freeman-Hawkins creeks area. The broods sampled in these areas had an average "R" value of 3.5. Population reductions due to overwintering brood mortality are temporary and as beetles immigrate from nearby vigorous populations, the original increasing status will recur within one or two years.

The preceding predictions are based on the biological capabilities of the beetle and the conditions that were found during very limited ground assessments. Harvesting was very active in late summer and autumn and several priority areas and management activities together with highly variable natural conditions could change the picture dramatically for 1990.

Table 3. Spring "R" values and 1990 population status, Nelson Forest Region, 1989.

Location	"R" values[1]	Population status[2]	Remarks
Perry Cr.	14.3	I	several pockets, lower Perry Cr.
Redstreak Cr.	13.9	I	expanding into adjacent creeks.
W. Boundary Cr.	12.1	I	woodpeckering severe, ambrosia beetle 50%.
Bull R.	10.0	I	rapid expansion over last two years.
Hawkins Cr.	9.0	I	good broods only in mature trees.
Morrissey	8.7	I	migration from Elko area.
Ingram Cr.	8.3	I	Ips and ambrosia common, woodpeckering light.
Roosville	7.3	I	increasing in ponderosa pine.
Shields Cr.	6.8	I	Ips and ambrosia common,woodpeckering severe.
Frances Cr.	6.8	I	in highly susceptible leave strips.

Location	"R" values[1]	Population status[2]	Remarks
Grano-Hellroarer crs.	6.7	I	early development variable, occasional dead larvae in 33% of trees, light woodpeckering, minor ambrosia beetle.
Warspite Cr.	6.3	I	continuing expansion, overmature stands.
Eholt	6.0	I	woodpeckering severe.
Tepee Cr.	5.3	I	numerous patches of 50+ trees.
Palliser R.	4.6	I	patchy, reduction from previous highs.
Grasmere	4.5	I	continuing in small-diameter lodgepole.
Chapleau Cr.	4.3	I	woodpeckering and ambrosia severe.
Norge Cr.	4.0	S	small pockets in mature stands.
Sand Cr.	3.7	S	brood mortality high, woodpeckering throughout, ambrosia beetle common.
Bloom Cr.	3.7	S	large infestations, some overwintering mortality.
Ferroux Cr.	3.3	S	Ips in 50% of trees, woodpeckering common.
Findlay Cr.	2.8	S	small patches in mixed stands.
Skookumchuck L/O	2.5	D	small patches in mixed stands.
Couldrey Cr.	0.4	D	major overwintering mortality after increasing in 1988.
Average	6.4		

[1]"R" value = an average population trend derived from the number of insects relative to the number of parent galleries originating within a representative bark sample.

$\leq$ 2.5	decreasing
2.6-4.0	static
4.1+	increasing

[2] I-increasing, S-static, D-decreasing

Pine needle sheathminer
Zelleria haimbachi

The pine needle sheathminer, in the third consecutive year of activity, moderately defoliated current foliage on lodgepole pine over 416 ha in three infestations in the Stacey-Gibbs-May creeks drainages, west of Grand Forks, compared to 235 ha in the same area in 1988. Roadside defoliation was again reduced with no damage noted in the Greenwood area but light attack occurred for 5 km along the Conkle-Ripperto creeks road. Mortality and dieback has not been recorded although some growth reduction could be expected. Populations often appear to build up and collapse very quickly causing notable damage for only short periods. However, large numbers are required to develop notable discoloration; populations could therefore remain intact for long periods with no apparent damage.

Pine needle diseases
Lophodermella concolor
Dothistroma (Scirrhia) pini
Davisomycella ampla

Pine needle cast, *Lophodermella concolor*, infection of one-year-old lodgepole pine needles was more widespread in 1989, but at decreased intensities in the 1988 infection areas. In the Bloom-Yahk creeks area, an average of 30-40% of the foliage was infected with only occasional small patches of severe. Increased infection, though generally light, was noted in regeneration in the Flathead River drainage and near the junction of the White and North White rivers, in young stands along the upper Elk and Bull rivers, and in most pine stands along Redding and Findlay creeks and the St. Mary River. In the latter area, *Hendersonia pinicola*, a secondary fungus which appears to act as a biological control agent of *L. concolor*, was also present at high levels. In the Fiva Creek drainage, 13% of lodgepole pine over an estimated 10 ha were infected while sporadic severe infection over approximately 2 ha at a Burrell Creek site was the only other noteworthy activity of this pest. *Davisomycella ampla* caused intermittent moderate infection of fringe regeneration lodgepole pine for 9 km along Champion Lakes road.

Red band needle disease, *Dothistroma pini*, on western white pine, was noted from south of Revelstoke for 15 km along Hwy 23 to Blanket Creek and again for 10 km from Cranberry Creek to Shelter Bay. Infection varied from moderate to severe on the lower half of crowns. Occasional, up to 1 ha, infection areas were noted along Hwy 6 with the most notable attacks in the Summit Lake area. Discoloration was generally moderate to severe on lower crowns.

White pine blister rust
Cronartium ribicola

White pine blister rust remains the single most important tree disease of western white pine. While inherent difficulties such as the scattered nature of infection, the tendency to top kill and reinfection, and the presence of mountain pine beetle preclude detection by aerial surveys, nevertheless, discoloration and mortality was noted throughout the region and severity of attack was documented by ground observations in several areas.

During surveys of young stands, in seven out of eight stands where the host occurred, mortality or infection occurred in an average of 23% (range 3-55%) of white pine crop trees. Of the affected stands, four had been recently spaced and three of these pruned as well. In the spaced and pruned plantations, western white pine represented 23% of the crop trees of which 10% were either recently infected or contained infections which were missed during silvicultural activity. A real concern therefore exists regarding the potential for continued, substantial loss of crop trees in some plantations before rotation is reached, despite current levels of management.

The blister rust was also common on *Pinus albicaulis*, whitebark pine, in two high-elevation areas visited in the West Kootenay. At Idaho Peak, the rust was common on branches and stems for approximately 1 km along the Idaho Peak Trail. At Granite Mountain, 50% of trees had major stem or branch cankering over an estimated 5 ha area. No mortality was found at either site and while the host species is of no general economic value, esthetics were a concern in

the latter location, as it is part of the Red Mountain Ski area.

DOUGLAS-FIR PESTS

Douglas-fir beetle
Dendroctonus pseudotsugae

Douglas-fir beetle infestations were mapped in 129 pockets over 292 ha, containing a conservative estimate of 3990 trees in the Nelson Region in 1989, an increase from the 12 small groups of less than 40 trees recorded in 1988 (Table 4). Additional trees will discolor in 1990, but the attack level will decrease.

Table 4. Location, number and area of Douglas-fir recently killed by Douglas-fir beetle, Nelson Forest Region, 1989.

TSA	Area(ha)	No. infestations	No. trees
Cranbrook	79	18	620
Invermere	205	87	3040
Golden	3	10	190
Boundary	5	14	140
Total	292	129	3990

Most of the infestations were recorded in the Invermere TSA with 32 and 26 groups of 1988-attacked trees discoloring in the Whiteswan Lake and Findlay Creek areas, respectively. Further patches of recent tree mortality included the Brewer-Dutch creeks area and scattered small groups of trees along the Rocky Mountain Trench between Radium and Premier Lake.

In the Cranbrook TSA, the main concentration of beetle activity was in the Wickman and Bloom creeks area (11 patches). Scattered small groups of recently killed Douglas-fir were also identified along the Rocky Mountain Trench from the Galton Range north to Wasa Lake, with a small concentration near the mouth of Wildhorse Creek.

In the Golden TSA, at least 10 small groups of 5 to 20 recently killed Douglas-fir trees were noted along the east side of McNaughton Lake in the Game to Nixon creeks area.

Despite the large increase in the number of red trees evident in 1989, in the East Kootenay, the overall Douglas-fir beetle population declined, with an average of 3.5 1988-attacked trees for each successful 1989-attacked tree (Table 5). Up to 40% of the trees pitched out the 1989 attack in smaller infestation pockets. Of the ten areas examined during fall surveys, a significant increase was noted only at Brewer Creek where the number of currently attacked trees doubled to 90 from 40 in 1988. At five of the sites, the attack ratio remained relatively stable while declining in the remaining four. Some of the decrease

in current attack may be attributed to beetles being attracted to nearby recent blowdown, especially in the southern Rocky Mountain Trench.

In the West Kootenay, only 16 spot infestations of recent faders totalling 5 ha were noted, primarily in the Boundary TSA. Reassessment at several sites visited in 1988 showed a substantial drop in beetle activity. At East Trapping Creek, only two newly attacked trees (both stressed) were noted in this 30-40-tree infestation. No new attacks were found at Nelse Creek where 20 attacks were noted in 1988. At Ingram Creek, only two damaged trees were currently attacked at a site where 30-40 trees had been attacked over several previous years. At a Conkle Lake Road site where high stumps harbored large broods, no current attack was noted in three adjacent areas checked. At Bauer Creek, however, where no red attack was found, 8 and 2 trees, respectively, were attacked at two sites. This situation of current attack independent of previous infestations was also reported by others and contradicts the evidence suggesting a substantial decline of beetle activity in the west.

Blowdown occurred over 52 ha in 10 areas involving mostly Douglas-fir in the Crawford Creek area and resulted in large populations of beetles in downed trees. Concern was sufficient to initiate management action in the main blowdown areas prior to the 1990 flight period.

A further decline in attack levels is predicted for 1990, with an average fall "R" value (ratio of overwintering brood to parent adults) of 2.3 compared to 6.4 in 1988 in the same general areas (Table 5). An "R" value near 1.4 generally indicates a static population, provided other factors remain constant. However, with increased precipitation, trees have greater resistance to attack and only in the very dry south aspect slopes and primarily in the larger infestation areas such as Wickman and Brewer creeks should the 1990 attack equal or exceed the 1989 levels. In wetter areas such as at Whiteswan Lake, further decreases will likely occur despite an "R" value of 3.1. In addition, the presence of a hymenopterous parasite, Coeloides vancouverensis, was more common in collections in 1989 than in 1988, especially along McNaughton Lake, Premier Lake, Bloom Creek and Wildhorse Creek, further decreasing populations.

Table 5. Douglas-fir beetle population trends, Nelson Forest Region, 1989.

Location	Fall "R" values	Current to red ratios
Nixon Cr.	1.1	1:4
Whiteswan L.	3.1	1:1
Alces L.	1.7	1:9
Premier L.	0.8	1:1.1
Brewer Cr.	4.0	1:0.4
Emily Cr.	2.5	1:1.4
Wildhorse Cr.	1.0	1:1
Wickman Cr.	6.5	1:0.9
Bloom Cr.	2.5	1:4
Galton Range	0.2	1:12
Average	2.3	1:3.5

Western spruce budworm
Choristoneura occidentalis

Western spruce budworm defoliated Douglas-fir over 17 600 ha in 49 infestations, five times the 3275 ha infested in 1988 (Map 3). Budworm populations have persisted in the Rock Creek to Anarchist Mountain area at infestation levels for the past 12 years, especially in the Johnstone Creek Provincial Park area.

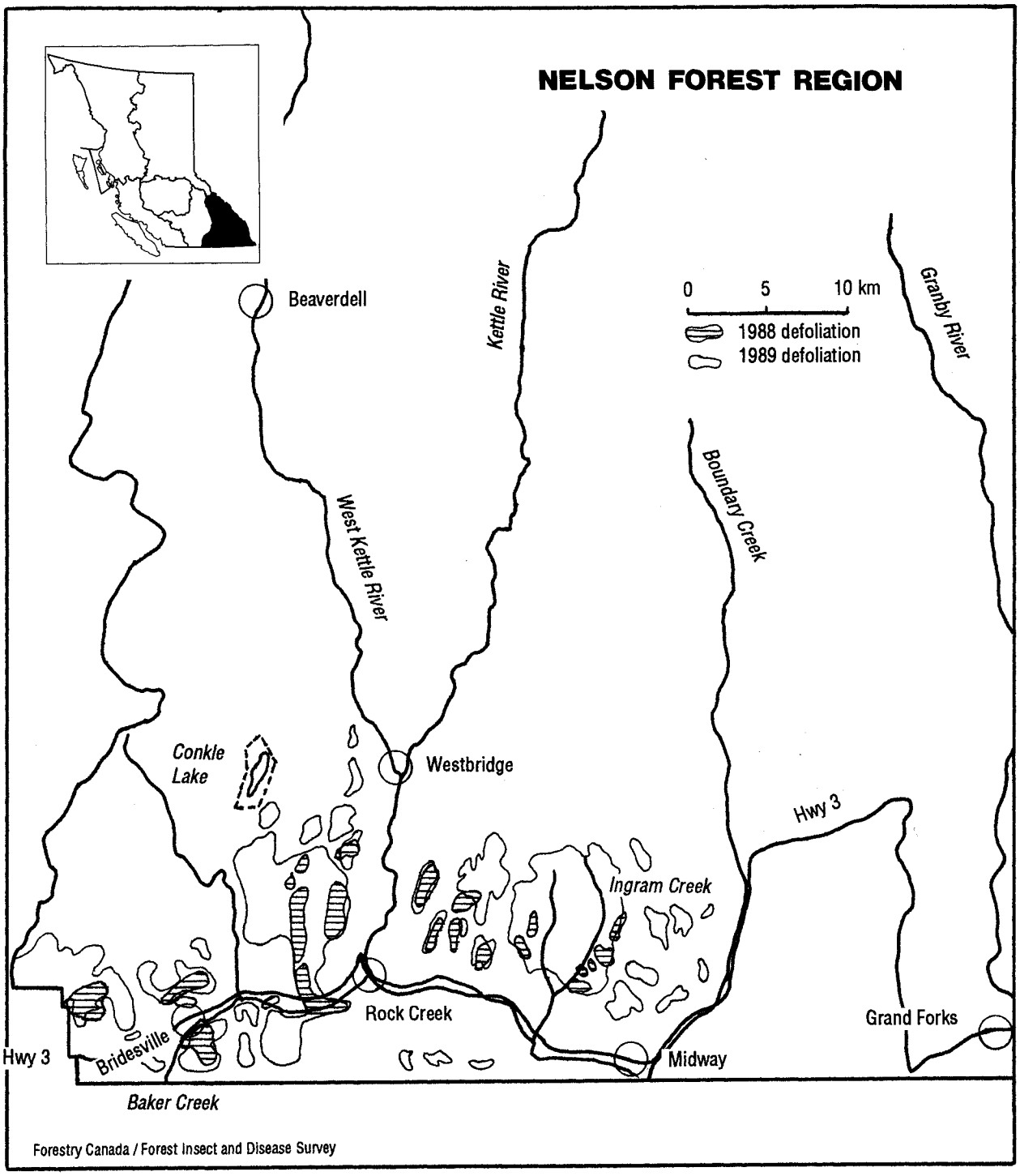
Generally light to moderate defoliation was recorded in all areas including Johnstone Creek Park and Bridesville where moderate to severe defoliation of some regeneration was visible from the ground. Severe defoliation was recorded for the first time in the McKinney Creek drainage over a 123-ha area. The light defoliation noted in the Nicholson, Bubar and Ingram creek drainages continued and expanded into the Bauer Creek drainage to the east. Light defoliation was also recorded for the first time in the Myers Creek drainage. Trace defoliation continued in the Kettle River Recreation Area as well as from Greenwood to Phoenix Mountain. Most affected areas were in the IDFf (Interior Douglas-fir) biogeoclimatic subzone.

While larvae were common on western larch, defoliation was generally not notable. Only in small patches of larch regeneration or mixed larch and Douglas-fir regeneration was defoliation more intensive with foliar feeding generally moderate with tip and terminal damage also common.

Numbers of larvae averaged 61 (range 2-300) per standard beating sample in 12 Douglas-fir stands between Anarchist Mountain and Rock Creek in the south and north to Beaverdell, similar to 1988 numbers which resulted mostly in light defoliation. Larvae were also common in three-tree beating samples on Engelmann spruce and western larch. Two mass collections of larvae were reared to determine parasitism. At Johnstone Creek, incidence of parasitism was 12.8% by Diptera and 5.1% by Hymenoptera as compared with 7.3% and 14.6% in 1988. At Ingram Creek, only diptera parasites were found affecting 33% of the larval population. A localized epizootic caused by the fungus, Entomophthora sp., also appeared to be active in the Myers Creek drainage although its extent or impact is not known at this time.

Egg sampling, at 11 locations to determine potential larval populations and predict defoliation in 1990, indicated severe defoliation in seven areas, moderate defoliation in three areas and light defoliation in only one area (Table 6). Severe defoliation in 1990 is predicted for all areas defoliated in 1988 except Rock Creek and Phoenix Mountain where moderate and light defoliation is expected, respectively. Moderate defoliation is also predicted in the Myers Creek drainage and in the Summit Drive area of Revelstoke National Park.

Fall egg sampling is a useful early indicator of building populations; however, abiotic conditions can severely affect overwintering larvae. Therefore, bud sampling in the spring is used to augment forecasting information. At several locations, bud sampling in May 1989 altered defoliation estimates based on 1988 fall egg-mass sampling. Both forecasting methods predicted somewhat more severe damage than actually occurred, indicating that larvae in early feeding stages in the spring were influenced by local environmental conditions.



Map 3. Areas where Douglas-fir was defoliated by western spruce budworm determined by ground and aerial surveys in 1988 and 1989.

Table 6. Location, 1987 to 1989 western spruce budworm egg-mass samples, 1988, 1989 bud samples, predicted and actual defoliation for 1989 and 1990, Nelson Forest Region, 1989.

Location	No. eggs[1] per 10 m^2			Percent[2] buds infested		1989 defoliation[3] predicted by			1990[3] predicted defoliation
	1987	1988	1989	1988	1989	eggs	buds	actual	
Anarchist Mtn.	49	72	193	12	33	MOD	SEV	LT	SEV
Conkle Lk. Rd.	33	65	212	-	14	MOD	LT	LT	SEV
Johnstone Cr.	558	359	368	26	48	SEV	SEV	MOD	SEV
McKinney Cr.	159	311	265	15	48	SEV	SEV	MOD	SEV
Bridesville	536	326	571	23	52	SEV	SEV	MOD	SEV
Rock Cr.	295	270	137	15	33	SEV	SEV	LT	MOD
Phoenix Mtn.	19	10	41	2	22	LT	MOD	LT	LT
Nicholson Cr.	-	425	375	-	62	SEV	SEV	LT	SEV
Ingram Cr.		208	335	-	36	SEV	SEV	LT	SEV
Revelstoke Nat. Park-		-	74	-	-	-	-	-	MOD
Myers Cr.	-	-	128	-	-	-	-	-	MOD

[1]No. egg mass/10 m^2 of foliage: 1-50, 51-150, 151+

[2]Percent buds infested: 1-15, 16-30, 31+

[3]Predicted defoliation: LT (light), MOD(moderate), SEV(severe)

[3]LT - discoloration barely visible
MOD - pronounced discoloration, some top stripping
SEV - bare branch tips, complete defoliation.

A pheromone-baited trap calibration project designed to detect increasing populations and predict infestations continued in 1989. Larval sampling, pheromone trapping (Multipher®trap) and defoliation estimates continued at the two sites in the region (Table 7). Several more years of field work at many locations in the province are needed before meaningful relationships are formulated.

Table 7. Location, number of larvae, adults and defoliation at spruce budworm pheromone calibration plots, Nelson Forest Region, 1989.

Location	Avg. no. larvae/tree[1]			Avg. no. adults/trap[2]			Defoliation[3]		
	1987	1988	1989	1987	1988	1989	1987	1988	1989
Conkle L. Rd.	5	7	7	183	417	50.2	NIL/TR	TR(1%)	TR
Phoenix Mtn.	<1	<1	3	46	256	46	NIL	NIL/TR	NIL/TR

[1]sampling method consists of beating three branches on each of 25 trees over a 60x90 cm sheet.
[2]five Multipher® traps spaced at more than 30 m intervals using the lure 0.03% trans-11-tetradecenal + cis-11-tetradecenal.
[3]NIL - no defoliation, TR - trace defoliation.

Larval parasitism was insufficient to affect populations. Based on fall egg-mass surveys, predicted defoliation for 1990 is severe in the IDFf biogeoclimatic subzone areas where notable defoliation has occurred for at least two years. An exception is the Rock Mountain Road site where moderate defoliation is predicted, possibly due to its immediate proximity to a 100-ha spray block. Areas of light to moderate predicted defoliation are in ICH (Interior cedar-hemlock) zones. Outward expansion could occur based on predicted levels of defoliation within the infestations, the fact that expansion has occurred over the last two years under current conditions, that the host and similar conditions are available over large areas beyond the current infestations and that larvae were found and isolated areas and minor defoliation noted and recorded as far as Garrity Creek near Nelson.

In the Nelson Region, the infestations are generally both currently and have been historically restricted to the IDFf subzone with minor "spillovers" into adjacent ICH zones. Since only IDFg subzones occur in East Kootenay and no infestations have occurred historically, these might be considered to be non-susceptible types. In contrast, the entire IDFf subzone could be susceptible to the budworm. In other regions, spruce budworm occurs in:

Region	Biogeoclimatic Zone[1]
Kamloops	PPBGd, IDFa, IDFb, IDFc, ICH
Cariboo	ICHb, ICHe, IDFa, IDFb
Vancouver	IFu, IFe

[1]PPBG - Ponderosa pine bunchgrass; IDF, IF - Interior Douglas-fir; ICH - Interior cedar-hemlock.

There seems to be a fairly broad range of zones in which the budworm is active. Therefore, it might be premature to base any management or conclusions on biogeoclimatic correlations.

Finally in the past several years , actual defoliation levels have been consistently somewhat mitigated by climatic conditions during the winter period as well as during early active larval periods. Similar conditions may reduce expectations to overall moderate defoliation; severe conditions could reduce populations even more.

Douglas-fir tussock moth
Orgyia pseudotsugata

The tussock moth population remained at endemic levels in the Nelson Region in 1989, with the exception of two ornamental spruce at Christina Lake which were lightly defoliated and had numerous egg masses. No larvae were found in beating samples. Number of moths collected in attractant-baited sticky traps increased from 1988, but indicate continued endemic level populations (Table 8).

Table 8. Location, average number of tussock moth adults trapped 1986-89, Nelson Forest Region, 1989.

Location	Avg. no. tussock moth adults per trap 1986	1987	1988	1989	No. traps per site
Rock Creek	<1	5	1	1	6
Christina Lake Golf Course	<1	7	0	2	6

Top-stripping of some ornamental spruce also occurred in the Kamloops area. Increased numbers of male tussock moth adults trapped and increasing egg-mass densities indicate the potential for limited defoliation in the Kamloops Region, which implies the need for continued vigilance in the Nelson Region.

MULTIPLE HOST PESTS

Pests of young stands

A total of 35 planted and natural young stands were surveyed for pest problems in 1989 (Table 9). In 27 of these stands, an average of 8% of the trees were dead or dying, mainly due to root rots, stem cankers or bear damage. In a further six stands, an average of 27% of the trees had pest problems causing significant growth loss, primarily caused by rodents, frost and terminal weevils. Some of the more important pests encountered in young stand surveys are discussed in more detail under the appropriate host, as indicated by an * in the table.

Table 9. Summary of pests of young stands, Nelson Forest Region, 1989.

Host[1]	No. stands	Pest	No. stands affected	% of trees avg.	% of trees range	Remarks
lP	21	stem rusts	8	5.5	1-26	major stem cankers causing tree mortality.
		root rots*	9	4.7	1-15	primarily Armillaria.
		Hylobius sp.	1	4	-	low incidence at Beaverfoot R.
		bear*	3	10	-	includes killed and partially girdled trees.
		rodents	2	57	54-60	recently spaced stands.
		Synanthedon sequoiae	1	8	-	
		Cinara sp.	2	19	1-38	small populations.
		Sclerophoma	1	4	-	
		Lophodermella concolor*	1	13	-	
		poor stock	1	60	-	seedlings mostly dead.
eS	16	spruce weevil*	5	5.3	3-8	generally increasing incidence.
		frost*	3	44	12-100	most severe in S.E. portion of region.
		root rot*	2	6	3-9	mainly Armillaria and Inonotus tomentosus.
		adelgids	12	70	8-100	common in most areas.
		spruce budworm*	1	2	-	trace defoliation.
		Cinara sp.	1	8	-	small colonies.
wL	13	root rot*	1	11	-	Armillaria in St. Mary R. drainage.
		frost*	1	29	-	top-kill in St. Mary R. drainage.
		rodents*	2	37	-	top-kill and partial girdling.
		needle blight*	4	75	-	severe infection causing growth loss.
		spruce budworm*	1	100	-	trace defoliation and dieback.

...

Host[1]	No. stands	Pest	No. stands affected	% of trees avg.	% of trees range	Remarks
D-fir	12	root rot*	5	4.4	1-13	leave trees in recently spaced stand.
		bear*	1	1	-	recently spaced stand, upper Kootenay R.
		Adelgids	4	66	4-97	light.
		Contarinia pseudotsugae	1	8	-	light
		Rhabdocline pseudotsugae	2	7	4-9	light
		Durandiella pseudotsugae	3	43	11-89	bark infections only.
		Cinara sp.	2	4	2-5	small colonies.
		deer browse	1	3	-	very light.
		Phaeocryptopus gaeumannii	1	20	-	light infection.
		spruce budworm*	1	13	-	light defoliation.
alF	3	root rot*	1	10	-	natural regen., Next Cr.
		frost*	1	100	-	extensive bud mortality, upper Ram Cr.
wwP	10	stem rust	6	37	11-55	infected trees dead or dying.
		root rot*	2	3	3	Armillaria root disease.
		Adelgids	1	6	-	incidental populations.
wH	9	root rots*	2	5	3-7	Armillaria root disease.
		Phoma sp.	1	100	-	minor branch dieback.
wrC	10	*Didymascella thujina*	3	38	17-62	minor infection.

[1]Host abbreviations: lP - lodgepole pine, eS - Engelmann spruce, wL - western larch, D-fir - Douglas-fir, alF - alpine fir, wwP - western white pine, wH - western hemlock, wrC - western red cedar.

Rhizina root disease
Rhizina undulata

An estimated 82 000 dead seedlings were associated with Rhizina root disease in 12 of 44 cut blocks examined in the region. Estimates were extrapolated from data collected along survey lines and portions of cut blocks affected. In an additional seven cut blocks, fruiting bodies were present but without related seedling mortality, and in four cut blocks, fruiting bodies were present where no planting had occurred (Table 10). Fruiting bodies were present in 20 of the 29 cut blocks within the ICH biogeoclimatic zone including nine of the ten most severely infected cut blocks. In the ESSF (Engelmann

spruce-subalpine fir) zone only 4 of 15 cut blocks had fruiting bodies but also included one of the more severely infected cut blocks at Angus Creek with 21% seedling mortality.

Six areas with seedling mortality in 1988 were resurveyed in 1989. Two cut blocks had no fruiting bodies and no further seedling mortality (down from 14 and 4% mortality in 1988), while at Bush River and Redding Creek, the frequency of fruiting bodies present and the area affected was reduced to an average of 1/5 of the 1988 level with only 1-2% additional seedling mortality (33 and 44% in 1988). At Cariboo Creek, north of Revelstoke, no new fruiting bodies were noted in June but mortality increased to 19% from 6% in fall 1988; similarly, at Downie Creek, seedling mortality increased from 15% to 34% with no new fruiting bodies present. Based on historical data along with current findings in the province, the fungus develops fruiting bodies during the first year following the burn and fruits with decreasing frequency during subsequent years. The fungus, however, may remain active for up to three years, based on suspected Rhizina caused mortality of 1989 planted seedlings in a cutblock severely infected in 1987. Further experimental planting of infected areas the second and third year following a burn is required before reliable recommendations can be given for a planting schedule of Rhizina-infected sites. Although Rhizina has been primarily associated with recently burned areas, fruiting bodies were also found in the unburned portions of recently burned cut blocks.

Table 10. Location and incidence of Rhizina root disease, Nelson Forest Region, 1989.

Low incidence of fruiting bodies		High incidence of fruiting bodies,
no seedling mortality	less than 10% seedling mortality	more than 10% seedling mortality
Lamb Cr.(ESSFa)	Redding Cr.(ICHa2)[2%]	Angus Cr.(ESSFc)[21%]
Norge Cr.(ICHa2)	Redding Cr.(ICHa2)[5%]	Donald(ICHa2)[25-62%]
Angus Cr.(ICHa2)	St. Mary R.(ICHa2)[9%]	McNaughton L.(ICHa2)N.P.
Beaver R.(ICHb)	Revelstoke Dam(ICHb)[9%]	Deadman Cr.(ICHb)[39%]
Bush R.(ESSFc)	Plant Cr.(ESSFc)[4%]	Cranberry Cr.(ICHa2)[38%]
Copper Cr.(ICHa2)		Nagle Cr.(ICHb)[25%]
McNaughton L.(ICHa2)		South Rd.(ICHa2)[20%]
Marioka Cr.(ICHa2)N.P.		Blue Ridge Rd.(ICHa2)[18%]
		South Rd.(ICHa2)N.P.
		Stevens Rd.(ICHa2)N.P.

Negative: Moose Cr., McMurdo Cr.(2 blks), Cariboo Cr., Ruby Cr., Lussier R., Bush R.(2 blks), Hawkins Cr., Skelly Cr., McNaughton L., Fred Laing Ridge, Key Rd., Downie Cr., Bannock Cr., Arthur Cr., Turner Rd., Sand Cr., Mosquito Cr., Blue Ridge Rd. and Blaylock Cr..

N.P. - not planted; [ ] - % seedling mortality; ( ) - biogeoclimatic zones

Black army cutworm
Actebia fennica

Black army cutworm populations decreased in the Nelson Region in 1989, with seedling and herbaceous feeding recorded on portions of only three cut blocks. The largest population was over 25 ha in a 1986-burned cut block along Vowell Creek, where 20% of the spruce seedlings had all of the foliage destroyed, but adventitious budding was evident; on a further 75% of the seedlings, 50% of the buds were destroyed. There was no evidence of any feeding having occurred on the cut block in 1988. At Chatter Creek, 2.5 ha of herbaceous growth including large numbers of aspen shoots, were totally stripped of foliage; however, bud damage to the lodgepole pine seedlings was minimal. Near Donald, herbaceous growth along with seedlings in small patches of up to 1 ha were moderately defoliated. Insignificant numbers of larvae were also found in several cut blocks in the Beaverfoot River drainage. Only 16% of the Douglas-fir seedlings totally defoliated in 1988 in a FRDA project near Bush Harbor had died due to cutworm feeding.

In the West Kootenay, at Redrock Harbour where 45% of Engelmann spruce seedlings were 100% defoliated in 1988, a walkthrough survey in June indicated good recovery with less than 10% mortality noted throughout the plantation. Mortality was concentrated at the upper end of the plantation where the burn appeared to have been most severe and the attack most intense. Sites with an average of one to three moths in pheromone traps in 1988, were revisited but no feeding activity was found at Cariboo Creek, Downie Creek or in a plantation above Redrock Harbour.

Cutworm populations were further reduced during the late-larval to pupal period, primarily by dipterous parasitoids, with only low numbers of pupae present in the Chatter Creek and Donald infestations, and moderate levels in the Vowell Creek area.

Adult cutworm were caught in nearly all pheromone-baited traps deployed at 31 sites, but potential moderate to high populations are predicted only for cut blocks north of Bush Arm, along the east side of McNaughton Lake, and in the West Kootenay at Nagle Creek, Fred Laing Ridge and at Revelstoke Dam (Table 11). Two trapping methods were used; the traditional sticky traps using 0.4% cis-7-dodecenyl and cis-11-tetradecenyl, and dry Multipher® traps using a newly formulated pheromone. Results were often contradictory and predictions are based on interpretations of catches from both methods. Further calibration studies will continue.

Table 11. Predicted black army cutworm population levels for 1990, Nelson Forest Region, 1989.

Low	Low-moderate	Moderate-high
Donald	Bush R.(CP 104)	McNaughton L.(CP 57)
Beaver R.	Bush R. "	Nagle Cr.
Moose Cr.	Bush R. "	Revelstoke Dam
Copper Cr.	Lussier R.	Fred Laing Ridge
St. Mary R.	Redding Cr.	
Angus Cr.	Redding Cr.	
McMurdo Cr.	Lamb Cr.	
Cariboo Cr.	Downie Cr.	
Ruby Cr.	Arthur Cr.	
Cranberry Cr.	South Rd. km 16.5	
Blue Ridge Rd.	Bannock Cr.	
South Rd. km 14.5	Deadman Cr.	
Turner Cr.	Goldstream R.	
Marioka Cr.		

Root diseases
Inonotus tomentosus
Armillaria sp.
Leptographium wageneri

Root rot organisms infected 80% of the lodgepole pine and 59% of the Engelmann spruce in mature to overmature stands surveyed in four drainages in the East Kootenays (Table 12). Root rot incidence was determined by assaying trees in continuous strips 5-m wide for +/- 1 km. All trees were tallied into categories either having or not having root rot symptoms. Groups of recent dead or symptomatic trees were sampled to determine the causal agent. Since *I. tomentosus* must be well established in a tree before visible symptoms are evident, at least two root cross sections were examined on 20 randomly selected apparently healthy trees to determine the percentage of non-symptomatic trees infected.

Tomentosus root disease

Table 12. Location and incidence of Inonotus tomentosus, Nelson Forest Region, 1989.

Location	Tree species	No. strips	Percent non-symptom trees healthy	Percent non-symptom trees infected	Percent dead/dying trees	Percent dead/dying area	Dead other causes[1]	No. centers /ha
Spillimacheen R.	lP	3	14	51	13	17	22	24
Beaverfoot R.	lP	3	29	55	16	13	0	30
Bull R.	lP	3	32	27	3	6	38	15
Dewar Cr.	lP	2	0	60	31	37	9	66
Average	lP	-	19	48	16	18	17	34
Spillimacheen R.	eS	4	48	41	10	5	1	5
Beaverfoot R.	eS	4	42	43	15	10	0	20
Bull R.	eS	2	24	55	21	26	0	55
Average	eS	-	38	46	15	14	1	27

[1]mainly Armillaria sp. and low incidence of Polyporus schweinitzii.

Tomentosus root rot, the most frequently encountered root disease, was present on 64% of the lodgepole pine. This fungus commonly infects 20- to 30-year-old pine and gradually moves through the root heartwood allowing tree growth to continue. However, when tree vigor is reduced by factors such as root-collar weevil or old age, the fungus invades the sapwood and root mortality follows. Growth-ring analysis of 50-60-year-old trees indicated a growth reduction of 51% in trees with over 50% of the root cross-section infected. The trees with the most advanced root rot were those which had been the fastest growing during the first 10-20 years. Losses to the existing severely infected stands are mounting, with an estimated annual net volume loss of 4.1 m^3/ha based on tree mortality and rough calculations of reduced growth. These figures will, however, increase with stand age.

In spruce stands, the impact of the root rot becomes evident at an early age with reduced growth followed by tree mortality common in 15-20-year-old regeneration in previously infected stands. These root rot pockets in young stands grow radially but often the rate of tree mortality slows down during the most vigorous growth period. As the trees reach maturity the rate of tree mortality and associated blowdown again increase.

Management of I. tomentosus-infected stands to date is limited to clear-cutting and planting of less susceptible species, the most susceptible being spruce followed by pine and larch.

Armillaria root disease

Armillaria root disease was present in 19% of the mature lodgepole pine but usually in association with tomentosus root rot, wind-damaged trees or in very close-growing stands. Only rarely were large Armillaria infection centers found without other stress factors involved. In mature Douglas-fir stands, an average of 10.5% of the trees in strips run at Hobo Creek and at Bull River had evidence of Armillaria root disease. Especially in the Bull River strip, most of the infected Douglas-fir was associated with clumps of infected, overgrown and dying lodgepole pine. In all Douglas-fir beetle infestation areas, root rot was present and along with drought stress, predisposed trees to initial establishment of the infestations. In a young spaced Douglas-fir stand near Next Creek 4% of the trees left had symptoms of Armillaria root disease. In all cases, it appeared to have followed attack by root and root-collar feeding insects, primarily Hylastes sp. These insects tend to feed on roots of recently cut stumps and will subsequently migrate to living trees in spaced stands.

In mature spruce stands, Armillaria root disease was frequently present in alpine fir trees but none was evident in the spruce trees sampled.

Armillaria root disease was recorded on most tree species in 10 of 19 young stands surveyed in the East Kootenay, ranging from a high of 13% in one Douglas-fir stand to an average of 5% where it was present in lodgepole pine and Engelmann spruce. Single stands of larch (11%) and alpine fir (10%) were also infected. Tree mortality in young stands caused by Armillaria root disease is often caused by rhizomorph-initiated infections resulting in large numbers of root rot centers. However, this type of infection declines as the trees reach 10-20 years old, after which transmission is primarily via root contact and progress of the disease within the stand is greatly curtailed.

In the West Kootenay, no specific root rot surveys were implemented; however, root disease was noted and assessed throughout the district during various other surveys. In young stand surveys, Armillaria root disease was found in 56% of stands assessed, with 1 to 5% of crop trees affected in a wide variety of host species. Of the nine stands affected, three were recently spaced; at Halfway River, 2% of 5 m plot trees were infected in this spaced and pruned stand; at Fiva Creek, an estimated 1% of natural lodgepole pine were infected in numerous pockets adjacent to a recently spaced area; at Sheep Creek, 2% of 1 m natural lodgepole pine regeneration were infected in scattered pockets throughout the block.

At Granite Mountain near Rossland, in three centers of mature alpine fir mortality, all trees examined were killed by Armillaria root disease while balsam bark beetle, the expected causal agent, was absent. At this site, Pinus albicaulis (whitebark pine) was also infected, a new host record in B.C. Along the Pend-d'Oreille River in an outbreak of fir engraver beetle, in two widely separated spot infestations of young to mature grand fir, all trees attacked by the beetle were also infected with Armillaria root disease. At Kokanee Creek Park, young grand fir were recently killed in three small root rot pockets while at Champion Lakes Park, two young alpine fir were infected at two widely separated locations.

Armillaria root disease in young stands is of primary concern especially in stands recently spaced. An assessment of root rot incidence prior to spacing

will assist in the develoment of an appropriate spacing regime for the stand. Indications are that where the fungus is present, the cut stumps are rapidly invaded and may subsequently infect adjacent crop trees via contacting roots. However, whether spacing enervates the disease or improves health and resistance to infection has not yet been determined.

Blackstain root disease

Blackstain root disease has frequently been overlooked as a serious root rot problem. General observations along McNaughton Lake and other blackstain areas suggest that it frequently precedes other pest problems, weakening trees prior to infection by Armillaria root disease or attack by bark beetles or engraver beetles.

Blackstain root disease had become firmly established in a mature lodgepole pine stand in the Skelly Creek drainage and in Douglas-fir seed trees along Windermere Creek. At Skelly Creek, the infection center covered approximately 3 ha, killing 70% of the pine in the 0.5 ha epicenter. Secondary insect activity (root weevils and Ips spp.) were present on all the diseased trees examined, with Ips in most cases being the final cause of death. Under the close-growing stand conditions, spread of the disease via root contact can be rapid with annual radial expansion of infection centers of up to 4.5 m.

At Windermere Creek, Douglas-fir seed trees were infected by blackstain with occasional tree mortality but more typically showing crown symptoms such as thinning and chlorotic foliage. Since blackstain-infected trees seldom produce a cone crop, Douglas-fir seed trees left in areas of known blackstain may serve little purpose. Even when healthy trees are left, root-feeding weevils, a common vector of the fungus, will soon migrate from stumps to attack and introduce blackstain to the few remaining trees.

Blackstain root disease was incidental on one of twenty mature lodgepole pine examined in a mountain pine beetle infestation at Ingram Creek.

Winter damage

In the Nelson Region, over 1500 ha of severe climatic injury was recorded in 1989, with an additional 540 000 ha of light to moderate damage. Damage was most frequently noted on the west side of the Rocky Mountains in the Elk and Flathead rivers systems where red belt, caused by low temperatures combined with strong winds during February, was common in lodgepole pine, whitebark pine and Engelmann spruce. Less severe damage, primarily bud mortality, was widespread in high-elevation stands in the Bloom to Yahk creeks area, Vowell Creek and in the Bush, Bluewater, and Beaver rivers areas.

Impact varied with tree species. In most of the spruce within the moderate to severe red belt areas, tree mortality was imminent with branch and top dieback to 5-cm diameter or greater along with no 1989 foliage or adventitious buds. In spruce above 1450 m elevation, 100% bud mortality occurred above the snowline on all age trees. At elevations of 1200 m, terminal bud mortality ranged from 10-50% depending on aspect and exposure. In plantation spruce along the upper Ram Creek and at Howell Creek, the form of young trees will be severely affected with ragged bushiness followed by a high percentage of multi-leadered trees as the live lower branches vie for leadership

between each other and the adventitious buds from frost-damaged old leaders. The impact will be less severe on the 10-20% of the trees with terminal bud mortality in plantations near Bluewater River and at Yahk River.

In moderately to severely affected stands of lodgepole pine and whitebark pine, 5 to 35% of the trees had severe branch and top dieback along with no new foliage in 1989, suggesting tree mortality by 1990. Some secondary bark beetles, Ips sp. and Scolytus sp., were already evident in trees with severe dieback, and local population buildup may lead to further mortality of weakened pine and spruce in 1990 and 1991. In addition, root rots, especially Armillaria root disease in lodgepole pine stands are extremely opportunistic when trees become weakened, and an increase in root rot infection centers is expected.

In western larch along exposed slopes and ridges in the Flathead and Wigwam rivers drainages, the outer tissue of the buds was severely damaged while the inner or base tissue remained functional and produced the much-delayed 1989 foliage by July. In the same general area, Douglas-fir buds were damaged, resulting in only limited, stunted 1989 foliage. In the Bush River and Glacier National Park areas, lightly to moderately discolored western hemlock foliage was widespread; however, buds generally remained healthy and the impact was minimal to light with only several 1-2-ha patches on which branch tip dieback was evident.

Animal damage

In the Nelson Region, animal damage was noted at a number of locations but primarily in younger stands, some of which were spaced and occasionally pruned under FRDA agreements. The most serious damage was caused by bears with squirrel and porcupine damage also noted and some basal damage possibly caused by rabbits. Although squirrel feeding seldom kills trees, extensive top-kill can virtually destroy tree form.

Of the 19 young stands surveyed in the East Kootenay, significant tree mortality (12%) was recorded only in a recently (FRDA) spaced 13-year-old lodgepole pine stand at Norge Creek, most of it within the past two years. An additional 7% had extensive partial girdling of the stem. Varying levels of bear damage were also observed in lodgepole pine and western larch in the St. Mary River drainage and in Engelmann spruce and Douglas-fir in the upper Kootenay River area. Bear damage is most pronounced in open growing understocked stands, conditions which are often created during spacing.

In a young 5-m-tall western larch and Douglas-fir stand near Brewer Creek, top-kill caused by squirrels averaged 2 m on 13% of the trees, 3% of which were from 1989 feeding.

At Halfway River, a number of western white pine were dead or dying due to bear feeding. Damage occurred over more than one year along a logging road immediately adjacent to a spaced 22-year-old stand averaging 5 m high. At Sentinel Mountain in a 19-year-old spaced stand, where the pine component was 75% of the crop trees, 54% of the pine were variously scarred or top-killed, probably by porcupine and squirrels. At Shields Creek in a plantation averaging 70% lodgepole pine, approximately 22 years old and 5 m high, 5% pine mortality caused by bears and an additional 61% scarring caused primarily by squirrels after spacing was noted. At Steward Creek, spacing was in progress in a pure

pine stand approximately 20 years old and 6 m in height. No mortality was recorded but 6% of spaced crop trees were bear damaged while 1% of unspaced pine was damaged.

The areas at Sentinel Mountain and Shields Creek were spaced in the fall of 1987; therefore, the damage recorded presumably occurred over the 16-20-month period after spacing. At both sites, there was evidence in felled non-crop trees of scarring activity prior to fall, 1987. At Shields Creek there was notable bear damage in adjacent older pine stands although not as severe as levels incurred in the spaced area.

While no damage was found in the spaced stand at Halfway River, the work was completed only in the fall of 1988 and presumably the 24% western white pine within the stand should be considered at risk. In all affected stands, it is probable that damage will occur or continue in 1990 and in some areas, bear damage may increase as access improves.

Roadside damage

In the Nelson Region, most of the roadside tree damage was of a chronic nature to young and semimature trees (primarily Douglas-fir and lodgepole pine) in gullies and ditches on the lower side of the highways. Some of the more notable areas in the East Kootenay included: the junction of Highways 95 and 3 where dead and dying trees extended to 50 m down the gullies; 1 to 1.5 km of partially killed trees near HaHa Creek, Jaffray, and along the north end of Moyie Lake; and almost continuous damage between Cranbrook and Lumberton. Smaller groups of 10-30 affected trees occurred along Columbia Lake, at Kimberley and TaTa Creek, near Windermere and at the junction of Highways 95A and 3 near Cranbrook.

In the West Kootenay, chronic occasional roadside mortality occurred along Highway 33 from Rock Creek to Beaverdell and for 25 km along Christian Valley Road. Overall, less than 1% of trees from young regeneration to semimature have been killed in spots of from 2 trees to a 30-tree patch of semimature Douglas-fir just north of Kettle Valley Recreation Area. The primary causal agent is suspected to be salt damage as most mortality occurred on the lower side of the highway and on inside curves. Herbicide damage, e.g. Tordon®, was excluded as the cause through testing.

Similar salt damage was common in many other areas of the district, affecting primarily young roadside regeneration of all species. Discoloration, defoliation and some tree mortality was noted from Grand Forks to Christina Lake and from there to Paulson Bridge, at the Paulson Summit area and for 10 km in the Nancy Greene Park area as well as in the Wilgress Lake area. Immediate proximity to the highways means that most affected regeneration was candidate for the mower.

Acid rain monitoring

Annual monitoring of the Acid Rain National Early Warning System (ARNEWS) plot along Bulldog Road in the Blueberry-Paulson summit area of the Nelson Forest Region continued in 1989, to identify changes in vegetation and tree vigour possibly due to aerial pollutants or acidified precipitation. Assessment of plot trees, off-plot trees, regeneration in subplots and ground vegetation

was done as part of the survey. A new element was added to monitor long-term foliar development and changes by foliar examination and developing a photo file of 10 tagged branches per host.

Winter flecking remained common throughout on older needles of all Engelmann spruce with both old and new Adelges cooleyi galls also common. A rust broom caused by Chrysomyxa arctostaphyli was noted on one spruce. The needle fungi, Pucciniastrum epilobii, Lirula abietis-concoloris and Tiarosporella abietis, were all identified from off-plot sample alpine fir. Infection rates both in and outside the plot were light. No anomalies or evidence of pollution effects were noted. Assessments will continue in 1990.

TRUE FIR PESTS

Two-year-cycle spruce budworm
Choristoneura biennis

Two-year-cycle spruce budworm defoliated 5930 ha of high elevation alpine fir and Engelmann spruce in eight stands throughout the region (Map 4), a substantial reduction from the 11 500 ha of defoliation reported in 1987, the most recent main feeding year. While the overall area affected was diminished, in the West Kootenay the area expanded from 1650 ha in 1987 to 5880 ha in 1989. The current infestations have been commonly reported in the adjacent Monashee Pass area but aerial surveys to delineate infestations were unavailable.

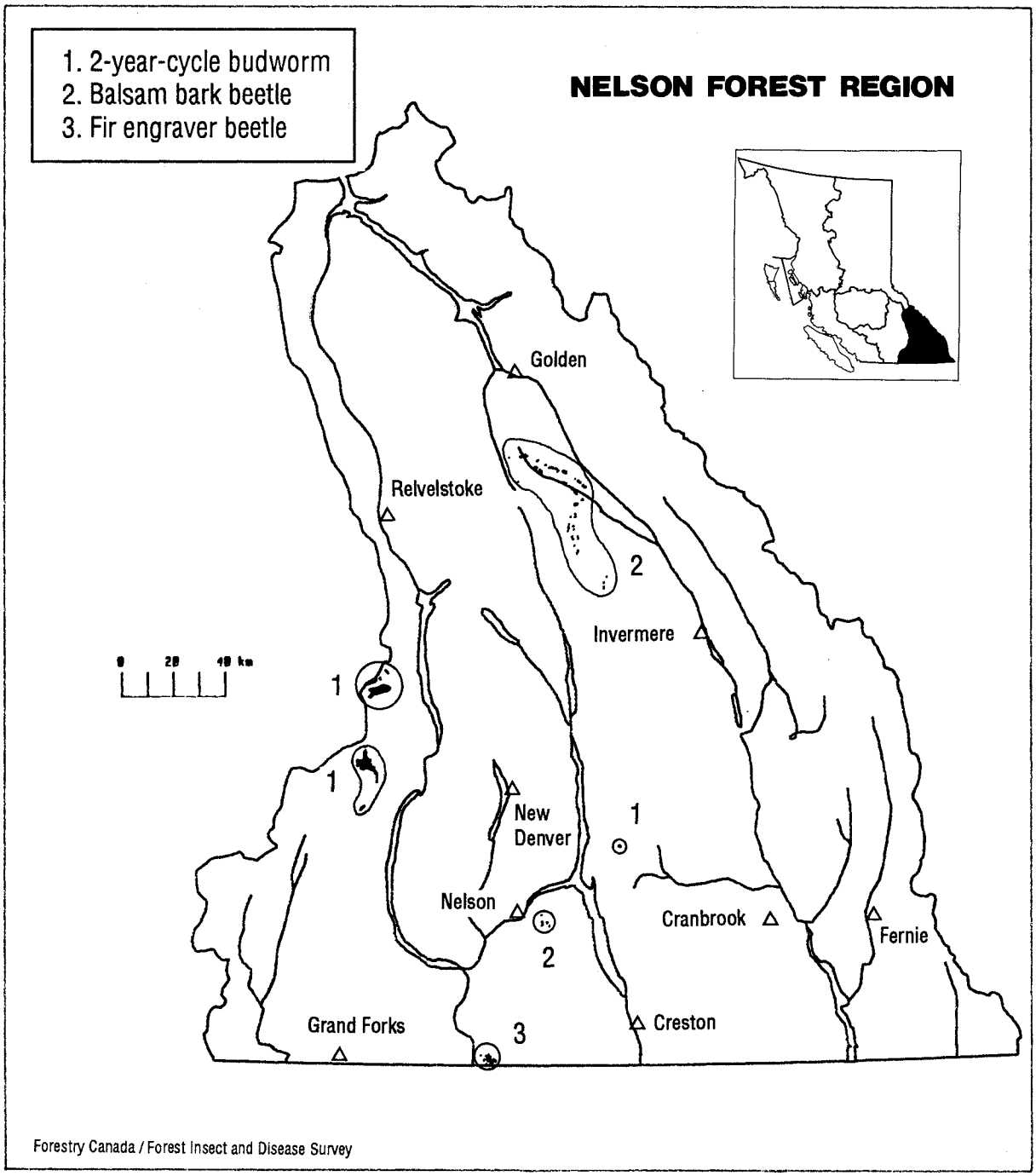
The main areas of infestation included Barnes and Plant creeks, where light to moderate defoliation was anticipated (Table 13), but also included South Fosthall, Cusson creeks and for the first time Galloping Bench Creek to the south. All areas were mapped as light defoliation except for a 180-ha area of moderate defoliation near the headwaters of Plant Creek.

In the East Kootenay, light defoliation was mapped over 40 ha of mature alpine fir and spruce in the St. Mary River drainage, a decrease from 10 000 ha in 1987, the last main feeding year. Additional defoliation, too light to map aerially, was noted along Vowell and Bugaboo creeks.

Table 13. Location, host, percent buds infested by two-year-cycle spruce budworm and predicted and actual defoliation, Nelson Forest Region, 1989.

Location	Percent buds infested		Defoliation potential for 1989 from counts[1]		Actual defoliation
	1988	1989	1988	1989	
Plant Cr.	20	55	LT	LT/MOD	LT/MOD
Barnes Cr.	52	28	LT/MOD	LT	LT

[1]percent buds mined averaged over the two years approximately equals expected defoliation during main feeding year.



Map 4. Areas where recent tree mortality and current defoliation were detected during ground and aerial surveys in 1989.

Foliage samples were taken from three locations in the Plant Creek drainage and from the Barnes and Bugaboo creeks and the St. Mary River drainages to determine the potential for bud feeding in 1990 and defoliation in 1991 (Table 14). Unlike the two-year-cycle budworm in most of the province which has the main feeding period in the even numbered year, only bud feeding by second and third instar larvae is anticipated in 1990 in the Nelson Region. The main feeding activity will be in 1991 and is expected to continue and intensify in the sampled areas.

Table 14. Location, number of two-year-cycle spruce budworm egg masses, predicted defoliation 1991, Nelson Forest Region, 1989.

Location	No. egg masses per 10 m^2 foliage	Predicted defoliation for 1991[1]
Plant Cr.	209	MOD
Barnes Cr.	272	MOD
Bugaboo Cr.	388	SEV
St. Mary R.	28	LT

[1] light (LT) - 1-100 egg masses
moderate (MOD) - 101-300 egg masses
severe (SEV) - 301+ egg masses

A project to calibrate pheromone-baited trap data to larval populations and resulting defoliation was continued at Redding Creek in 1989, with a second plot established in the Bugaboo Creek drainage (Table 15). Several more budworm generations have to be monitored at numerous locations in the province before meaningful relationships can be formulated.

Table 15. Location, number of larvae, adults and defoliation at two-year-cycle spruce budworm pheromone calibration plots, Nelson Forest Region, 1989.

Location	Avg. no. larvae/tree[1]		Avg. no. adults/trap[2]		Defoliation	
	1987	1989	1987	1989	1987	1989
Redding Cr.	1	<1	29	56	Trace	Nil
Bugaboo Cr.	-	5	-	179	-	Trace

[1]sampling method consists of beating three branches on each of 25 trees over a 60 by 90 cm sheet.
[2]five Multipher® traps spaced at more than 30-m intervals.

Western balsam bark beetle
Dryocoetes confusus

Recent tree mortality, as detected by aerial surveys, covered over 1600 ha in the Nelson Region, unchanged from 1988 (Map 4). The main concentrations and expansions remained in the Spillimacheen River (1100 ha) and Vowell Creek (250 ha) drainages and included 113 ha in 12 infestations of expanded activity in the Lasca Creek drainage.

Consistent recording of annual fluctuations of beetle-killed trees is complicated by the scattered patchy occurrence, the retention of discolored foliage for up to five years and the extensive mortality caused by other agents. Earlier surveys in the Prince Rupert Region indicated that between 50 and 65% of the alpine fir mortality was caused by balsam bark beetle, often in association with root disease which was responsible for most of the remaining tree mortality. A ground survey in a mixed spruce-balsam stand at Cariboo Creek had 34% cumulative beetle-caused mortality of which 4% was 1988 attack. Advanced Armillaria root disease was associated with 12% of the trees. The presence of tomentosus root rot was restricted to the portion of the root adjacent to and in contact with infected spruce roots.

Fir engraver beetle
Scolytus ventralis

The fir engraver caused light to severe mortality of grand fir over 237 ha in 30 infestations (Map 4), primarily in the Pend-d'Oreille River drainage; several spot infestations were also noted in the Creston area. Infestation varied from spot to 30 ha in size.

Attack was widespread throughout the area. In several spot infestations checked, Armillaria root disease was found in all trees attacked by the beetle. This association might prove very common under intensive surveying; however, since the root rot had been presumably in the drainage for many years prior to this outbreak, a direct causal relationship is unlikely. It is probable the stress created by several years of below-normal precipitation was the primary factor in causing this outbreak. Stress is known to be a key in the development of the fir engraver to epidemic proportions. As a major pest in western forests, it has been periodically at outbreak levels and often in association with drought conditions.

In four areas assessed during fall surveys to determine the levels of new attack, the ratio of red to green attack averaged approximately 6 to 1, thus indicating a sharp reduction in the number of red trees expected in 1990. Top-kill was noted, and partial and repeat attacks were found as well as considerable variability in brood development. Attacks and mortality are expected to continue, especially in trees with advanced stages of root rot infection.

Foliar diseases
Pucciniastrum epilobii
Delphinella sp.
Phacidium abietis

Foliar diseases on alpine fir continued through the host range in much of the Nelson Region but at greatly reduced rates, causing only minor discoloration in most areas. Pucciniastrum epilobii caused minor infections at the ARNEWS plot on Bulldog Road, while Delphinella sp. caused minor tip dieback at this site and two other pathogens, Lirula abietis-concoloris and Tiarosporella abietis, were present but incidental. P. epilobii was severe on midcrowns of young regeneration over approximately 1 ha on Granite Mountain where Phacidium abietis was also recorded. Foliar diseases can be expected to continue on an annual basis with severity and extent primarily related to localized conditions appropriate to successful infection.

LARCH PESTS

Larch casebearer
Coleophora laricella

Larch casebearer defoliation declined dramatically in the Nelson Region with no infestations mapped during aerial surveys. The decline came after only one year of significant expansion to 486 ha of light to moderate defoliation in 1988, mostly in the West Kootenay.

Defoliation in the West Kootenay was noted mainly at parasite release areas during pupal collections in late May to early June and varied from nil to only very light. Only at the Castlegar West and Castlegar Pulp release sites was occasional moderate defoliation noted on some of the young regeneration larch. Activity in the East Kootenay was similar with trace to very light defoliation noted at a few release areas, especially in the regeneration.

The incidence of pupal parasites from 17 locations averaged 23% (range 1-54%), down from an average of 32% in 1988. Parasitism by the introduced parasite Chrysocharis laricinellae averaged 18% (range 0-51%) and by Agathis pumila averaged <1% (range 0-3%). At Schroeder Creek, approximately 40 km over a mountain range from the nearest release location, 5% and <1% parasitism respectively by C. laricinellae and A. pumila was found, indicating that these introduced controlling agents have probably dispersed successfully into the general pest range.

The cause for the rapid decline in infestation levels after only one year of major expansion has not been determined; however, the 32% parasitism in 1988 is believed to be a major contributing factor. Low levels of activity precluded the need for special overwintering assessments of general populations; however, feeding damage and visible defoliation are expected to remain at similar levels for 1990.

Larch sawfly
Pristiphora erichsonii

Occasional single larva and small colonies of larch sawfly in conjunction with some trace defoliation and minor upper crown and terminal stripping was all that remained of the 112 ha of light to moderate defoliation in the Miller Creek area in 1988. Populations totally collapsed in the Elk River Valley, where 400 ha of moderate to severe defoliation was recorded in 1988. The expected collapse followed 84% parasitism of cocoons found from fall 1988 samples. Occasional small colonies also continued in the Castlegar to Keenleyside Dam area but no defoliation was noted.

Larch needle diseases
Hypodermella laricis
Meria laricis

The incidence of the needle disease, *Hypodermella laricis*, increased in the Nelson Region in 1989, with a total of 167 ha mapped during aerial surveys, mostly in the Boundary TSA.

During aerial surveys in the West Kootenay, 153 ha of light to severe infection by *H. laricis* were mapped in seven areas, mostly in the Boundary TSA. Affected areas in the Lynch, Sand, Snowball and Sandner creeks drainages ranged from 10 to over 70 ha in size.

By the end of May, areas of severe defoliation ranging from spot to an estimated 10 ha in size were common from Westbridge to Beaverdell and along the main Kettle River wherever the host occurred, with the severe discoloration primarily in midcrowns. With reflushing, infected areas became less evident in the summer. Discoloration in other areas became more notable, such as severe midcrown discoloration patches up to 10 ha from Eholt to Grand Forks; similar discoloration was noted in the McRae Creek drainage to Paulson Bridge. In the Halfway River drainage, light to moderate discoloration primarily in midcrowns was common, with light infection noted throughout one area along White Grouse Creek.

In the East Kootenay, infection was generally light (less than 40% of foliage infected) to occasional patches of moderate to severe infection in most stands in the St. Mary River system, Brewer-Dutch creeks, Findlay Creek, Moyie Lake to Yahk and along the Kootenay River north of Whiteswan Lake to the Palliser River. In a young stand near Dutch Creek, 49% of the trees were severely infected, 24% moderately and 14% lightly.

Light infection by *H. laricis* was scattered throughout many areas and was initiated primarily by cool moist conditions during the spring spore-dispersal and needle-elongation period. While cool wet weather occurred sporadically throughout the summer, *Meria laricis*, which can infect needles at all stages of development, was found only from one sample near Salmo.

The impact of severe foliage infection was examined in a young spaced larch stand near Brewer Creek. The height increment was measured for 1988 and 1989 on 20 lightly and 20 severely infected trees. The 1989 height increment of the severely infected trees was suppressed to 68% of the 1988 growth, while in the lightly infected trees the 1989 growth was 95% of the 1988 growth.

Climatic conditions during periods of spore dispersal are the primary factor in determining infection rates; therefore, it is not possible to predict the potential for discoloration.

Larch budmoth
Zeiraphera improbana

Larch budmoth continued at endemic levels throughout the region, with only slightly expanded populations noted during May ground surveys, and caused light damage at Anarchist Mountain and Johnstone Creek Park. No larvae or larval damage was found in approximately 800 fascicles checked at the Aaron Hill site near Castlegar. No evidence of this pest was noted in the East Kootenay; monitoring will continue in 1990.

Woodborers

Woodborers of the family Buprestidae were found in larch at two locations and, in the absence of other causal agents, were considered to be the primary cause of death of larch at these sites. Woodborers are normally secondary in nature, often coming in after the tree is dead.

At Bauer Creek, woodborers killed scattered individual western larch as well as pockets of up to six trees over a large area. Trees were generally semimature and formed part of the main canopy. At a Myers Creek site where natural fir and larch regeneration had been recently spaced, an estimated 30 to 40 trees were killed over an approximately 5-ha area. Larch of all age classes from advanced regeneration (3 m) to semimature were affected. At this site the beetle, *Scolytus unispinosus*, known to cause occasional mortality of predisposed trees, was also found.

Bolts from both locations are in rearing to identify the species responsible. Monitoring and sampling will continue in 1990 to further assess the extent and potential of this pest.

Spike-top of larch
Potebniamyces coniferarum

Spike-top of larch, caused by the fungus *Potebniamyces coniferarum*, was common on seed trees along the lower Lussier River. Although the disease should not affect the seed production function of the trees, infection of both larch and Douglas-fir regeneration may be of greater concern as they approach the sapling size. A short walk-through tally indicated that 3% of the young Douglas-fir and 5% of the larch had advanced leader infection. Indications are that leader infection may act as an attractant for squirrel bark feeding; however, following bark feeding the evidence of prior infection is largely obliterated.

SPRUCE PESTS

Spruce beetle
Dendroctonus rufipennis

In the East Kootenay, low spruce beetle populations were recorded in numerous drainages. Only at Redding Creek were the number of overwintering adults indicative of an increasing population, with an "R" value of 4.2. Although much of the 1990 flight should be absorbed by the chronic blowdown along leave block fringes, several groups of less than five standing tree attacks can be expected. Along the Vermilion River, in Kootenay National Park, overwintering adult spruce beetle were sparsely distributed over 75 ha of spruce blowdown. Cumulatively, these beetles, emerging in 1990, may pose a threat to the surrounding mature spruce stands. A small active infestation along the Spillimacheen River was reported by industry.

Infested recent blowdown was also recorded in the following areas: along Meachen Creek (0.5 ha); in the Monroe Lake-upper Bull River area 20+ fringe trees were blown down with an additional 2-8 windthrown trees per hectare attacked in the stand; the upper Bush River had numerous patches of 5-10 blowdown trees along 14 km; very scattered blowdown occurred along McMurdo Creek and the Palliser River; and there was a decrease to only occasional current attack in the Beaverfoot River Valley in small infestations adjacent to previously flood-damaged spruce. These situations are generally indicative of only a minor localized population build-up leading to small groups of standing trees being attacked before subsiding.

In the West Kootenay, no new spruce beetle infestations were recorded and despite only limited success in the trial control project at the upper Duncan River-Glacier National Park spruce beetle infestation, no new faders were noted in the area during aerial surveys and no attack was reported from ground probes. Attack was reported in the Ladybird and Norns creeks drainages near Castlegar but nothing was found during aerial surveys.

In the Asher Creek drainage near Trout Lake, 51 ha of inaccessible old grey spruce beetle-killed trees were recorded in an area reported by industry and BCFS to harbor current attack. Plans were made to address this site with access and harvesting.

Spruce weevil
Pissodes strobi

Spruce weevil killed an average of 5% of the 1989 spruce leaders in five of nine spruce plantations surveyed in the East Kootenay. Current attack levels were relatively static in the younger (10-13 years) upper Beaverfoot River (4%) and Bluewater River (6%) cut blocks but 2.5-to 4-fold increases were recorded in 15-to 20-year-old plantations in the lower Beaverfoot River (8%), Next Creek (5%), the lower Yahk River (3%) areas and along the Kootenay River in Kootenay National Park (17%).

DECIDUOUS TREE PESTS

Forest tent caterpillar
Malacosoma disstria

Forest tent caterpillar, accompanied by varying levels of western tent caterpillar, defoliated primarily trembling aspen over 9900 ha in 60 infestations. This was a sixfold increase from 1500 ha defoliated in 1988.

In the Golden to Blaeberry River area, 8100 ha of severe defoliation were mapped during the second year of the infestation. Defoliation covering 1400 ha continued along the Kootenay River south of Fort Steele at reduced levels, but greatly intensified north along the Kootenay River to the Wasa Lake area where most deciduous trees were totally denuded. Smaller patches of defoliation continued near Yahk and near Creston. In the Hosmer-Fernie area, defoliation expanded to cover 100 ha but was generally light to moderate.

Table 16. Location, average number of 1989 egg masses per tree and predicted defoliation of deciduous stands by forest tent caterpillar, Nelson Forest Region, 1989.

Location	Average[1] dbh (cm)	Average no. egg[2] masses/tree	Predicted defoliation
Fernie	8	2	light
Fort Steele	7	20	severe
Wasa Lake	7	18	severe
Golden	11	37	severe
Blaeberry R.	6	10	severe
Average	8	17	

[1]No. egg masses by tree diameter that will cause complete defoliation, based on Information Report NOR-135; "Forest Tent Caterpillar in the Prairie Provinces." by V. Hildahl and A.E. Campbell.

DBH	No. egg masses
2.5	2
5.0	5
7.5	9
10.0	11
12.5	14
15.0	19

[2]Three trees sampled per location, all new egg masses tallied per tree.

In the West Kootenay, only three small infestations of moderate to severe defoliation were recorded totalling approximately 70 ha compared to no infestations noted in 1988. Severe defoliation of trembling aspen was noted at

Mount Mackenzie and Dupont Creek near Arrowhead. No evidence of resurgence of the pest in the traditional Trail-Warfield infestation area was noted.

Egg-mass surveys at five sites during fall surveys, to determine the potential for defoliation in 1990, suggested an overall population reduction, but still capable of totally defoliating the trees at all sites, except in the Fernie area where only light defoliation is anticipated (Table 16).

Gypsy moth
Lymantria dispar

For the eleventh consecutive year, no moths were caught in pheromone-baited traps placed at 35 locations in the region to detect possible gypsy moth incursions. Traps were distributed primarily in forested recreation areas within provincial and national parks and in areas adjacent to the Canada-USA border. Approximately 300 traps were distributed province-wide by Forestry Canada-FIDS as part of an interagency cooperative program with Agriculture Canada (Plant Health) and BCFS. A total of 26 adult males were trapped this year (12 in 1988), mainly in the Vancover Region but also included one moth near Kelowna where moths have been caught for three consecutive years.

Pacific willow leaf beetle
Pyrrhalta decora carbo

Skeletonizing of primarily willow species by the Pacific willow leaf beetle continued for the fourth consecutive year from Revelstoke to Mica Dam. Feeding activity, however, was somewhat reduced and sporadic. Generally spotty infestations also continued at reduced levels from New Denver to Revelstoke and Nakusp to Fauquier. Feeding damage was noticed for 5 km along Kuskanax Road and along Steward Creek Road near Christina Lake. Discoloration was generally light with only occasional small patches of moderate to severe damage. No mortality has been noted and predictive methodology has not been developed for this pest. Infestations generally last 2 to 10 years.

Birch leafminer
Lyonetia saliciella

For the fifteenth consecutive year, discoloration of birch stands was evident in parts of the northern two-thirds of the region. In the West Kootenay, light partial discoloration to 64% of the foliage was noted for 10 km along Kaslo Creek to Kaslo and for several kilometers north to Schroeder Creek. Discoloration varied from light to severe for 15 km along Stevens Creek near Whatshan Lake. Activity declined in the Donald, Golden, Rogers Pass and Kaslo areas before larval feeding was complete and discoloration was no longer evident later in the season or recorded during aerial surveys.

Apple and thorn skeletonizer
Choreutis pariana

The apple and thorn skeletonizer caused intermittent light to severe skeletonizing, primarily of apple, over much of the West Nelson District. Leaf browning was noted from June to August. This pest has several generations per year. In Nelson and from Balfour to Nelson, moderate to severe discoloration was noted on apple trees by mid-June. Throughout Nakusp, the majority of the

severe feeding damage was not evident until early August, while near Castlegar, moderate damage was noted in late July and light occasional damage was noted at this time in the New Denver area. In coastal B.C., damage occurs annually, while in the interior, infestations are sporadic.

HEMLOCK PESTS

Western hemlock looper
Lambdina f. lugubrosa

Western hemlock looper larvae appeared consistently in low numbers in traditional outbreak areas after being conspicuously absent for several years (Table 17). Larvae occurred primarily on western hemlock but also on western red cedar and mostly in old growth stands, but not exclusively.

Table 17. Location, host and number of hemlock looper larvae per three-tree beating, Nelson Forest Region, 1989.

Location	No. larvae	Host
Bigmouth Cr.	11	wH
Woolsey Cr.	8, 1	wH, wrC
Goldstream R.	2	wH
Tangier R.	2	wH
Downie Cr.	1	wH
Copper Queen Cr.	1	wH
Halfway R.	1	wH
Box L.	1	wH
Average	3.4	

Western hemlock looper is capable of rapid increases in larval numbers to outbreak levels. In the last outbreak when 8035 ha were defoliated in 1982 and 32 000 ha in 1983, larval numbers in beating samples increased rapidly from endemic to an average of five larvae per sample in 1980, 12.4 in 1981 and outbreak in 1982. Historically in the interior, defoliation is likely in the year in which eight larvae per sample are found. It should be noted, however, that in examination of historical outbreaks, in 19% of cases, high larval populations occurred with no visible defoliation following, but in 46% of cases top-kill and tree mortality occurred.

OTHER NOTEWORTHY PESTS

A number of other pests which were common but currently not causing significant damage were also noted, including those capable of causing prominent damage or which to date have caused only minor damage in the region.

Pest	Host[1]	Location	Remarks
INSECTS			
Adelges cooleyi Cooley spruce gall adelgid	eS,D-fir	throughout host range	generally light to moderate.
Adelges piceae balsam woolly adelgid	gF,alF	S. portion of region	all sites surveyed were negative.
Gonioctena americana American aspen beetle	tA	Fruitvale	light to severe on fringe aspen over 0.2 ha.
Hylobius warreni Warren's root collar weevil	lP	throughout host range	common at low levels.
Leucoma salicis satin moth	Po	New Denver, Silverton	occasional larvae.
Nymphalis antiopa mourning cloak butterfly	willow	Cranbrook, Wasa	stripped individual groups of trees.
Pikonema alaskensis yellowheaded spruce sawfly	ornamental spruce	Keenleyside Dam	2 trees lightly to moderately defoliated.
Rhyacionia buoliana European pine shoot moth	pP	Keenleyside	negative.
Pineus spp. spruce gall adelgid	eS	throughout host range	generally light, severe at Dewar Cr., severe stem attack Boundary Cr.
Pleuroneura sp. balsam shoot-boring sawfly	gF	E. Arrow Cr., Creston	increased to 45% of shoots on understory, 10% on mature trees.
Profenusa thomsoni ambermarked birch leafminer	wB	Revelstoke	lt. to mod. discoloration of roadside birch.
Pseudexentera oregonana an aspen leafroller	tA	Greenwood	lt. on 100% of aspen over est. 300 ha, scattered.

Pest	Host[1]	Location	Remarks
Tenthredinidae a birch sawfly	wB	Nakusp	light occasional attack for 5km north of Nakusp.
DISEASE			
Apostrasseria sp.	eS	Cariboo Cr.	new host record.
Armillaria ostoyae Armillaria root disease	-P	Granite Mtn.	new host record on whitebark pine.
Atropellis piniphila Atropellis canker	lP	Canal Flats	major stem canker on 55% of trees.
Chrysomyxa ledi red-huckleberry rust	eS	upper Kootenay R.-Vermilion R.	reduced from 1988 but severe patches-Vermilion R., light-Kootenay R.
Coleosporium asterum western pine-aster rust	lP	throughout host range	moderate-Flathead R.
Cronartium coleosporioides stalactiform blister rust	lP	Steward Cr., Sentinel Mtn.	occasional single stem infections.
Didymascella thujina cedar leaf blight	wrC	W. Nelson	infections common, mostly light.
Herpotrichia sp. brown felt blight	eS	Dewar Cr.	2% seedlings dead, 16% upper 2/3 of seedling dead.
Rhabdocline pseudotsugae Douglas-fir needle cast	D-fir	Flathead R. Kootenay L. Columbia L.	ranging from light to severe, generally higher-elevation stands.

[1]eS - Engelmann spruce, D-fir - Douglas-fir, gF - grand fir, alF - alpine fir, tA - trembling aspen, lP - lodgepole pine, Po - poplars, pP - ponderosa pine, wB - white birch, -P - pine, wrC - western red cedar.

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