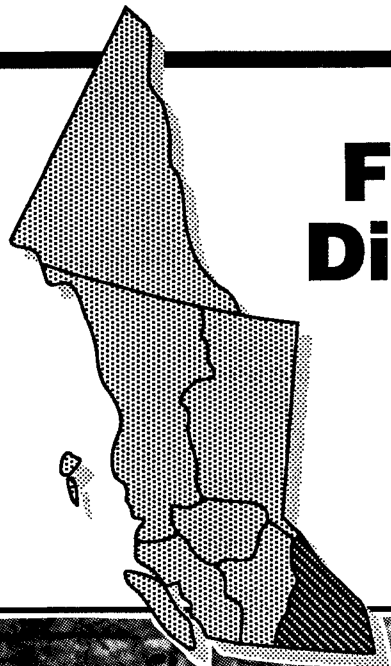
FIDS Report 91 - 3



Forest Insect and Disease Conditions

Nelson Forest Region
1990

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Forestry Canada   Forêts Canada

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, 1990.

II Maps of major beetle and defoliator infestations in the Nelson Forest Region, 1990.

III Summaries of pest problems in provincial and national parks in and adjacent to the Nelson Forest Region, 1990.

IV Summary of pheromone trap programs, Nelson Forest Region, 1990.

V Summary of pest problems in young stands, Nelson Forest Region, 1990.

VI Pest reports:
- Summary of forest pest conditions in the Nelson Forest Region.
- Status of forest pests in the Dominion Government Block-Morrissey Creek, Nelson Forest Region, 1990.
- Gray spruce looper in the Nelson Forest Region.
- Western hemlock looper in the West Nelson Forest Region - 1990.
- Status of western hemlock looper outbreak in the Nelson Forest Region, 1990.
- Western spruce budworm in the Kamloops, Nelson and Vancouver Forest Regions, October 1990.

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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 1990, 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 1990 field season extended from mid-May to mid-October during which a total of 347 insect and disease collections were submitted to the Pacific Forestry Centre (Map 1). Approximately 350 contacts and on-site pest examinations were made with British Columbia Forest Service (BCFS), other government agencies, forest industry personnel and private individuals.

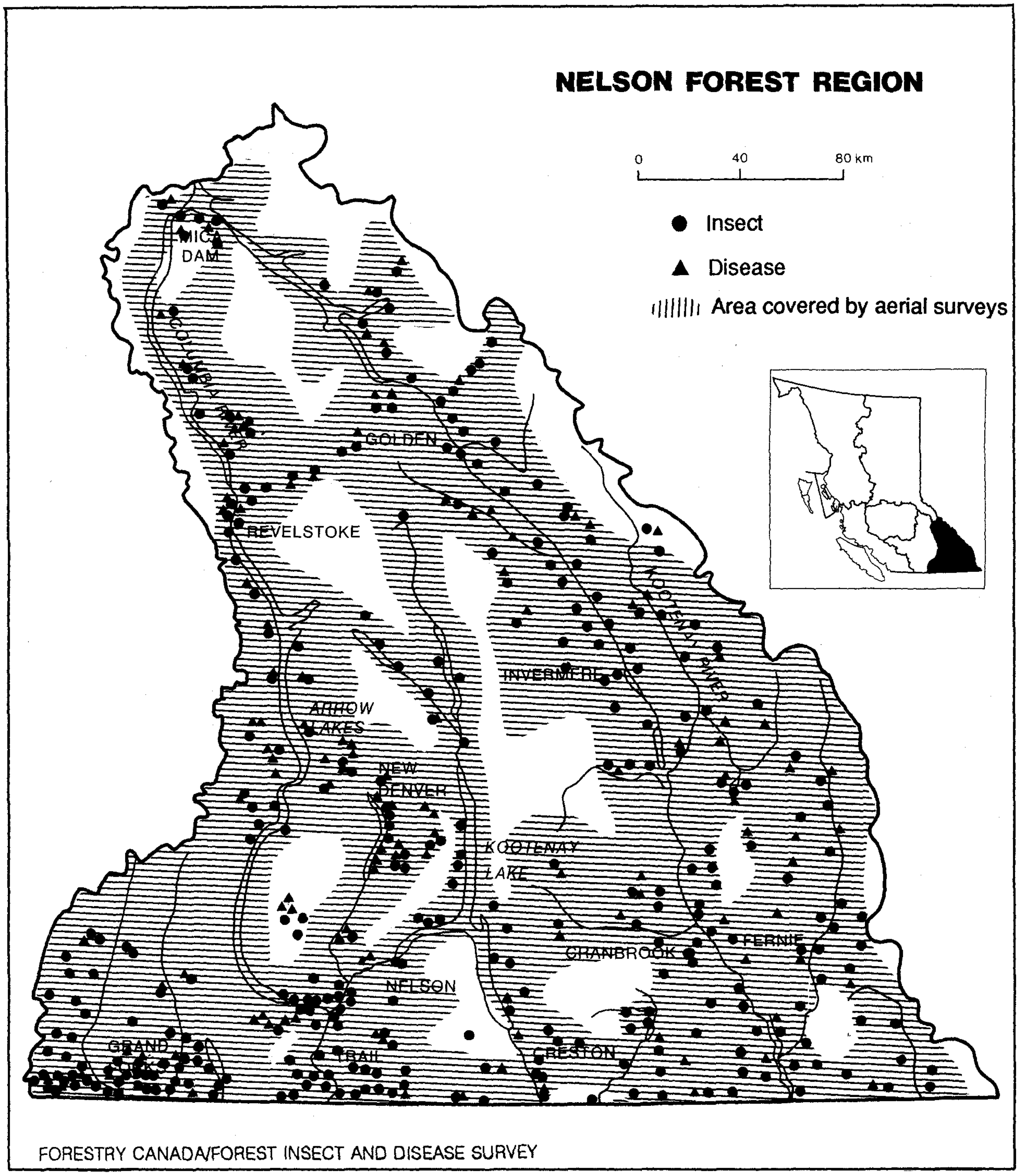
Special thanks are extended to the BCFS for the provision of approximately 58 hours of fixed-wing aerial survey time and assistance in producing preliminary regional sketch maps. The area covered by aerial surveys is shown on Map 1.

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.
VOB 2KO Ph. 422-3465

Forest Insect and Disease Survey,
Box 7,
New Denver, B.C.
VOG 1SO 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. 363-0600



Map 1. Locations 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 1990.

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 declined in the southern portion of the Boundary TSA but remained the most damaging pest in the region, killing more than 1.1 million lodgepole, western white and ponderosa pines over 23 010 ha, compared to 1.6 million trees over 31 785 ha in 1989. **Pine needle diseases** were more widespread on lodgepole pine in the southern part of the region and continued on western white pine in parts of the West Kootenay. **White pine blister rust** infected an average of 27% of the western white and whitebark pines in 11 of 14 young stands surveyed.

Douglas-fir beetle populations remained relatively stable, killing approximately 4000 trees over 64 ha throughout the region. **Western spruce budworm** defoliation of Douglas-fir decreased in area and intensity covering 1160 ha in the Boundary and Revelstoke TSAs, down from 17 608 ha in 1989; moderate to severe defoliation and an increase in area is predicted for 1991. **Douglas-fir tussock moth** larval populations remained at low levels; however, the number of moths caught in pheromone-baited traps increased significantly.

Spruce beetle populations were generally at low levels with small groups of red trees mapped north of Revelstoke. Emerging broods in 1991 may attack standing trees along Bush River, at Hoodoo Creek and at Munroe Lake. **Spruce weevil** killed an average of 9% of the spruce leaders in eight of eleven stands. **Yellowheaded spruce sawfly** caused light to severe defoliation of native spruce in the Castlegar--Robson area and for 15 km into the Crescent Valley.

Mature **two-year-cycle spruce budworm** lightly defoliated 600 ha of fir--spruce stands in the White River drainage with additional light defoliation by immature larvae in the Monashee and Purcell mountain ranges. Bud sampling indicated generally moderate defoliation in the Purcells and severe in the Monashees for 1991. **Western balsam bark beetle** populations increased slightly, killing mature alpine fir over 1780 ha, primarily in the Spillimacheen River drainage but major increases were also recorded in the Lasca Creek area.

Larch looper defoliated nearly 12 000 ha of western larch between Creston in the east, Burrell Creek in the west and south of Kaslo, Slocan and Fauquier. **Larch casebearer** defoliation of western larch remained at low levels with light to moderate discoloration of regeneration near Castlegar, between Galena Bay and New Denver and along the Arrow Lakes north of Edgewood. The incidence and severity of **larch needle diseases** increased with 5550 ha of infected larch mapped in 1990, mainly in the Boundary, Kootenay Lake and Arrow TSAs. A **larch shoot moth** killed up to 5% of the terminal growth of young dominant trees along Columbia Lake.

Western hemlock looper defoliated 915 ha of western hemlock north of Revelstoke. Egg sampling suggests that moderate to severe defoliation could occur in 1991. The **gray spruce looper** defoliated 1370 ha of western hemlock, mainly along the west side of the Arrow Lakes from Nakusp to Arrow Park and along Slocan Lake.

Root diseases killed an average of 3.9% of all tree species in young stands surveyed. In young larch stands, 36% of the trees in contact with inoculum died. Spacing in young stands appeared to increase incidence of Armillaria and blackstain root diseases. Armillaria root disease increased following mountain pine beetle infestations and was associated with Douglas-fir beetle attack. **Rhizina root disease** killed an estimated 70 000 seedlings in recently burned cut blocks; planting depth appeared to affect the seedling susceptibility. **Black army cutworm** populations remained low with moderate feeding recorded only on 20 ha north of Golden. Pheromone trapping indicated potential infestation level populations at Swan and Vowell creeks. Recovery from **climatic damage** was limited in 1990, with up to 90% of the mature lodgepole pine killed over 487 ha in the southeast of the region. **Animal damage**, mainly bear and squirrel, was variable but significant, especially to leave trees in recently spaced stands. No positive **pinewood nematode** samples were found in collections from stressed trees or from reject lumber at sawmill sites.

In **pests of young stands**, 28% of the trees had pests causing growth loss and 8% had pests leading to tree mortality.

Forest tent caterpillar populations decreased, defoliating 4315 ha of trembling aspen, primarily in the Golden to Blaeberry River area; only trace to light defoliation is predicted for 1991. **Ambermarked birch leafminer** caused moderate defoliation from Shelter Bay to Goldstream River north of Revelstoke and in small patches near Castlegar. **Western winter moth** populations increased in the Castlegar to Trail--Fruitvale area with moderate defoliation in scattered patches of up to 10 ha. The **American aspen beetle** severely defoliated aspen over 5 ha at Fruitvale. The **alder woolly sawfly** severely defoliated young alder in the Castlegar area. The **apple and thorn skeletonizer** caused light to severe foliage browning to apple trees from Castlegar to Balfour, along Highway 6 north to Nakusp and, to a lesser degree, in Revelstoke and near Creston.

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. Biogeoclimatic zones referred to include: ICH - Interior cedar--hemlock; ESSF - Engelmann spruce--subalpine fir; IDF - Interior Douglas-fir and MSa - Montane spruce.

PINE PESTS

Mountain pine beetle
Dendroctonus ponderosae

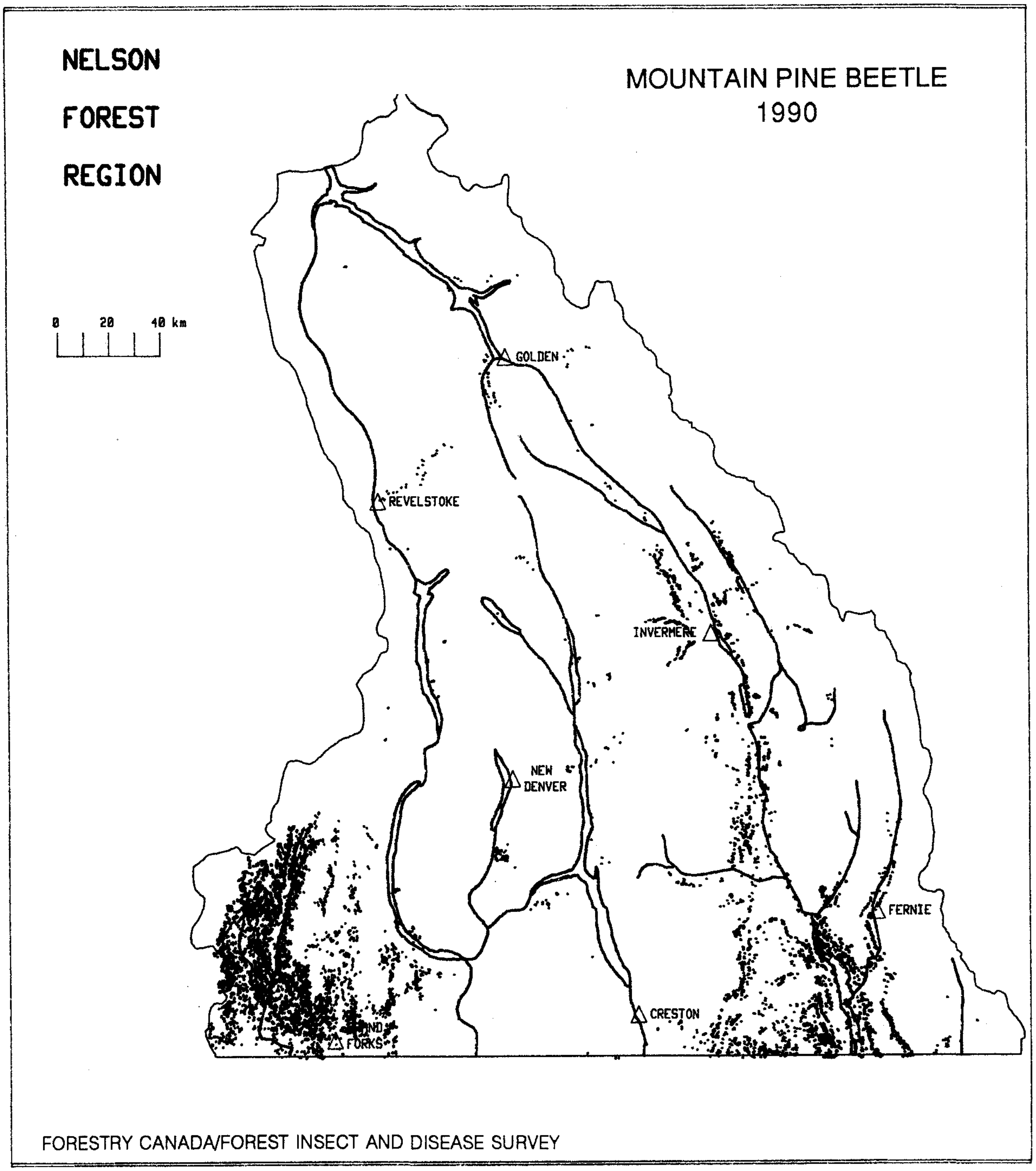
Mountain pine beetle killed more than 1.1 million lodgepole, western white and ponderosa pines over 22 400 ha in 4561 infestations in the region, with an additional 17,800 trees over 610 ha in Kootenay, Glacier and Mt. Revelstoke national parks (N.P.) (Table 1, Map 2). This was a decrease from 31 000 ha in 1989 and 25 575 ha in 1988.

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, 1990.

TSA or Park	Tree species[1]	No. of infestations	Area (ha)	Trees killed (faders)[2] No.	Vol.(m^3)
Boundary	lP,pP,wwP	2315	12 500	521 759	187 843
Arrow	lP,wwP,pP	195	1 110	38 293	25 533
Revelstoke	wwP	15	4	120	120
Kootenay L.	lP,wwP	207	360	12 850	5 455
Cranbrook	lP,wwP,pP	1336	6 580	466 500	167 900
Invermere	lP,wwP	465	1 845	69 100	24 840
Golden	lP,wwP	28	6	150	102
Subtotal		4561	22 405	1 108 772	411 793
Kootenay N.P.	lP	89	566	17 300	6 251
Glacier N.P.	wwP	23	41	390	390
Mt. Revelstoke N.P.	wwP	12	4	120	120
Subtotal		124	611	17 810	6 761
Total		4685	23 016	1 126 582	418 554

[1] lP - lodgepole pine; wwP - western white pine; pP - ponderosa pine

[2] Trees attacked in 1989, discolored in 1990



Map 2. Areas of pine recently killed by mountain pine beetle as determined by aerial and ground surveys, 1990.

The main beetle activity in the region continued in the Boundary TSA where 12 500 ha of pine were infested, down from 19 566 ha in 1989; this was the first decrease in the TSA since 1983. A decrease in area, 6570 ha, down from 7965 ha in 1989, was also recorded in the Cranbrook TSA following significant beetle mortality at high elevations in 1989. A similar decrease was also noted in the Invermere TSA, while only minor changes occurred in the Arrow, Kootenay Lake, Golden and Revelstoke TSAs. For 1991, an increase in the number of faders is expected in the Cranbrook TSA, some of the newer infestation areas in the Invermere TSA and the northern portion of the Boundary TSA, based on the level of current attack found during fall surveys. In the remaining TSAs, little change is expected in 1991. Harvesting, host availability, immigrating populations, climatic conditions, accessibility, management philosophy and implementation are all influential in changing the beetle situation within the region and from district to district.

Boundary TSA

In the Boundary TSA, mountain pine beetle infestations decreased to 12 500 ha from 19 566 ha in 1989 (80% of the regional decline). Most of this decline occurred in the southern half of the TSA where some reduction in beetle activity was noted in the fall of 1989. Drainages significantly affected included Sutherland Creek and adjacent drainages, the Christina Lake to Granby River area, the area between Midway and Grand Forks south of Highway 3, the Wallace and Windfall creeks drainages, along Boundary Creek, south of Blythe Creek and Kelly River on the Kettle and West Kettle rivers and in the Ingram and Nicholson creeks drainages.

In the northern portions of the TSA, there was a 10% increase in area of attack. Major increases were particularly evident in the upper Kettle River drainage north of Copperkettle Creek to the Kamloops Forest Region boundary with many new and expanding infestations in the Damfino, Rendell and Goatskin creeks areas. Despite accelerated road building and harvesting in the Grano--Hellroarer creeks area, plenty of host appear to be available and the continued spotting into previously unaffected areas, including Arthurs and Cochrane creeks, indicates active healthy populations on these plateau areas. Despite substantial harvesting of affected areas over the past five to seven years, especially in the Trapping Creek and Collier lakes areas, the beetle has survived well and increased into many areas between the Kettle and West Kettle rivers from the Crouse Creek--Beaverdell area north and including Trapping Creek. In the upper Boundary Creek area, increases were noted from Henderson Creek north, mainly as the beetle infestations move into higher-elevation stands. In the upper Granby River, attack remains relatively scattered with some notable increases in the Kennedy to Almond creeks area.

Arrow TSA

In the Arrow TSA, beetle activity increased to 1110 ha from 906 ha in 1989, with increased intensity in most previously infestated areas. Infestations of up to 5 ha with 25% tree mortality were noted in the Gladstone and Sunshine creeks area and up to 100 ha in the Cayuse to Little Cayuse creeks area along the east side of Lower Arrow Lake and in the Worthington--Eagle creeks area near Edgewood. In the Nancy Greene Lake--Gem Hill area, continuing expansion of beetle infestations occurred especially to the north and including Robson Ridge between Blueberry Creek and Lower Arrow Lake. Infestations continued in the Lemon and Chapleau creeks area but fewer faders were noted along Dayton Creek. Beetle populations remained relatively stable in the Dog Creek and the Moberly--Shields creeks area.

Revelstoke TSA

In the Revelstoke TSA, only 4 ha of beetle activity on western white pine were mapped in 15 infestations. Occasional scattered beetle attacks occurred, mainly along the Illecillewaet River.

Kootenay Lake TSA

In the Kootenay Lake TSA, the area of recent beetle activity increased to 360 ha from 205 ha in 1989, but at the same time, intensity decreased in most areas, with fewer trees being killed. Most of the beetle activity remains in young stands at the lower end of the susceptibility range in the Hawkins--Freeman creeks area, where small spot infestations of 10 to 20 trees are widely dispersed. Some increased concentration of attack was noted at the upper end of Cold and Freeman creeks. An increasing number of groups of 2 to 10 faders have also been recorded along the Moyie River north of Yahk over the last two years.

Cranbrook TSA

In the Cranbrook TSA, infestations decreased to 6580 ha, from 7965 ha in 1989. The main contributing factor to the decline in area and volume of beetle-killed pine fading in 1990 was a very high level of brood mortality at higher elevations in February and March 1989. This resulted in a small flight at elevations above 1400 m south of Cranbrook, upper Yahk River, Gold Mountain, Galton Range, and throughout the Flathead River drainage in 1989.

At lower elevations, the main increase in fading pine was mapped in the Rocky Mountain Trench and the lower portion of major side drainages to the south of Cranbrook, especially between the Elk and Bull rivers, where 10-20-ha patches expanded to 50 or more hectares. Along the Elk River between Elko and Fernie, in the Mount Baker area and in the variable-aged stands of the Wigwam and Lodgepole creeks area, the size of infestation pockets increased to 5-10 ha from groups of 10-50 trees in 1989. In the Moyie Lake and lower Yahk River areas, there was an increase in the number of small groups of 20-100 trees, which is typical of beetle infestations in younger-aged stands. North of Cranbrook, slight increases were noted only in the Ta Ta Lake area.

Invermere TSA

Infestations in the Invermere TSA continued a downward trend to 1845 ha from 2427 ha in 1989 and a high of 13 600 ha in 1986. The main beetle activity remains on the slopes along Toby, Horsethief and Frances creeks and on the east side of Columbia and Windermere lakes. In many of these infestations, the rate of spread has been minimized by a combination of climatic conditions, logging and various means of beetle management (pheromones, MSMA, etc.).

While the number of faders in the Cartwright Lake area has remained under control despite highly susceptible stands, small pockets of recently killed pine continue to develop to the north in the Jubilee Mountain and Parson area.

Localized increasing populations were also noted in the Pinnacle, Stoddart and Shuswap creeks and the Echoes--Reed lakes areas. Populations in the Cross, Palliser and Kootenay rivers drainages remained at low levels and little change was noted in the Findlay Creek drainage.

Golden TSA

The mountain pine beetle remained relatively inactive in the Golden TSA, covering only six hectares. Widely scattered groups of 5-20 faders were mapped in the Columbia Reach, at Golden, and in the drainages of the Kicking Horse, Blaeberry, Bush and Beaver rivers.

National Parks

Recent beetle-killed pine were mapped over 610 ha in Kootenay, Glacier and Mt. Revelstoke national parks. Most of this occurred in Kootenay National Park, where the main infestation along the Kootenay River declined slightly but outward expansion from Redstreak Creek into MacKay and Kimpton creeks continued. Infestations in western white pine on the eastern edge of Glacier National Park and in lodgepole pine at Field in Yoho National Park contained the most active mountain pine beetle populations in the northern part of the region.

Factors influencing population dynamics

Climatic conditions are a key factor in shaping the character of a beetle infestation. In the past few years, weather conditions affecting beetle populations have ranged from drought in the mid 1980s, to severe cold in 1989, resulting in extensive overwintering brood mortality in some areas. In 1990, a cool wet spring combined with a shortened fall affected the beetle population in a number of ways. Initially, the beetle flight was delayed; although it was too cool for the mature beetles to fly, the immature brood was still developing. Consequently, when the flight occurred, most of the beetles were flying at the same time, resulting in increased mass attack. However, the tree resistance levels were at a maximum, following ideal moisture conditions over the past two years, and as a result, the pitchout levels were considerably above normal. This was especially evident in the East Kootenay where an average of 22% of the 1990-attack was pitched out. High pitchout levels (averaging 41% but ranging to 92%) were most prominent in the high-elevation stands where most of the brood was winter-killed in 1989 and into which beetles from lower elevations were migrating back to. In newer and smaller infestation areas, especially in the Invermere TSA, an average of 28% of the attack was pitched out. In young stands, pitchout averaged 21%, even at low elevations. In ponderosa pine, tree resistance was the main factor in a substantial reduction in successful 1990 beetle attack, with pitchout averaging 90%. Although the high pitchout levels operated as a braking action to beetle population expansion in several situations, it does so only temporarily and mainly where populations are relatively low.

The shortened beetle development period also resulted in a high percentage of the 1990 progeny entering the winter period in the highly cold-sensitive egg and early-instar larval stages. Populations at mid to high elevation and in younger thin-barked trees are most susceptible to overwintering mortality.

Stand age and tree size are becoming a greater factor in beetle behavior in a number of areas, such as the Rocky Mountain Trench, Elk and Bull rivers and Wigwam Creek. In young stands, mountain pine beetle attack is usually confined to the lower portion of the bole with Ips spp. occupying the mid to upper portion. The mountain pine beetle broods, though relatively small, are successful and in some cases, of adequate size to maintain a static population. In the drier areas, where tree stress is common, the beetles appear to be able to maintain a higher population level in younger stands than in more productive sites where beetle populations cannot be sustained without beetle migration from older stands. In neither case is the stand a net exporter of beetles; expansion of the population size is dependent upon the immigration of beetles from adjacent older stands or from interspersed pockets of older trees.

When beetle infestations occur in young stands, the pattern of attack is less concentrated than in highly susceptible older stands. The pockets of attack become smaller and more widely scattered as the beetles have to fly farther and spend more time searching for susceptible host. When groups of trees are successfully attacked, expansion the following year is usually minimal and often nonexistent by the third year, as the local population dies out. This short existence of small pockets of beetle is partially due to tree resistance but of equal importance is that beetle numbers are often too low and the flight is too spread out to successfully attack healthy trees.

Beetle migration continues to play a major role in infestation advancement, especially in parts of the West Kootenay. A portion of all beetle populations migrate beyond the current infestation boundaries, but this portion increases as populations increase and as the number of locally susceptible trees decreases in relation to the number of beetles. As the migrating population increases so does the success ratio of new infestations. This general movement is evident in the major north-south drainages of the Boundary TSA where the host has been depleted through a combination of aggressive harvesting of affected areas and aggressive beetle attack reducing remaining pine hosts in a number of drainages. Also in the Trapping Creek and Beaverdell areas, the host has been depleted primarily through salvage logging in two large areas which were acting as outside boundaries to a concentrated current infestation of susceptible stand types between the logged areas. Additional migratory pressure has also come from large infestations in the adjoining Kamloops Region, with beetles migrating over the ridges at the heads of drainages. Similar situations are developing in the lower Elk and Bull rivers; however, the host in these drainages is generally younger and less susceptible, resulting in smaller and more scattered attacks.

For further implications of root rots following pine beetle infestations in young stands, see the root rot section of this report.

Table 2. Status of lodgepole pine in stands affected by mountain pine beetle, Nelson Forest Region, 1990.

Location	Percent of pine attacked[1]				Percent healthy
	Current (1990)	Partial (1990)[2]	Red (1989)	Grey (pre 1989)	
Boundary TSA					
State Cr.	13	1	4	2	74
Rock Cr.	16	1	5	4	68
Kelly R.	9	0	4	13	72
Lind Cr.	3	1	6	16	71
W. Boundary Cr.	19	1	6	12	60
Sand--Snowball crs.	2	0	8	7	77
Hellroarer Cr.	4	0	6	1	88
Arrow TSA					
Sheep Cr.	12	2	8	10	56
Cranbrook TSA					
Phillipps Cr.(low)	28	11	13	17	31
Phillipps Cr.(high)	2	22	20	12	44
Fernie	34	14	17	7	28
Wigwam Cr.	19	0	16	2	63
Lime Cr.	34	4	23	5	34
Gold Mtn.(low)	31	7	22	6	34
Bloom Cr.	36	9	15	8	32
Gilnockie Cr.	30	3	13	4	50
Rock Cr.	53	5	8	3	31
Tepee Cr.	37	5	7	9	42
Moyie L.	24	4	15	1	56
Ta Ta L.	24	5	9	10	52
Bull R.	73	3	8	10	16
Invermere TSA					
Canal Flats	56	6	9	3	26
Cartwright L.	18	13	11	1	57
Horsethief Cr.	29	11	21	7	32
Parson	28	14	12	2	44
Pinnacle Cr.	22	5	13	0	60
Kootenay Lake TSA					
Hawkins Cr.	17	5	8	3	67
National Parks					
Redstreak Cr.	39	9	26	1	25
Field	29	10	14	13	34
Average %	26	7	12	6	49

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

[2]The partial attacks were primarily pitchouts. In the East Kootenay, an average of 22% of the trees attacked in 1990 were pitched out.

Forecasts

Overall, in 1991 the number of discolored trees should remain similar to 1990 in the West Kootenay but there is a high potential for some increase in the East Kootenay. Current attack levels increased in 1990 to 26% from 23% in 1989, primarily in the east, with increases from 32% to 41% (Table 2). However, there were significant variations between individual drainages as indicated by the range in "R" values from 0.1 to 21.6 (Table 3), and although they were not all calculated from the same infestations as in 1989, they were generally higher than in 1989. An "R" value is the ratio of overwintering brood to parent adults and provides an indication of beetle brood productivity.

In the West Kootenay, in southern areas such as the Lind and Sand--Snowball creeks areas, spring, summer and fall assessments all indicated a continued declining population, with insufficient current attack to assess brood. Other southern areas such as Ingram, Nicholson, Windfall and Wallace creeks face declines mainly due to aggressive logging or stands containing primarily grey or young pines. In the northern part of the Boundary TSA and at the heads of some drainages, a continuing increase in beetle activity is expected. In the largely inaccessible upper Granby and Burrell creeks area, further expansion of beetle infestations should occur, based on aerial surveys. In the Boundary Creek drainage, both "R" values and current to red attack ratios indicated continuing expansion of beetle activity in the north. Similar conditions at State and Hellroarer creeks in the northern portion of the Kettle River drainage indicated a highly vigorous beetle population within the reportedly large, susceptible, pure pine stands, especially in the plateau areas between creeks. On the western edge of the TSA, at both Kelly River and Rock Creek, attack and brood levels indicated a return to increasing populations following a slight decline in the number of faders in 1990; however, availability of suitable host in these areas should dictate the levels of infestation.

In the East Kootenay, the population trends indicate a general increase in the number of trees due to discolor in 1991. Broods observed in the spring indicated a major increase in 1990 attack but this was partially offset by a reduction in successful attack. In comparison of "R" values, 25% of the areas indicated a decline in the "R" value from 1989 but remaining above the 4.1 threshold. In other words, there should be a slowing down in the rate of brood production.

The main areas of static to increasing populations are expected in the Rocky Mountain Trench from Canal Flats south and along the Elk and Bull rivers. Some increase can also be expected in the area to the south of Cranbrook along Tepee and Bloom creeks and the lower Yahk River. Current attack in these areas averaged 43%, the current to red ratio averaged 3:1 and "R" values increased to an average of 12.0 in 1990 from 6.5 in 1989. Smaller infestations in the Moyie and Cartwright lakes, Pinnacle Creek areas and at Parson and Field all indicated an increasing population as well, with "R" values increasing to 9.6 from 6.0 in 1989, a current to red ratio of 1.7:1 and current attack levels at 24%. Static to decreasing populations are expected in most of the remaining currently active beetle infestation areas including the more-established infestations along the Horsethief, Wigwam, Phillipps and Hawkins creeks where current to red ratios averaged 1:1.

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

Location	"R" values[1]	Population status[2]	Remarks
Morrissey Cr.	21.6	I	relatively new infestation area, large trees
Hawkins Cr.	17.0	I	pockets of older trees concentrating beetle
Bull R.	14.3	I	relatively new infestation area, large trees
Fernie	13.0	I	new increasing infestation area
Horsethief Cr.	12.9	I	large infestation area
Cartwright L.	12.6	I	scattered pockets in highly susceptible stands
Baynes L.	11.4	I	rapid expansion over last few years
Moyie L.	9.8	I	young stands, spotty, expansion losing momentum
Tepee Cr.	9.3	I	increasing in older low-elevation stands
Volcanic Cr.	9.0	I	woodpeckering common
Rock Cr.	9.0	I	moist host, parasites common
Freeman Cr.	8.8	I	young stands, spotty
Perry Cr.	8.7	I	small pockets, lower Perry
Sand--Snowball crs.	8.4	I	
Ingram Cr.	8.3	I	moist host, some parasites
Hellroarer Cr.	7.9	I	
Kelly R.	7.2	I	variable age classes
State Cr.	7.2	I	healthy brood
Redstreak Cr.	6.4	I	older part of infestation, slowing down
Gold Mountain	6.3	I	large older infestation
Sparwood	6.3	I	recent infestations, susceptible stands
Nancy Greene L.	5.8	I	small population
Phillipps Cr.	5.6	I	large older infestation
McRae Cr.	5.5	I	mixed stands
Eholt	5.3	I	early-instar larvae
Skookumchuck Cr.	5.2	I	small ongoing infestation
Carmi Cr.	3.0	S	poor brood survival
Henderson Cr.	3.0	S	small population, dry trees, secondary beetles common
Upper Yahk R.	1.0	D	spotty, high elevation
Couldrey Cr.	0.1	D	poor brood survival
Wickman Cr.	0.1	D	high elevation, poor brood survival
Average	8.3		

[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

The preceding predictions are based on the biological capabilities of the beetle and the conditions that were found during limited ground assessments. Harvesting was very active in several priority areas and management activities together with highly variable natural conditions, could change the situation dramatically for 1991.

Ambrosia beetle in mountain pine beetle-killed trees

Trees recently killed by mountain pine beetle will often attract ambrosia beetle, primarily Trypodendron lineatum, the following spring. In 15 areas assessed throughout the region, ambrosia beetle had attacked 32% (range 0 to 80%) of the mountain pine beetle-killed trees. Attack level was generally moderate with an average of 10.2 holes per 15x15 cm bark sample. Of the trees attacked at six of the sites, ambrosia beetle attack was present on over 50% of the tree circumference, and in lower percentages at the remaining sites. Damage is more of an aesthetic nature than structural but it reduces the lumber grade and by some countrries it is considered a more critical importing restriction than blue stain.

Pine needle diseases
Lophodermella concolor
Dothistroma (Scirrhia) pini

Pine needle cast, caused by L. concolor infections of one-year-old lodgepole pine needles, was again common at light intensity through much of the southern portion of the region. Notable areas included increases to generally moderate infection levels in the Flathead (15 000 ha), Elk River including south to Corbin (16 000 ha), Bull River (3000 ha), and Lodgepole Creek areas where an estimated 800 ha of severe infection was recorded. In the chronic infection area between Bloom Creek and Yahk River, defoliation had decreased to generally light over an estimated 3500 ha, mainly at elevations above 1200 m. In the Blackwater Creek area north of Golden, infection levels increased to generally light but also included several 100-ha patches of moderate infection. This area has in the recent past been much less prone to significant foliage infection. In the West Kootenay, moderate infection was common throughout the Rock Creek drainage, extending over approximately 20 km. In the Mosquito Creek--East Arrow Park area, light to severe infection occurred in numerous pockets but was particularly severe in a 28-ha plantation at Makinson Flats. In most areas sampled, a secondary fungus, Hendersonia pinicola, was present at very high levels early in the season. H. pinicola may act as a biological control of L. concolor by invading needles infected by the latter and preventing the development of ascomata.

A preliminary attempt was made to quantify the impact of this needle cast on young trees. Terminal growth was measured for 1989 and 1990 on 25 trees in each of two categories: those with more than 75% and those with less than 50% of the 1990 foliage infected. In the trees severely (>75%) infected, the 1990 growth was 32% less than it was in 1989, compared to the lightly (<50%) infected trees in which the 1990 growth increased by 10% over that of 1989. The total growth loss in the East Kootenay in 1990 due to this disease was conservatively estimated to be the equivalent of destroying a 162-ha, 12-year-old plantation. In chronic infestation areas, annual accumulated losses are substantial.

Red band needle disease, caused by Dothistroma pini, affected western white pine throughout the wet belt areas, most notably in the Revelstoke to Castlegar and the New Denver to Kaslo areas where infection was generally moderate to severe in the mid and lower crowns. In a one-hectare permanent plot established in 1982 near Summit Lake, discoloration and needle loss averaged 65%, increasing to 78% on the lower two-thirds of the crown, similar to 1989. Previous height and diameter measurement comparisons indicate that as overall defoliation increases, annual increment decreases dramatically. At 70% overall defoliation, height and diameter growth were reduced by 75 and 87% compared to lightly defoliated trees.

White pine blister rust
Cronartium ribicola

White pine blister rust remains the single most important pathogen of western white pine. Inherent difficulties such as the scattered nature of the infection, the tendency to top-kill and progressively reinfect, and the presence of mountain pine beetle preclude reliable detection by aerial surveys. Nevertheless, discoloration and mortality were noted throughout the region and severity of attack was documented by ground observations in several areas.

During surveys of young stands containing white pine, blister rust was present in 11 of 14 stands. Of the 145 trees examined, 39 (27%) were infected by the rust. Infection was most severe in closegrowing or recently spaced natural stands, where an average of 52% of the trees were infected, compared to 25% in the more opengrowing, planted stands.

White pine blister rust aecia were also present at low incidence levels on limber pine, Pinus flexilis, near Golden. Infection levels were considerably higher (± 50%) on whitebark pine, Pinus albicaulis, causing severe deformity at Granite Mountain near Rossland and McLatchie Creek south of Fernie. Collections of blister rust were taken at each location to determine rust race differences. Such collections contribute to research directed at minimizing the impact of the rust on white pine, thus enhancing its utilization, not only as a commercial species but also to employ its root rot resistance capabilities.

DOUGLAS-FIR PESTS

Douglas-fir beetle
Dendroctonus pseudotsugae

Douglas-fir beetle infestations were mapped in 151 pockets over 64 ha, containing a conservative estimate of 3945 trees successfully attacked in 1989 and discoloring in 1990 in the Nelson Region, little changed from 3990 faders in 1989 (Table 4).

Table 4. Location, number and area of Douglas-fir recently killed by Douglas-fir beetle, Nelson Forest Region, 1990.

TSA	Area(ha)	No. infestations	No. trees
Cranbrook	27	16	645
Invermere	25	91	2915
Golden	2	7	125
Boundary	6	22	160
Arrow	1	7	40
Revelstoke	2	6	50
Kootenay Lake	1	2	10
Total	64	151	3945

In the Invermere TSA, which continues to harbor the major portion of the Douglas-fir beetle infestations in the region, an estimated 2915 trees were recorded. The larger infestations continued relatively unchanged in the Whiteswan Lake and Findlay Creek--Whitetail Lake areas. Smaller pockets of recent beetle-killed trees were also mapped in the Premier Lake, Brewer Creek, Kootenay River--Nine Mile Creek areas and at scattered locations along the Rocky Mountain Trench from Columbia Lake to Radium Hot Springs.

In the Cranbrook TSA, there was a slight increase in the number of fading beetle-killed trees in the Wild Horse River drainage while at Wickman Creek, the second main infestation area in the TSA, the number of recently killed trees was reduced by logging during the flight period. Log decks, acting as trap trees, absorbed a large portion of the 1990 flight. Most of the small pockets of beetle activity recorded along the Rocky Mountain Trench and in the Bloom Creek area in 1989 have collapsed, with the main persistent area being near Roosville. Blowdown in the lower Flathead River drainage in both 1989 and 1990 has increased the residual beetle population to the point where some standing attack can be expected in 1991.

In the Golden TSA, seven small pockets of recently killed Douglas-fir trees were mapped adjacent to the 1989 infestation area at Game Creek, along the east side of McNaughton Lake. This area has a very high root rot incidence which is commonly found to be one of the factors in predisposing Douglas-fir to beetle attack.

In the Boundary TSA, there was a slight increase in the number of small infestations of 5-20 trees, primarily in the West Kettle River Valley between Conkle Lake and Beaverdell. Many of the pockets of recently killed trees were not closely associated with previously attacked trees and the proclivity for new spot infestations to occur may negate apparent reductions in beetle activity.

In the Arrow TSA, the number of spot infestations increased, primarily in inaccessible stands along the Slocan Valley. Most of the infestations appear to be associated with the numerous root rot pockets in the same general area.

In the Revelstoke TSA, 50 Douglas-fir were recently killed in the Bigmouth Creek area. Due to inaccessibility, no ground checks were made. The only previous records of Douglas-fir beetle activity in the area north of Revelstoke were in 1960 and 1950, when only 5-10 trees were attacked. The infestations of 1989 in blowdown areas in the Crawford Creek area were addressed through an aggressive logging and trap tree program and no faders were noted during aerial surveys, although two new pockets of blowdown were noted farther south at Wallis Creek.

In the Kootenay Lake TSA, scattered groups of up to 5 recently killed trees were mapped along the north side of the west arm of Kootenay Lake. Near Crawford Bay, Douglas-fir recently damaged by snowslides may pose a threat to adjacent trees when the broods emerge in 1991.

In the East Kootenay, the overall Douglas-fir beetle population continues to decline. The ratio of successfully attacked trees compared to the previous year continued to decline in all areas from five currents for every red in 1988, to 1 current for every 3.5 and 9.6 red trees in 1989 and 1990, respectively. The major factor in the decline in beetle attack was the increase in tree resistance following adequate moisture levels. In both 1989 and 1990, the pitchout level was high, 40% in 1989 and 62% in 1990. These pitchout or partially attacked trees then become prime candidates for reattack the following year, which is what happened in most infestation areas in 1990 and which will be the main focus of the 1991 beetle attack. However, this habit of reattacking partials and previous pitchouts tends to keep, at least the larger infestations, a continuing problem despite a declining beetle population and also provides an argument for beetle mop-up operations to prevent a rapid beetle population build-up when beetle propagation conditions again become optimum. This scenario also affects the schedule of color change in the beetle-attacked trees; frass with or without pitch appears on the pitched out or partially attacked trees and the tree remains green the following spring but upon reattack, these already stressed trees with damaged cambium and associated fungi discolor very rapidly by mid to late summer.

In those trees that were successfully attacked, the brood production has also declined over the past two years. An annual comparison of fall "R" values in the major infestation areas shows a decline from an average of 6.4 in 1988 to 2.3 and 1.2 in 1989 and 1990, respectively (Table 5). All areas examined had a decrease in the "R" value. However, as the beetle populations decline, the beetle attacks tend to progress farther up the bole and the brood production determined at the level sampled on the lower bole may become less indicative of the actual reproductive ratios.

In the Boundary TSA, surveys indicate an overall reduction in the number of faders in the known infestations for 1991 in the district. The largest population examined was at Cranberry Ridge where 6 current attacks were recorded as compared to 18 red and 39 grey trees at two sites. In two infestations at Conkle Creek, a total of 32 grey, 2 red and 1 current attack were found, while at one site near Beaverdell, no current attacks were found in a patch of 1 red and 13 grey trees.

At Enterprise Creek in the Arrow TSA, the current to red ratio was 1:1 but included reattacks and the broods were small. Seven spot infestations of 2-15 currently attacked trees were found in and adjacent to two groups of 20-30 red and greater numbers of grey trees. Of 12 currently attacked trees examined, six were reattacks of previous partial or pitched out attacks. These factors, considered in conjunction with the elimination of drought stress but the continuation of high levels of Armillaria root disease, would suggest that beetle activity will continue in 1991 at equal or reduced levels.

As in 1989, the sheer number of beetles in larger infestation areas continues to pose a threat to nearby healthy trees and further tree mortality is expected, but at an annually decreasing level, until the population is too small to successfully attack healthy trees. Fresh blowdown, other stress factors, and harvesting and/or management actions could change the population behavior.

For a brief discussion on the interaction between Douglas-fir beetle and root rots, see the section on root rots.

Table 5. Douglas-fir beetle population trends, Nelson Forest Region, 1990.

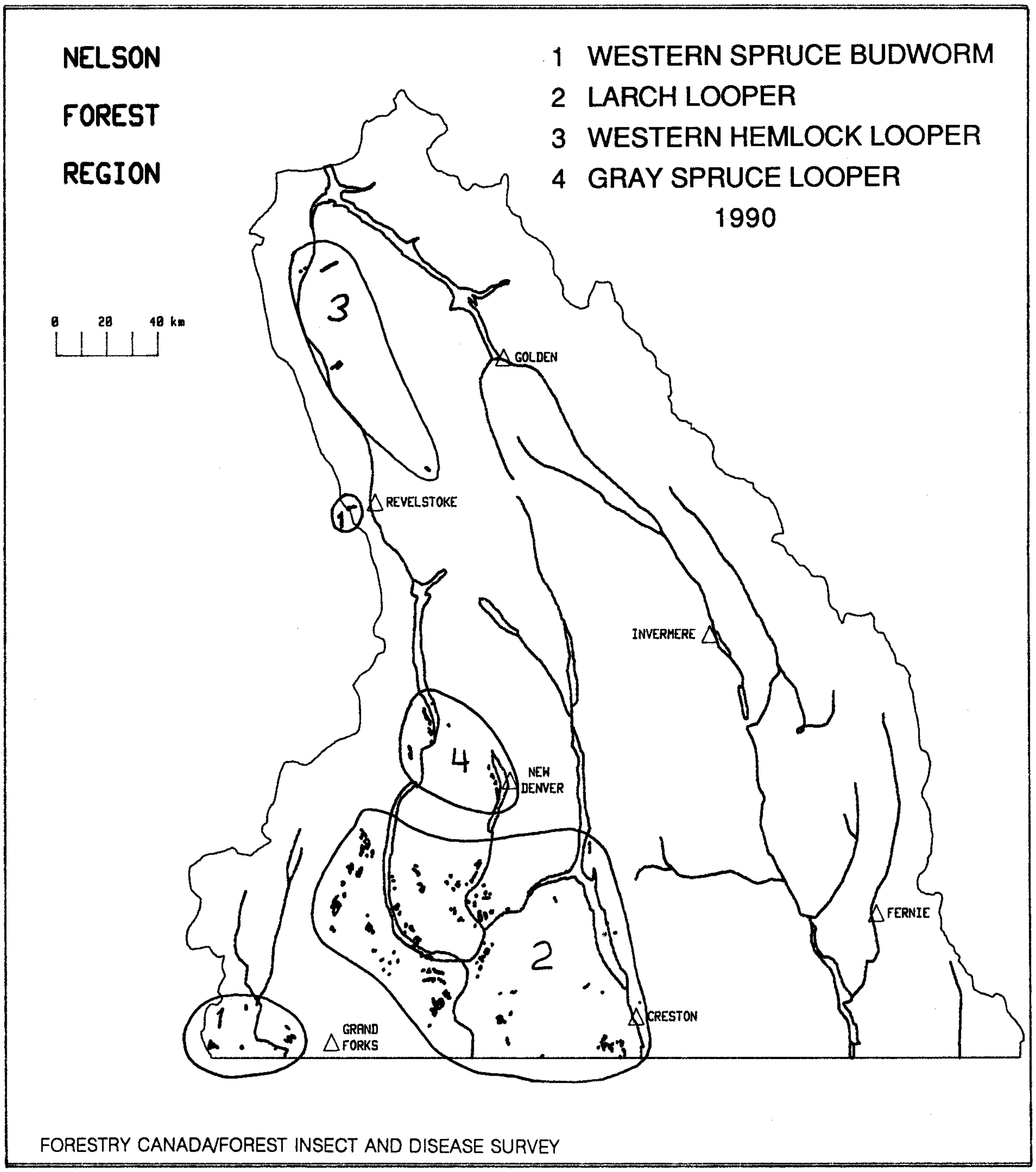
Location	Fall "R" values[1]	Current to red ratios	Percent pitchout
Game Cr.	1.2	*	100
Whiteswan L.	1.8	1:2	30
Whitetail L.	0.6	1:6	31
Wild Horse R.	1.0	1:3	53
Wickman Cr.	2.5	1:7	56
Nine Mile Cr.	0.1	*	100
Average	1.2	1:4.5	62

[1] An "R" value above 1.4 indicates an increasing population; however, Douglas-fir beetle populations will decrease in the absence of severely stressed trees or recent blowdown. Also, brood productivity must be considered in conjunction with the current to red ratio.

*No successfully attacked green trees were found; all sampling was from previous partial or previous pitch out trees that were reattacked in 1990.

Western spruce budworm
Choristoneura occidentalis

Western spruce budworm defoliated Douglas-fir over 1160 ha in 12 infestations, a 93% decline from the 17 600 ha mapped in 1989 (Map 3). The main infestations remain in the Ingram Creek to Anarchist Mountain area where budworm-caused defoliation has occurred for three years and annually since 1978 in the Anarchist Mountain to Rock Creek area. In addition, 200 ha of defoliation was recorded west of Revelstoke.



Map. 3 Areas where current defoliation was detected during aerial and ground surveys in1990.

Light defoliation was recorded on over 300 ha at Anarchist Mountain, and 100 ha at Johnstone and Ripperto creeks. In the Greenwood to Midway area, five infestations, totalling 400 ha, were mapped along the Ingram Range between Ingram and Motherlode creeks. Douglas-fir was lightly defoliated over 200 ha in the Clanwilliam area west of Revelstoke. The most recent budworm defoliation in this area was the 25 ha recorded in 1977. This, as well as previous infestations in this area, have been recorded only in conjunction with major infestations in the adjoining portions of the Kamloops Forest Region.

Spring bud counts and larval sampling suggested that defoliation would be reduced from 1989 but not to the extent that occurred (Table 6). Bud counts were down at all areas with an average of 22% of the buds infested in the early spring compared to 39% in 1989. However, moderate to severe defoliation at five of eight areas sampled in the southwestern portion of the region and light defoliation in the Revelstoke area was still suggested.

Table 6. Location, bud and egg-mass samples, 1990 defoliation and predicted defoliation for 1991, Nelson Forest Region, 1990.

Location	Percent[1] buds infested	No. eggs[2] per 10 m^2	1990 defoliation	Predicted defoliation 1991
Anarchist Mtn.	33	400	light	severe
Conkle L. Rd.	10	288	light	severe
Johnstone Cr.	29	400	light	severe
McKinney Cr.	38	236	light	severe
Bridesville	16	302	light	severe
Phoenix Mtn.	11	45	trace	light
Nicholson Cr.	36	376	light	severe
Ingram Cr.	16	480	light	severe
Myers Cr.		551	light	severe
Beaverdell	-	320	trace	severe
Mt. Revelstoke	9	49	trace	light

[1]Percent buds infested	[2]No. egg masses/10 m^2 of foliage	Predicted defoliation
1 - 15	1 - 50	light
16 - 30	51 - 150	moderate
31+	151+	severe

light - discoloration barely visible
moderate - pronounced discoloration, some top stripping
severe - bare branch tips, complete defoliation

Several factors appear to have influenced the budworm population. The most significant may have been the cold, wet spring weather which disrupted the phenological sychronization between the host tree and the budworm. The tree shoot development was delayed during the emergence of the early-instar larvae from overwintering hibernacula to begin spring feeding, thus inhibiting their initial development. In addition, heavy rain during larval emergence can, and in this case may have, dislodged large numbers of hibernacula and larvae.

Larval parasitism was insufficient to significantly affect the population levels. An average of 12.3% of the larvae collected from Midway, Rock Creek and Myers Creek were parasitized, similar to the 14.6% parasitism in 1989. At Myers Creek, parasitism increased from 7.3% of the early-instar larvae to 15.9% and 28.2% of the mid-and late-instars, respectively.

Egg sampling at 11 sites to determine potential larval populations and predict defoliation indicated a return to more severe and widespread defoliation in 1991. Of the areas sampled, severe defoliation is forecast at nine locations and light only at Phoenix Mountain and Mount Revelstoke National Park (Table 6). Expansion into areas not visibly defoliated during aerial surveys in 1990 is also predicted, as indicated by the 320 egg masses collected in a sample along Cranberry Ridge near Beaverdell. Larval numbers in all fringe areas such as Beaverdell, Arlington Lakes and Mount Revelstoke National Park, where defoliation varied from nil to light and where sampling was done in both 1989 and 1990, increased two- to ninefold. This further substantiates the egg mass results at Cranberry Ridge and further implies considerable outward expansion potential pending climatic conditions.

The predictive techniques of bud and fall egg sampling are useful early indicators of population size and potential defoliation levels; however, abiotic conditions can severely affect larval survival through till defoliation occurs. This, along with the small sampling size, results in the predicted defoliation often being more severe than what actually occurs.

A pheromone-baited trap calibration project designed to detect increasing populations and predict infestations continued in 1990 (Table 7). Since pheromone traps are not as time and space specific as conventional sampling methods, they may provide a more consistent measurement of annual population trends once calibration between moth counts, larval densities and defoliation levels are determined. This program will continue in 1991.

Table 7. Location, number of larvae, adults and defoliation at spruce budworm pheromone trap calibration plots, Nelson Forest Region, 1990.

Location	Avg. no. larvae/tree[1]			Avg. no. adults/trap[2]			Defoliation		
	1988	1989	1990	1988	1989	1990	1988	1989	1990
Conkle L. Rd.	7	7	6.1	417	50	170	trace	trace	light
Phoenix Mtn.	<1	3	1.4	256	46	153	trace	trace	trace

[1]sampling method consists of beating three branches on each of 25 trees over a 60x90 cm sheet.

[2]five Multipher[R] traps spaced at more than 30-m intervals using the lure 0.03% trans-11-tetradecenal + cis-11-tetradecenal.

Douglas-fir tussock moth
Orgyia pseudotsugata

The tussock moth population remained at endemic levels in the Nelson Region in 1990, with no larvae found in random beating samples in the Christina Lake area where numerous egg masses were found in 1989. The number of moths caught in attractant-baited sticky traps increased to an average of 13.4 from 1.5 in 1989, but remain below the threshold level of 25 (Table 8). The recommended strategy for predicting infestations suggests that when moth catches increase for two consecutive years and reach a moth density of 25 or more, egg-mass surveys should be initiated, which conceivably could occur in 1991 with the potential for defoliation in 1992. These increases correspond with increasing tussock moth populations in the Kamloops Region where severe defoliation is predicted in a number of areas for 1991.

Table 8. Location, average number of tussock moth adults trapped 1988-90, Nelson Forest Region, 1990.

Location	Avg. no. tussock moth adults per trap			No. traps per site
	1988	1989	1990	
Rock Creek	1	1	8.3	6
Christina Lake Golf Course	0	2	18.5	6

SPRUCE PESTS

Spruce beetle
Dendroctonus rufipennis

Spruce beetle populations remained at low levels in 1990 but groups of 2-20 red trees were mapped in the Kirbyville and Liberty creeks area north of Revelstoke. This area was inaccessible and no ground surveys were conducted to determine the current status of the beetle. The only current attack in standing trees was recorded in scattered groups of two to three trees over approximately 75 ha in the flood plain at the junction of the Simpson and Vermilion rivers. Small broods of nine mainly late-instar larvae per 15x15 cm bark sample, indicate only a very low potential for an infestation to develop.

Some localized standing-tree attack near 1989 blowdown areas is expected in 1991 and further assessment should be conducted and consideration given to management options where mature stands are at risk. In the Bush River area, across from Rice Brook, "R" values averaged 2.4 in scattered and small groups of blowdown ("R" values above 1.4 indicate an increasing population). Similar population levels were found in 200 blowdown trees over 5 ha at Hoodoo Creek in Yoho National Park ("R"=2.1); in several hectares of fringe and in-stand blowdown at Munroe Lake at the headwaters of the White River ("R"=1.4); in winter-damaged trees in the Flathead River drainage system ("R"=2.9) and in one- and two-year-cycle beetle in an avalanche area at No Name Creek off the St. Mary River ("R"=2.6). In chronic blowdown areas in the Redding Creek drainage, beetle populations are stable, mainly utilizing the available downed trees, but moderate infestation potential remains should one-and two-year-cycle broods coincide. Early 1990 blowdown of mainly small-diameter spruce over about 20 ha at the junction of the White and North White rivers attracted only an average of 0.4 attacks and five larvae were found per 15x15 cm bark sample.

Spruce weevil
Pissodes strobi

In the region, an average of 9% of the 1990 spruce leaders were attacked by spruce weevil in eight of eleven young stands surveyed, where spruce was a major species.

Spruce weevil killed an average of 10.8% of the 1990 spruce leaders in six of seven spruce plantations surveyed in the East Kootenay (Table 9). Current attack levels were higher than in 1989 in five of the six plantations with weevil damage. The greatest increase was along the Kootenay River, where infestations have been a chronic problem, but significant increases were also noted in relatively new infestations in the Vowell Creek drainage (7% from 2% in 1989), where young regeneration is just reaching the height range most susceptible to the weevil, 1.5 to 9 m.

In the West Kootenay, spruce weevil activity remained unchanged at near 4% in the two stands surveyed at Goldstream River and Cariboo Creek. In two other stands at Hiram Creek and Little Slocan Lake, where spruce was a minor component, no current attack was recorded but over the previous two years, 9% and 6% of the trees, respectively, had been attacked.

Table 9. Spruce weevil damage trends, Nelson Forest Region, 1990.

Location	Percent of leaders attacked		Remarks
	1990	1989	
Forster Cr.	3	2	open growing trees up to 11% current attack
Vowell Cr.	7	2	increasing population in open growing stand
Beaverfoot R.	9	6	river bottom young spruce
Blackwater Cr.	5	4	young well-spaced stand with increasing population for three years
Kootenay R. (KNP)	23	17	opengrowing 5-7 m trees
Quartz Cr.	18	32	the only decreasing population noted
Goldstream R.	4	-	opengrowing young stand, 9% old attack
Cariboo Cr.	3	-	plantation 3-4 m tall, 6% old attack

Spruce weevil control trials, in which leaders are clipped and stored in specially constructed containers on site to encourage the escape and enhancement of natural predators, are continuing in the Beaverfoot River and Koch Creek drainages.

Yellowheaded spruce sawfly
Pikonema alaskensis

The yellowheaded spruce sawfly, Pikonema alaskensis, caused light to severe defoliation of ornamental and native spruces throughout the Castlegar community, in the Robson area and for an estimated 10 to 15 km into the Crescent Valley area.

The sawfly, a native of B.C., feeds on a variety of spruces. It has not been reported as a major forest pest which may in part be due to its apparent preference for open growing situations such as trees used as ornamentals in residential areas or in hedge rows. In the current situation, the sawfly was found for several years feeding primarily on a few ornamental spruces on the north side of Keenleyside Dam. Good overwintering survival conditions and favorable dispersal conditions this past spring precipitated the sudden outbreak over a large area centered around Castlegar.

The adults, which are fly-like in appearance, emerge from the soil in May to mid-June and disperse to lay eggs in the new flush of several spruce species. Eggs hatch in 5-10 days and begin to feed on current foliage. After current foliage is stripped, older foliage becomes the food source until mid-July when the green, striped, 20-mm long larvae spin down to the duff or top soil to overwinter as cocoons. Damage is usually limited to minor branch loss but continued severe defoliation could cause major branch dieback or mortality which has been reported when complete defoliation occurs.

Infestations may last for several years, or until natural controls such as parasites, predators, diseases or adverse weather conditions take effect. Losses during this period may be substantial especially where appearance is important in high value ornamentals. Control efforts on a single-tree basis can be effective using chemicals normally available for control of other ornamental pests. Timing is crucial. Egg hatch should be determined by physical examination of new growth beginning in early June. Trees should be sprayed soon after larvae are first noted. Control is required annually until the general infestation subsides as adults have no trouble moving to healthy trees from nearby infested areas each spring.

TRUE FIR PESTS

Two-year-cycle spruce budworm
Choristoneura biennis

Both first-and second-year budworm larvae lightly defoliated alpine fir and Engelmann spruce in the Nelson Forest Region in 1990.

Mature budworm defoliated 5-10% of the current year's alpine fir and Engelmann spruce foliage over an estimated 600 ha in the upper White River drainage. This was the first indication of budworm feeding in the area since 1980 when 3500 ha were moderately defoliated. Very light defoliation was also noted in the side drainages of the Vermilion River (KNP). These two-year-cycle spruce budworm populations mature in even years (1990, 1992, etc.) as opposed to the populations in the Purcell and the east slopes of the Monashee mountain ranges which mature in odd years.

Egg sampling indicates that moderate defoliation should occur in 1992 in the White River drainage (134 egg masses per 10 m^2 foliage) while defoliation in the Vermilion River system should increase to light (66 egg masses). While the most severe defoliation occurs during feeding by the mature larvae in even years, some defoliation will also be evident from feeding by the early-instar larvae in odd years, i.e., 1991.

Immature budworm larvae lightly to moderately defoliated the current year's foliage on fringe and understory trees in the Plant Creek area and on the plateau between South Fosthall and Plant creeks. In the East Kootenay, similar levels of defoliation occurred over 250 ha along the St. Mary River, 125 ha along Bugaboo Creek and 55 ha at Vowell Creek. Bud sampling in the Whatshan Range area indicates generally moderate to severe defoliation for 1991, while light to moderate defoliation can be expected in the Purcell Range (Table 10).

Table 10. Location, host, percent buds infested by two-year-cycle spruce budworm and predicted 1991 defoliation, Nelson Forest Region, 1990.

Location	Host[1]	Percent buds infested	Predicted defoliation 1991[2]
Plant Cr.	eS	60	severe
Plant Cr. (plateau)	eS	53	severe
St. Mary R.	alF,eS	12	light
Vowell Cr.	alF,eS	31	moderate
Bugaboo Cr.	alF,eS	10	light

[1]eS - Engelmann spruce, alF - alpine fir

[2]Predicted defoliation: light - 1-25% of buds infested
moderate - 26-45% of buds infested
severe - 46% + of buds infested

A dispersal study of first-year budworm larvae indicated that there was little difference in attack levels between the fringe and the center of a 50-ha cut block. In a 1989 Engelmann spruce plantation at Plant Creek, 30-cm seedlings were examined from 5 to 150 m from the cut block fringe at approximately 10-m intervals. Within 20 m of the fringe, 80% of the seedlings were infested and had 2 or more larvae, while beyond this to the center of the cut block, an average of 65% (range 50-70%) of the seedlings had an average of 2 larvae. The absence of egg masses on the seedlings indicates that early-instar larvae are readily wind-dispersed over a considerable distance.

The impact upon seedlings and young stands in clearcuts within infestation areas is expected to be minor due to the dependence upon immigration of larvae from adjacent mature stands, high mortality of dispersing larvae, reduced feeding by early-instar larvae every second year allowing seedling recovery, and the strong resilience of young trees following defoliation.

Western balsam bark beetle
Dryocoetes confusus

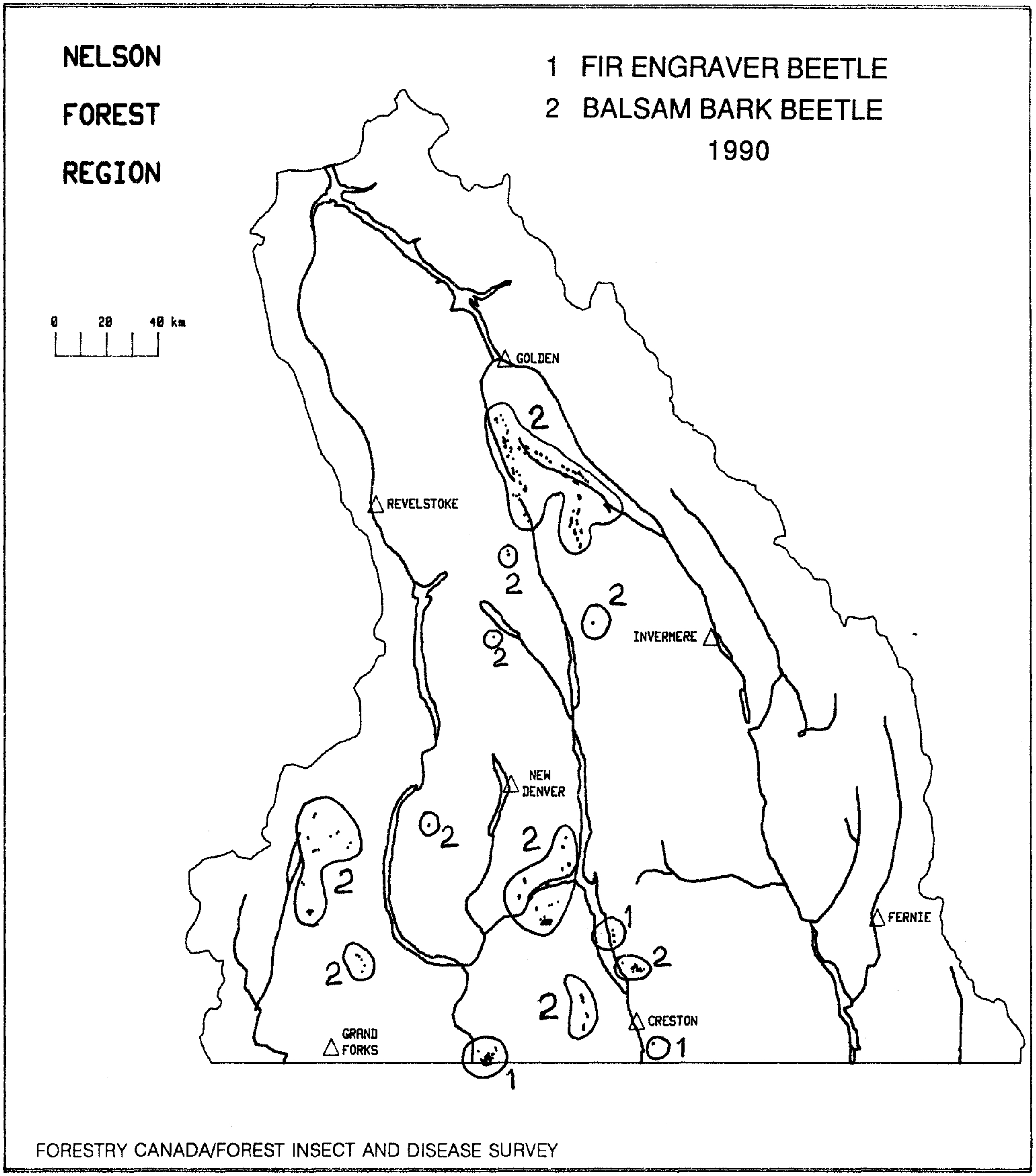
Recent tree mortality, as detected by aerial surveys, covered 1780 ha in the Nelson Region, a slight increase from 1989 (Map 4). The main concentration remains in the Spillimacheen River (700 ha) and Vowell Creek (250 ha) drainages, while there was a threefold increase to 320 ha along the West Arm of Kootenay Lake, primarily in the Lasca Creek drainage. Other areas where smaller concentrations of balsam bark beetle-killed trees were mapped included the Beaver River in Glacier National Park, in the Kootenay Mountain Range north of Nelson, Skelly Creek, the Blazed--Next creeks area and near Traverse Creek.

In addition, scattered groups of 5-10 recently killed trees are common in most mature alpine fir stands. These are frequently root rot centers around which the beetle populations initially become established within the stand and which the emerging broods seek out and attack. Balsam bark beetle populations, once established in a stand, continue to selectively kill small groups of trees throughout the stand at a relatively constant level. The occasional significant increases in population and tree mortality in the mature to overmature stands are associated with population buildup in blowdown and the vulnerability of the older trees when exposed to drought stress. Accumulated mortality increases with stand age and appears to stagnate when approximately 67% of the trees over 20-cm dbh are attacked.

Fir engraver beetle
Scolytus ventralis

The fir engraver beetle continued to cause mortality of grand fir with 242 ha mapped in 25 infestations in the Nelson Region (Map 4). In the Pend-d'Oreille River area (216 ha), the number of red trees was greatly reduced on the north side of the river with only widely scattered groups of 5 red trees mapped. On the south side of the river, the total area affected was similar to 1989 but the number of trees was reduced and somewhat more scattered. Discolored trees were generally centered around the Church Creek area. In the Creston and Boswell to Crawford Bay areas, there was an increase in the number and area of small pockets of tree mortality (37 ha). In two infestation areas examined along the east side of Kootenay Lake, 60% of the grand fir were recently killed by the fir engraver beetle; however, only 5-10% of the stand were grand fir. Observations in the Crawford Creek area indicated that similar levels of engraver beetle attack had killed a high percentage of the grand fir in this drainage during earlier infestation periods.

Brood examinations on the south side of the Pend-d'Oreille River indicated that very few of the 1990 attacks were successful. Recent successful attacks had only a few eggs or adults in the galleries. Most early spring or late 1989 attacks were unsuccessful, with tree growth already visibly encroaching on the entrance hole scars. In all areas sampled, no larvae, pupae or teneral adults were found.



Map 4. Areas where recent tree mortality was detected during aerial and ground surveys in1990.

As in previous examinations, all beetle-attacked trees along the east side of Kootenay Lake had Armillaria root disease. Similar to its association with other bark beetles, the root rot was present in the stand prior to the beetle infestation but when drought periods occur, the infected trees were under greater stress than the non-infected trees, and therefore, more vulnerable to engraver beetle attack.

Ground surveys in all areas examined indicated a major reduction in the 1990 attack levels with a subsequent reduction in red trees expected in 1991. Only very scattered tree mortality along with some continuation in top and branch mortality is expected in 1991.

A balsam shoot-boring sawfly
Pleuroneura sp.

Damage to new grand fir shoots has gradually been increasing in the range of grand fir. The intensity increased in the Creston area (Table 11) and was recorded for the first time at Nelway and King George VI Park. In the Creston area, damage was first recorded in 1988, after a 20-year absence. At Nelway, an average of 13% of new shoots on all the regeneration were infested over 2 ha, while at King George VI Park, all the regeneration was lightly to moderately infested over 0.1 ha.

Table 11. Damage trend of a balsam shoot-boring sawfly at Creston, Nelson Forest Region, 1990.

Year	Percent of current shoots infested: understory	overstory	Area
1988	1	1	0.5 ha at East Arrow Cr. Rd. and Rykerts
1989	45	10	1 ha at East Arrow Cr. Rd., 0.5 at Rykerts
1990	60	20	1.5 ha at E. Arrow Cr. Rd. and Rykerts, trace to light from Rykerts to Wynndel

With the terminals and lateral tips being the preferred points of attack, the impact on understory and intermediate trees after three years of feeding has become apparent with multiple tops and excessive branching of the laterals.

LARCH PESTS

A larch looper
Semiothisa sexmaculata

The larch looper, *Semiothisa sexmaculata*, defoliated nearly 12 000 ha of western larch in 190 infestations from Creston in the east to Burrell and Howe creeks in the west and the international border in the south to Kaslo, Slocan and Fauquier in the north (Map 3). This is the first appearance of this larch pest at infestation levels since 1977, when 4600 ha of defoliation occurred over the same general area. Larvae have been collected on occasion but defoliation was recorded only this year and in 1977.

Defoliation was predominantly on western larch, but the occasional western hemlock and Engelmann spruce understory regeneration were also affected. Light defoliation occurred over 3460 ha, moderate over 3020 ha and severe over 3316 ha. As in the previous infestation, feeding damage was generally confined to the north, east and west aspects and at elevations from approximately 1000 to 1800 m, although some exceptions were noted, especially in severely defoliated areas where south-facing slopes were also affected.

While attack occurred over a broad region, some of the more notable infestations in the Arrow TSA occurred in the Slocan and associated drainages including Koch and Little Slocan creeks, along north-facing drainages of the west arm of the Kootenay River, in the Erie Creek area and south in the Archibald and Wallack creeks areas, in the China--Sullivan creeks drainages, along creeks flowing north into Blueberry Creek, along Robson Ridge and several creeks flowing south into Lower Arrow Lake. In the Boundary TSA, defoliation was notable on the east slopes of upper Howe Creek and the north part of the Burrell Creek drainage. In the Kootenay Lake TSA, defoliation was especially notable along Corn Creek west of Creston and at Smallwood Creek and adjacent drainages.

Larval feeding was nearly complete and few larvae were found during the available sampling period in September; however, these were collected for rearing to aid in parasite determination. Pupal sampling was initiated at four sites to help assess population levels. The average number of pupae found per 30x30 cm duff sample ranged from 6 at Grizzly Creek, to 31 at a Blueberry Creek site with an average of 7 and 16 pupae found at Sullivan Creek and Smallwood Creek, respectively. All areas assessed were moderately to severely defoliated. Cocoons of a braconid larval parasite, *Phytodietus* spp., were also noted at all sites during pupal sampling and represented numerically an average of 23 to 38% of the cocoons and pupae present in the collections. Further parasitism may also occur and will be determined from mass collections currently in rearing.

The previous outbreak lasted only one year and no top-kill or mortality were recorded. Visual assessments of buds at several sites showed no damage; therefore, no top-kill or branch dieback is expected. As this insect is active very late in the season, it has also been speculated that loss of increment would be minimal, up to 20% at most. The loss of possible reserves for next year's foliage would present a problem only in the case of repeated severe defoliation by this pest, which is unlikely, or in conjunction with some other pest such as the needle diseases or larch casebearer which certainly is possible.

As little historical information is available, it is difficult to forecast the trend for 1991; however, the level of parasitism (38% to date at one site), the generally low numbers of pupae found, and the relative historical lack of success of this insect suggests a much reduced level of defoliation in 1991, limited to such areas as Blueberry Creek where pupal numbers were highest.

Larch casebearer
Coleophora laricella

Larch casebearer activity remained at very low levels in 1990 with no aerially detectable defoliation recorded. Small patches of light to moderate defoliation were noted during ground surveys from Galena Bay to New Denver, from Nakusp to Fauquier and in the Edgewood to Whatshan area. Similar levels of defoliation, which occasionally reached severe, were also noted on mainly regeneration and fringe trees at Rossland and near the Castlegar pulp mill. At all other areas, including the parasite release sites, defoliation ranged from nil to very light.

The incidence of pupal parasites from 18 locations averaged 13.3% (range 0-35.5%), the third consecutive annual decline from 23 and 32% in 1989 and 1988, respectively. Parasitism by the introduced parasite, Chrysocharis laricinellae, averaged 5% (range 0-35.5%), a decline from 18% in 1989. At the same time, parasitism by another introduced parasite, Agathis pumila, increased to 8.3% from less than 1% in 1989. At Inonoaklin Creek along Arrow Lake, 60 km north from the nearest parasite release location, 4% of the pupae were parasitized by C. laricinellae and 2.5% by A. pumila. This indicates that these introduced parasites are probably well distributed throughout the range of the larch casebearer. Unknown casebearer mortality averaged 16.4%.

With over 70% adult emergence, populations can be expected to remain at the current level in 1991, especially in those areas with light to moderate defoliation this year. However, due to fiscal restraints, no predictive overwintering population assessments were made in November.

Larch needle diseases
Meria laricis
Hypodermella laricis

The incidence of needle cast caused by Meria laricis, along with lighter incidence of H. laricis, on western larch, increased dramatically in the Nelson Region in 1990, with a total of 5550 ha mapped in 112 infection areas during aerial surveys, mostly in West Nelson. This was an increase from only 167 ha in 1989. In addition, trace to moderate infection of the lower two-thirds of the crown was intermittent throughout the host range.

The majority of the infections occurred in the Boundary TSA, where 2900 ha of mainly moderate defoliation were mapped. The largest infected areas occurred in the Christina Lake area with 1200 ha of discoloration on both sides of the lake. Other areas with moderate defoliation were in the Granby River drainage south of Gable Creek (700 ha), and at July and Boundary creeks near Greenwood (800 ha). Severe defoliation was mapped over 125 ha in the Kelly River to Little Goat Creek area and on 50 ha along Tuzo Creek.

In the Kootenay Lake TSA, 1550 ha of moderate discoloration were mapped. The largest infection area was near Kitchener over 500 ha, with smaller patches from 120 to 250 ha mapped along Kootenay Lake at Woodbury Creek, Lockhart Creek, near Argenta, and in the Falls and Sproule creeks drainage on the west arm of the lake.

In the Arrow TSA, much of the infection was in the area south of Rossland, where 450 ha were mapped. Smaller infection centers were recorded in upper Lamb Creek (150 ha), Blueberry Creek (100 ha), along Arrow Lake (150 ha), at Koch Creek (150 ha), and in small scattered patches in the Salmo to Nelson area.

Most of the infection by M. laricis occurred in the spring when protracted periods of calm, cool, wet weather conditions favored infection; further infection and disease intensification also occurred during extended moist periods through to midsummer. Weather conditions in the East Kootenay, although moist, were accompanied by strong winds during the sporulation period, which greatly inhibited needle infection.

Extensive loss of the foliage manifests itself in growth loss. In earlier studies of impact on young stands by H. laricis, height growth of severely infected trees was suppressed by an average of 30%. The impact of M. laricis, however, is expected to be even greater due to infection and foliage loss continuing into the summer.

Although there are no reliable predictive techniques available, the inoculum source will be abundant and if the spring weather conditions should be favorable for infection, similar or more severe infection levels can be expected in 1991.

A larch shoot moth
Argyresthia laricella

This larch shoot moth was found in localized pockets of western larch in the Columbia--Windermere lakes area. Damage averaged less than 1% in young larch (12 years) in the Brewer--Dutch creeks area but in small groups of trees, up to 5% of the trees were affected. The main damage consisted of mortality to one-year-old vertical shoots, primarily the terminals and uppermost laterals. There was also a strong preference for the open tops of the dominant and codominant trees. The physical environment which this pest appeared to prefer would suggest that conditions created in spaced larch stands could favor its expansion as a pest problem.

HEMLOCK PESTS

Western hemlock looper
Lambdina fiscellaria lugubrosa

The western hemlock looper defoliated 915 ha of primarily western hemlock in mature to overmature western hemlock--western red cedar stands in seven infestations north of Revelstoke (Map 3). This was the first outbreak in the region since 1983, when defoliation covered more than 32 000 ha from Whatshan Lake in the south to Canoe Reach on McNaughton Lake in the north. In the current infestation, light defoliation occurred in the Albert Creek area, in three infestations along Downie Creek, and at Scrip Creek along the Columbia River, with trace to very light defoliation along Bigmouth Creek.

Larval sampling for hemlock looper indicated potential defoliation in 1991 at Bigmouth Creek, Goldstream River, Downie Creek, Woolsey Creek, Tangier River, Martha Creek and Copper Creek. At Cusson Creek and Akolkolex River, seven and six larvae were found, respectively, just below the threshold of eight at which defoliation is predicted for the following year. A comparison at six sites sampled in both 1989 and 1990 shows an approximate sevenfold overall increase in numbers of larvae. Other areas of old-growth hemlock not sampled, but within the traditional outbreak areas from Redrock Harbour in the north to near Whatshan Lake in the south, might also be considered at risk.

Egg sampling from three areas also indicates an increase in both extent and severity of defoliation by hemlock looper for 1991 in the Revelstoke TSA (Table 12). Samples consisted of Old man's beard lichen collected along the length of the crown from five codominant trees at each location.

Table 12. Hemlock looper egg sampling and predictions, Nelson Forest Region, 1990.

	Avg. no. of eggs per 100 g lichen				Predicted defoliation
Location	Healthy	Parasitized	Infertile	Old	for 1991[1]
Bigmouth Cr.	89	34	5	10	severe
Downie Cr.	300	34	10	34	severe
Tangier R.	14	4	0	4	light

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

The high levels of egg parasitism found at two sites (Bigmouth Creek - 26%, Tangier River - 22%) was unusual in this the first year of infestation; parasite populations commonly lag somewhat in an infestation build-up. It is not clear how this will affect looper populations in 1991. In previous outbreaks, when an average of 30% parasitized eggs (parasitized as a percentage of the total number of eggs, excluding infertile and old eggs) were found in a population, a collapse has sometimes followed the next year. A collapse occurred in 1984, after two years of severe defoliation and 29% egg parasitism in 1983. Larval parasitism from two collections at Downie Creek was nil or negligible at 0 and 0.8%. Historically, larval parasitism has not significantly affected population levels. Similarly, no parasitism was present in pupal collections from the same area. Looper infestations have generally lasted 2 - 3 years and then collapsed. High egg parasitism, adverse weather conditions, starvation and a nuclear polyhedrosis virus (NPV) have all been factors in previous population collapses.

Top-kill can be expected following one year of moderate to severe defoliation. In three previous infestations in the same area, up to 50% tree mortality followed two years of defoliation and 70 to 100% by the third year of the infestation. Most of the mortality has occurred on mature and overmature western hemlock but in mixed stands, mortality of other species such as western red cedar, Douglas-fir, Engelmann spruce and true firs has also been recorded. Severe defoliation and some tree mortality were also recorded over 200 ha in a 80-100-year-old mixed stand near Nakusp in 1973.

Gray spruce looper
Caripeta divisata

The gray spruce looper, *Caripeta divisata*, defoliated 1370 ha of western hemlock in 24 infestations in the Arrow TSA (Map 3). This is the first major outbreak in B.C. by this pest since a minor infestation in 1961 near Terrace.

Light defoliation occurred over 230 ha, moderate defoliation over 1065 ha and severe over 75 ha. Defoliation occurred primarily along the west side of the Arrow Lakes from the Nakusp area to just south of Arrow Park, with two small areas of damage just north of Nakusp. Feeding in these areas was evident from the shoreline to approximately 900 m elevation. Two infestations were noted above Box Lake at approximately 700 to 950 m elevation. Along Slocan Lake, infestations occurred from Wragge Creek to Nemo Creek, including approximately 400 ha of moderate to severe defoliation in Valhalla Park between Nemo Creek and Wee Sandy Creek at elevations from shoreline (550 m) to 1000 m. Two small pockets of light defoliation were also noted at Memphis Creek near the southeast corner of Slocan Lake. Infestations were predominantly on east-facing slopes.

Populations were found mainly on western hemlock with only very light and trace feeding on Douglas-fir and western red cedar, respectively. Feeding was predominantly on the main crowns with some complete upper crown stripping. Regeneration was not completely defoliated, even in the most severely attacked areas, with most current foliage at least partially retained. There was also little webbing evident in infested areas, further suggesting a preference for the upper crowns and little tendency to either spin down or be knocked down into the lower canopy. The looper overwinters as a pupa; eggs are laid singly or in small groups on needles in June and the six larval instars feed into mid-October.

Larval mortality was common and noted at all sites where ground assessments were made. This was probably due, in all cases, to a species of *Entomophthora* causing a fungal disease, as physical signs of disease were virtually the same at all sites. Disease-caused larval mortality in two mass collections was 38 and 16%, respectively, at Vipond Cr. and Nakusp; however, as contamination was likely, this was not a reliable indicator of levels of disease in the populations. Rearing is continuing to help determine the level of parasitism in the populations. Both *Entomophthora* spp. and nuclear polyhedrosis virus (NPV) are known to occur in populations.

The only previously recorded outbreak of this looper occurred in 1961, east of Terrace in the Zymoetz River Valley. In that infestation, however, only light feeding on the lower crowns of larger trees was reported, with overall averages of 18 and 15% defoliation based on two 50-tree plots assessed. Understory feeding was estimated at 25 to 80%. Larval numbers continued for several years, averaging 6.8 from 29 collections in 1962 and 62 larvae at Lava Lake in 1964, but down to a maximum of 6 larvae in 1965 throughout the district. Defoliation was negligible in 1962, the year following the outbreak, and no evidence of permanent damage was mentioned.

In the current outbreak, two trees were felled in a severely defoliated area to assess bud damage and the potential for top-kill. Buds appeared intact and healthy. Based on this assessment, historical information and the presence of high levels of fungal disease, it is projected that no permanent damage should result from this outbreak and that overall defoliation levels will be much reduced in 1991. However, where defoliation was severe, increment may be reduced for several years until refoliation is complete. If severe defoliation does occur in any area for a second year, secondary insects such as various bark beetles may attack the stressed trees.

MULTIPLE HOST PESTS

Root diseases

Armillaria sp.
Leptographium wageneri
Inonotus tomentosus

The role of root rots in a variety of forest situations was examined in 1990. The main emphasis was on the impact on young stands and on how they respond to different management practices or natural stand-altering conditions. Although the annual percentages of mortality may be low, they have an accumulative effect over a stand's rotation period. The rate of spread within a stand is dependent on a variety of factors; initially, it depends upon the number of inoculum centers such as old infected stumps. While the adjacent trees are rapidly infected through root contact, subsequent spread is governed more by stand age, stress, and species composition.

During **pest of young stand surveys**, an average of 3.9% of the leading tree species (2528 trees) in 17 of 27 stands were dead or dying due to root rot (Table 17). Armillaria root disease in Douglas-fir stands was the most severe, with 8.3% of the trees infected, but all tree species were infected to a lesser extent. Blackstain root disease was found in 2 of 16 lodgepole pine stands, while Tomentosus root rot was present in only 3 of 19 spruce stands.

The progression of Armillaria root disease in young stands was followed over the past few years at two areas. In a seven-year-old lodgepole and ponderosa pine stand at Mosquito Creek, the incidence of root rot increased from 3 and 13% of each host, respectively, in 1988 to 4 and 38% by 1990. These results would suggest that ponderosa pine should not be considered as an alternative or resistant tree species for Armillaria root rot-infected sites. In a 15-year-old Douglas-fir plantation at Fitzstubbs Creek, the incidence of

Armillaria root disease increased from 2% suspect in 1986 to 6% dead in 1990, with at least 8 infection centers containing up to 18 trees dead or dying between or adjacent to plots. At the current spread rate, over 40% of this stand would be dead by age 100, with significant growth loss in the remainder of the trees. Assessment of natural regeneration in these two plots indicates that primarily western red cedar and western hemlock are becoming well established but as tree removal by root disease is indiscriminate and as the regeneration is already becoming infected, few will likely provide usable alternate crop trees. Pre-harvest assessments should identify these problems and provide the basis for planning the appropriate action on root rot-infected sites before investments are made in planting and spacing.

Surveys for **Armillaria root disease in young western larch** stands were conducted to gain some insight into the effectiveness of using western larch as an alternate species for planting in root rot-infected sites. The surveys suggested that the pattern of attack varies between wet and dry sites. In young stands in the drier MSa to IDF sites along the lower Elk River and along Brewer Creek, 94% of the trees (18) killed were less than 20 years old, while only 8% of the trees over 20 years were killed. All trees had root contact with an old infected stump. Of the root systems examined, there was no evidence of infection having spread beyond these young trees having initial root contact with the inoculum source. Representative sampling (72 trees) along the infected roots of the old stumps indicated that 29% of the larch that had root contact with the inoculum source were infected.

In the more moist sites, MSa to ICH along the Elk and St. Mary rivers, the mortality of trees with roots in contact with the original inoculum source averaged 36% (8 trees), three of which (38%) were over 20 and up to 30 years old. However, the main difference between the dry and moist sites was that these initially infected young trees were spreading the disease beyond the sphere of direct influence of the old infected stumps. Of the young larch (23 trees) in contact with this secondary infection source, 33% were dead or dying at an average age of 35 years. In these stands, an average of 9.6% of the larch had been recently killed by Armillaria root disease.

The survey consisted of identifying infected old stumps in young larch stands. The roots of all adjacent dead or obviously stressed young trees were then excavated to determine the source of infection. In addition, all the roots in contact with several of the infected major roots of the infected stumps and of the infected young trees were tallied as to being infected or uninfected. Further surveys are planned for 1991 to determine whether or at what age larch susceptibility to Armillaria root disease declines.

During surveys of young stands, the susceptibility of young larch was also evident. In a permanent plot at Smallwood Creek, where no infection was noted in 1988, 1% of plot trees were dead only five years after planting; similar tree mortality was noted throughout the plantation. This was in line with a previous survey in a 12-year-old stand where 5% scattered tree mortality was caused by Armillaria root disease. Both stands were in the ICH zone and will continue to be monitored.

A relationship between **Armillaria root disease and spacing** was suggested during surveys of recently spaced young lodgepole pine. In most pure pine stands, the incidence of this root rot is very low and need not be a major consideration in the spacing program. However, when trees are stressed by mammal damage or intermixed with a susceptible host such as Douglas-fir, the incidence immediately after spacing can increase dramatically. In a pine stand mixed with Douglas-fir at Blazed Creek, 4% of the leave trees were dead or dying within one year after spacing. Most of the infected trees were in close physical association with stumps of dead trees that had been cut during spacing and infection had been present in the root system prior to spacing. This would suggest that appropriate spacing around dead or dying trees could reduce the loss of leave trees. Observations in adjacent unspaced stands indicated that the number of root rot centers was not significantly different from that in the spaced stand, but all the root rot-infected trees in the unspaced stand had other defects such as extensive Atropellis cankers or mammal damage. Pre-spacing surveys should identify these problems, their possible association with root rots and the potential impact on the leave trees following spacing.

The practice of spacing stands known to harbor large populations of small mammals can lead to disappointing results, with not only increased top-kill and tree mortality directly caused by mammals but also increased incidence of Armillaria root disease. Armillaria root disease was found in young pure lodgepole pine stands (25 years and older) only where mammal damage (squirrel and/or rabbit) was also evident. In a recently spaced pine stand on Fairmont Ridge, Armillaria-caused tree mortality (10%) was present only on those trees with greater than 50% of the stem girdled by mammal feeding. Of the trees with 50-75% of the stem girdled, 19% were infected, while 44% of the trees with over 75% of the stem girdled were dying due to Armillaria root disease. As previous observations have indicated, Armillaria root disease in vigorously growing pine stands, while present, tends to be of minor consequence but very rapidly asserts itself when trees are in a stress situation.

A link between **black stain root disease and spacing** was indicated when 5 and 2% of the leave trees were infected in recently spaced lodgepole pine stands in the Palliser and White river drainages, respectively. Although black stain root disease was known to be present in older mainly Douglas-fir stands in these drainages, there was no record of its occurrence in young pine stands. The root-feeding weevils which act as vectors for the disease are initially attracted to the abundance of recently cut stumps but in their indiscriminate feeding habit, they may also feed on the roots of the leave trees. The dead trees were in close physical contact with a recently cut stump which had evidence of weevil feeding and of black stain root disease which may have been transferred through root contact to or from adjacent leave trees.

The long-term implication of black stain root disease in spaced pine stands is uncertain. In young Douglas-fir stands, infection centers have spread radially up to 4.5 m per year. However, radial expansion of the infection centers via root contact should be minimal due to the relatively wide spacing of living trees. Therefore, spread and maintenance of the disease in the stand will be largely dependent upon the indiscriminate feeding activity of the insect vectors until increased root contact is established between the leave trees. Should this become a significant problem in young stands, the removal of all trees in a buffer strip around the infection centers has been recommended as a control measure. Since the disease survives for only two to three years within dead stumps, the buffer strip could be replanted shortly after to the same species or to a more resistant species such as spruce or western larch.

Follow-up surveys of **black stain in mature pine stands** at Kelly Creek indicated a more widespread problem than was originally indicated in 1989. Two random continuous strip surveys (8x400 m) in apparently healthy mature to overmature stands beyond the previously identified infected areas had an average of 12% infection based on tree mortality and symptomatic trees. In addition, 3 of 20 non-symptomatic trees sampled were infected. Trees with advanced infection had a clear basal resinosis prior to showing significant crown symptoms, as opposed to the basal whitish sheen associated with Armillaria-infected trees.

Incidence of Armillaria root disease increased following mountain pine beetle infestations in the Flathead River drainage. Recent root rot-caused tree mortality averaged 12% in a 60-70 year old lodgepole pine stand in which 42% of the pine had been beetle-killed in 1979. At the time of beetle attack, the stand had relatively low susceptibility to beetle and as a result, the beetle-killed trees are scattered in groups of 2-5 trees throughout the stand, leaving a somewhat effectively spaced stand of 1125 trees per hectare. Root rot to date has reduced the stocking to 895 trees and projecting similar losses to harvest time, there will be only 435 harvestable pine or less than 200 m^3 per hectare. This same scenario may well be in store for the numerous age class 3 (age 40-60) and 4 (age 60-80) stands currently under beetle attack in the region. The impact carries over into the next rotation as recorded in young stand surveys in 1989 when regeneration following mountain pine beetle in the same general area had three to five times the number of infection centers per hectare (120) compared to regeneration in non-beetle areas.

Douglas-fir beetle and Armillaria root disease have been, to some degree, associated with each other in most infestations examined. Observations made during the development and continuation of the current population suggest that there is a close link. However, just the presence of root rot alone does not appear to place adequate stress on enough trees simultaneously to initiate a beetle infestation. Instead the root rot-infected trees serve as a breeding reservoir for a resident beetle population, the size of which is dependent upon the severity and extent of the root rot. When additional stress, primarily drought, occurs, the root rot-infected trees are the first to be affected and, as such, become attractive to the beetles and the focal point for new infestations. However, in trees with extensive root systems, evaluation of the extent of root rot in mature trees has been difficult. These observations were supported when, courtesy of the BCFS, eight beetle-attacked trees were pushed over with most of the root system intact for determination of root rot incidence. Five of the trees had root rot of which three had advanced decay with mycelium at the root collar. One additional tree with advanced root rot, also pushed over, was not attacked by beetles. This small exercise illustrates that conclusive signs of root rot can often be difficult to detect during conventional above-ground surveys even when extensive root rot is present.

The impact on **root rots of different logging methods** varies substantially. Adjacent Engelmann spruce--alpine fir stands in which clear-cut and partial-cut harvesting techniques had been used were compared in the Monk--Boundary creeks area. In the clear-cut blocks, the incidence of root disease in the 19-year-old regeneration was only 1%, slightly less than the average of 4% incidence in the mature unlogged stand. However, in the partial-cut blocks, 55% of the leave trees and 10% of the 10-to 20-year-old regeneration were infected. In cedar--hemlock stands along Boundary Creek, where the cedar had been selectively removed, 30% of the leave trees (mainly western hemlock), had advanced symptoms of root rot. Extensive top-kill, which often is indicative of root rot in hemlock, was present on an additional 60% of the trees. In trees with top-kill, 3 out of 10 were found infected, following excavation of a major root from each tree. In an adjacent unlogged stand, only 2% of the trees in a survey strip had symptoms of root disease. Similar increases in root rot incidence, when areas were partially cut, were also noted in Douglas-fir at Ram Creek where infection increased from 9 to 30% twenty years after logging. These observations suggest that even when root rot appears to be at a low incidence in a stand based on crown symptoms and basal resinosis, partial cutting will damage root systems, aggravate the root rot and incidence may increase dramatically, ranging from three- to twelvefold within 20 to 30 years, unless appropriate precautions are adhered to.

Rhizina root disease
Rhizina undulata

An estimated 70 000 dead seedlings (Engelmann spruce, western red cedar, Douglas-fir, and lodgepole pine) were associated with Rhizina root disease in 9 of 24 cut blocks examined in the region (Table 13). Estimates were extrapolated from data collected along survey lines and portions of cut blocks affected. Significant seedling damage was recorded only in the ICHa2 biogeoclimatic zone, but fruiting bodies were also found in ICHb, ESSFa, ESSFc, and MSa. Fruiting bodies were present in 13 of the 24 sites but their numbers and size were reduced from that of 1989 while seedling mortality remained high.

Table 13. Location and incidence of Rhizina root disease, Nelson Forest Region, 1990.

Low incidence of fruiting bodies		High incidence of fruiting bodies,
no seedling mortality	less than 10% seedling mortality	more than 10% seedling mortality
Semlin Cr.(ESSFa)	Skelly Cr.(ESSFc)[5%]	Tate Cr.(ICHa2)[32%]
N. Haller Cr.(MSa)	Swan Cr.(ICHb)[3%]	Whitney Cr.(ICHa2)[30%]
Haller Cr.(MSa)	Yellow Cr.(ICHb)[2%]	Game Cr.(ICHa2)[24%]
Sprucetree Cr.(ICHa2)		Bush Harbour (ICHa2)[27%]
		Akolkolex Cr.(ICHa2)[24%]
		Boulder Cr.(ESSF)[11%]

Negative: St. Mary R.(ICHa2), Meachen Cr.(ESSFc), Crawford Cr.(ICHa2), Vowell Cr.(ESSFc), Marioka Cr.(ICHa2), Rady Cr.(ICHa2), Nagle Cr.(ICHb), Gerrard Cr.(ICHa2), Akolkolex Cr.(ICHa2).

( ) - biogeoclimatic zones; [ ] - % seedling mortality.

A resurvey of Rhizina-exposed western white pine seedlings marked in 1989 suggested that this species may be somewhat resistant to fatal infection by Rhizina. Fifty white pine seedlings which had fruiting bodies within 5 cm of the stem were marked in 1989 in a plantation near Donald; of these, 42 (84%) showed no external symptoms of infection by the fall of 1990. In the plantation, 43% of the lodgepole pine were killed compared to 17% of the western white pine. There was also some evidence which suggested that western red cedar was less susceptible to Rhizina in a plantation at Bush Harbour where cedar and spruce were interplanted; cedar mortality was 14% compared to 27% of the Engelmann spruce.

Follow-up surveys of three 1989 plantations suggested that there is little difference in levels of seedling mortality whether the blocks are spring or fall-burned (Table 14). In spring-burned blocks, the fungus proliferates soon after burning and may infect newly planted seedlings. Fruiting bodies begin to appear by midsummer.

Table 14. Progression of Rhizina-related seedling mortality and relation to fruiting bodies, Nelson Forest Region, 1990.

Location	Year burned	Percent seedling mortality			% seedlings with sporophores	
		fall 89	spring 90	fall 90	dead	healthy
Blue Ridge Rd.	fall 1988	8(16)	13(20)	29 Df=29 eS=14 wL=32	29	4
Deadman Cr.	fall 1988	32(38)	38(41)	41 Df=44 lP=32	43	5
Cranberry Cr.	spring 1989	23(38)	46(50)	50 Df=50	60	3

( ) - percent of seedlings dead plus seedlings that were symptomatic.
Df - Douglas-fir; eS - Engelmann spruce; wL - western larch; lP - lodgepole pine

Data and observations at numerous sites suggest that where Rhizina incidence is high the first year, disease incidence drops significantly the second year and where disease incidence is low to moderate the first year, it continues at similar levels the second year. The suggested explanation is that the total food base was utilized during the first year when disease incidence was high, leaving little food material for the second year. Because little fungus growth occurs during the winter, 1989-planted seedlings dead or symptomatic in the spring of 1990 were probably killed in 1989; therefore, at Deadman and Cranberry creeks, virtually all seedling mortality (41 and 50%, respectively) can be attributed to the first year of infection (Table 14). At Blue Ridge Road, 20% of the mortality could be attributed to year one and only 9% to year two. At Game Creek, Rhizina incidence was stratified throughout the cut block in the fall of 1989, when the block was planted in 1990, an average of 36% of the seedlings were killed in the strata which had been classified as moderate in 1989, compared to only 14% in the strata classified as severe the previous year.

Delaying planting by one full growing season, especially in the case of sites classified as severe, may reduce the amount of seedling mortality. In a fall 1988-burned cut block at Game Creek, the potential severity of Rhizina root rot, based on the abundance of fruiting bodies, was moderate to severe. The block was planted in the spring of 1990 with seedling mortality averaging 24% by mid October. Estimates of potential seedling mortality, if the cut block had been planted in 1989, were in the 40 to 60% range based on observations from other infected cut blocks with similar levels of Rhizina fruiting bodies present.

Measurements of seedling planting depth suggest that this may be a factor in seedling susceptibility to Rhizina (Table 15). Both dead and healthy seedlings that had Rhizina fruiting bodies within 5 cm of the stem were measured from the top root branch to the soil level at five sites in ESSF, ICH and MSa biogeoclimatic zones. With the healthy seedlings, the difference in planting depth was insignificant between the three species but greater variation was observed with the infected seedlings. This could indicate that certain species are more tolerant to deeper planting or it may indicate only that certain species are generally planted deeper. The bottom line appears to be that seedlings planted deeper than 4 cm have little chance of survival in the presence of Rhizina.

Table 15. Seedling mortality levels compared at various planting depths.

Planting depth (cm)	Percent seedling mortality		
	Douglas-fir (120)	Engelmann spruce (168)	Lodgepole pine (198)
0 - 1.25	0 (20)	0 (16)	12 (32)
.26 - 2.50	25 (32)	9 (44)	26 (78)
.51 - 4.00	56 (36)	56 (36)	63 (38)
.10 +	100 (32)	100 (72)	98 (50)
Healthy			
mean depth	2.08	2.08	2.06
s.d.	+/-0.36	+/-0.28	+/-0.36
Infected			
mean depth	4.60	5.59	4.29
s.d.	+/-0.79	+/-1.70	+/-1.02

- ( ) sample size.
- s.d. standard deviation.

Forecasting which cut blocks will develop a Rhizina problem remains elusive, although some generally preferred environments are being recognized.

It might be feasible and economical to select the most vulnerable of these sites and test burn several patches of a few square meters in the spring prior to broadcast burning. The ensuing development or lack of fruiting bodies may provide some indication of a potential outbreak.

Black army cutworm
Actebia fennica

Black army cutworm populations further declined in the Nelson Region in 1990, with seedling and herbaceous feeding recorded on portions of two cut blocks. The largest population was over 20 ha in a 1988-burned cut block near Game Creek, where 19% of the Engelmann spruce and lodgepole pine were stripped of foliage. Although foliage can drop from recently planted western larch without provocation, 85% of the larch within the infestation area were stripped of foliage compared to only 4% outside the infestation area. Seedling mortality is not expected to exceed 4%. At Vowell Creek, light bud feeding on spruce seedlings planted in 1988 continued over approximately 20 ha.

Larval collections from the Game Creek infestation indicated that parasitism was negligible at 4.7%. Good progeny survival was further substantiated by pupal counts averaging 10 per 900 cm^2, a significant increase from only occasional pupae found in the 1989 infestation areas. These numbers could signal an increasing incidence of defoliation in nearby 1989 burns in 1991, i.e., Swan Creek, along with continuing defoliation in the current infestation area.

Pheromone-baited dry Multipher[R] traps deployed at 14 sites indicated that there is a potential for light to moderate defoliation at Swan Creek and at Vowell Creek in 1991 (Table 16).

Table 16. Predicted black army cutworm population levels[1] for 1991, Nelson Forest Region, 1990.

Low	Low-moderate	Moderate-high
Gerrard Cr. (8)	Swan Cr. (535)	Vowell Cr. (613)
Nagle Cr. (23)		
Akolkolex Cr. #1 (25)		
Akolkolex Cr. #2 (23)		
Marioka Cr.(24)		
Boulder Cr. (43)		
Rady Cr. (70)		
Cariboo Cr. (97)		
Bush Harbour (121)		
Keystone Cr. #1 (150)		
Keystone Cr. #2 (140)		
Yellow Cr. (210)		

[1]Moth catches of 350 to 600 indicate a low to moderate potential for infestations to develop, while in areas with over 600 moths, the potential is moderate to high.
( ) - number of moths per trap.

Climatic damage

Current climatic damage was not recorded but during aerial surveys, tree mortality as a result of 1988-89 winter damage was mapped over 487 ha. The most extensive tree mortality was recorded in the Morrissey Creek area where up to 90% (average 50%) of the mature lodgepole pine were killed over 185 ha. Other drainages with significant mature tree mortality included McLatchie Creek (average 20%), Couldrey Creek (50%), Sage Creek (40%) and Lladnar Creek (50%). Survey strips at Couldrey Creek contained 55% dead lodgepole pine with an additional 5% expected to die within one year. A further 25% had extensive branch dieback but were expected to survive. In the worst patch in the Morrissey Creek drainage, tree mortality was 92% and included trees of 50-cm dbh and over, but averaged 20 cm. The surviving damaged trees are initially highly vulnerable to Armillaria root disease and tree form can be severely altered into thick heavily limbed and spike-topped trees exposed to heart rot.

Other pests were also associated with the dead and dying trees. The most significant was the presence of Armillaria root disease on 80% of the trees. Woodborers infested 40% of the trees, turpentine beetle 20%, and mountain pine beetle 5%. The latter pest has been rapidly increasing in the lower portion of the Morrissey and Lodgepole creek drainages over the past few years and the stressed trees may have drawn a few additional beetles into the area but the overall course of the beetle population is not expected to be greatly affected by the winter-killed trees. Since the weather that killed the trees also killed most of the beetle population, the tree stress level should be alleviated by the time the beetle move into the area.

A characteristic gravitational draining of the tree's fluids was evident on all the dead trees. When the foliage and branches are quickly killed, transpiration ceases and the accumulated fluids in the tree's mass drain downward. As the pressure builds at the base of the trees, any breaks in the bark become an escape route, creating a wet outer bark with thick columns of pitch-like substance. This exudation acts as a strong deterrent for, and seriously impedes, brood development of insects such as mountain pine beetle in recent winter-killed trees.

In young plantations, tree mortality was minimal because most of the trees were under the snow level, but the impact was significant on the terminals. In an 11-year-old spruce plantation at Cabin Creek, all the trees had multiple tops, averaging 5.5 per tree (range 3 to 10). In the 540 000 ha of light damage where bud damage was reported throughout the East Kootenay in 1989, an average of 70% of the spruce had multiple leaders. These numbers will be reduced with time but multi-stemmed trees will result along with its associated problems, such as breakage and heartrot.

Animal damage

Although no surveys were conducted specifically for animal damage, the impact during young stand surveys was usually dramatic where it occurred. The greatest tree mortality was caused by bear damage in a western larch plantation at Erie Creek and in a recently spaced lodgepole pine stand at Blazed Creek where 32 and 28%, respectively, of the leave trees had been damaged by bear in the past year; of these, 12 and 15% were killed (4 and 3% of the total stand). Several other areas where bear damage has been noted on a regular basis are the

Yahk Ridge and upper Findlay Creek areas. The main concentration of bear damage tends to shift around within recently spaced stands and seems to gravitate towards the most recently spaced sections. Where bear populations are high, accumulated bear-caused tree mortality in spaced stands will frequently reach 10-15% within three to five years following spacing.

Squirrel damage was severe in a recently spaced 25-year-old lodgepole pine stand east of Columbia Lake. Feeding damage was present on 72% of the trees, with 32% having 50% or more of the stem girdled. Based on previous observations, approximately half (16% of the stand) of the severely damaged trees will die above the point of feeding. In addition to tree mortality directly attributed to the physical scarring, the roots of severely damaged trees were readily invaded by root rot which was contributing to their rapid death. In recently spaced pine stands, squirrel damage usually increases for the first one to two years before dropping to the pre-spacing frequency. In the absence of control sites, there also appeared to be a greater squirrel problem in dense natural stands where the number of stems were drastically reduced (72% incidence) than in stands with lower stocking prior to spacing (14%).

Voles caused light damage to spruce and lodgepole pine seedlings in the St. Mary River drainage in 1990. New plantations, most notably in the Redding Creek area, had groups of 10-20 seedlings damaged or chewed off at the base. Although the current level of damage is relatively insignificant, similar levels of damage were noted the year prior to extensive seedling damage in 1987 in the Prince Rupert Forest Region. Studies at that time indicated that mortality rates were higher in the burned sites than non-burned sites and that most of the seedlings were damaged above the first whorl, therefore allowing 80% of the damaged seedlings to recover but resulting in an increase in multi-stemmed trees. Since the vole populations tend to fluctuate on a four-year cycle, 1991 should be a peak population year.

Pinewood nematode
Bursaphelenchus xylophilus

No pinewood nematode were found in wood samples from stressed trees in 32 stands and from reject wood at eight mill sites. In forested areas, samples were selected from representative samples of trees stressed by agents such as climatic damage, drought, flooding, bark beetle, root rot, heart rot, woodborer attack and defoliator damage. Mill and log yard samples focused on low-grade lumber, especially lumber with woodborer holes. In the Pacific Region, only one of 785 samples contained pinewood nematode in 1990. Since 1980, a small number of positive samples have come from damaged or recently dead white spruce, lodgepole and ponderosa pines and Douglas-fir from five locations in the Nelson, Kamloops, Prince Rupert and Yukon forest regions.

As European pressure for certification of nematode-free wood products increases, additional research and surveys have been conducted in attempts to exclude certain tree species (western red cedar and western hemlock) and into alternatives to kiln drying as the only acceptable means of wood treatment.

Gypsy moth
Lymantria dispar

A single male gypsy moth was caught in a pheromone-baited trap at Hoodoo Creek campground in Yoho National Park in 1990. A total of 40 traps were deployed at 35 forested campground areas in the region. This was the first recorded incidence of the gypsy moth in the Nelson Forest Region in 12 years of a cooperative trapping program between Agriculture Canada, the BCFS and Forestry Canada. Previous isolated single-moth catches in B.C. have not been indicators of impending infestations. The remaining 120 adult males caught in 8000 sticky traps in B.C. this year (26 and 12 in 1989 and 1988, respectively), were in the Vancouver Region. No moths were trapped in Kelowna where a small infestation was treated in 1989.

The potential damage by this pest on forested stands is similar to other major defoliators, with up to 90% growth reduction and tree mortality by the third year of an infestation. However, this threat is not restricted only to the deciduous species favored by the early-instar larvae but is also extended to true fir, hemlock, pine and spruce which are favored by the older larvae which consume 70% of the lifetime food intake.

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 1990, 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. Monitoring of long-term foliar development and changes by foliar examination and developing a photo-file of 10 tagged branches per host also continued. Additional five-year assessments were done primarily to monitor tree growth and determine foliar and soil chemistry. Comparisons of results to similar information collected at plot establishment will further help to identify any changes.

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 rust, Chrysomyxa weirii, was common but very light on spruce, visibly affecting only 1989 foliage. No anomalies or evidence of pollution effects were noted during normal annual assessments; material from the "5-year" collections is still being processed. Assessments will continue in 1991.

PESTS OF YOUNG STANDS

A total of 27 planted and natural young stands were surveyed for pest problems in 1990 (Table 17). These surveys are part of an ongoing program and, due tothe small sample size, data from individual years do not necessarily reflect the overall situation in the region. In 20 of these stands, the major tree species had pest problems that were life-threatening, mainly root rots and animal damage. Of the 3208 trees examined, 62% were pest free, 28% had pests causing growth loss and 8% had pests that often lead to tree mortality. By species, the pines had the most severe problems: 38% of the ponderosa pine had major pest problems, white pine (28%) and lodgepole pine (13%); Douglas-fir and western larch had 9 and 7%, respectively, while Engelmann spruce, alpine fir, western red cedar, and hemlock were all near 2%. 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 17. Summary of pests of young stands, Nelson Forest Region, 1990.

Pest	No. stands affected	No. trees affected	% of trees affected[1] avg.	% of trees affected[1] range	Severity index[2]
Lodgepole pine - 1110 trees in 16 stands assessed, major species in 13 stands					
Armillaria sp.*	5	12	3	1-5	6
Inonotus tomentosus	1	2	2		6
Leptographium wageneri*	2	8	3	2-5	6
Hylobius sp.	3	10	3	1-8	5
Cronartium comandrae	1	3	2		5
Endocronartium harknessii	6	14	4	1-18	5
squirrel*	2	90	43	14-72	5
bear*	2	15	17	8-27	5
stem defects	4	51	17	3-35	4
top-kill	3	11	20	12-29	4
Atropellis canker	1	1	1		4
Pissodes terminalis	4	17	4	1-12	4
Lophodermella concolor*	2	112	25	4-47	3
Douglas-fir - 386 trees in 18 stands assessed, major species in 7 stands					
Armillaria sp.*	7	32	14	2-32	6
bear*	2	2	10	10-11	5
stem defects	1	4	8		4
top-kill	1	2	25		4
Rhabdocline pseudotsugae	5	57	26	5-82	3
Adelges cooleyi	6	24	35	10-100	3
climatic	1	9	100		3
Melampsora medusae	1	3	38		3
Phaeocryptopus gaeumannii	2	7	7	5-10	3
Contarinia sp.	1	2	3		2
Cinara sp.	2	2	10	10-11	2

(Cont'd)

Table 17 (Cont'd)

Pest	No. stands affected	No. trees affected	% of trees affected[1] avg.	range	Severity index[2]
Engelmann spruce - 668 trees in 19 stands assessed, major species in 5 stands					
Inonotus tomentosus	3	14	6	8-11	6
Pissodes strobi*	6	44	8	3-13	4
Adelges cooleyi	13	233	80	14-100	3
climatic (buds)*	2	11	9	8-11	3
mechanical	1	1	7		3
Western larch - 340 trees in 14 stands assessed, major species in 5 stands					
Armillaria sp.*	2	6	5	1-10	6
Inonotus tomentosus	1	1	10		6
bear*	1	18	32		5
mistletoe	1	23	44		4
top-kill	4	35	20	10-25	4
stem defects	2	10	11	5-17	4
Meria laricis*	8	225	87	12-100	3
Semiothisa sexmaculata*	1	40	100		3
Choristoneura biennis*	1	2	5		2
Western hemlock - 125 trees in 10 stands assessed, major species in 1 stand					
Armillaria sp.*	1	1	2		6
top-kill	1	2	5		4
stem defects	2	5	54	8-100	4
Scolytids	1	1	2		3
Cinara sp.	1	1	3		2
Western white pine - 145 trees in 14 stands assessed, major species in 2 stands					
Armillaria sp.*	1	1	14		6
Cronartium ribicola*	11	39	41	4-100	5
stem defects	3	6	41	5-100	4
Dothistroma pini*	2	2	14	4-25	3
tip miner	1	1	14		2
Cinara sp.	1	1	5		2
Alpine fir - 127 trees in 13 stands assessed, major species in 2 stands					
Armillaria sp.*	1	2	50		6
top-kill	3	31	61	33-100	4
Pucciniastrum epilobii	5	24	55	17-100	3

(Cont'd)

Table 17 (Cont'd)

Pest	No. stands affected	No. trees affected	% of trees affected[1] avg.	range	Severity index[2]
Western red cedar - 294 trees in 10 stands assessed, major species in 3 stands					
Armillaria sp.*	1	6	3		6
stem defects	1	2	100		4
Didymascella thujina	1	12	31		3
Ponderosa pine - 13 trees in 1 stand assessed, major species in none					
Armillaria sp.*	1	5	38		6

[1]Percent of trees affected includes only trees from stands in which the pest occurred.

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

DECIDUOUS TREE PESTS

Forest tent caterpillar
Malacosoma disstria

Forest tent caterpillar, accompanied by varying levels of northern tent caterpillar, Malacosoma californicum pluviale, defoliated primarily trembling aspen over 4315 ha in 19 infestation pockets. Defoliation was lighter and covered less than half the area defoliated in 1989 (9900 ha).

The most severe defoliation occurred in the relatively small patches of deciduous trees in the Spillimacheen to Parson area, south of the main areas defoliated in 1989. Defoliation declined to moderate in the Nicholson--Golden area and to generally light in the Blaeberry River area. This was the third year of the infestation in this area. Light defoliation continued along the Kootenay River flats in the Creston area but populations collapsed in the Fort Steele and Yahk areas. In the Fernie--Hosmer area, only trace defoliation was noted on some south aspect trembling aspen.

There was no recurrence of defoliation in the Mount Mackenzie and Dupont Creek area where 70 ha of trembling aspen were defoliated in 1989.

Early-larval populations indicated moderate to severe defoliation for all areas; however, larval mortality became apparent by the mid-instar stage. A total population collapse occurred in the Wasa--Fort Steele area and populations were significantly reduced in all other areas. The high larval mortality was in part attributed to adverse cold and wet weather conditions following larval emergence which, in many cases, occurred prior to foliage flush. Stress caused by these climatic conditions also favored the rapid development and spread of disease in the tent caterpillar population. A nuclear polyhedrosis virus (NPV) was present in all larval samples from the Wasa Lake--Fort Steele area.

Egg-mass surveys also indicated further population reduction to basically endemic levels in 1991, with light defoliation expected only in the Nicholson area (Table 18).

Table 18. Location, average number of 1990 egg masses per tree and predicted defoliation of deciduous stands by forest tent caterpillar in 1991, Nelson Forest Region, 1990.

Location	Average[1] dbh (cm)	Average no. egg[2] masses/tree	Predicted defoliation
Nicholson	5	3	light
Fort Steele	5	<1	trace
Wasa Lake	5	<1	trace
Golden	8	<1	trace
Blaeberry R.	5	1	trace
Washout Cr.	5	<1	trace
Average	5.5	1	

[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.

Birch leafminers
Profenusa thomsoni
Fenusa pusilla
Lyonetia saliciella

Discoloration by this leafminer was more intense and widespread than in 1989, causing moderate browning to mainly roadside birch from Shelter Bay through to Revelstoke and continuing north to Goldstream River. Only light to moderate discoloration in the Revelstoke area was present in 1989. At a new infestation near Castlegar, there was scattered light discoloration of young birch. This introduced leafminer has gradually spread westward, feeding on native birch, unlike Fenusa pusilla, which caused light defoliation near Canal Flats and which appears to be confining most of its feeding to ornamental birch. The native birch leafminer, Lyonetia saliciella, which has over the past fifteen years caused extensive discoloration of birch in the Golden to Rogers Pass and Kaslo to Meadow Creek areas, was not evident in 1990 after a major decline in 1989.

Western winter moth
Erannis vancouverensis

Populations of western winter moth increased in the region in 1990, with light defoliation over 10 ha of trembling aspen, hazelnut and Saskatoon at Fruitvale; the main defoliator over 5 ha was the American aspen beetle. At Beaver Falls, white birch was lightly to moderately defoliated over approximately 1 ha. Spot infestations were common on the west side of the Columbia River between Castlegar and Trail. Low, but increasing numbers of larvae were also observed in the Creston area. This pest reaches infestation proportions only intermittently in the interior, mainly in years preceded by extended mild fall weather.

American aspen beetle
Gonioctena americana

This leaf beetle, in association with western winter moth, severely defoliated young trembling aspen over 5 ha at Fruitvale. Defoliation by this leaf beetle has been increasing in the Fruitvale area since 1988 when 0.1 ha was recorded, increasing to 0.2 ha in 1989. Along with the alder woolly sawfly, it was also causing severe defoliation of roadside alder for 0.3 km along St. Cyr Creek north of Revelstoke.

Alder woolly sawfly
Eriocampa ovata

This sawfly severely defoliated young alder over 0.2 hectares at Castlegar and along with the American aspen beetle, severely defoliated roadside alder for 0.3 km along St. Cyr Creek. It is a European species that initially became established on red alder on the coast but has since spread to other alder species in the interior of B.C. With two generations a year, population increase can be rapid.

Apple and thorn skeletonizer
Choreutis pariana

The apple and thorn skeletonizer again caused intermittent light to severe foliar skeletonizing, primarily of apple, over much of the West Kootenay, including the Revelstoke and Creston areas. Damage was particularly evident in the Castlegar through Nelson to Balfour area, at Kaslo and along Highway 6 from Highway 3 to Nakusp including New Denver. With two or more generations a year, defoliation may initially appear in mid-June and continue through till August. When populations are not kept under control, infested trees will die back.

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(s)[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
Corythucaha sp. Lace bug	B	St. Mary L.	light defoliation
Dendroctonus brevicomis western pine beetle	trap	Roosville	first record in East Kootenay
Dendroctonus valens red turpentine beetle	pP,lP	southern part Rocky Mtn. Trench	killing small groups of trees
Ectropis crepuscularia saddleback looper	trap	Revelstoke	negative, cooperative trapping trial with U. of California
Hylobius warreni Warren's root collar weevil	lP	throughout host range	common at low levels
Ips mexicanus Monterey pine ips	lP	south Rocky Mtn. Trench	in high-elevation stands
Leucoma salicis satin moth	Po	Slocan L., Golden	occasional larvae, trace defoliation

Pest	Host(s)[1]	Location	Remarks
Rhyacionia buoliana European pine shoot moth	pP	Keenleyside Dam	negative
Pineus spp. spruce gall adelgid	eS	throughout host range	generally light
DISEASE			
Chrysomyxa ledi red-huckleberry rust	eS	upper Kootenay R.--Vermilion R.	light infection
Coleosporium asterum western pine--aster rust	lP	throughout host range	light Flathead R.
Cronartium coleosporioides stalactiform blister rust	lP	Steward Cr., Sentinel Mtn.	occasional single stem infections.
Cucurbidithis pithyophila var. *pithyophila* cucurbidithis canker	P	Golden	twig dieback on 25% of limber pine
Didymascella thujina cedar leaf blight	wrC	W. Nelson	infections common, mostly light
Mycosphaerella populicola a leaf spot	tA	Mosquito Cr.	new host record
Podosporium sp. needle blight	gF	Nelway	new record, occasional on underside of needles
Pucciniastrum epilobii fir--fireweed rust	alF	W. Kootenay	light, common throughout on current foliage
Rhabdocline pseudotsugae Douglas-fir needle cast	D-fir	Flathead R., Kootenay L., Columbia L., W. Kootenay	ranging from light to severe, occasional throughout W. Kootenay
Venturia macularis shepherd's crook	tA	Kicking Horse R., Morrissey, W. Kootenay	300 ha of moderate to severe defoliation, light in most aspen stands

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