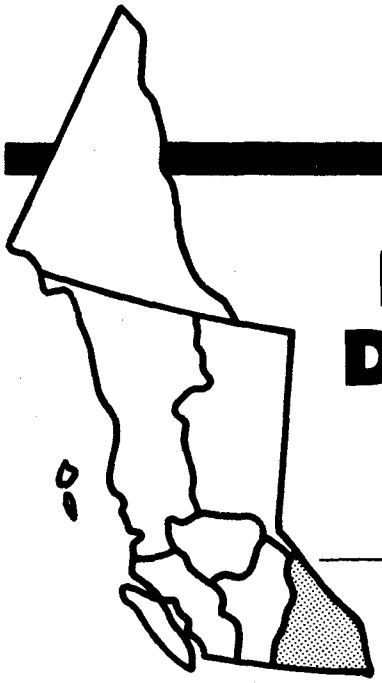

Forest Insect and Disease Conditions

Nelson Forest Region
1986

H.P. Koot and J. Vallentgoed

Government of Canada
Canadian Forestry Service

Gouvernement du Canada
Service canadien des forêts

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SUMMARY

This report outlines the status of forest insect and disease conditions in the Nelson Forest Region and Mt. Revelstoke and Glacier National Parks in 1986, and attempts to forecast population trends and highlight pests that are capable of sudden damaging outbreaks resulting in forest management problems.

Mountain pine beetle continued to be the most damaging pest in the Region, killing more than 1.2 million lodgepole and western white pine on 25 670 ha as compared to 1.0 million trees on 14 600 ha in 1985. This is the first increase after four successive years of decline. After many years at endemic levels, the **western pine beetle** increased to infestation levels in ponderosa pine stands in three locations in the Boundary and Arrow TSA's. The **red turpentine beetle** was common on ponderosa pine in fire-damaged stands in the East Kootenay. **Engraver beetle** populations were frequently high in association with **mountain pine beetle** infestations in the Region. **Pine needle sheathminer** severely discolored lodgepole pine stands of up to 200 ha in several areas between Kaslo and Fernie. **Western pine shoot borer** killed terminals and laterals of young ponderosa pine in several locations in the Boundary TSA. **Pine stem rusts** were prominent in several pine plantations in the Golden TSA. Pine needle diseases including **red band needle disease** and a **pine needle blight** were less evident than in 1985. For the first time, **pinewood nematode** was identified (pending confirmation) from two wood samples in the Region.

Spruce beetle infestations declined sharply to mostly endemic levels from 575 ha of infestation in 1985. The first occurrence of the **Allegheny spruce beetle** in the Region was found near Howser Creek. This species is not yet recognized as an economically important species in Canada.

Light to moderate defoliation of Douglas-fir by **western spruce budworm** expanded to nearly 3 700 ha in 15 infestations in the Boundary TSA, up from 60 ha in 1985. **Douglas-fir beetle** infestations increased slightly to 27 small centres of attack. **Douglas-fir tussock moth** populations remained at low endemic levels while two species of **Douglas-fir leaf scarab** caused some minor defoliation in the East Kootenay. **Armillaria root disease** was common at low intensity levels in several Douglas-fir and lodgepole pine plantations examined in the Region.

With a few exceptions, **larch casebearer** populations declined to endemic levels in most previously defoliated areas. After three consecutive years of defoliation, the **larch budmoth** outbreak collapsed. **Larch needle diseases** continued at low levels throughout the host range. Populations of **larch sawfly** were at endemic levels, but for two pockets of light defoliation at Castlegar and Skookumchuck Creek.

Recent alpine fir mortality by the **western balsam bark beetle complex** covered 2 400 ha in 145 widely scattered areas of the Region. **Two-year-cycle spruce budworm** lightly defoliated alpine fir and spruce on 500 ha in the upper St. Mary River and Dewar Creek drainages. Surveys for **balsam woolly aphid** were again negative in grand and alpine fir stands along the Canada-U.S.A. border.

Conifer sawfly populations declined on western hemlock after causing light defoliation along Boundary Creek near Creston. **Western blackheaded**

budworm populations returned to endemic levels after declining to 195 ha of defoliation in 1985 from 19 000 ha in 1984.

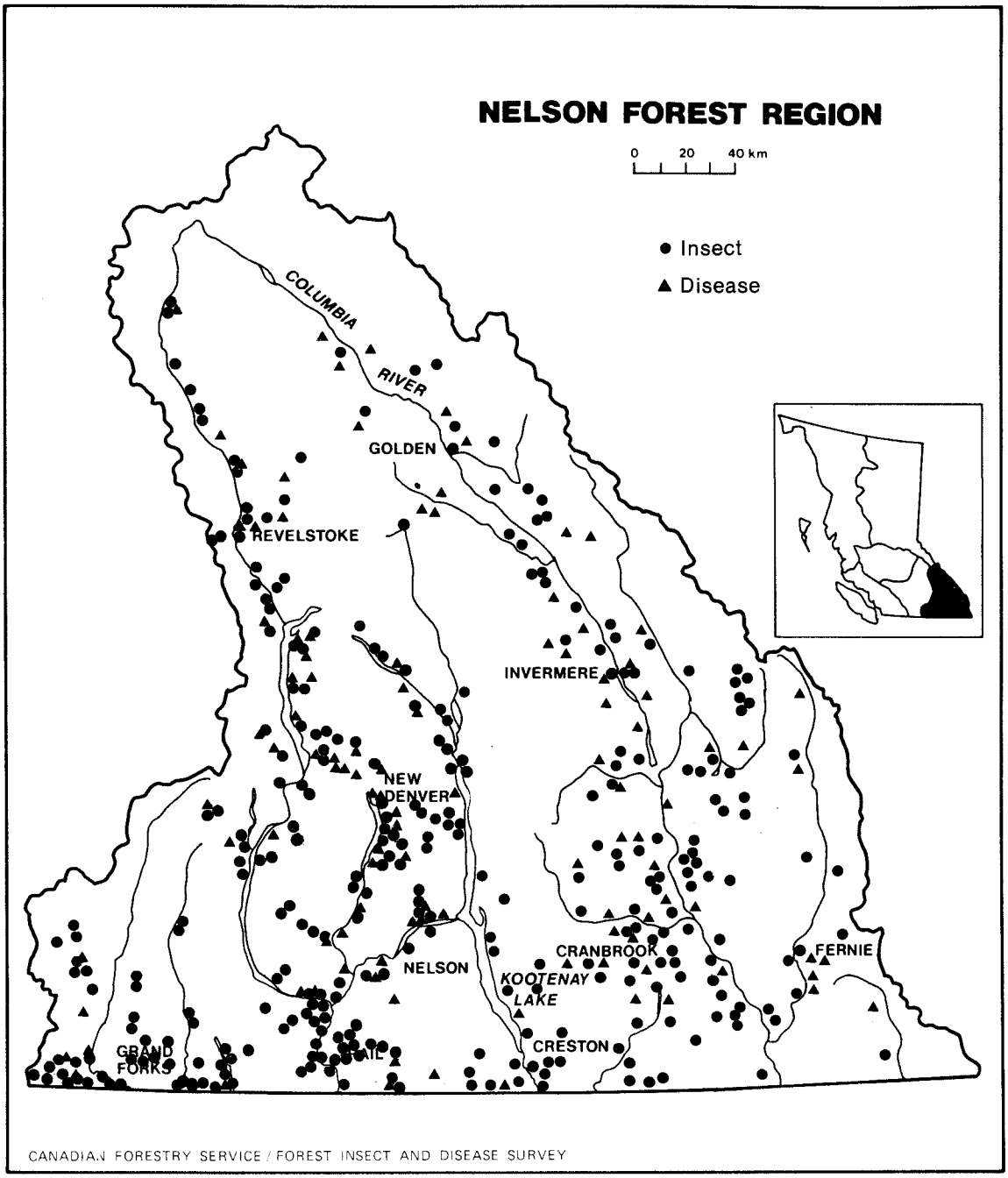
Forest tent caterpillar infestations in deciduous stands expanded to 1 200 ha, most notably in the Trail area. This is a tenfold increase from 1985. **Satin moth** populations generally declined with only small pockets of defoliation occurring near Bridesville and Moyie on trembling aspen and black cottonwood, respectively. **Birch leafminers** discolored birch stands in the northern half of the Region for the twelfth consecutive year. No **gypsy moths** were caught in any pheromone-baited traps placed at 34 locations in the Region. Infections of **poplar shoot and leaf blights** on aspen and cottonwood increased with up to 90% foliage discoloration in isolated small areas.

Although initial larval populations of **black army cutworm** were very low in East Kootenay burns, pheromone-baited traps indicate a potential for damage to newly planted seedlings in several areas in 1987. **Winter injury**, **drought damage**, and **salt damage** were more prominent than in previous years, occurring in scattered locations mostly in eastern portions of the Region.

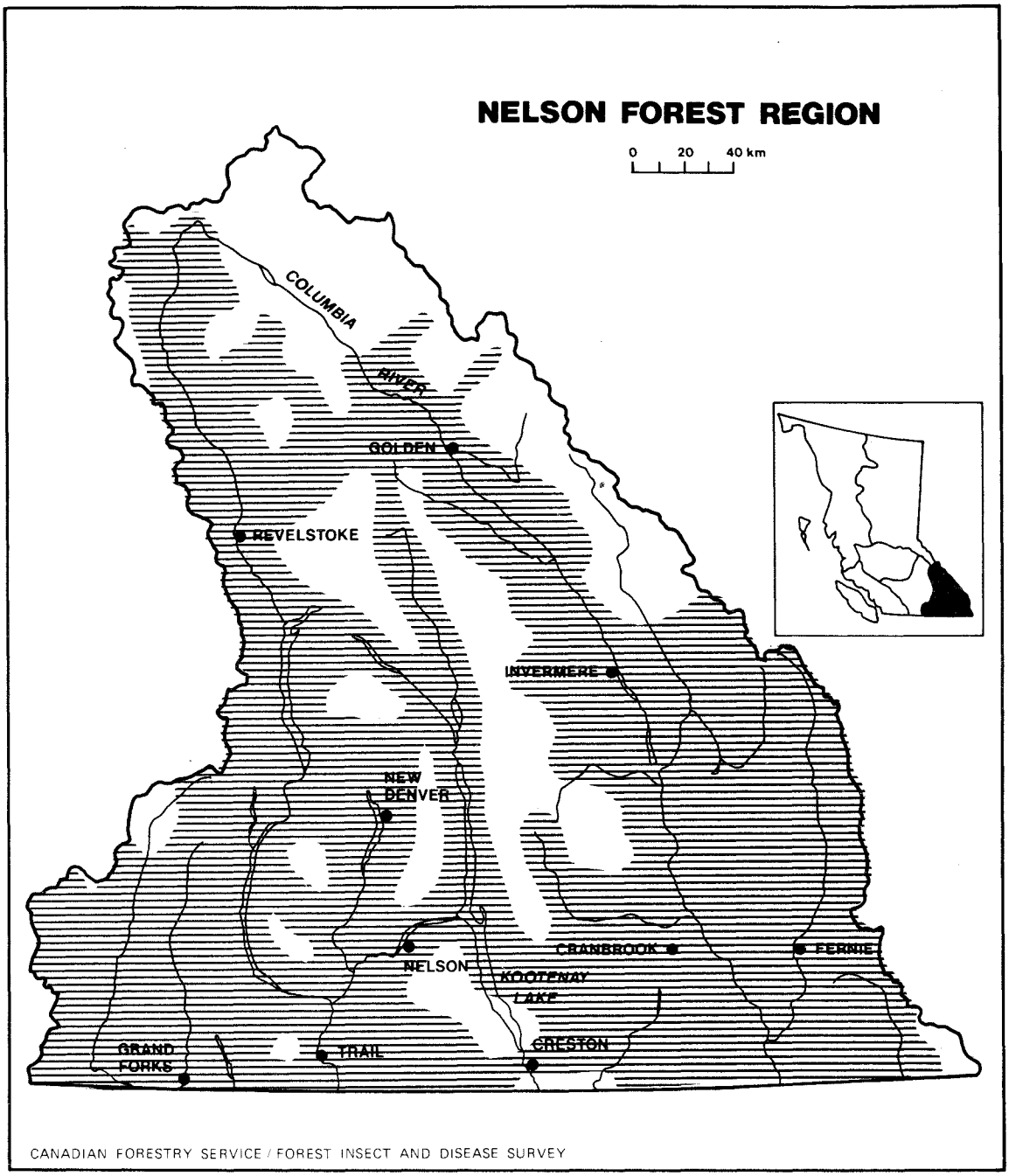
The 1986 field season which began on May 20 and ended October 2 was characterized by a short period of very warm temperatures in late spring, followed by mixed conditions in June, a moist and cooler than average July, a warm dry August and a cool moist September. Several diseases such as leaf and needle blights became noticeably more prominent with the advance of summer as a result of the moist conditions in many parts of the Region. With the increase in inoculum, the incidence and intensity of foliar diseases in 1987 may increase under normal weather conditions.

A total of 311 insect and 128 disease collections were submitted by FIDS for identification to the Pacific Forestry Centre. An additional 25 insect and 25 disease samples were collected by provincial agencies, industry and private sources. Locations where one or more collections were made by FIDS are shown on Map 1.

Approximately 52 hours of fixed-wing flying and 2 hours of helicopter flying time were provided by the B.C. Forest Service and Parks Canada, respectively, to observe, map and photograph currently active forest pest damage in the Nelson Forest Region and two National Parks. The area covered by aerial surveys is shown on Map 2.



Map 1. Locations where one or more forest insect and disease samples were collected in 1986.



Map 2. Areas covered by aerial surveys to map bark beetle and defoliator infestations, 1986.

PINE PESTS

Mountain pine beetle, Dendroctonus ponderosae

Mountain pine beetle killed more than 1.2 million lodgepole and western white pine over 25 670 ha in 3 208 infestations in the Nelson Forest Region, and an additional 7 640 pines on 2 450 ha in Kootenay, Glacier and Mt. Revelstoke National Parks (Table 1 and Map 3). This is an increase in area from 14 600 ha and 665 ha recorded in 1985 in the Region and National Parks, respectively, after four successive years of decline.

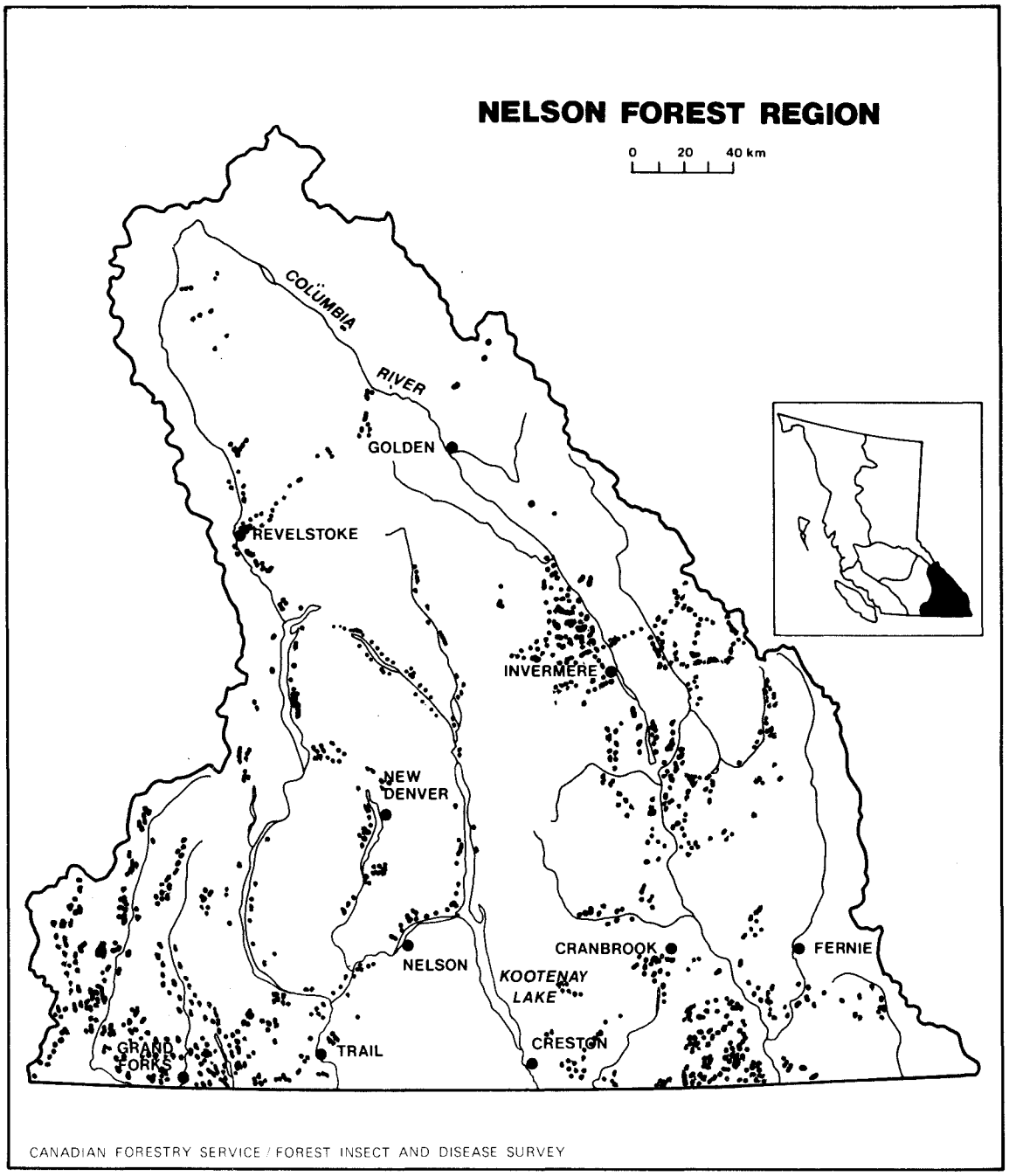
Table 1. Location, number, area and volume of pine recently killed by mountain pine beetle as determined from aerial and ground surveys, Nelson Forest Region and National Parks, 1986.

TSA[1] or Park	Tree Species[2]	No. of Infestations	Area (ha)	Trees killed (faders)[3] No.	Vol. (m^3)
Cranbrook	lP	1029	3 800	191 100	68 800
Invermere	lP	678	13 600	663 400	238 800
Golden	lP, wwP	30	440	11 000	4 000
Revelstoke	lP, wwP	94	1 530	3 900	3 800
Kootenay Lake	lP, wwP	182	400	3 500	3 300
Boundary	lP	960	5 150	327 500	117 900
Arrow	lP, wwP	235	750	14 700	7 800
Total		3208	25 670	1 215 100	444 400
Kootenay N.P.	lP	90	1 600	5 500	2 000
Glacier N.P.	lP, wwP	17	75	440	400
Mt. Revelstoke N.P.	wwP	8	835	1 700	1 700
Total		115	2 510	7 640	4 100
GRAND TOTAL		3 323	28 180	1 222 740	448 500

[1]Timber Supply Area
[2]lP - lodgepole pine; wwP - western white pine
[3]Trees attacked in 1985, discolored in 1986.

While many of the apparent expansions in the Region can be associated with previous good overwintering brood survival, some of the increase such as occurred in Boundary TSA can be attributed in part to more intensive aerial coverage.

The most dramatic increases occurred in the West Kootenay where infestations expanded from 1 500 ha in 1985, to nearly 8 000 ha in 1986. In the East Kootenay, beetle infestations expanded to 17 800 ha from 12 500 ha in 1985, in spite of host depletion from previous beetle attacks, timely harvesting of susceptible and infested stands, wild fires and stand



Map 3. Areas of lodgepole pine recently killed by mountain pine beetle, determined by aerial and ground surveys, 1986.

management practices such as pheromone-baiting. Losses in the Invermere TSA could have been moderated except for the occurrence of large wild fires in 1985. This necessitated giving harvesting priority in favor of 2 million m^3 of surplus inventory created by fires, resulting in reduced harvesting of beetle-killed pine.

In the Cranbrook TSA, infestations occurred over 3 800 ha compared to 3 850 ha in 1985. The status of beetle infestations did not change significantly in most of the major problem areas, which include Ward-Gilnockie creeks, Caven, Bloom, Purcell, Linklater and Wickman creeks. However, new infestations developed near Cranbrook along Peavine Creek, near Lumberton, and Jim Smith Lake, where very little evidence of beetle activity was noted previously. Recent timely harvesting of infested pine throughout much of this area has lessened the potential for expansion considerably. Elsewhere, small scattered pockets along steep slopes near St. Mary Lake doubled in size while small infestations along the Galton Range apparently declined in intensity and extent.

After four successive years of decline in the Invermere TSA, infestations increased to 13 600 ha from 8 300 ha in 1985. Most of this expansion occurred north of Invermere in the Steamboat Mountain, Forster Creek and Frances Creek areas where current (1986) attack averaged 10% of the pine and the ratio of 1986 attack to 1985 attack was 2 to 1 (Table 2). The substantial increase in small pockets of new lodgepole pine faders observed north of Halgrave Lakes suggests a northward expansion on both sides of Steamboat Mountain. This is despite previous attempts at controlling the northward migration of the beetle by cut-and-burn operations and timely harvesting. Elsewhere in the TSA the status of infestations is similar to 1985, including in the designated control blocks adjacent to the B.C./Alberta border. Some minor increases were noted along the Upper Cross and Mitchell rivers where B.C.F.S. cut-and-burn operations are ongoing. In nearby Kootenay National Park the number of recent faders increased to 5 500 in 90 infestations, from 4 000 in 58 infestations in 1985. Most of the increases have occurred along the lower slopes of Mounts Selkirk, Daer and Harkin and east of Radium Hot Springs on both sides of Sinclair Creek. In this latter area (1986) attack averaged 30% of the pine component and the ratio of current attack to 1985 attack was 2 to 1. Any control action contemplated in the Park would probably be restricted to discrete patches near Kootenay Crossing, which are within the designated control zone.

Table 2. Status of lodgepole pine in stands infested by mountain pine beetle, Nelson Forest Region, 1986.

Location	Percent (%) of pine attacked				Percent Healthy
	Current attack (1986)	Partial attack (1986)	Red (1985)	Grey (prior to 1985)	
Westside Rd.	11	8	1	7	73
Forster Creek	9	8	4	4	75
Steamboat Mtn.[1] (Ridge Rd.)	0	17	25	35	23
Sinclair Creek (Kootenay N.P.)	30	11	16	14	29

Location	Percent (%) of pine attacked				Percent Healthy
	Current attack (1986)	Partial attack (1986)	Red (1985)	Grey (prior to 1985)	
Larsen Lake	23	4	11	34	28
Wickman Creek	3	3	2	2	90
Porcupine Creek	5	5	10	7	73
Rathmullen Creek	9	5	4	14	69
Wallace Creek	11	0	6	15	68
Phoenix Mtn.	24	0	14	24	38
Collier Lakes	10	12	17	19	42
Mt. Ferroux	5	7	13	11	64
Average	13	7	9	14	59

[1]Data not used in determining averages as this area is in older infestation.

The number of infestations in lodgepole pine and western white pine stands doubled to 30 in the Golden TSA, and increased in area to 440 ha from 325 ha in 1985. This increase was largely due to new white pine faders occurring in pockets of 2 to 20 trees each along McNaughton Lake at Beaver Canyon. The only other noteworthy infestations occur in lodgepole pine over several hundred hectares along the Blaeberry River. Their status has not changed perceptibly in the past several years. In Glacier National Park, beetle activity increased along the Beaver and Illecillewaet rivers, where 75 ha were infested compared to 65 ha in 1985. Expansion of the infestation is limited in the Park and there is no threat to adjoining provincial crown land.

In the Boundary TSA, 960 infestations covered approximately 5 148 ha, a continued expansion from 250 infestations on 1 200 ha in 1985 and 109 infestations over 1 025 ha in 1984. Much of the large increase in both number of infestations and area affected is due to an expanded aerial survey. In the area north of Grand Forks between the Granby River and Christina Lake, activity increased with infestations of 0.25 ha to 20 ha quadrupling in number, attributable only in part to intensified surveying. A dramatic increase in beetle activity was also noted south of Eholt Creek between Greenwood and Wilgress Lake near Jewel Lake, Copper Mountain and at Sutherland Creek east of Christina Lake. Dozens of infestations varying from 0.25 ha to 30 ha in size were harbored in Texas Creek and east to McRae, Walker and Boundary creeks and in side drainages including Henderson, Windfall and Wallace creeks. These areas were not surveyed in 1985. Similarly, in previously unsurveyed areas many recent faders were mapped along the Kettle River north of Westbridge, including Fourth of July Cr., Crouse Cr., Waddell Cr. and associated subdrainages as well

as Beaverdell Cr. to Collier Lakes. Other active areas include Mt. Ferroux-Weird creeks, Arlington Lakes and West Kettle River, where the beetle problem continues despite extensive salvage logging over the past five years (interrupted in 1986 by a long strike). At Rathmullen Creek considerable recent salvage logging has taken place and a pheromone-baiting program continues in efforts to concentrate beetle activity within manageable parameters. In the Bitter-O'Farrell creeks area near the U.S. border east of Grand Forks, beetle activity and salvage logging continue unabated. Spot infestations increased and continue north in the Granby Creek drainage to Sally Creek, in the Kettle River drainage north to the TSA boundary and at Nevertouch Lake, Damfino Creek and Copperkettle Creek. Similar activity continues along the West Kettle River south of Beaverdell including Kelly River, west of Conkle Lake along East Conkle Creek and south along Rock and McKinney creeks.

Ambrosia beetles in the Boundary TSA in association with the mountain pine beetle attacked an estimated 25% of lodgepole pine in Snowball Creek and 15% of lodgepole pine at Rathmullen Creek during the spring of 1986. The presence and persistance of this woodborer in pine beetle-attacked trees is not uncommon, but has export implications as several overseas countries have quarantines on lumber showing signs of ambrosia beetle attack.

In the Arrow TSA, a total of 235 infestations covered 750 ha, up from 15 infestations over 250 ha in 1985. Dramatic increases in the number of infestations were primarily due to increased beetle attack in western white pine, which accounted for 40% of the affected area. Numerous spot infestations occurred throughout the TSA, particularly in the Moberly Creek drainage, along the west side of the Columbia River south of Castlegar, Champion Lakes, Whatshan River, Trout Lake, the west side of Slocan Lake and the east side of Arrow Lake from Halfway River to Nakusp and east to Wilson Lake. Infestation expansions in lodgepole pine stands occurred in several areas including Moberly Creek, Nancy Greene Lake and in the chronic Springer-Chapleau creeks area where beetles have virtually run out of host material at high elevations.

In the Revelstoke TSA, the increase was primarily due to increased attack of western white pine, where 94 infestations occurred over 1 531 ha, up from six infestations over five hectares in 1985. Spot infestations, primarily of 5-50 trees each, occurred along Bigmouth Creek, Goldstream River, Carnes Creek and south to Revelstoke along the Columbia River, along Highway 1 from Albert Canyon to Revelstoke and along the Upper Arrow Lake from Revelstoke to Shelter Bay.

In the Kootenay Lake TSA, 182 infestations occurred over 404 ha, up from 15 infestations over 35 ha in 1985, but below the 1984 level of 507 ha. In the Hawkins-Freeman creeks area, 15 spot infestations of 2-12 lodgepole pine each were noted, similar to 1985. Due to the potential for a major outbreak in these nearly pure, mature lodgepole pine stands, this area is being aggressively addressed by the B.C.F.S. with salvage logging, access roads and close monitoring. Virtually all other areas of mountain pine beetle attack were in western white pine and were substantially increased over 1985. Beetle infestations of 0.25 ha to 50 ha (with 10% attack) each were noted on the south side of Kootenay River west of Nelson, especially along Sandy and Eagle creeks. Spot infestations were common along Kootenay Lake from Nelson north to the Lardeau River, Trout Lake, Duncan Lake and Duncan River north to Hatteras Creek with noteworthy infestations along Little Glacier and North creeks. Small

infestations in western white pine were also noted along Goat River, Kamma Creek and west of Leadville Creek. Along Kitchener Creek, white pine faders were common in groups of 5-20 trees from Kitchener to Yahk.

There was a substantial increase in attack on western white pine through much of the Region from fewer than 25 infestations mapped in 1985 to 432 in 1986. Excellent brood survival in the spring of 1985 plus abnormally favourable climatic conditions during the 1985 flight window may have allowed a dramatic expansion. An expanded aerial survey and increased emphasis on this host also contributed to increased numbers. However, none of the above seem sufficient to supply the complete picture. Lodgepole pine was similarly affected, but less noticeably. How these spot populations build and affect surrounding susceptible hosts in 1987 cannot be projected with a lack of historical information.

The 1986 beetle population trend in the Nelson Forest Region was characterized by an overall increase. Due to a relatively mild 1985-86 winter, the survival rate of beetle progeny examined in seven areas in late spring averaged about 75%. This is considered good survival in terms of potential population growth. Based on the ratio of surviving overwintering progeny to parent beetles, the population trend ('R' value) ranged from 5 to 12.6 and averaged 8.9; an 'R' value greater than 4.1 indicates increasing populations. Subsequent surveys in the Fall in 12 infested stands supported this forecast and indicated a current (1986 attack) to red (1985 attack) ratio of 1.4 to 1. This again is indicative of a continuation and possible increase in tree mortality in many currently infested stands in the Region. High risk areas for potential increase in beetle activity include those in Invermere TSA north of Invermere along both sides of and on Steamboat Mountain to Bugaboo Creek, Dutch Creek, and Sinclair Creek in Kootenay National Park. Included in Cranbrook TSA are areas immediately west and south of Cranbrook and farther south between Bloom and Gold creeks. In the West Kootenay the greatest potential for expansion is in the Boundary TSA north of Grand Forks between the Kettle River and Christina Lake.

Western pine beetle, Dendroctonus brevicomis

The western pine beetle, D. brevicomis, infested ponderosa pine in three locations in the Boundary TSA and at least one in the Arrow TSA, causing generally minor losses. Three spot infestations were mapped during aerial surveys. At one site near Grand Forks, approximately 100 codominant and intermediate trees were killed by the western pine beetle although Ips emarginatus and D. valens were also active. At a site near Fruitvale, mature ponderosa pine were attacked over an estimated five hectares. Fifteen red trees and two current attacks were noted in this interrupted salvage operation.

The western pine beetle normally attacks downed or stressed trees but under epidemic circumstances becomes aggressive and kills apparently vigorous trees of all age classes with sufficiently thick bark to harbor the developing brood. At the Grand Forks site a number of conditions combined which may have predicated the attack, including a dry summer in 1985, a dry rocky site and slash from which Ips beetles may have been the initial attacking agent to stress the trees. At Fruitvale, mature to overmature ponderosa pine in a moist southern interior cedar-hemlock (ICHa) biogeoclimatic subzone (not a preferred site for ponderosa pine) in conjunction with the 1985 drought may have been sufficient to initiate the attack.

Major epidemics of western pine beetle occurred during the droughts of the 1920's and 1930's, devastating ponderosa pine in the NW United States and parts of southern B.C. While conditions and host availability preclude a repetition in the Nelson Forest Region, completion of salvage logging at the Fruitvale site prior to the May/June 1987 flight is important to prevent further losses. The Grand Forks site may require some action although no currently attacked trees were noted during walk-through surveys.

Red turpentine beetle, Dendroctonus valens

Attacks by this ordinarily non-aggressive beetle increased substantially, particularly in fire-damaged stands in the East Kootenay. About 5% of immature fire-scorched ponderosa pine were infested over several hundred hectares of range-burned area north of Skookumchuck. Many of these trees are expected to die due to the intensity of infestation and the frequent associated attack by Ips spp. Similar conditions prevailed in the "Spen Fire" at Thunderhill Provincial Park and in adjacent stands along the Findlay River.

In the West Kootenay turpentine beetles in concert with D. brevicomis and Ips emarginatus killed 100 intermediate and codominant ponderosa pine at Grand Forks.

Turpentine beetles were also found in stumps and severely stressed trees in association with the primary agent, D. brevicomis, in a 5-ha infested area near Fruitvale.

Pine engraver beetle, Ips pini

The pine engraver, generally a secondary beetle, attacked 40 lodgepole pine in a one-hectare infestation at the Plumbob-Newgate roads junction. Large numbers of beetles apparently developed in adjacent slash piles created by land clearing, and subsequently attacked the living trees. Outbreaks are usually of short duration, seldom lasting more than one season.

Elsewhere, the pine engraver and other Ips spp. were common in stressed lodgepole pine and those associated with mountain pine beetle attack throughout the host range in the Nelson Forest Region.

Pine needle sheathminer, Zelleria haimbachi

Increased populations infested and discolored new shoots of lodgepole pine in scattered areas, mostly in the East Kootenay. Severe browning and defoliation of up to 100% (average 50%) of 1986 growth occurred in 30- to 60-year-old pine stands and roadside regeneration between Yahk and Cranbrook. Discoloration was most severe on terminals and on shoots in the upper crown. Occasional ponderosa pine were also infested. Several hundred hectares were moderately defoliated in the Kimberley-Meadowbrook area and along Coal Creek near Fernie.

In the West Kootenay sheathminers infested 95% of semimature and young regeneration lodgepole pine on a 0.5-ha area near Kaslo. Discoloration of 1986 needles averaged 40% over entire crowns. Similar damage was noted for several kilometres along Highway 31, north and south of this site.

This needle miner is generally of limited economic importance. No tree killing has been observed, but growth reduction would be strongly suspected where severe defoliation has taken place. Severe defoliation by itself can be serious in arboreta, ornamental plantings, and Christmas tree plantations.

Western pine shoot borer, Eucosma sonomana

Terminals and upper crown lateral shoots on young open-grown ponderosa pine were killed by the western pine shoot borer in several locations in the Boundary TSA. Early spring assessments and collections showed 20% of young trees (2-5 m) in a one-ha area in Grand Forks and 64% of 3-6 m pine in a 2-ha plantation near Rock Creek were previously infested by the shoot borer. An average of one or two shoots were killed per tree (damaged shoots may be retained for several years). At the Grand Forks site, current attack was 5%. In a late season survey an estimated 20-40% of roadside regeneration near the Christina Lake Golf Course showed current and old shoot borer damage. Shoot-kill was light, averaging 1 or 2 shoots per tree. Damage caused by this insect is limited to retarded height growth and branchiness.

Pine stem rusts, Cronartium spp.

Throughout the host range, various stem rusts are responsible for mortality, top-kill and branch dieback of young sapling to mature pines.

Aerial and ground surveys for white pine blister rust, Cronartium ribicola, showed that repeated infection frequently increased the amount of mortality and top-kill over time. In two surveys, 33 and 17% of young white pine were dead or infected by this cankering agent at Fitzstubbs Creek and an adjacent site, respectively. It is noteworthy that in this area, white pine growing in Armillaria obscura root rot centres appeared not to be affected, while Douglas-fir were dead or dying from this root disease.

At two other locations, the high infection intensity of both stalactiform blister rust, C. coleosporioides, and comandra blister rust, C. comandrae, resulted in alterations to proposed silvicultural treatments of regeneration lodgepole pine. Along Blackwater Creek in the Golden TSA where 30% of pines were infected on 10 ha, proposed thinning of the area resulted instead in the removal of infected stock and replanting with Douglas-fir. At Blackwater Ridge where 30% of pine were infected on 20 ha, thinning will emphasize removal of infected stems.

Intensity of damage in pine stands varies greatly, depending on susceptibility of pine species and even of individual trees within species, climate and, except for western gall rust, Endocronartium harknessii, the proximity and abundance of secondary hosts.

Red band needle disease, Dothistroma (Scirrhia) pini

The incidence and intensity of infections in western white pine stands decreased for the second consecutive year throughout the Region in 1986, due in part to unfavourable dry conditions during much of the spore dispersal and infection period in 1985.

Red band needle disease, D. pini, the imperfect form of Scirrhia pini, was first identified in the Nelson Forest Region at Hills, south of Nakusp, in 1982. The disease has since been found from the U.S.-Canada border to Begbie Creek south of Revelstoke and this year was the suspected cause of needle loss and discoloration in the Cusson Creek area.

In a one-hectare permanent plot established in 1982 near Summit Lake, current infection was light but overall defoliation due to repeated infection averaged 71% in the 20 plot trees. This compares to only 56% overall defoliation recorded in 1982 at time of plot establishment, 75% in 1983, 82% in 1984 and 64% in 1985. While 1986 figures compare favourably with 1984 results (71% defoliation, down from 82%), there has been little recovery and the continued loss of photosynthetic capacity has resulted in very little diameter growth (avg. 0.6 cm per tree over the four-year growing period), and only an average of 0.6 m height growth per tree over the same period (0.15 m per year). This compares very unfavourably to normal growth expectations of 0.3 to 0.4 m height growth per year in healthy young stands as determined from studies on height growth of young white pine in northern Idaho. Within the plot, a clear inverse relationship on a per tree basis between growth and percent defoliation over the study period may also be noted (Table 3).

Table 3. Percent defoliation and four-year average DBH and height growth of white pine plot trees infected with D. pini at Summit Lake, Nelson Forest Region, 1986.

Avg. % defoliation	# trees	Avg. DBH growth (cm)	Avg. ht. growth (m)
81-90	6	.04	.2
71-80	3	.23	.3
61-70	5	.96	.6
51-60	5	.9	1.2
<50	1	2.1	1.0

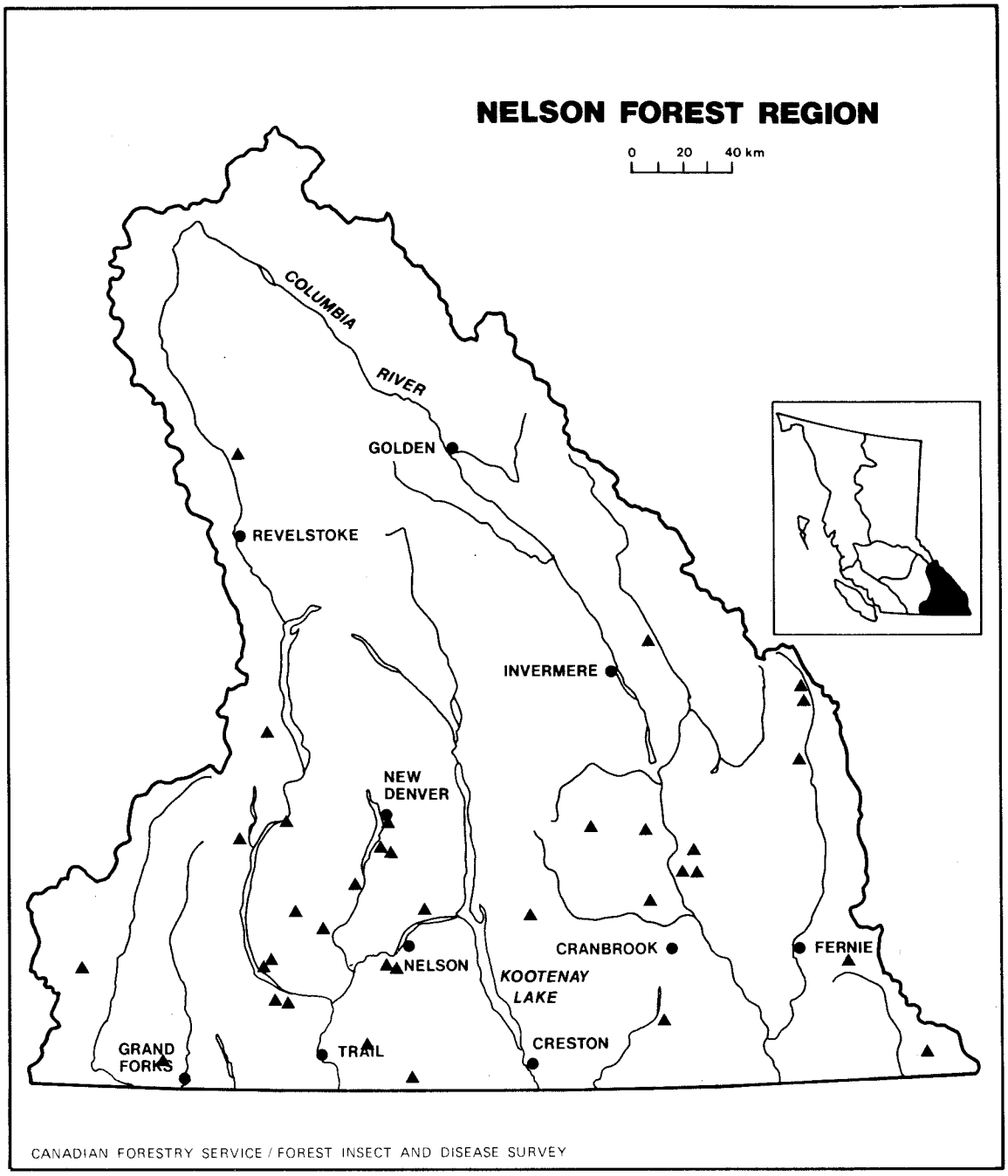
In 80% of white pine, defoliation varied from light to severe for 4.4 km along Fosthall Rd. near Cusson Creek where the white pine component represents about 5% of the stands. However, D. pini, the suspected causal agent, was not confirmed. Additional sampling will be required in 1987.

Variable weather conditions during the 1986 spore dispersal period preclude predictions for 1987.

Pinewood nematode, Bursaphelenchus (lignicolus) xylophilus

Pinewood nematode was tentatively identified (subject to verification) in two wood samples from the Nelson Forest Region in 1986. One from a fire-scorched and woodborer-infested ponderosa pine near Skookumchuck, and the other from a stressed lodgepole pine near Christina Lake. Woodborer (Monochamus sp.)[1] adults

[1] a nematode vector



Map 4. Locations where samples for pinewood nematode were taken, 1986.

plus stem discs and wood chips from upper, mid, and lower sections of stressed or dying lodgepole pine were examined from 28 other areas, but contained no pinewood nematodes (Map 4). Several other native bacterial nematodes were isolated from seven of these samples.

After three years of special surveys for this pest, this is the first positive indication of its presence in standing trees in British Columbia. Surveys were required to provide phytosanitary certification for export of wood products to several countries.

A pine needle blight, Leptomelanconium pinicola (cinereum)

Infection levels of this needle blight decreased throughout the chronically infected ponderosa pine stands in the Elko-Baynes Lake-Grasmere area. Less than 10% of year-old needles were infected in 1986 as compared to 60% in 1985. Light infections may be a consequence of low moisture conditions in the 1985 growing season. With the exception of 1980, this blight has been common in the area since 1977, causing significant premature needle loss which averaged 30% per year. After periods of severe infection and needle loss, the foliage took on a characteristic "bottle brush" appearance.

Elsewhere, symptomatic infections occurred on two-year-old foliage of 15% of ponderosa pine on several hectares at Wasa Lake Provincial Park.

Squirrel damage

Basal debarking of regeneration lodgepole pine by squirrels killed 20% of stems over one hectare along Wildhorse Creek. Tree mortality resulted from repeated debarking of the same trees over several years. Nearly 80% of lodgepole pine showed no signs of damage.

Identifying characteristics of squirrel barking are the lack of tooth marks on the sapwood and the presence of bark strips ($\pm$ 3x8 cm) which accumulate on the ground under the injured tree. These bark strips readily distinguish squirrel work from injuries by rabbits or porcupines.

A hyperparasite of dwarf mistletoe, Colletotrichum gloeosporioides

A special survey was initiated to improve the distribution data of this fungus in mistletoe-infected stands. This hyperparasite of dwarf mistletoe plants has been shown to exert significant natural biological control. In plantations where extensive infection was observed, fewer than 20% of the mistletoe cankers bore healthy aerial shoots (Parmeter et al. 1959).

Prior to 1986, the only sample recorded in the Region came from New Denver. This year, samples of the hyperparasite were collected in six of seven mistletoe infected stands examined, including one from Douglas-fir at Sanca Creek, which is a new host record for the Pacific Forestry Centre herbarium.

Since the potential of C. gloeosporioides as a biological control agent for dwarf mistletoe is encouraging, continued emphasis on its distribution and incidence will be maintained in 1987.

SPRUCE PESTS

Spruce beetle, Dendroctonus rufipennis

Spruce beetle infestations in mature Engelmann spruce stands covered 41 ha as determined by aerial surveys, down sharply from 575 ha in 1985 and 3 770 ha in 1984. Volume losses also declined to 114 m^3 in four infestations, down from 19 070 m^3 in 44 infestations.

In the Revelstoke TSA infestations in the Pingston Creek drainage and South Cranberry Creek collapsed with no attack noted during aerial surveys.

In the Kootenay Lake and Arrow TSA's where 40 ha and 75 ha, respectively, of attack were found in 1985, no new outbreaks were noted during 1986 aerial surveys.

Two small light infestations occurred in the Cranbrook TSA at Meachen and Perry creeks covering several hectares in sites where attacks have not been recorded since 1982.

In the Invermere TSA, two small infestations totalling 11 ha and 42 m^3 were noted in the North White River drainage where no spruce beetle has been mapped since 1969, although infestations occurred as recently as 1981 in the adjacent Middle White River drainage. At McMurdo and Vowell creeks in TFL 14, beetle activity is being contained with the use of trap trees as part of the management plan for those areas.

In the Upper Duncan River and on the Glacier National Park boundary, salvage logging and a lethal trap tree program continues, with no successful beetle attack found in standing trees. However, the slashing of a line to mark the Park boundary resulted in 80-100 mature Engelmann spruce being felled. A ground check in July determined that the beetle had successfully attacked these felled trees in 1986. Adults, eggs and young larvae were found in all trees sampled. A program has now been completed to protect standing trees from attack. In August, all infested trees were bucked to 75 cm lengths and 15 cm tops and sections placed upright. Since the beetle flight will not occur until spring 1988, the sections will have approximately 1.5 summers to dry sufficiently, precluding any chance for survival of beetle brood to maturity and flight. This project will be monitored in 1987 to assess the effectiveness of the technique.

Allegheny spruce beetle, Dendroctonus punctatus

The Allegheny spruce beetle is a little known species, and, until recently, found principally in the north. Prior to 1985, when it was collected in the Mackenzie area, its presence in British Columbia was recorded only near the Yukon border. In 1986 its known range moved much farther south with collections in the Likely area and for the first time in the Nelson Region near Howser Creek west of Duncan Lake. This beetle which is found on the lower boles of mature spruce is presumed to have a two-year life cycle and is reported to kill only scattered trees in generally non-commercial sites. This species is not yet recognized as an economically important insect in Canada, possibly because of competition with the more aggressive D. rufipennis and also because some of the damage by D. punctatus may have been masked by other species.

Spruce weevil, Pissodes strobi

The incidence of attack by the weevil continued at low endemic levels throughout most of the Nelson Forest Region with only occasional recently attacked leaders noted on roadside regeneration. One exception was along Koch Creek where approximately 5% of leaders were recently infested on young naturally regenerated Engelmann spruce over a 10-ha area. The spruce weevil has not historically been an important pest in the Region.

DOUGLAS-FIR PESTS

Western spruce budworm, Choristoneura occidentalis

Light to moderate defoliation by C. occidentalis occurred over 3 688 ha in 15 infestations in the Boundary TSA in 1986. This is a dramatic expansion from 60 ha in 1985 and 100 ha in 1984. Populations of budworm and defoliation, generally ranging from 60 - 300 ha, have persisted between Rock Creek and Bridesville for the past nine years, especially in the Johnstone Creek Park area. A large expansion in area attacked was noted only in 1981 when 1 000 ha were lightly defoliated within the Bridesville to Rock Creek area. This is the first year that the budworm has expanded beyond its traditional range.

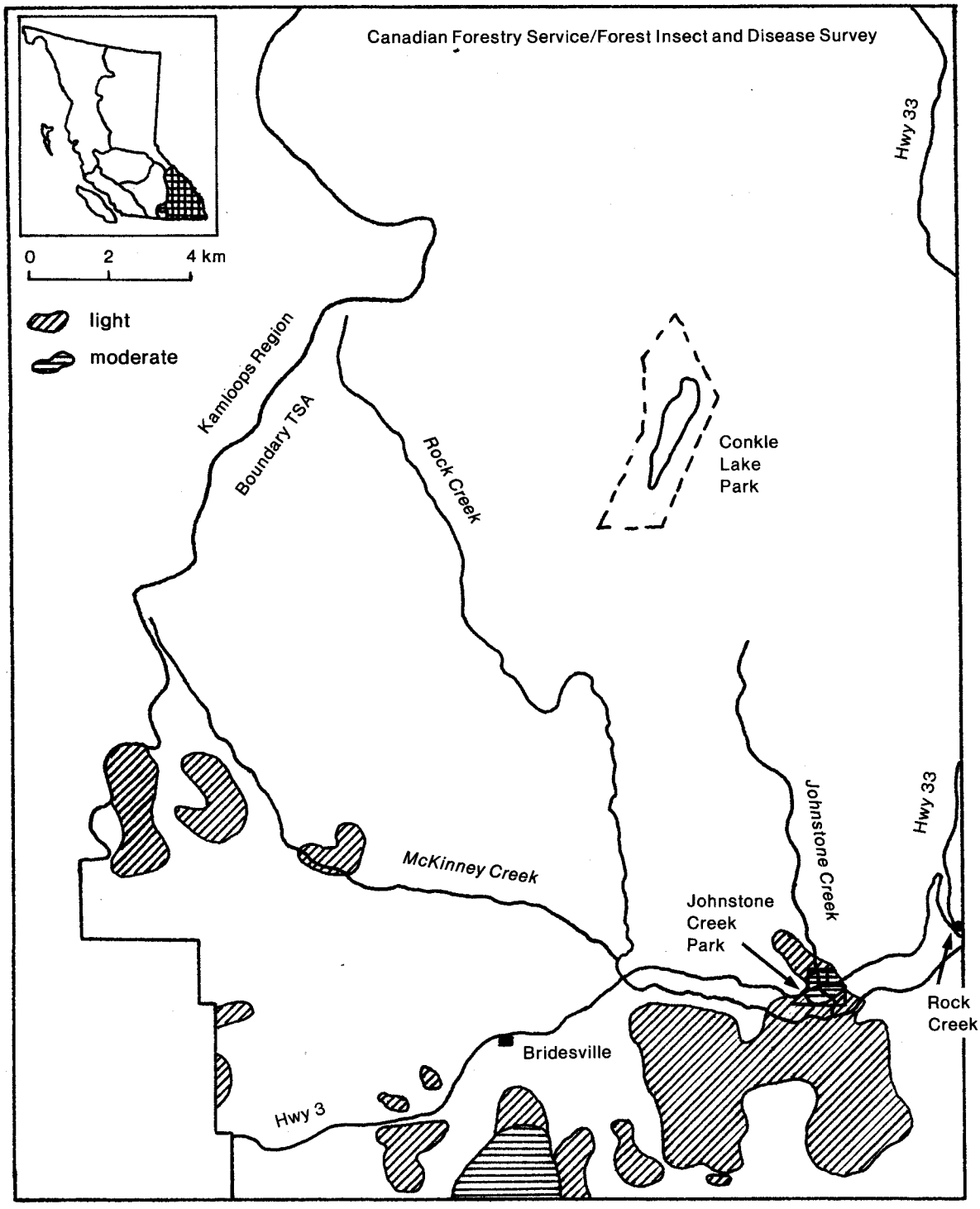
The majority of 1986 defoliation was concentrated just north of the Canada-U.S.A. border between Anarchist Mountain and Rock Creek. While most defoliation was classified as light, two areas of moderate defoliation occurred, one along Baker Creek which extended into Washington State and another at Johnstone Creek Park. Three large areas of light defoliation also occurred in the McKinney Creek drainage near the TSA boundary.

Populations of larvae increased to an average of 79 (range 0-300) per standard sample size in nine samples between Anarchist Mtn. and Rock Creek, up from 6 larvae (range 0-25 per site) in 8 standard samples in the same area in 1984. No larval sampling was done in 1985. Larvae reared from two mass collections resulted in 2% parasitism by tachinid flies at one site and 2% parasitism by hymenopterous insects of the genus Glypta at the second site. Parasitism at this low incidence is insufficient to influence the population dynamics.

Egg sampling at eight locations to determine potential larval populations and related defoliation in 1987, indicates severe defoliation in four areas, trace to light defoliation at three sites and no defoliation at one site (Table 4). Light to moderate defoliation in 1986 in areas such as Anarchist Mtn., Rock Creek, Bridesville and Johnstone Creek Park is expected to increase to severe defoliation in 1987.

In efforts to determine if the pest will move into new areas, several additional sites were sampled. At a McKinney Creek site where very light feeding was noted from the ground only, light defoliation is expected; south of Conkle Lake where no defoliation was observed during aerial surveys, light defoliation is also expected. At Phoenix Mtn. and Westbridge, virtually no defoliation is expected.

Barring severe overwintering larval mortality, egg mass surveys suggest an increase in severity of attack, a possible "filling in " between the areas of



Map 5. Areas of Douglas-fir defoliated by western spruce budworm, Nelson Forest Region, 1986.

current attack previously mentioned and a moderate outward expansion of the infestations in 1987. This projection parallels the general expected trend for western spruce budworm elsewhere in B.C. in 1987.

Continued severe defoliation in areas of previous damage may result in some minor top-kill and branch dieback, particularly of understory trees, but no tree mortality is expected.

Table 4. Location of 1986 western spruce budworm egg mass samples and predicted defoliation of Douglas-fir in the Boundary TSA in 1987, Nelson Forest Region, 1986.

Location	No. egg masses/10 m^2 foliage 1986	Predicted defoliation[1]	Status
Anarchist Mtn.	303	severe	increase
Rock Creek	455	"	"
Bridesville	755	"	"
Johnstone Cr. Park	442	"	"
McKinney Cr.	39	light	"
S. of Conkle L.	50	"	"
Phoenix Mtn.	7	trace	"
Westbridge	0	nil	static

[1] Light - discolored foliage barely visible from the air, some branch tip and upper crown defoliation.
Moderate - pronounced discoloration, noticeably thin foliage, top third of many trees severely defoliated, some completely stripped.
Severe - bare branch tips and completely defoliated tops, most trees more than 50% defoliated.

Douglas-fir beetle, Dendroctonus pseudotsugae

Douglas-fir beetle attacks were at a low incidence in the Nelson Forest Region in 1986 with a total of 273 trees attacked in 27 infestations, generally in areas of traditional beetle activity.

Near Arrowhead along the Upper Arrow Lake, four spots totalled 25 attacked trees. More than 120 trees were mapped in 14 spots along the north side of the west arm of Kootenay Lake, where none were mapped in 1985 and 12 spots were found in 1984. Along Kootenay Lake one spot occurred south of Kaslo, two north of Balfour, and two south of Crawford Bay, totalling only 40 trees attacked. In a continuing infestation along Akokli Creek near Boswell, 85 recently attacked trees were mapped in four spots among numerous previously attacked (grey) trees.

Poor access precluded ground assessments at many of the sites. However, at Deer Creek northwest of Castlegar, D. pseudotsugae was found to be active in two of four locations with five trees attacked. Armillaria root disease was determined to be the primary causal agent of decline and mortality at these sites.

Douglas-fir tussock moth, Orgyia pseudotsugata

The tussock moth population remained at endemic levels in 1986. No larvae were found in beating samples anywhere in the Region including previous infestations at Rock Creek and Christina Lake Golf Course. Six pheromone-baited traps (0.1% z-6-heneicosen-11-one) at each of the two outbreak sites resulted in only one adult trapped per site. This is similar to 1985 and a further indication that Douglas-fir tussock moth populations will remain at endemic levels in 1987.

Leaf scarabs of Douglas-fir, Dichelonyx spp.

A Douglas-fir leaf scarab, Dichelonyx fulgida defoliated up to 50% of the 1986 growth of immature Douglas-fir on 20 ha, in and adjacent to Elko Provincial Park and on 10 ha at Kikomun Creek Provincial Park.

Another leaf scarab, the green rose chafer, Dichelonyx backi was common in Douglas-fir stands in the Cranbrook-Fort Steele area, but caused no noticeable defoliation.

Though fairly common, most leaf scarab damage is generally light and has little adverse affect on tree growth.

Armillaria root disease, Armillaria sp.

Armillaria root disease is common throughout the Nelson Forest Region, affecting all age classes of trees, and is of special concern in young plantations. In windthrown semimature Douglas-fir along Springer and Lemon creeks, all trees inspected were Armillaria-infected. While 10% of Douglas-fir in a 40-ha plantation near Shelter Bay was reported infected in 1985, no infections were found in a 1986 survey of nearby plantations. In a similar-sized plantation of 10-year-old Douglas-fir at Fitzstubbs Creek near Wilson Lake, 16 permanent plots have been established. More than 4% of plot trees were infected and other dead or infected trees were noted outside the plots. At an adjacent one-hectare plot, 5.5% of 857 Douglas-fir averaging 2.5 m in height were dead or infected. Infection was scattered throughout the stand and included two centres of 10 and five trees, respectively, which will create substantial holes in the plantation. Losses are expected to increase and continue throughout the rotation at these sites.

Management alternatives are available, including stumping prior to planting on more level sites. The planting of resistant species in identified infection centers is being considered with western white pine as the preferred alternative. On the above mentioned one-hectare site, 11% of stems were white pine but at least 17% of these were dead or infected with blister rust. Projections are that losses here will also increase as stems averaged only one metre in height. A third alternative is simply to accept some losses and increase stocking density to compensate.

In a three-hectare plantation near Mosquito Creek west of Nakusp, an estimated 5% of young lodgepole pine were killed or currently infected by Armillaria obscura. Pines were killed individually and in pockets of 2 or 3 and as the stand is very young (avg. 2 m), mortality may increase and continue throughout the rotation, causing understocked openings. Individual, semimature

lodgepole pine were also infected by A. obscura along Kokanee Creek, but no major openings were noted.

A bacterial gall, Bacterium pseudotsugae

This gall disease distorted or killed up to 20% of immature Douglas-fir stems over 30 ha in a mixed lodgepole pine - Douglas-fir stand near Dogsleg Lake north of Invermere. The galls are globose, rough and persistent, and they occur mostly on trees of low vigour. Other stem abnormalities such as fluting and burl formations were also common in this area, but their cause is unknown.

LARCH PESTS

Larch casebearer, Coleophora laricella

With the exception of a few localized pockets of infestation, casebearer populations in the Nelson Forest Region declined to endemic levels in most previously defoliated areas. This is the second year of decline. Defoliation was limited to isolated pockets of moderate to severe discoloration of immature larch in parts of the West Kootenay near Castlegar, Montrose and Fruitvale. Some light defoliation occurred at Thrums, Rossland, Keenleyside Dam and Anarchist Mountain. In the East Kootenay, light defoliation occurred to small groups of roadside regeneration larch near Rykerts, Wycliffe, and along Gold Creek Road. Occasionally, defoliation was associated with feeding damage caused by the larch budmoth, Zeiraphera improbana, and with discoloration by the needle diseases Hypodermella laricis and Meria laricis. At times, this has made it more difficult to precisely separate the causal agent in a given area.

The incidence of pupal parasitism in June of both native and introduced parasites decreased to 5.5% (range 1-24%), from 14% in 1985 in 17 sites examined. More than 5 300 adult Chrysocharis laricinellae parasites from Austria and Switzerland were released against the larch casebearer in four infested stands near Castlegar, Montrose and Fruitvale. This is part of a biological control program continued by CFS-FIDS since 1966. Parasites were released in six batches of 200 to 1 600 each from mid-July to early August.

In assessing the efficacy of parasitism on larval populations, percent parasitism as determined from spring pupal collections was compared to the number of larvae per 100 fascicles in the fall at the same sites. An expected inverse relationship occurs (see graph) with a change in percent parasitism appearing to affect larval populations in the same year.

Catches in pheromone-baited traps, deployed for the third successive year, declined to an average of 50 moths per trap in 16 parasite release areas. This compares to 69 at six locations in 1985 and 89 at 16 locations in 1984. Traps to monitor spread of casebearer populations beyond the known distribution limits within the Nelson Forest Region attracted an average of 11 male moths per trap at two locations north of Nakusp and 1 per trap near the south end of Kootenay National Park. These indicate a slight expansion of casebearers beyond the previously known limits of distribution. However, there were no adults caught in traps in larch stands east of Elko, near Sparwood and in the Flathead River Valley.

Assessments of overwintering larval populations at 18 locations in the

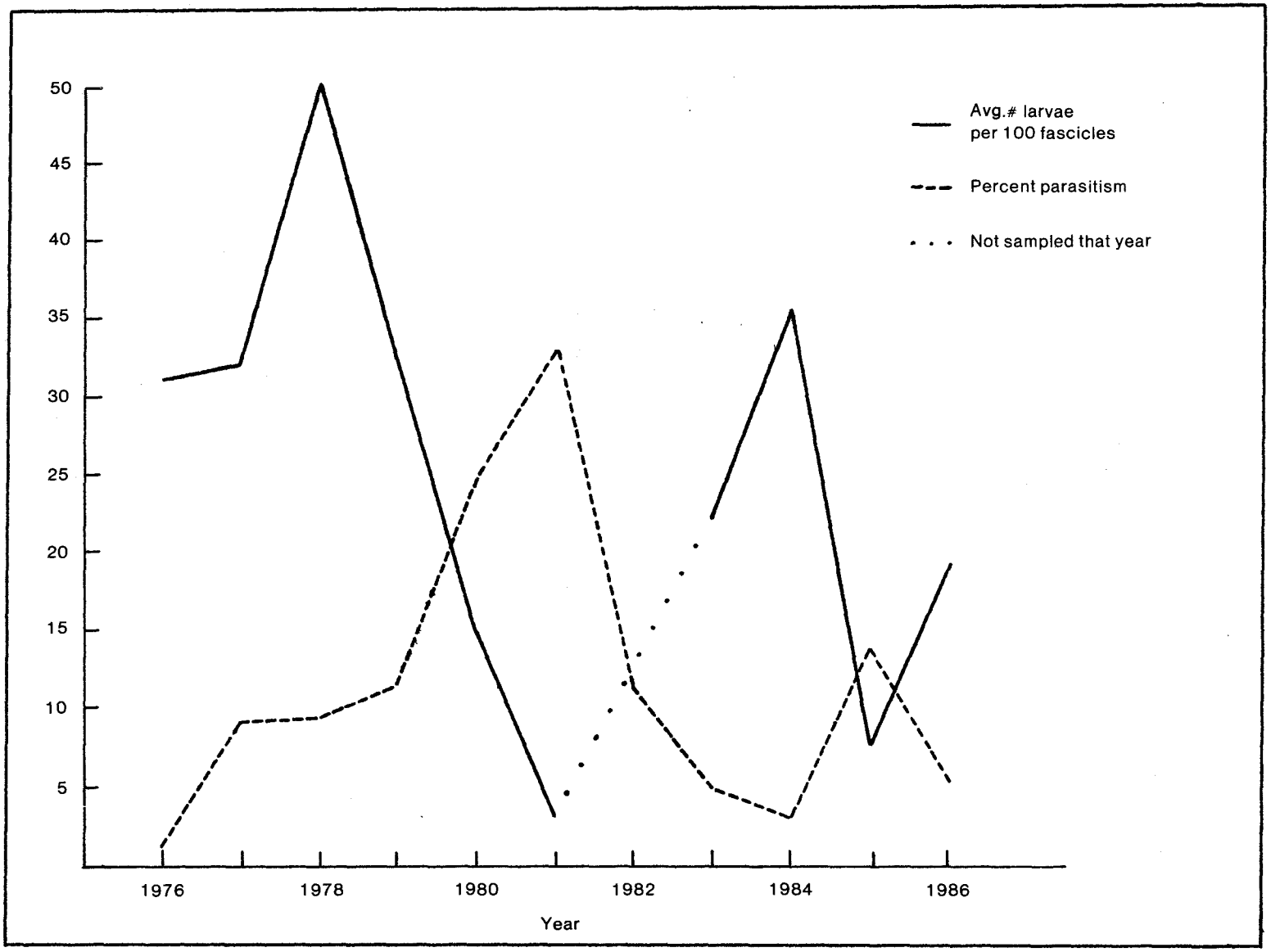


Fig. 1. Population fluctuations and percent parasitism of larch casebearer, Nelson Forest Region, 1976-1986.

Region indicate defoliation varying from negligible to light in the East Kootenay and up to moderate in several areas of the West Kootenay near Castlegar, Rossland and Fruitvale in 1987. Predictions are based on the number of larvae per 100 fascicles of foliage (Table 5).

Table 5. Predicted defoliation of western larch in 1987 by larch casebearer based on overwintering larval populations, Nelson Forest Region, 1986.

Location	Avg. no. overwintering larvae per 45-cm branch	100 fascicles	Predicted defoliation, 1987[1]
Jaffray	1.9	1.0	negligible
Koocanusa	.1	.1	none
Ellenvale Creek	3.9	2.7	negligible
Six Mile Lane (Cranbrook)	9.1	3.5	"
Wycliffe	47.3	23.9	light
Cranbrook Reservoir	57.1	22.5	"
Cranbrook	.3	.2	none
E. Arrow Creek	1.4	.8	negligible
Rykerts	18.6	10.1	"
Salmo	3.2	1.6	"
Fruitvale	53.4	32.1	light
Beaver Falls	102.6	64.3	moderate
Rossland	79.9	54.9	light
Thrums	17.1	10.2	negligible
Castlegar (pulp mill)	121.1	66.2	moderate
Castlegar (west)	43.2	31.2	light
Johnstone Cr. Prov. Park	7.7	5.8	negligible
Anarchist Mtn.	20.1	13.8	light

Defoliation[1] (based on ground observation)
Negligible - no visible defoliation or discoloration
Light - up to 25%; moderate - 26-50%; severe - 51+%.

Larch budmoth, *Zeiraphera improbana*

After three consecutive years of defoliation, the larch budmoth outbreak in the Nelson Forest Region collapsed in 1986 with no visible damage recorded during aerial and ground surveys. Defoliation occurred on 5 800 ha in 1985.

Spring surveys to determine larval populations and feeding damage were done in 15 areas where defoliation had occurred the previous year. Minor tip feeding of larch regeneration occurred at Redding Creek, on 30-40% of fascicles in a mature stand at Johnstone Creek, and on 5-20% of fascicles at Anarchist Mtn. Assessments at eight previously defoliated areas in the West and East Kootenay were negative.

At Aaron Hill east of Castlegar 10% of fascicles on all trees were less than 5% defoliated. Because of the limited information on this insect's biology, this site was chosen to initiate a phenology program. On May 27, 200 larvae were collected and preserved for study, averaging 5 larvae per 45-cm

branch sample. A further collection of 80 larvae was taken June 2 by which time larvae were already difficult to find. This was followed by duff sampling for pupae and pheromone trapping for adults.

Near America Creek five pupae were recovered, but duff sampling at Aaron Hill, Anarchist Mtn. and Johnstone Creek was negative. No pupae were found during field surveys and no adults were reared from duff samples sent to the Pacific Forestry Centre. However, pheromone traps produced positive results at the above and several other locations (Table 6) ranging from 0 to 115 adults per trap/site. Sequential trapping at two sites suggested an adult flight period after the first week in July.

Table 6. Location, dates set and retrieved and average number of larch budmoth in pheromone-baited traps, Nelson Forest Region, 1986.

Location	# Traps	Dates Set	Dates Retrieved	Avg. no. adults/trap
Memphis Creek	2	June 21	July 7	0
	2	July 7	July 31	5
Aaron Hill	2	June 16	July 9	0
	2	July 9	July 29	62
Springer Creek	5	June 21	July 31	0
Johnstone Cr. Park	5	June 18	August 19	21
E. of America Creek	5	June 17	Sept. 29	1
Skookumchuck L/O Rd.	5	June 20	Sept. 28	115
Redding Creek	5	June 19	Sept. 27	22
Dewar Creek	5	June 18	Sept. 27	44

Larch needle diseases, Hypodermella laricis and Meria laricis

The incidence and intensity of larch needle diseases generally declined throughout the Region for the second consecutive year. This is probably again due to drier conditions less favorable to initial spore dispersal during bud burst and needle elongation.

In the West Kootenay, while the presence of both H. laricis and M. laricis occurred endemically throughout the host range, several exceptions were of note. Light to moderate infection by both diseases occurred at Thrums (2 ha), Enterprise Cr. (150+ ha), Christina Lake (5 ha) and Winlaw (2 ha). Areas primarily or exclusively infected by M. laricis included severe infection in the Halfway River-St. Leon River drainages on 1 000 ha, for 20 km west of Fauquier and north to Nakusp and light infection for 5 km along Wilson Creek. In all areas, the incidence of infection was 100% except at Stagleap Creek where only 60% incidence of light infections in small patches occurred. M.

laricis is capable of infecting needles throughout the foliation period in moist conditions.

In the East Kootenay significant infection occurred in only two areas. H. laricis caused light infections on nearly all larch over 200 ha at Skookumchuck Creek. At Dutch Creek, M. laricis was the primary agent, where localized pockets of 2-10 ha each were lightly infected.

Tree mortality is not expected but reduced increment growth does result from continued severe infections, and since the success of these diseases is largely weather-determined, no prediction is made for 1987.

Larch sawfly, Pristiphora erichsonii

Sawfly populations in larch stands were generally at endemic levels following a decline in 1985, although some light defoliation was evident on a few trees in localized areas.

Near Castlegar and along Skookumchuck Creek, sawflies caused some minor defoliation of small groups of immature larch where feeding was restricted to individual branches.

No change in status is foreseen in 1987.

A dieback of western larch, Potebniamyces coniferarum

This pathogen is suspected of causing up to 20% dieback of branch tips on larch regeneration at Hellroaring Creek west of Kimberley, and on seedlings along Lamb Creek near Moyie. There are only two positive occurrences of P. coniferarum identified (CFS Herbarium) on larch in B.C. It is not seen as a significant problem within larch stands, but may cause some crown deformity in young growth.

Larch shoot moth, Argyresthia laricella

Twig mining by these shoot moths killed 20% of branch tips on half of the immature roadside larch near Fenwick Creek. Similar damage intensities were noted on young larches in scattered locations along Brewer Creek Road, near Skookumchuck and at Whiteswan Lake.

Repeated attacks may lead to crown deformity in young larch.

TRUE FIR PESTS

Western balsam bark beetle complex, Dryocoetes confusus, Ceratocystis dryocoetidis

The beetle D. confusus and its associated blue stain fungus, C. dryocoetidis, is common and sometimes chronic in mature high-elevation alpine fir stands in the Region.

Recent tree mortality over nearly 2 400 ha ranged from 5 to 15% of the alpine fir component in 145 infestations in widely scattered areas. Only 30 small infestations over 260 ha were recorded from aerial surveys in 1985, but

the sporadic and frequently remote occurrence of these outbreaks defies a consistent and accurate assessment for comparison from year to year. Studies have indicated that the beetle rarely attacks more than 10 trees/ha in one year.

Due to the increasing emphasis on alpine fir by the forest industry and B.C. Forest Service and because of gaps in the knowledge of the insect/disease complex and association with root rot, ground surveys were conducted at two locations in TFL 14 in the Spillimacheen River Valley along Cabin Creek Road and at McMurdo Creek.

The results of this survey (Table 7) indicate that the balsam bark beetle complex was the major factor in the high rate of alpine fir mortality. Root rot (Armillaria sp.), at least in this area, was not a significant factor (3% infection) relating to tree mortality. The absence of root disease was further evidenced by the lack of downed trees in the area. Lodgepole pine comprised 30% of the stand component and suffered <5% mortality, which was attributed to Fomes pini and endemic populations of the bark beetles, Dendroctonus ponderosae and D. murrayanae.

Table 7. Percent (%) alpine fir mortality by causal agent as determined by ground cruises in the Spillimacheen River Valley, Nelson Forest Region, 1986.

	Percent (%) alpine fir mortality					
	Balsam bark beetle		Unknown	Root	Total	%
Location	1986 attack	previous attack	cause	rot	mortality	healthy
Cabin Cr. Rd.	5	42	2	0	49	51
McMurdo Cr.	12	12	0	3	27	73

Two-year-cycle spruce budworm, Choristoneura biennis

In the East Kootenay, light defoliation totalling 500 ha occurred in three inaccessible high-elevation alpine fir-spruce stands in the upper St. Mary River and Dewar Creek drainages for the first time since 1983. Populations were endemic in previously defoliated stands along Glenogle Creek, Bugaboo Creek and in the White River drainage system. "Off-year"-cycle spruce budworm larvae infested new growth of alpine fir and spruce at Baker Creek, where defoliation is expected to intensify when larvae mature in 1987.

In the West Kootenay moderate defoliation attributed to two-year-cycle budworm was common on the upper crowns of roadside spruce west of Castlegar along Highway 3. Minor feeding on leaders also occurred on 80% of spruce for 2 km along Inonoaklin Creek west of Needles.

Balsam woolly aphid, Adelges piceae

For the third consecutive year, alpine and grand fir were examined for balsam woolly aphid in stands adjacent to the Canada-USA border. This survey, in response to a report of the aphid in Idaho, prompted examination of stands

near Rykerts, Boundary Creek, Salmo and Nelway. No symptoms such as crown thinning or flattened tops or any signs such as gouting or wool tufts on stems were evident.

In south coastal British Columbia, where the aphid does occur, a major expansion was tentatively identified outside the 1976 infestation zone, which is also outside the quarantine zone.

WESTERN HEMLOCK PESTS

Conifer sawflies, *Neodiprion* spp.

Populations of conifer sawflies declined on western hemlock and alpine fir, causing only light defoliation on 400 ha along Boundary Creek near the B.C.-Idaho border. Defoliation was restricted to feeding on the year-old growth only, and there was little associated discoloration. In this same area in 1985 many trees were totally stripped of their old growth and some suffered up to 90% defoliation. Some scattered top-kill and minor mortality of hemlock seems inevitable as a result.

Elsewhere, sawflies persisted in areas where previous light defoliation occurred at Kokanee, Giveout, Bayonne and Keen creeks. Feeding damage was generally very light and limited to older needles.

No defoliation is expected at Boundary Creek in 1987, where cocoons averaged only 4 per duff sample and old empty cocoons outnumbered new cocoons ten to one.

Burlap trapping was attempted at Keen Creek for the purpose of pupal collection. Two trees were loosely doublewrapped with 30 cm of burlap at dbh in areas of high larval populations. No pupae were recovered.

Western blackheaded budworm, *Acleris gloverana*

Western blackheaded budworm populations completely collapsed in 1986 with no defoliation noted after a significant decline in 1985 to 150 ha from approximately 19 000 ha of defoliation in 1984. In a total of 31 beating samples of western hemlock foliage, positive collections were made at only six sites, averaging 7.3 larvae per beating. A maximum of 19 larvae was obtained at Goldstream Creek where defoliation occurred in 1985, but none at a similar infestation site at Cusson Creek. No defoliation or expansion of populations is anticipated in 1987.

WESTERN RED CEDAR PESTS

Cedar leaf blight, *Didymascella thujina*

Repeated severe infection by cedar leaf blight causing premature foliage drop has resulted in severe crown thinning of western red cedar along Boundary Creek, west of Creston. Damage intensity was further enhanced by cedar flagging, a naturally occurring non-infectious condition associated with periods of lower than average rainfall. Long-term effects should be minimal since severe infections of leaf blight are usually of short duration.

DECIDUOUS TREE PESTS

Forest tent caterpillar, *Malacosoma disstria*

The forest tent caterpillar moderately to severely defoliated approximately 1 200 ha of primarily trembling aspen, but also white birch, black cottonwood, fruit trees and roadside shrubs in 37 infestations. This was a tenfold expansion from 125 ha of defoliation in 1985. Defoliation occurred in the Trail-Warfield area for the third consecutive year and has expanded west to Rossland, east to Montrose, southeast to Casino and north to China Creek, south of Castlegar. A 100-ha patch was noted at Crawford Creek on the east side of Kootenay Lake with isolated minor infestations (0.1 - 20 ha) at Castlegar, Crescent Valley, Eholt and Goat River west of Kitchener.

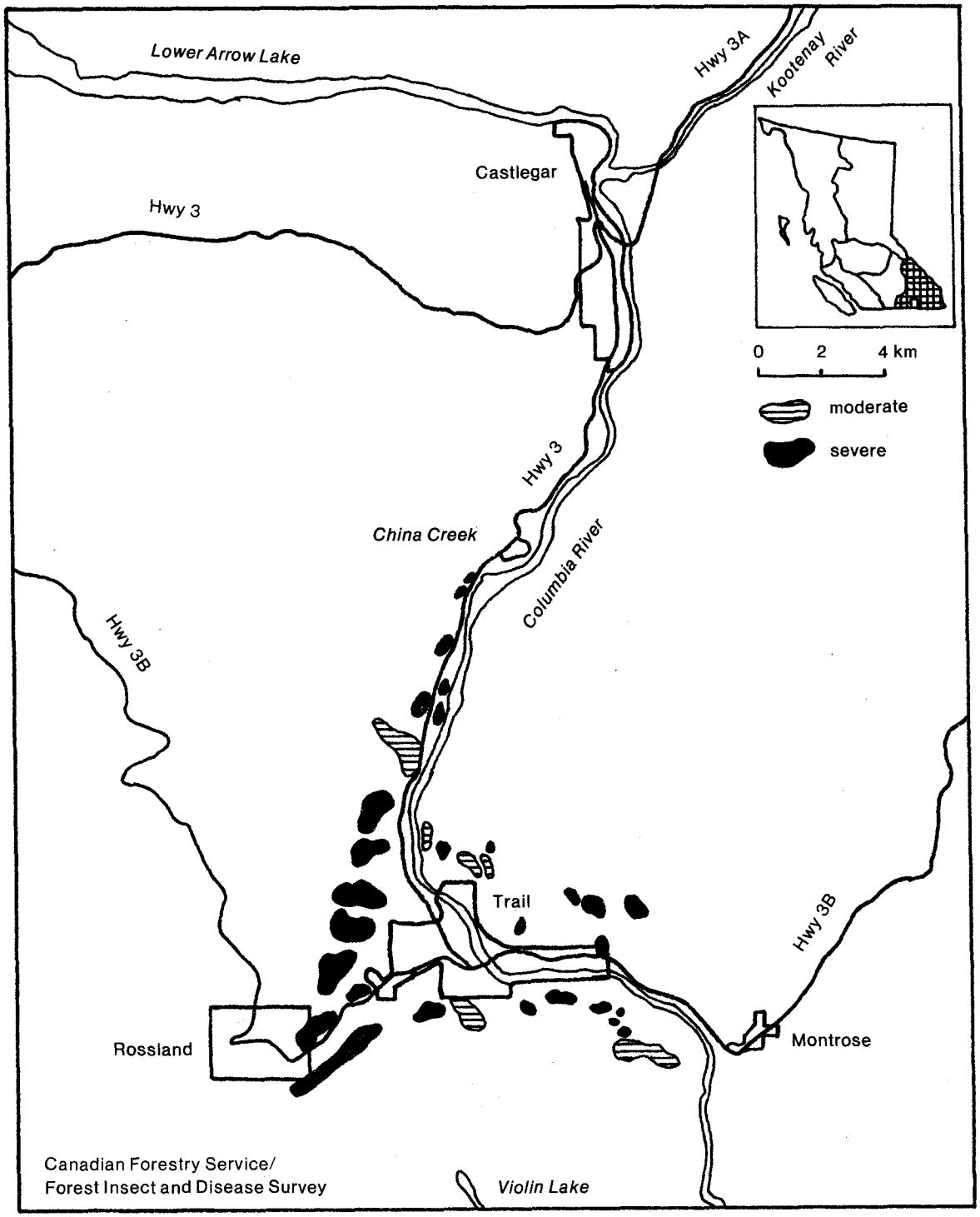
Egg mass surveys conducted at five sites during fall surveys to determine the potential for future defoliation suggest increasing defoliation intensity in all 1986 infestation areas (Table 8). Some expansion may occur north to Blueberry Creek and east to Montrose. The presence of egg parasites, virus and adverse weather conditions may dramatically affect populations. However, the larval parasites and virus in 1986 populations were at low levels and not yet significant as controlling agents.

Table 8. Location, number of 1985 and 1986 egg masses and predicted defoliation of deciduous stands by forest tent caterpillar, Nelson Forest Region, 1986.

Location	Avg. dbh (cm)	Avg. # Egg Masses new (1986)	old (1985)	Predicted defoliation (1987)[1]	Status
Rossland-Warfield	10	44	20	severe	increasing
Casino	9	137	19	"	"
Blueberry Cr.	8	12	2	"	"
Murphy Cr.	9	62	6	"	"
Goat Cr.	4	8	1	"	"

[1]No. egg bands by tree diameter that will cause complete defoliation:

dbh	# egg bands
2.5	2
5.0	5
7.5	9
10.0	11
12.5	14
15.0	19



Map 6. Areas of deciduous trees defoliated by forest tent caterpillar, Nelson Forest Region, 1986.

Satin moth, *Leucoma salicis*

While defoliation continued in several isolated pockets of previous infestations, there was a general population decline in the Region. Up to 50% defoliation of trembling aspen in small 0.2-3 ha stands continued for the fourth consecutive year in the Anarchist Mtn.-Bridesville area. Similar damage levels occurred on 5 ha of black cottonwood at Moyie, mostly in the upper crowns of mature trees.

Populations in the New Denver and Silverton areas declined to near endemic levels with only minor feeding observed, after causing up to 50% defoliation of scattered black cottonwood in 1985. No larvae or damage were noted in the Nelson and Trail areas, where light defoliation occurred in 1985.

The only permanent damage attributable to satin moth feeding was at Moyie where repeated heavy defoliation killed a few understory black cottonwood.

Burlap sacking attached to each of two trees at two locations to facilitate collection of pupae for subsequent parasite rearing was not considered successful for that purpose. It was hoped that satin moth larvae would pupate under the layers of sacking wrapped around the stems, but this did not occur.

Populations and damage may decline in the Bridesville and Moyie areas since many natural enemies including parasitic wasps, flies, mites and a polyhedrosis virus usually reduce larval numbers in the third or fourth year of infestation.

Birch leafminer, *Lyonetia saliciella*

For the twelfth consecutive year discoloration of birch stands was prominent in the northern half of the Region. Severe browning of up to 100% of the foliage occurred in scattered patches along the Illecillewaet River from Glacier National Park to Revelstoke, along the Blaeberry River and Horsethief Creek. Similar damage intensities occurred on 900 ha near Kaslo, 1 000 ha at Meadow Creek, and 2 000 ha between Rapid Creek and Trout Lake.

Damage was light to moderate north of Invermere between Forster and Frances creeks and in the chronically infested area along Kicking Horse River between Golden and Yoho National Park.

Even in areas of chronic infestations, no lasting adverse effects such as top-kill or dieback were noted.

Gypsy moth, *Lymantria dispar*

No moths were caught in any pheromone-baited traps placed at 34 locations in the Region to detect gypsy moth populations. Park visitors from outside the Region, particularly from eastern Canada and the U.S.A., are considered the primary vector responsible for the distribution of this insect.

This detection survey is part of a continuing cooperative interagency program in which 7 000 traps were distributed province-wide and caught 24 male

moths in 19 traps at 8 locations. New catches were at Kelowna, Clinton, south of Kamloops, Point Roberts, Vancouver, Victoria and Chilliwack.

Gypsy moth populations have not yet become established in British Columbia, nor has defoliation been observed. A major concern of the forestry sector is the potential for quarantine restrictions if this pest became established, possibly leading to large and expensive control programs such as occurred in Oregon in 1984. The trapping program will continue in 1987 for the eighth consecutive year in the Region.

Pacific willow leaf beetle, Pyrrhalta decora carbo

The Pacific willow leaf beetle skeletonized willow foliage along roadsides and in large openings north of Revelstoke from Bigmouth Creek to south of Carnes Creek. Foliage skeletonization averaged 80% on most trees though some were up to 100% skeletonized in isolated spots.

Infestations of this pest may continue for several years, recur irregularly, and were last noted in this area in 1980. No economic importance has been attributed to this pest, with activity essentially limited to causing unsightly browning of roadside willow.

A noctuid on elder, Zotheca t. viridula

Light to severe defoliation of elder occurred in many areas where this host is found in the West Kootenay. Severe spot defoliation was noted in the Castlegar area. Occasional light to moderate feeding occurred from Trail to Salmo. There was severe isolated defoliation along Hwy. 6 north to Nakusp and Hwy. 33 from Nakusp to Galena Bay. Feeding was also common from New Denver to Kaslo and north to Trout Lake.

This noctuid, while common in B.C., has not been previously reported at epidemic levels and has no economic impact. However, in addition to giving an unsightly appearance to roadside elder, it may also be partially responsible for branch dieback noted in some areas.

Poplar shoot and leaf blights, Venturia spp.

Infections of trembling aspen and black cottonwood increased in the Nelson Forest Region. Up to 50% foliage browning of mature black cottonwood by V. populina occurred on approximately 30 ha near Kuskonook on Kootenay Lake. Severe scattered infection was also noted on mature and immature roadside trees at Winlaw, Vallican, Schroeder Cr. and in the West Kettle River area north of Rock Creek. V. macularis caused up to 100% incidence of infection with 25-90% foliage discoloration on five hectares of trembling aspen in the Crescent Valley. Similar infection rates occurred in spots near Robson, Passmore, Vallican, Nakusp to Fauquier, New Denver to Kaslo, Riondel, Lumberton to Cranbrook, Jim Smith Provincial Park, Kimberley to TaTa Creek and Fairmont to Invermere.

Although currently not a major economic species in British Columbia, increment loss and loss of young regeneration make Venturia spp. a serious problem in some European centres.

MULTIPLE HOST PESTS

Black army cutworm, *Actebia fennica*

Although five larvae were found in parts of the extensive 1985 burns (wildfires) in the Invermere TSA by BCFS personnel in early May, none was found (by CFS) during extensive surveys in June. It may be that the few black army cutworm present were victims of a late snowfall and frost in mid-May. Suspected feeding damage to ground vegetation was found in 4 of 12 sites in 4 fires near Canal Flats and in one near Cranbrook. There was no evidence of larvae or feeding in the Lost Ledge Fire near Lardeau.

Despite the fact that few cutworm larvae were found in 1986, pheromone trap data (Table 9) indicate a potential risk to proposed planting sites in the Giby and Ram Fires in 1987. Criteria for basing this forecast come from data obtained from surveys and pheromone trapping by FIDS in the Prince Rupert Forest Region over the past two years. This information suggests that an average of 10 or more moths per trap (for 0.4% pheromone) may indicate a potential for moderate to high population levels capable of causing defoliation to ground cover and/or seedlings. However, this is only a guideline based on inconclusive data. Much has yet to be learned about the life history and habits of black army cutworm.

Table 9. Average number of black army cutworm moths caught in pheromone-baited traps placed in areas of 1985 summer wild fires, Nelson Forest Region, 1986.

Location	No. moths caught (0.4% concentration[1])	Potential population levels, 1987[2]
Lardeau - Lost Ledge Fire (2 sites)	0	-
Blackfoot Cr., Km 45 - Black Fire	1	L
Blackfoot Cr., Km 49 - Black Fire	6	L
Lussier R., Km 27 - Ram Fire	17	M-H
Lower Coyote Cr., - Ram Fire	14	M-H
N. White R., east side - Giby Fire	22	M-H
N. White R., Km 71, Giby Fire	26	M-H
N. White R., Km 71, Giby Fire	3	L
N. White R., Km 68, Giby Fire	3	L
Findlay Cr., Km 16, Spen Fire	.4	L
Lavington Cr., Spen Fire	.2	L
Fir Mtn., Spen Fire	.4	L
Wildhorse Cr., Wild Fire	.4	L

[1] basic formulation is cis-7-dodecenyl acetate
[2] classification is based on data collected in the Prince Rupert Forest Region, <10 moths/trap - light feeding potential; 10+ moths/trap - moderate to high feeding potential.

Planting sites should be examined during early spring, especially for those proposed in the Giby and Ram fires, where trapping indicated the presence of cutworm populations. Initial feeding on herbaceous ground cover by early instar larvae is difficult to detect. Careful examination for larvae in duff

samples and feeding on emerging plants will provide an indication of cutworm population levels. Following is a table (Table 10) with suggested guidelines for determining when changes in planting schedules should be considered.

Table 10. Black army cutworm early instar larval counts and potential seedling damage, Nelson Forest Region, 1986.

Larval instar	No. of larvae/1000 cm^2	Potential damage to newly planted seedlings
2-3	5	expect seedling mortality, delay planting until better assessment of population can be made
4-5	5	expect patches of mortality on drier knolls and some south slopes
5+	15+	major infestation

Cone and Seed Pests

Cone crops on Engelmann spruce and Douglas-fir were generally light to moderate and spotty in most areas of the Region. In 1985 cone crops were heavier but the percentage of infested cones was similar to 1986.

In Engelmann spruce cones examined in five areas, the incidence of infestation ranged from 15-75%, the average was 47%. The most abundant cone pests were the spiral spruce-cone borer, Hylemya anthracinum, found in 40% of samples, followed by a spruce seedworm, Cydia strobilella, 8%, and a spruce cone gall midge, Dasineura canadensis, 4%. A cone disease, inland spruce cone rust, Chrysomyxa pirolata, infected less than 5% of cones examined.

The incidence of infestation of Douglas-fir cones ranged from 0-85% in five areas examined, the average being 44%. The Douglas-fir cone moth, Barbara colfaxiana, and the Douglas-fir seed wasp, Megastigmus spermotrophus, infested 21% and 16% of samples, respectively.

Control of cone and seed pests in most natural stands is not practical, even though there is a need for seed from these areas. Preventive measures against damage are possible and practical only in limited areas such as seed orchards and seed production areas.

In addition to examination of cones for insect pests, two samples from western larch and one from western white pine were collected for seed analysis. Also, one collection of Engelmann spruce cones which was 17% infected by Sirococcus shoot blight, Sirococcus strobilinus, helped to clarify the disease's life cycle.

Winter Injury

Up to 80% foliage desiccation, primarily of the needle tips of lodgepole pine and alpine fir, occurred on 115 ha along Morrissey Ridge, south of Fernie. Douglas-fir, which made up 30% of the stand component, was not affected. The very abrupt margin of damaged areas indicates that the injury took place in a very short period of time, probably in late winter or early spring when rapid drops of temperature or unusually warm conditions can occur. Similar damage has occurred in this area previously, but no tree mortality is expected.

Severe shoot kill of up to 100% on individual Engelmann spruce occurred on about 50 ha along the Palliser River. By mid-summer the new flush appeared healthy, but previous shoot kill will probably promote bushiness.

Drought Damage

Scattered open-growing immature Douglas-fir exhibited drought damage in the form of dead buds, scattered foliage discoloration and defoliation at Bednorski Lake near Wardner. Symptoms were most prominent over 25 ha on the lower half of an exposed south slope. Judging by the size of dead buds, damage was probably related to the dry summer of 1985.

Yellowing and browning of needles, symptomatic of moisture stress, occurred on several hundred hectares of immature western hemlock near Dewar Creek. This problem may be the result of low soil moisture conditions during the previous summer. The normal moisture regime in this area is moderate and supports fast-growing larch mixed with hemlock.

Salt Damage

Salt damage in the form of foliage desiccation, discoloration and occasional mortality occurred on scattered immature roadside Douglas-fir, lodgepole pine and ponderosa pine along Highway 3 from Cranbrook to Fernie and along the highway from Wasa to Invermere. Damage was also common on young white pine between Revelstoke and Rogers Pass. The increased intensity in 1986 may be the result of accumulated salt deposits which did not leach out during dry conditions in 1985 and the following winter. Damage frequently occurred along steep banks on the lower sides of roads.

ACID RAIN MONITORING

A total of 15 Acid Rain National Early Warning System (ARNEWS) plots have been established in British Columbia as part of a nationally standardized series of plots to monitor changes in vegetation, tree vigour and soils due to acidic rainfall. In the Nelson Forest Region one plot was established in the Blueberry-Paulson summit area in 1985 and visited in 1986.

Monitoring of ground vegetation, regeneration in subplots and assessment of plot trees was done as part of an annual survey. A lichen/liverwort inventory was also established as several species are very sensitive to changes in air and moisture qualities. No anomalies were found in the plot except in the case of four Engelmann spruce where minor needle blotching could not be directly attributed to climatic damage, insect or disease activity and will require further sampling to determine causal agent(s).

PESTS OF YOUNG STANDS

Three young stands, both planted and natural, were examined by FIDS using a fixed-radius plot system to identify and quantify pest problems which could affect future crops. Some of the more important pests have been discussed individually by host; however, all pests are summarized in Table 11.

Table 11. Summary of pest problems in young stands, Nelson Forest Region, 1986.

Location	Species[1]	Planted (P) or Natural (N)	Stand (years)	No. of trees examined	Pest	% of trees affected	Remarks
Shelter Bay[2]	Df	P	10	54	Adelges cooleyi	93	generally small populations
					Phaeocryptopus gaeumannii	72	light to moderate infection with up to 10% needle cast
					Contarinia pseudotsugae	39	light attack
					Melampsora sp.	4	light to moderate infection
	eS	N		3	Pineus pinifoliae	67	few old and new galls
	wwP	N		12	Cronartium ribicola	17	severely infected
					P. pinifoliae	8	small population
	wH	N		10	none recorded		
	wC	N		15	none recorded		
	alF	N		3	none recorded		
Fitzstubbs Creek	Df	P	10	47	A. cooleyi	100	large populations causing sooty residue on many trees and some possible growth loss
					P. gaeumannii	6	very light infection
					Armillaria obscura	4	two plot trees showing crown symptoms
	wwP	N		21	C. ribicola	33	branch and stem infection, some tree mortality expected
					Cinara sp.	5	small colonies noted
	eS	N		6	A. cooleyi	100	few old and new galls, some aphids
					Cinara sp.	17	small colonies noted
	wL	N		1	Meria laricis	100	severe infection on lower crown

Location	Species[1]	Planted (P) or Natural (N)	No. of Stand (years)	trees examined	Pest	% of trees affected	Remarks
	wH	N		4	tip dieback	25	minor incidence
	alF	N		4	none recorded		
	wC	N		16	none recorded		
St. Mary River[2] (Km 24 - River Rd.)	lP	N	17	71	Pissodes terminalis	1	1986 attack
					Zelleria haimbachi	1	damage very light
					Synanthedon sequoiae	1	one old pitch tube only
					Dioryctria sp.	1	1986 buds infested
					forked top	1	affects 1 tree only
	eS	N		12	A. cooleyi	92	avg. 3-4 galls per branch
	wH	N		4	M. laricis	25	5% of foliage infected
	Df	N		4	A. cooleyi	25	very light attack
					Rhabdocline sp.	25	10% of foliage infected

[1]alF - alpine fir, Df - Douglas-fir, eS - Engelmann spruce, lP - lodgepole pine, wH - western hemlock, wL - western larch, wC - western red cedar, wwP - western white pine

[2]recently spaced plantations

OTHER NOTEWORTHY PESTS

Pest	Host[1]	Location	Remarks
Ambrosia beetles, *Trypodendron* sp.	lP	Grand Forks area	About 25 & 15% of mountain pine beetle-infested lP at Snowball Cr. and Rathmullen Cr., respectively, harbor large populations. Common elsewhere in mountain pine beetle infestations.
Aspen leafminer, *Phyllocnistis populiella*	tA	Wilgress Lake-Grand Forks, Revelstoke, Fauquier-Nakusp	Severe roadside infestation for 10 km west of Grand Forks, scattered, light to moderate elsewhere.
Birch dieback, *Sirococcus* sp.	wB	Hills-Summit Lake	Light infection and dieback continue in area, not found elsewhere in 1986.
Conifer-aspen rust, *Melampsora medusae*	wL	Keenleyside Dam area	Forty percent foliage infection on 100% of trees in early spring sample.
Conifer-cottonwood rust, *Melampsora occidentalis*	bCo	Moyie Lake	Twenty-five percent foliage infection on nearly all regeneration over 1 ha along lake.
Fall webworm, *Hyphantria cunea*	roadside shrubs	Christina Lake	Avg. 5 to 10 webs per km for 5 km in Christina Lake Golf Course area and occasionally west along Hwy. 3 to Grand Forks.
Green-striped forest looper, *Melanolophia imitata*	wH	Host range	Remains at endemic level throughout Region.
Engraver beetles, *Ips* spp.	pP	Grand Forks	Common in + 100 codominant and intermediate trees also attacked by *Dendroctonus brevicomis*.
Lodgepole pine terminal weevil, *Pissodes terminalis*	lP	Freeman Creek (Km 22) Marion Lake	Approximately 1-2% of regen. attacked on 25 ha partially spaced stand, >1% damage over 50 ha.
Pine needle scale, *Phenacaspis pinifoliae*	lP	Hellroaring Creek	Heavy infection on several roadside lP.

Pest	Host[1]	Location	Remarks
Poplar and willow borer, Cryptorhynchus lapathi	W	Springer Creek-New Denver	Common spot attacks on willow in Springer Cr. area and north along Hwy. 6 to New Denver.
Snow mould, Herpotrichia juniperi	alF	Idaho Peak (New Denver)	Moderate to severe infection on all regeneration plus lower crowns of some mature at upper elevations.
Warren's root collar weevil, Hylobius warreni	lP	Marion Lake	Minor incidence over 50 ha.
Yellow root rot, Poria subacida	lP	St. Mary Lake	Causing severe windthrow over approx. 5 ha.

[1] alF - alpine fir, bCo - black cottonwood, lP - lodgepole pine, pP - ponderosa pine, tA - trembling aspen, wH - western hemlock, wL - western larch, wB - white birch, W - willow

Canada