Forest insect and disease conditions British Columbia & Yukon 1989

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Contents

Abstract

This summary of forest pest conditions in British Columbia and the Yukon Territory in 1989 highlights pests that are or may become major forest management problems. It was compiled from field reports and other records of eleven Forest Insect and Disease Survey rangers, and with contributions from the forest industry, researchers, and agencies. The status and impact of more than 45 major forest pests are described and some forecasts are made for 1990.

Résumé

Ce résumé de l'état des insectes et des maladies des arbres en Colombie-Britannique et au Yukon en 1989 donne les grandes lignes de ce que sont ou pourraient être les grands problèmes d'aménagement forestier. Il a été compilé à partir de rapports et autres relevés effectués sur le terrain par les onze forestiers du Relevé des insectes et des maladies des arbres et des données fournies par l'industrie forestière et des chercheurs et des organismes oeuvrant dans ce domaine. Il décrit l'état et l'impact de plus de 45 insectes et maladies des arbres d'importance et présente certaines prévisions pour 1990.

Introduction

The Forest Insect and Disease Survey (FIDS) of Forestry Canada is responsible for producing an annual national overview of important forest pest conditions and their implications. In the Pacific Region, surveys to detect and monitor important forest insects and diseases and environmental factors are conducted. Additionally, surveys and records are maintained in support of quarantine programs, forest research projects, and insect collections and herbaria. Surveys are conducted with the cooperation of the British Columbia Forest Service, the forest industry, other federal and provincial agencies, municipalities, educational centers, and research programs at the Pacific Forestry Centre and other Forestry Canada centres across Canada.

This regional report reviews the status and impact of major forest insects and diseases and the effects of environmental factors on conifer and broadleaf forests in British Columbia and the Yukon Territory in 1989. Damage trends and expansion of infestations can be determined by comparison to previous years' reports.

The subjective terms 'light', 'moderate', and 'severe' are used throughout this report to describe levels of total defoliation; these are defined as 1 to 25%, 26 to 50%, and more than 50% defoliated, respectively.

The report is compiled from information obtained largely from field observations and records of 11 FIDS rangers collected during their field assignments from May to October in six provincial forest regions and the Yukon Territory. More detailed information on the status of forest pests is available in regional reports compiled by the following rangers:

Cariboo	- Bob Erickson and Bob Ferris
Kamloops	- Peter Koot and Jim Loranger
Nelson	- Leo Unger and John Vallentgoed
Prince George	- Rod Turnquist and Bob Ferris
Prince Rupert	- Rod Garbutt and Alan Stewart
Vancouver	- Nick Humphreys and Dennis Clarke
Yukon Territory	- Rod Turnquist

Other staff of the Forest Insect and Disease Survey (FIDS) project in 1989 were:

Allan Van Sickle	- FIDS Head
Colin Wood	- Chief Ranger
Joan Strobbe	- Secretary
Lee Humble	- Entomologist, insectary and collection
Bob Duncan	- Insectary biologist, diagnostics
Jane Seed	- Insectary, rearing and data base
Al Funk	- Mycologist, disease identification
Brenda Callan	- Mycologist, diagnostics
Daphyne Lowe	- Technician, herbarium and collection

Summary

This summary is of pests which were most prominent in the Pacific Region in 1989 and most likely to be of interest and concern to the forest community. Equally significant in terms of losses but not reported in detail are several forest diseases such as root rots, stem rusts, cankers, decays, and dwarf mistletoes. These are perennial and, once established, fluctuate little from year to year, so they are not surveyed on an annual basis. Also not included are losses caused by pests to nurseries and regeneration.

There was very little overall change in the status of most major forest pests in 1989; however, sudden temperature changes in early 1989 across British Columbia resulted in climatic injury to conifers at more than 115 areas totaling 22 700 ha in six forest regions.

Mountain pine beetle was the most damaging forest pest in British Columbia in 1989. An estimated 1.57 million m^3 of mature pine were killed in more than 8625 infestations which covered about 53 350 ha in six regions. Infestations expanded in the Nelson Region but declined elsewhere. Overall, populations are forecast to continue in 1990. **Western pine beetle**, **turpentine beetle**, and **lodgepole pine beetle** were common, some for the third consecutive year, and contributed to pine mortality in parts of the Nelson Region. **Ambrosia beetle** attacks increased in stands infested with mountain pine beetle in parts of the Cariboo, Nelson, and Prince George regions; however, **pine engraver beetle** was less evident than in the previous 3 years. Following a decline in 1988, **pine needle sheathminer** populations increased and defoliated lodgepole pine regeneration in the southern interior and southwest coastal areas. **Pine needle diseases** were common on year-old and older needles throughout the interior, for the third consecutive year in some areas. Quarantine-related surveys reinforced the previous conclusion that **pinewood nematode** is very rare and is only present in individual predisposed trees at a few widely distributed locations. **European pine shoot moth** has become established in ornamental pines in urban areas in southwest coastal areas and the Okanagan Valley, and it was found for the first time in Douglas-fir in a plantation in the lower mainland; this was a new record for North America. Formal surveys for **Scleroderris canker** and **European larch canker** were discontinued.

Western budworm defoliated more than 165 800 ha of mixed-age Douglas-fir in parts of four forest regions, about half the area affected in 1988. Limited numbers of **Douglas-fir tussock moth** were found in parts of the Kamloops Region near previously defoliated stands, for the first time since 1985, and in urban Kamloops for the second consecutive year, but very few egg masses were found. Mortality of mature Douglas-fir killed by **Douglas-fir beetle** continued following 2 years of increased tree mortality, mostly in the Fraser River drainage in the Cariboo, Kamloops, and Prince George regions, and in the southeastern part of the Nelson Region. Populations of **western false hemlock looper** increased slightly in Douglas-fir stands in the Kamloops Region for the first time since the last outbreak of 1981-83, although no defoliation occurred.

The area and volume of mature and overmature spruce killed by **spruce beetle** declined for the seventh consecutive year; however, local increases occurred north of Prince George and east of Bella Coola. The area of alpine fir and white spruce defoliated by **eastern spruce budworm** in northeastern British Columbia increased more than threefold to 123 750 ha, and extended into the Yukon and Northwest territories. Immature **2-year-cycle budworm** very lightly defoliated new buds in 55 areas over 17 000 ha in east central British Columbia, and populations are forecast to continue in 1990. Mature **"off-cycle" 2-year-cycle budworm** lightly defoliated new shoots in 15 high-elevation fir and spruce areas over 9800 ha in parts of the Kamloops and Nelson regions, and for the first time north of Mackenzie over 11 385 ha, but less damage by immature larvae is expected in 1990. Active **balsam woolly adelgid** populations were found for the first time in two areas within the existing quarantine zones on mid-Vancouver Island. Increased populations of **balsam shoot boring sawfly**, not previously considered a noteworthy pest, killed high numbers of new shoots of high-elevation true firs in parts of the Vancouver and Nelson regions. Mortality of grand fir by **engraver beetles** increased significantly in the southern part of the Nelson Region due to predisposition of the trees by drought stress during the previous 2 to 3 years. More than 450 pockets of mature alpine fir recently killed by **western balsam bark beetle** covered 22 000 ha in parts of six forest regions, mostly where infestations have persisted for many years and particularly in the Prince Rupert Region.

The area of western hemlock near Holberg on northern Vancouver Island defoliated by **western blackheaded budworm** increased for the third consecutive year to over 7400 ha, up from 4800 ha in 1988. Populations are forecast to continue in 1990. On the Queen Charlotte Islands budworm populations collapsed, but tree mortality was widespread and patchy following

four consecutive years of feeding by **hemlock sawfly**.

In western larch stands in southeastern British Columbia, **larch casebearer** populations generally were at low levels, as in the previous 2 years; parasitism averaged 23% overall, similar to that in 1988. **Larch sawfly** populations declined in western larch in the western part of the Nelson Region, where trees were defoliated in 1988 for the first time in 20 years. The sawfly again defoliated exotic larch at Terrace and tamarack in the southwestern part of the Yukon Territory, south of the border in northern British Columbia, and in Prince George; some of these areas were defoliated for the third consecutive year. Populations of larch sawfly on exotic larch in the University of British Columbia Research Forest near Haney declined further and caused only very light defoliation; larch in Stanley Park were also lightly defoliated. New **needle blight** infection and discoloration of western larch was generally light; only pockets of moderate and severe infection were observed in western and southwestern parts of the host range in the Nelson and Kamloops regions. **Larch budmoth** remained at endemic levels in western larch in the West Kootenay.

Populations of **black army cutworm** in previously infested areas in interior British Columbia declined significantly. Small numbers of larvae were found at only 14 sites in wetter parts of the Nelson, Prince George, and Prince Rupert regions; however, based on pheromone trap catches, cutworms could pose a threat in 1990 plantings that were slash-burned in 1989. For the second consecutive year, **Rhizina root disease** infected and killed newly planted seedlings in recently burned sites in parts of the Nelson and Prince Rupert regions; fruiting bodies were present, but seedlings were not affected at additional sites including one in the northern part of the Kamloops Region. Infection in recently burned adjacent sites is possible in 1990. **Inonotus root disease** infected 68% of the mature and overmature lodgepole pine and 59% of the Engelmann spruce in four drainages in the eastern part of the Nelson Region. Surveys of more than 175 young stands across the province in 1989 found the most common, the most damaging and the most widespread problems included **climatic injury, animal feeding,** and **native needle diseases**. Less common but locally significant were **terminal and root collar weevils** and **stem rust cankers**.

The most common pests active in twelve coastal and three interior seed orchards included **Cooley spruce gall adelgid**, which lightly infested Douglas-fir and white spruce, and **balsam twig aphid** which severely infested Sitka spruce at one orchard and was common on amabilis fir at four orchards. Cone crops at coastal seed orchards were affected by several pests including **Douglas-fir coneworm** and **Douglas-fir cone gall midge** which infested most cones in four orchards.

Feeding damage to conifers including seedlings by **voles, rabbits and porcupines** was again common in parts of the Prince Rupert and Vancouver regions and in the Yukon Territory.

In deciduous forests and particularly in stands of trembling aspen, pests were again numerous and widespread. Defoliation of trees and shrubs by **forest tent caterpillar** was more widespread and severe at more than 325 locations covering 122 500 ha, mostly in the Prince George Region, including the Peace River area, and to a lesser extent in the Cariboo and Nelson regions. Only 25 adult male **gypsy moths** were trapped in 25 traps in 11 areas in British Columbia this year, compared with 12 moths in 12 traps in seven areas in 1988. **Satin moth** populations near Vancouver declined significantly; however, **large aspen tortrix** in southwestern Yukon Territory increased for the second consecutive year and severely defoliated trembling aspen over 10 000 ha, which is ten times the area affected in 1988. Discoloration of native birch by **leafminers** was common in parts of the Nelson Region, in some places for the fifteenth year. Maples and other deciduous hosts in the Vancouver Region were more widely and severely defoliated by **western winter moth** than in the previous 2 years. **Winter moth** defoliation increased in the lower mainland in the Vancouver Region, but remained at very low levels on southern Vancouver Island for the fifth consecutive year. The known distribution of the introduced **apple ermine moth** increased significantly in southern and southwestern British Columbia, since first detected in British Columbia in 1981 on Vancouver Island. Nineteen disease and seven insect collections in 1989 were **new records** within either British Columbia or the Yukon Territory. An additional 48 diseases were recorded for the first time on new hosts.

Pine Pests

Mountain pine beetle

Dendroctonus ponderosae

Although the area and volume of lodgepole pine and some western white pine killed by the beetle declined to the lowest level since 1977, the beetle continued to be the most damaging forest insect in British Columbia. More than 8625 active infestations still cover 53 350 ha (Map 1) from the international border to northeast of Prince Rupert (Table 1). This is twice the area burned by forest fires in British Columbia in 1988, and the volume lost (1.57 million m^3) represents about 5% of the lodgepole pine annually harvested in British Columbia.

Active infestations continued throughout the six forest regions in British Columbia, and these infestations are forecast to continue in 1990. An infestation in the Cariboo Region which developed in 1987 in mature pine at Chilko Lake near the Coast Mountain Range declined by nearly half to 700 ha. Elsewhere, the following areas contained recently killed mature pine: Kamloops Region - 12 100 ha, down more than 30% from 1988; Nelson Region - 31 800 ha, up 20%; Vancouver Region - 550 ha, down 35%; Prince Rupert Region - 5400 ha, down more than 50%; Prince George Region - 2800 ha, down 30%.

Overwintering mortality was generally less than 10%, but exceeded 75% in higher-elevation stands in southeastern British Columbia. Elsewhere, 64% of the ratios of progeny to parents at 50 locations were greater than 4.0, which indicated increased populations for flight and attack during 1989.

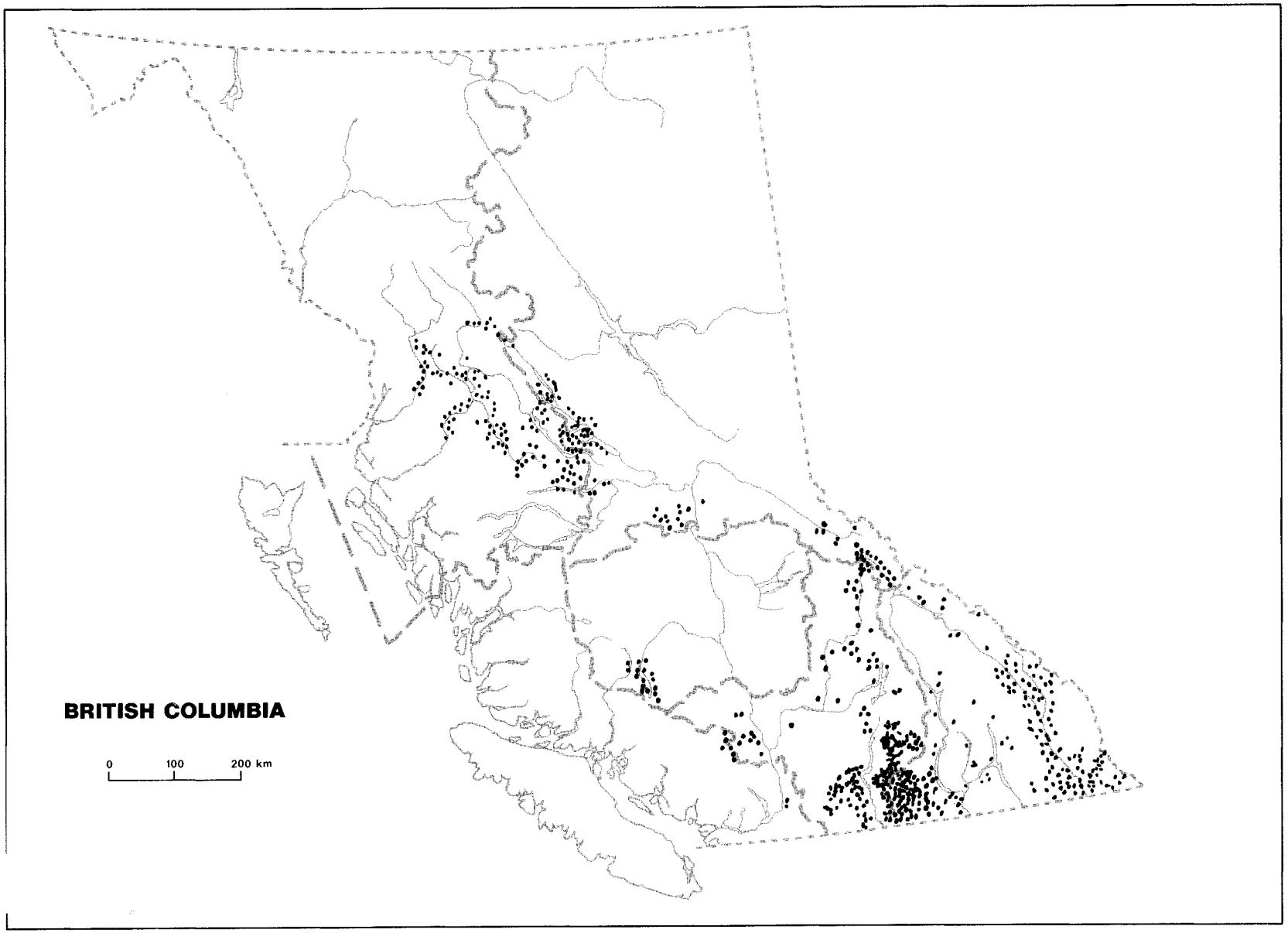
Infestations in the Nelson Region increased, for a second consecutive year, by 20% to 31 800 ha in more than 5315 separate pockets which contained an estimated 1.6 million attacked trees (591 000 m^3). The increases were again in the East Kootenay, in the Cranbrook Timber Supply Area (TSA), and for the fourth consecutive year in the Boundary TSA in the West Kootenay. There was little change elsewhere in the Arrow, Kootenay, and Revelstoke TSAs, and a decline in the Invermere TSA. Infestations along the British Columbia-Alberta border and in Glacier and Yoho national parks were generally stable for the fourth consecutive year. However, increased numbers of small groups of recently killed pine occurred at Redstreak in Kootenay National Park and in the Flathead and Elk river valleys. New attacks in 24 stands cruised in the region declined slightly to an average of 24%; this still indicates significant additional tree mortality in 1990. Current attacks were again highest in the East Kootenay (average 37%, range 24 to 62%), including the Bull River, Horsethief Creek, and near Redstreak in Kootenay National Park. New attacks in the West Kootenay declined overall (average 13%, range 6 to 23%) in ten stands infested on average for 5 years; the highest levels of attack occurred at Hellroarer and Kelly creeks in the upper Kettle River Valley, and in the Wallace River drainage in the Boundary TSA.

Infestations in the Franklin Arm area of Chilko Lake in the Cariboo Region declined by nearly half to 700 ha in 206 pockets. The decline, which followed annual increases since 1987 when the infestation was first recorded, was due to reduced host availability. Pine mortality remained low elsewhere in the region. Infestations at Chilko Lake are forecast to decline further in 1990. New attacks elsewhere in the region remain at very low levels and are not expected to increase in 1990.

The area of mature pine killed by the beetle in the Kamloops Region in 1989 declined, for the second consecutive year, by more than 30%; about 1.2 million trees (620 000 m^3) in more than 1490 separate pockets were killed. The major decline was in the eastern part of the Okanagan TSA, due to accelerated harvesting in the Daves, Campbell, Stirling, and Saunier creek drainages, near Okanagan Mountain Provincial Park, and east of Vernon at Coldstream Creek. Groups of 5 to 10 beetle-killed white pine were again more numerous in the Kamloops TSA near Adams and Barriere lakes and from Vavenby to Albreda. Tree mortality is forecast to continue in the Kamloops Region in 1990, mostly in the Okanagan and Merritt TSAs where current attack in four stands infested on average for 4 years averaged 13%, up slightly from 1988.

In the Prince George Region the area containing recently killed pine declined, for the second consecutive year, by 30% to 2800 ha. Most of the 459 separate infestations, which contained about 122 000 trees (98 000 m^3), again were in the Skeena, Sustut, and Middle River drainages northwest of Fort St. James, including near Takla and Trembleur lakes. Cut-and-burn operations southwest of Prince George and south of Vanderhoof have contributed to the reduction of beetle populations. Pine mortality is forecast to continue in the Fort St. James area in 1990, based on new attacks in four stands which averaged 14%, up from 11% in 1988.

Cooperative aerial and ground surveys in Mt. Robson Provincial Park and west of Jasper National Park located 35 pine killed by mountain pine beetle and



Map 1. Areas where recent tree mortality due to mountain pine beetle was detected during aerial surveys in 1989.

Table 1. Number, area and incidence of new and old attack of mountain pine beetle by forest region, based on recently killed trees recorded by aerial and ground surveys in British Columbia in 1989.

Forest Region	Number of infestations	Area (ha)	Trees killed[a] No. (000)	Trees killed[a] Vol. (000 m³)	Stands cruised[b] No.	Stands cruised[b] Avg. yrs. infested	Damage category[c] H	C	R	G	P
							% of trees				
Cariboo	206	700	36	11	-	-	-	-	-	-	-
Kamloops	1490	12 100	1233	620	4	4	52	13	7	19	9
Nelson	5318	31 800	1642	591	22	5	49	24	13	11	3
Prince George	459	2800	122	98	4	5	62	14	9	11	4
Prince Rupert[d]	1100	5400	400	240	5	3	54	17	17	8	4
Vancouver	53	550	14	10	-	-	-	-	-	-	-
Total	8626	53 350	3447	1570	35	4	55	17	11	12	5

[a]Trees attacked in 1988, discolored in 1989.
[b]Some stands located in younger infestations may not represent average condition.
[c]H - Healthy; C - Current, attacked in 1989; R - Red, attacked in 1988;
G - Grey, attacked in or before 1987; P - Partial or strip attacked in 1989.
[d]Regular aerial surveys were limited in eastern portions of the region in 1989, so data is based in part on 1988 data and general observations in 1989.

234 newly attacked pine. Cut-and-burn control operations are scheduled for the fifth year since 1985.

Infestations in the Prince Rupert Region declined in area by more than half and contained 400 000 trees (240 000 m³) in 1100 separate infestations. The decline of infestation in the central part of the region in the Nilkitkwa, Kispiox, and eastern Skeena river drainages and near New Hazelton was due mostly to host depletion through harvesting. However, there was little change in the Morice and Lakes TSAs in the eastern part of the region. Pine mortality in the western part of the region was down significantly in the Nass and Skeena river valleys, including the Kitwanga and Cranberry Junction areas; these declines were also due to host depletion. New attacks in the region increased on average by 7 to 17% (range 6 to 28%) in five stands infested for an average of 3 years; the highest level of infestation occurred at Coyote Creek near Cedarvale and near Sideslip Lake north of Cranberry Junction. There were no reports of additional lodgepole pine mortality in the Dease Lake, Cassiar, and Lower Post areas where trees were killed by lodgepole pine beetle, *Dendroctonus murrayanae*, in widely scattered pockets over 5800 ha in 1988.

The area containing recently killed lodgepole pine in the Vancouver Region declined again by nearly half to 550 ha and 14 000 trees (10 000 m³). This was the lowest level recorded in the 8 years since major infestations were first mapped in the Homathko River Valley and east of Pemberton. Pine mortality is expected to decline further, based on the trend over the previous 5 years; cruises of declining and remote infestations were discontinued.

Overall, infestations will continue in 1989 throughout many recently infested pine stands in parts of four forest regions. This prediction is based on the number of new attacks in 35 representative stands infested on average for 4 years. The frequency of new attacks ranged from an average of 13% in the Kamloops Region to 24% in the Nelson Region, with the average across the province being 17%, up from 13% in 1988. Current attacks exceeded the 1988 levels in the Kamloops, Prince George, and Prince Rupert regions, but declined slightly in the Nelson Region. Cruises in declining infestations and in isolated areas of the Cariboo and Vancouver regions and the eastern part of the Prince Rupert Region were discontinued due to limited host availability and remoteness.

Increased numbers of mature ponderosa pine were also killed by mountain pine beetle in the Nelson Forest Region. Other bark beetles including western pine beetle, *Dendroctonus brevicomis*, and turpentine beetle, *D. valens*, were common, and contributed to pine mortality in parts of the Nelson Region. There was less evidence this year of pine engraver beetle, *Ips pini*, which had been common for the previous 3 years. Increased attacks by ambrosia beetles, *Trypodendron* spp., were widespread in mountain pine beetle-infested stands in

parts of the Cariboo, Nelson, and Prince George regions.

Single-tree disposal and salvage of beetle-killed and adjacent susceptible pine continued at high levels in most beetle-infested TSAs. Salvage harvesting of economically accessible beetle-killed pine may result in reduced annual allowable cuts in the near future.

Pine needle sheathminer

Zelleria haimbachi

Sheathminer populations increased in previously infested lodgepole pine stands over 7900 ha in 36 separate areas mostly in the Kamloops Region, and to a lesser extent in parts of the Nelson and Vancouver regions. This followed a decline to 1000 ha in 1988 after 2 to 3 years of moderate to severe defoliation.

Discoloration of immature lodgepole pine regeneration in the Kamloops Region was mostly light in 33 separate patches totaling 7525 ha near Adams, Barriere, and Shuswap lakes, up tenfold from 1988. Moderately discolored stands covered about 1200 ha in two areas at the western end of Shuswap Lake. New areas of lightly discolored pine covered about 2500 ha in eight areas east and west of Adams Lake; defoliation was light in previously infested stands over about 3825 ha in 23 widely scattered patches in the Salmon Arm area. There was no evidence of discoloration in the Kamloops and Lytton areas where new pine shoots were mined and discolored in 1988.

Semimature lodgepole pine were moderately discolored for the third consecutive year in three patches totaling 415 ha at Gibbs Creek near Grand Forks, up from 235 ha in 1988. Populations declined after discoloring roadside pines between Greenwood and Grand Forks for 2 years and regeneration over 200 ha west of Kimberley in 1988.

In the Vancouver Region, pine were discolored for the fourth consecutive year near Pemberton and for the first time near Boston Bar. Only 6% of the new shoots were infested on about 70% of the pine regeneration at Twin One Creek on the east side of Lillooet Lake south of Pemberton, where populations have lightly discolored scattered immature pines annually since 1986. In the Anderson River Valley east of Boston Bar, increased populations infested and discolored about 15% of the new shoots on about 60% of the immature pine for the first time for about 5 km along the access road. Nearby, in the Mowhokam River Valley, an average of 20% of the shoots on 80% of single trees and scattered pockets of lodgepole pine were newly discolored for about 10 km.

Overwintering population assessments were insufficient to forecast trends in 1990; however, infested stands usually recover after 2 years of defoliation.

Pine needle diseases

Elytroderma deformans
Lophodermella concolor

Infection of year-old needles of lodgepole and ponderosa pines by native needle diseases was common for the third consecutive year in parts of the Cariboo, Kamloops, Nelson, and Prince Rupert regions.

Infection of year-old and older lodgepole pine needles by Lophodermella needle disease in most parts of the East Kootenay was less severe but more widespread than in 1988. Patches of moderate and severe discoloration in generally lightly infested areas occurred in the Elk, White, Bull, and St. Mary river drainages. Infection was less severe south of Cranbrook, where 30 to 40% was common at Bloom and Ward creeks, although there were occasional patches of 90% infection. In the northern part of the Prince Rupert Region, severely infected lodgepole pine occurred in widespread patches near Boya Lake. Elsewhere, however, in the southern Yukon Territory, in adjacent areas of the northern part of the Prince Rupert Region, along the Alaska Highway, and in the Kamloops Region, infection was common but less severe.

Infection of ponderosa pine by Elytroderma needle disease is widespread throughout the host range in the Cariboo and Kamloops regions. Needle discoloration and brooming were common on up to 60% of the trees in the Clinton and Heffley Creek areas, and were widespread but less severe in the southern Okanagan.

European pine shoot moth

Rhyacionia buoliana

Since provincial quarantine regulations lapsed in 1981, distribution surveys were continued and pheromone baits were tested in 1988. Survey results indicated that the shoot moth is established in localized urban areas from Victoria to Courtenay, in the lower mainland, and in the Okanagan Valley. These areas, however, have not increased in number and there is no evidence of shoot moth populations in native pines. Formal surveys of native and exotic pines were discontinued in 1989. However, the shoot moth was found for the first time on Douglas-fir in North America, in a single shoot in a plantation at Richmond in the Vancouver Region.

Distortion of shoots caused by a gouty pitch midge, *Cecidomyia pininopsis*, is similar to the damage caused by shoot moth; this type of damage was more common in the Lytton area in the Kamloops Region than in 1988.

New tips and deformed leaders on about 5% of immature lodgepole pine infested by the midge were also common near Boston Bar in the Mowhokam River Valley.

Pinewood nematode

Bursaphelenchus xylophilus

Based on more than 1200 samples from recently dead or dying trees and potential vectors collected from throughout British Columbia since 1982, this nematode remains extremely rare in forests in British Columbia and the Yukon Territory; only individual predisposed trees are affected at a few widely distributed locations.

After extensive sampling, the pinewood nematode, of either *m* or *r* forms, was only recovered from five widely scattered and previously damaged trees and from one woodborer, *Monochamus maculosus*. Of these, three samples were designated as *m* form by Dr. R. Anderson of Biosystematics Research Centre. The two samples collected earlier were not designated as to form. In a sampling of 10 chip piles by Agriculture Canada (Plant Health), pinewood nematode was detected at six scattered locations; two were designated *m* form and four as the *r* form. In 1988 as part of a national FIDS survey, more than 200 potential vectors including wood borers, bark beetles, and wood wasps were collected in the Pacific Region and submitted to Memorial University of Newfoundland for extraction of nematodes. Nationally, more than 5000 insects were processed, and while several genera of nematodes commonly associated with insects were obtained, the pinewood nematode was not found in any of the insects. This confirms that the pinewood nematode is not abundant in Canada, and that any damage in the forest is below the level of detection.

More than 75 stem sections from five host species were collected from 20 locations in five forest regions in 1989 to study the potential of various wood boring insects to vector the nematode.

Scleroderris canker

Gremmeniella abietina

Formal examinations in British Columbia, where only the North American strain of this fungus was previously collected, were discontinued after surveys throughout British Columbia in 1988 were again negative. This fungus which has caused extensive mortality of young pines in plantations and nurseries in eastern Canada and the United States, was found only rarely as a lower branch saprophyte on lodgepole, ponderosa, and whitebark pine in British Columbia between 1968 and 1978 near Penticton, Canal Flats, Castlegar and Kimberley.

Douglas-fir Pests

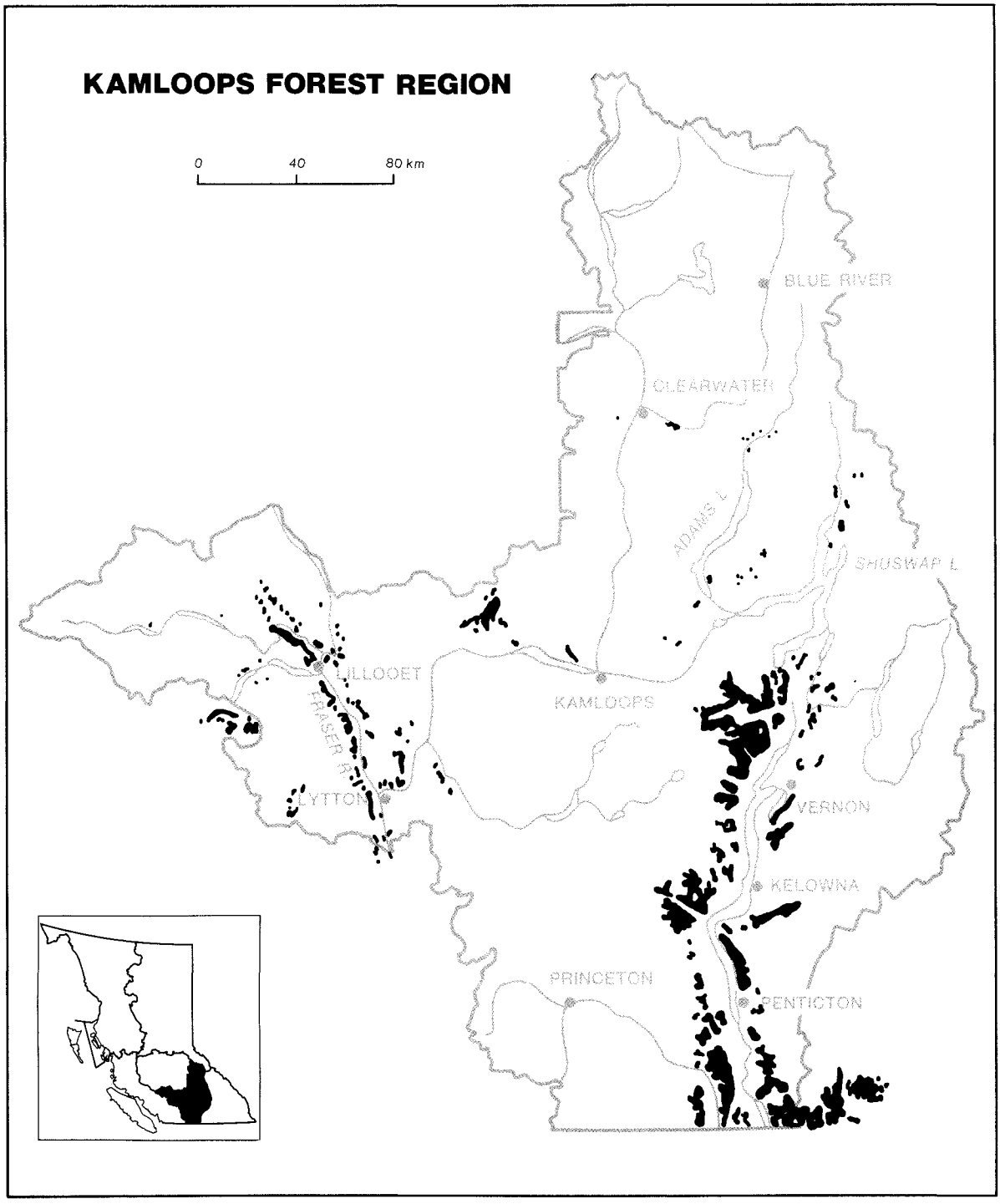
Western spruce budworm

Choristoneura occidentalis

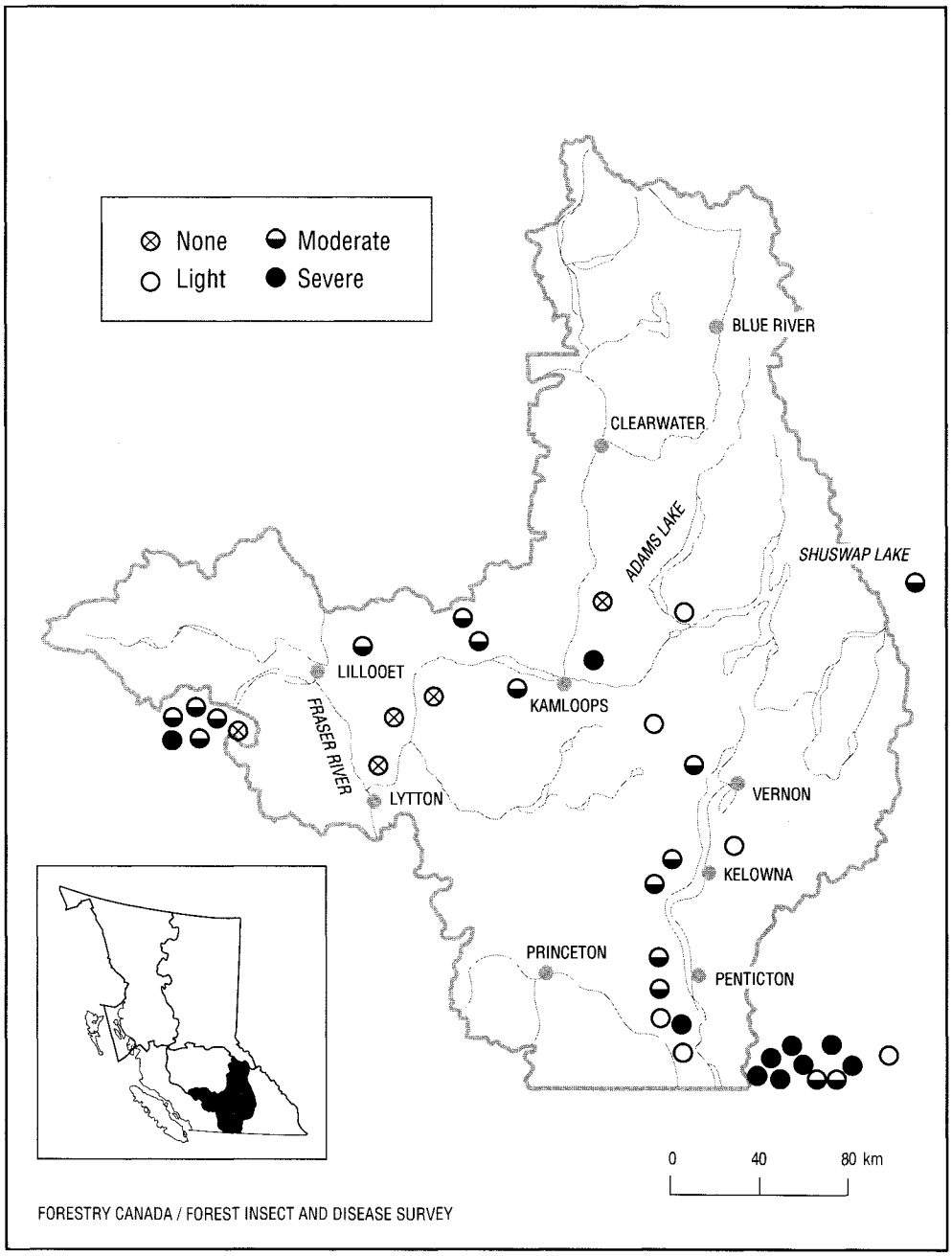
More than 165 800 ha of mixed-age interior Douglas-fir in parts of three forest regions were defoliated by western budworm in 1989 (Map 2), about half the area affected in 1988. There were more than 460 separate areas of infestation of which 85% (143 320 ha) was in the Kamloops Region, 11% (17 600 ha) was in the Nelson Region, and 4% (4880 ha) was in the Vancouver Region. Defoliation was light on 79% of the area, moderate on 19%, and severe on 2%; these defoliation levels were similar to those observed in 1988. As in 1988, the most severe defoliation was mostly in the Shuswap Lake area, near Vernon, Kelowna, and Penticton, and for the first time in the western part of the Nelson Region.

Defoliation decreased on 248 000 ha including the eastern part of the Cariboo Region and, for the second consecutive year, the North Thompson and Adams river drainages in the Kamloops Region. Areas of expansion totaled 54 000 ha and included the southwestern part of the Nelson Region, the Bridge and Fraser river drainages west and south of Lillooet in the Kamloops Region, and near Pemberton in the Vancouver Region. Infestations in the Okanagan Valley were largely unchanged over about 105 000 ha. Of the total area infested since 1983, 44% has been defoliated for 1 year, 32% for 2 years, 17% for 3 years, 5% for 4 years, less than 1% for 5 years, and less than 1% for 6 years.

Parasitism of late-instar larvae occurred at all 13 sites sampled and averaged 10% (range 1 to 22%); this is still too low to effectively reduce populations. The population decline in the Kamloops Region has been



Map 2. Defoliation by the western spruce budworm detected by aerial surveys in 1989.



Map 3. Defoliation by the western spruce budworm forecast for 1990, based on 1989 egg surveys.

attributed to larval starvation in chronically infested areas and also to possible depletion of nutrient reserves of early-instar larvae following emergence during a prolonged warm and dry fall in 1987. The population collapse in the eastern part of the Cariboo Region is attributed in part to disease.

Still, 10% more egg masses were collected at 37 infested stands in three regions than in 1988, indicating a slight overall increase. Increases occurred at 5 of 10 sites in the Okanagan TSA, 4 of 8 sites in the Kamloops TSA, 1 of 2 sites near Lytton, 6 of 11 sites in the Bridesville, Johnstone Creek and Anarchist Mountain areas of the Nelson Region, and at 2 of 6 sites east of Pemberton. Defoliation is forecast to be severe at 10 of the sites, mostly in the Nelson Region, moderate at 16, light at 6, and absent at 5 (Map 3).

Tree mortality and growth loss is variable. Continued monitoring of damage of long-term study plots in

open-growing Douglas-fir near Cache Creek indicates that tree mortality averaged 30 to 40% in 1987, one year after collapse of the infestation in these stands. Decline in diameter increment of mature trees occurred 1 or 2 years after the first year of defoliation in 1979, and increment has been almost nil since 1982. Monitoring continued in 64 research plots established in young open-growing Douglas-fir. These plots were established in 1986 in areas which had sustained 0 to 7 years of defoliation. As of 1988, tree mortality averaged 4.9% but varied widely (from 0 to 75%). A trend of increasing mortality with increasing number of years of defoliation is apparent (R. Alfaro, Forestry Canada, Victoria, personal communication).

In cooperative aerial spray trials, *Bacillus thuringiensis* (Dipel (R) 264) was applied to Douglas-fir at ultra low volumes over 150 ha west of Westbank in the Kamloops Region. Much of the spray was deposited on needles and 86% larval mortality occurred after 6 days in feeding bioassays (I. Otvos, Forestry Canada, Victoria, personal communication). A 100-ha block of Douglas-fir near Johnstone Creek in the Nelson Region was sprayed aerially for the second consecutive year by the British Columbia Forest Service. Spraying of previously treated blocks elsewhere in the Kamloops Region by the British Columbia Forest Service was discontinued.

As part of a study to improve and calibrate detection methods for western budworm, mid to late instar budworm larvae and adult males were monitored in four regions at 10 sites where populations were still low but which had a history of budworm outbreaks. Up to 17 larvae per tree were collected per 1 m^2 beating (three branches on 25 trees/plot) and up to 840 male adults were caught in a total of 50 traps. Further analysis and additional sampling is necessary before numbers can be correlated with population potential and damage.

Douglas-fir tussock moth

Orgyia pseudotsugata

Small numbers of larvae and pupae were present in ornamental spruce trees in urban Kamloops for the second consecutive year since the last outbreak collapsed in 1984. Also, for the first time since 1985, 1 to 39 larvae were collected in standard FIDS samples at permanent sample sites and near previously defoliated stands in the region between Savona and Chase and near Kelowna.

The number of male adults in pheromone-baited sticky traps placed in Douglas-fir stands selected for the greatest historical frequency of outbreaks increased for the fourth consecutive year. About 1890 adult males were trapped in 73% of the traps at 16 of 18 permanent monitoring sites in the Kamloops Region. This is 34% more than the number trapped in 1988. Numbers also increased in the western part of the Nelson Region, where 24 adult males were trapped in 11 of 12 traps at two locations, compared to only one per trap at one location in 1988.

In an effort to more precisely locate the focus of any infestation, additional single traps were placed 1 km apart by FIDS. An additional 1782 male adults were trapped in 60 of 76 traps in three areas in the Kamloops Region, up from 478 at 25 sites in 1988. A further 429 male adults were trapped at 52 locations (average 8 per location) monitored by the British Columbia Forest Service, the same as in 1988. Numbers declined slightly at 18 of the 37 sites monitored for 2 years, and increased slightly at 14 sites.

The 1989 trap data indicates that limited defoliation of Douglas-fir could occur in localized areas in 1990. Egg mass surveys, however, found only one to four masses at sites where 25 or more male moths were trapped between Savona and Pritchard, at Jamieson Creek north of Kamloops, and near Winfield in the Okanagan Valley. This may further limit the extent and severity of any defoliation.

Douglas-fir beetle

Dendroctonus pseudotsugae

Mortality of mature Douglas-fir increased to nearly 2000 groups of 2 to 15 trees, although some patches contained 200 recently killed trees; the total area affected was more than 1800 ha, mostly in the Fraser River drainage in the Cariboo, Kamloops, Prince George and Vancouver regions, and in the eastern part of the Nelson Region. The increase followed an increase over 2 years in the number of Douglas-fir killed by the beetle; many of the trees were predisposed to attack by drought and root disease.

Most of the 1280 groups of recently killed trees in the Cariboo Region, totaling 1160 ha, were widely scattered throughout the region from Clinton north to Quesnel and from Horsefly west to Redstone. More than 320 groups in the Kamloops Region were widely scattered in the Thompson River drainage over a total of 85 ha from Cache Creek to Pavilion, in the Deadman River Valley, and between Barriere and Clearwater. Groups of 20 to 30 standing mature beetle-killed Douglas-fir totaling 3844 trees in 132 pockets over about 300 ha were scattered throughout the Rocky Mountain Trench in the Nelson Region, and there were occasional groups of 150 to 200 killed trees from south of Radium to the international border. In the Prince George Region 204 pockets of Douglas-fir mortality were widely distributed south and west of Prince George

over a total of 110 ha. Increased numbers of beetle-killed trees in 44 areas in the Vancouver Region covered 175 ha, and included five patches of 10 to 30 overmature trees at Twin One Creek at the top end of Lillooet Lake.

The number of new attacks in adjacent trees indicates that mortality of mature and overmature Douglas-fir will likely continue in 1990 in most areas where trees were killed this year, particularly in the Cariboo Region. Population assessments in the eastern part of the Nelson Region indicate increasing populations in areas where severely stressed trees or recent blowdown have occurred in 6 of 10 drainages from Elko north to Radium and north of Bush Arm.

Western false hemlock looper

Nepytia freemani

Populations increased significantly in Douglas-fir stands in parts of the Kamloops Region for the first time since the last outbreak in 1981-83.

The numbers of larvae in standard FIDS samples ranged from 1 to 33 (average 7) near Spences Bridge, and from Savona to Falkland including Cherry Creek and Pritchard. However, the numbers of larvae, and the low numbers of eggs on needles of Douglas-fir at three sites, indicate that populations are still too low to cause defoliation in 1990. Since 1963, periodic infestations have occurred in parts of the Kamloops Region, usually along with infestations of Douglas-fir tussock moth which is currently on the increase elsewhere in the region.

Spruce Pests

Spruce beetle

Dendroctonus rufipennis

The area and volume of mature white and Engelmann spruce killed by the beetle in British Columbia declined for the seventh consecutive year. However, local populations increased north of Prince George and southeast of Bella Coola. Host depletion, salvage, and sanitation have contributed to the general decline in spruce beetle populations and resulting mortality of mature white and Engelmann spruce in the interior regions. Most of the 1000 ha of infested spruce mapped in aerial surveys was in 118 separate infestations, mainly in the Kamloops and Prince George regions; the infested area has decreased from 1675 ha in 1988.

In the Kamloops Region, recent mortality of mature spruce was again confined mostly to previously infested stands in the Lillooet District. Infested areas at Connel, Noel and McGillivray creeks totaled 905 ha in nine pockets, which is similar to the area infested in 1988. Older infestations in the Tulameen River drainage declined further, to two pockets totaling 24 ha, down from 430 ha; this decline was due primarily to harvesting. Additional pockets of 2 to 10 recently killed spruce occurred in the Fraser Canyon, near Princeton, and near the Barriere lakes.

Beetle populations in the Nelson Region, mostly in scattered blowdown at the heads of drainages in the East Kootenay, declined overall. However, at Redding Creek west of Kimberley, late-instar 2-year-cycle broods in windthrow attacked in 1988 pose a threat to adjacent standing spruce in 1990. New attacks, averaging 6 per 500 cm^2 of bark sampled in more recent blowdown in the Bull, White, and Bush river drainages, were common. This indicates potential for very light attacks in standing trees in 1991. There were no new attacks in standing spruce at the southern boundary of Glacier National Park, where beetle broods in bolts were partially reduced by the 'drying out' treatment.

Local populations increased in the Prince George Region, mostly in recent windthrow and in standing spruce near Weedon, Kerry and Davis lakes, and pose a threat to adjacent stands in 1990-91. Recent blowdown was widespread in the McGregor and Table river valleys and in Mt. Robson Provincial Park, and new beetle attacks are a potential threat in 1991.

Mature Sitka spruce adjacent to recent windfall in a 5-ha pocket near Odegaard Falls east of Bella Coola in the mid-coast part of the Vancouver Region were attacked by spruce beetle in 1988. Surviving broods may pose a threat to nearby mature spruce in 1990.

Beetle populations in spruce predisposed by mud slides associated with road construction along the Haines Road in the northern part of the Prince Rupert Region have been effectively reduced to endemic levels by control programs including salvage and strip debarking of felled trees. Small population increases occurred in the southern part of the region, mostly in the Morice TSA.

True Fir Pests

Budworms

Choristoneura spp.

Defoliation of spruce and alpine fir forests by eastern and 2-year-cycle budworms covered 123 750 ha and 17 000 ha, respectively, in parts of four forest regions (Map 4). An additional 11 400 ha of fir and spruce were defoliated by a budworm, the taxonomy of which is still being determined.

Current foliage of white spruce and alpine fir was defoliated by eastern spruce budworm, *Choristoneura fumiferana*, over 123 750 ha in more than 200 separate patches north and west of Fort Nelson. This is more than three times the area affected in 1988. Defoliation again extended into the Northwest and Yukon territories and occurred for the fifth consecutive year in some areas around Fort Nelson. Defoliation was severe over about 10% of the area, mostly from Nelson Forks to the territories boundary. Light and moderately defoliated stands occurred equally over most of the remaining areas from Coal River east to Smith River and Liard Hot Springs, south of Fort Nelson in the Muskwa River, and north to the Beaver River drainage.

The average number of egg masses on spruce foliage at five sites near Fort Nelson exceeded 100 per 1 m^2 of foliage, and at two sites the number of egg masses exceeded 13 per m^2. This indicates continuing high populations of eastern spruce budworm and potentially severe defoliation in many previously defoliated stands in northeastern British Columbia in 1990. Despite a high moth catch (1143 male moths per trap), egg mass samples from the northeastern part of the Prince Rupert Region contained either no egg masses or only one per branch, too few to cause any noticeable defoliation in the area in 1990.

There were no follow-up applications of *Bacillus thuringiensis* in defoliated seed blocks near Fort Nelson that were sprayed aerially by the British Columbia Forest Service in 1988.

Defoliation of alpine fir and spruce forests by 2-year-cycle spruce budworm, *Choristoneura biennis*, was very light over 17 000 ha in 55 infestations in four forest regions. This was down from 102 000 ha in 1988, a feeding year, and from 59 750 ha in 1987. Defoliation by immature 'on-cycle' budworm totaled 7300 ha in about 40 separate areas, including 2800 ha in the Cariboo Region, 300 ha in the Kamloops Region, and 4200 ha in the Prince George Region. Mature 'off-cycle' budworm defoliated about 15 areas in the Kamloops and Nelson regions totaling 9800 ha, and probably an additional 11 385 ha in the Ospika River drainage north of Mackenzie in the Prince George Region. Taxonomic and pheromone studies are in progress to more accurately determine the species.

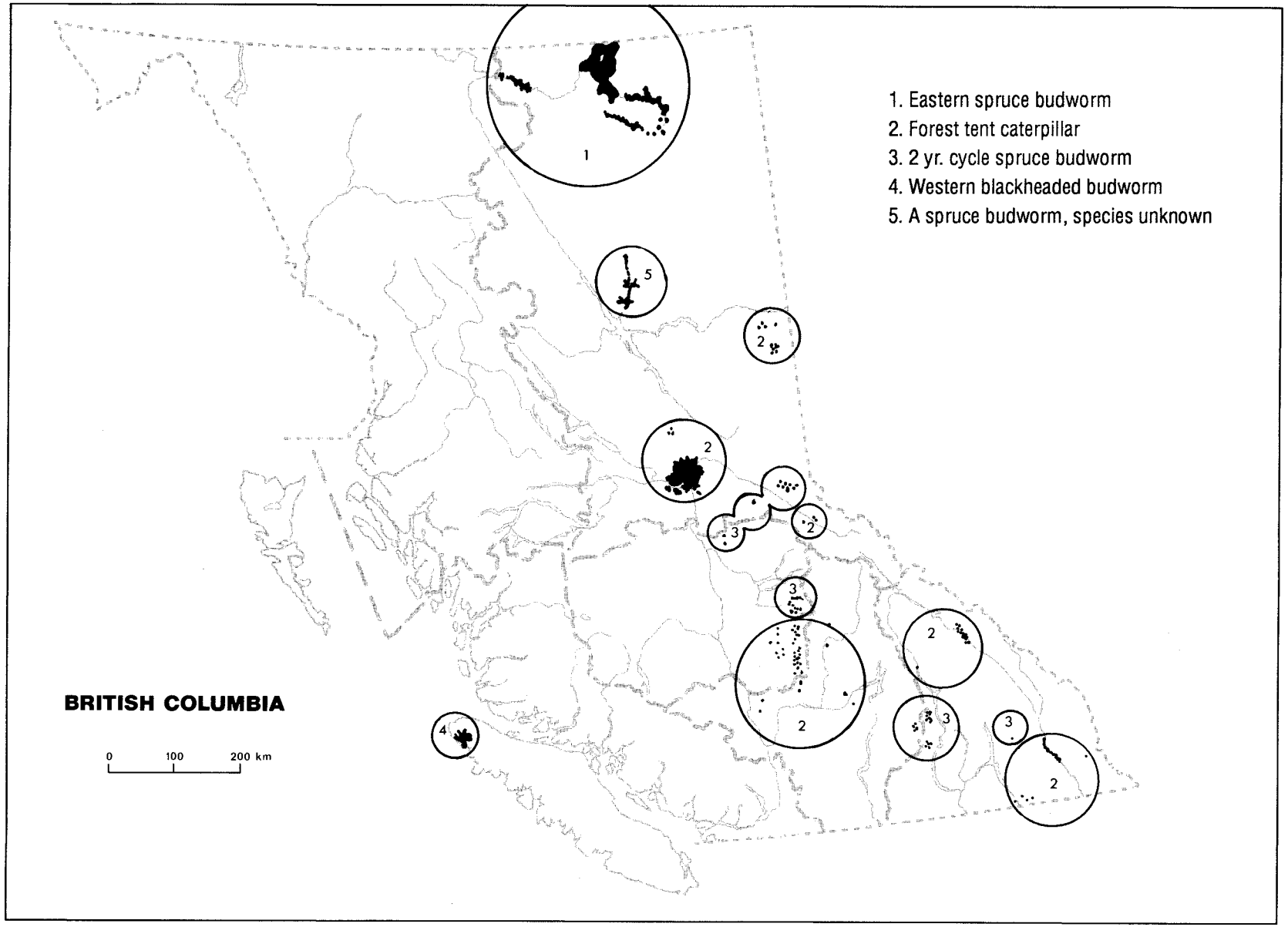
New shoots of alpine fir and white spruce east of Prince George were infested and lightly defoliated by immature larvae of 2-year-cycle budworm over about 4200 ha. Based on the numbers of infested buds, defoliation by mature larvae is forecast to be mostly light and moderate, although in isolated areas it will be severe. Areas affected will include the Everett and Tumuch creek drainages, near Slim and Stoney lakes, and along the Bowron Coal Road.

In the Kamloops Region, six separate fir-spruce stands totaling 300 ha were lightly defoliated in the upper part of the Fishtrap Creek drainage east of Bonaparte Lake. There was no evidence of infested buds elsewhere in the region, where infestations were widespread in the North Thompson, Adams, and Shuswap river drainages and near Mabel Lake in 1988.

Defoliation of new shoots of fir and spruce by immature larvae in the northeastern part of the Cariboo Region was light in 15 areas totaling 2800 ha. This was mostly between Canim and Horsefly lakes and west of Barkerville in the Willow River Valley, where more than 240 separate infestations occurred in the mature feeding year in 1988. Defoliation by mature larvae is forecast to occur in 1990; defoliation will be mostly moderate in stands in the Big River Valley and severe in the Swift River Valley.

Mature 'off-cycle' budworm lightly defoliated new shoots of high-elevation fir and spruce over 9800 ha in 15 areas in the Kamloops and Nelson regions. In the Upper Kettle River Valley at Keefer Lake in the eastern part of the Kamloops Region, fir and spruce over more than 3800 ha were defoliated, up from 2200 ha in 1988. In the West Kootenay, fir and spruce in seven areas, including Plant and Barnes creeks in the Arrow Lakes TSA, were lightly defoliated. In the East Kootenay, defoliation occurred at Bugaboo Creek in the Invermere TSA, and over 50 ha in the upper St. Mary River drainage, west of Kimberley, where immature larvae were common in 1988. Egg samples from infested stands in the Nelson Region indicate high numbers of immature budworm larvae in new buds in 1990.

Larvae and adult male budworm populations continued to be monitored in four regions to improve identification and calibrate methods to detect budworm



Map 4. Areas where current defoliation was detected during aerial surveys in 1989.

populations in fir-spruce forests. Further study, however, is necessary before data can be correlated with population damage and potential.

Balsam woolly adelgid

Adelges piceae

Continuing surveys on Vancouver Island found active adelgid populations on true fir for the first time in the China Creek drainage south of Port Alberni and near Qualicum Beach; both these areas are within the quarantine zone. Additional surveys of grand fir along the international border in the Nelson Region have not found any significant occurrence of the adelgid, which has recently increased significantly in subalpine and grand fir in northern Idaho. The status of quarantine regulation zones in southwestern British Columbia was reviewed. There is now a satellite quarantine zone around West Thurlow Island following the discovery of the adelgid there in 1987, and the zone on Vancouver Island has been extended north to include Qualicum Beach following the recent discovery of the adelgid at Parksville.

Predator recovery surveys continued for the third consecutive year; results are expected in 1990. Methods of controlling the adelgid on seedlings were tested in 1987-88, but none of the treatments provided an acceptable level of control.

Consequently, restrictions on the movement of *Abies* from infested zones into the uninfested areas of the province are still necessary.

Balsam shoot boring sawfly

Pleroneura sp.

Sawfly populations increased significantly for the second consecutive year and killed many new shoots of true firs in higher-elevation forests in the Vancouver and Nelson forest regions.

Bud damage was widespread in the Vancouver Region, where up to 60% (average 40%) of the buds on 80% of the amabilis fir were killed over about 50 ha southwest of Powell River. Lateral shoots on 70% of 20-year-old amabilis fir at Chipmunk Creek near Chilliwack were also killed. North of Sechelt, 5 to 30% (average 10%) of the buds on 65% of the immature amabilis fir were infested over a widespread area near Richardson Lake and Gray Creek; two stands in the Capilano watershed were similarly affected.

Near Creston in the Nelson Region, increased sawfly populations along the Arrow Creek access road destroyed most terminals on understory grand fir and defoliated about half of the lateral shoots on the understory and 10% of the overstory. Only 1% of the understory shoots were infested in 1988.

The sawfly, not previously considered a noteworthy pest of true firs in British Columbia, was recorded for the first time in the Vancouver Region in 1988 near Holberg, and for the first time in 15 years in the Nelson Region near Creston. Current sampling methodology precludes an accurate forecast; however, historical records indicate that populations can be expected to continue in previously infested stands in 1990.

Fir engraver

Scolytus ventralis

Mortality of grand fir by fir engraver beetles increased significantly in the southern part of the Nelson Region. Single trees and up to 50% of the grand fir over areas up to 30 ha were killed in the Pend-d'Orielle area of the West Kootenay; the largest damaged area was near Seven Mile Dam. The significant population build-up was attributed to the availability of hosts predisposed by drought stress during the previous 2 to 3 years.

Western balsam bark beetle

Dryocoetes confusus

The area of recently killed mature alpine fir mapped during aerial surveys totaled 22 000 ha in more than 450 separate pockets in parts of all six forest regions, although most mortality occurred in the Prince Rupert Region.

Infestations have persisted in the Prince Rupert Region for many years but were mapped in only 52 areas totaling 12 875 ha in 1989. However, aerial surveys in the eastern part of the region were limited, and in 1988 more than 240 pockets were mapped over 57 700 ha in this area. Most of the recently mapped tree mortality was in the northwestern part of the region, in the Taku River drainage and east of Atlin, and in the Dease Lake and Cassiar areas. Additional small pockets of 5 to 10 trees totaling 135 ha were mapped in the upper Skeena River drainage.

More than 80 separate areas totaling 3900 ha containing alpine fir recently killed by the western balsam bark beetle were mapped in the Prince George Region; this threefold increase is largely due to expanded aerial surveys. Most mortality occurred in chronically infested areas east of Prince George and in new areas northwest of Fort St. James.

In the Cariboo, Kamloops, Nelson, and Vancouver regions, areas containing recently killed alpine fir increased overall to 2160 ha, 310 ha, 1600 ha, and 1175 ha, respectively, in about 320 separate stands, up from

3535 ha in 240 areas in 1988.

Annual fluctuations in the areas containing recently killed mature alpine fir are due in part to the limited aerial surveys in the more remote areas. In addition, there is some uncertainty about the length of time reddened needles remain on affected trees; some reddened needles remain on beetle-killed trees for at least 5 years.

Hemlock Pests

Western blackheaded budworm

Acleris gloverana

Following four consecutive years of blackheaded budworm and hemlock sawfly feeding, populations on the Queen Charlotte Islands collapsed; 7350 ha were affected in 1988. Near Holberg on northern Vancouver Island, western hemlock was defoliated over 7400 ha (Map 4), up from 4800 ha in 1988; some areas were defoliated for the third year. In the eastern part of the Prince Rupert Region, new shoots on alpine fir were moderately defoliated over about 65 000 ha, up from 58 000 ha in 1988; this was the most widespread defoliation since this outbreak was first recorded in 1982.

As predicted, budworm populations increased on northern Vancouver Island and defoliated all age classes of western hemlock in about 124 separate areas near Holberg. Defoliation was severe for the first time in eight areas totaling 1100 ha, while moderate defoliation increased to 16 areas over 3950 ha, and lightly defoliated areas declined to 2350 ha. The infestation expanded near Holberg and to the southwest near Raft Cove and Winter Harbor, but decreased in the William Lake and Cape Scott Provincial Park areas.

Parasitism of mid to late instar budworm larvae averaged 13% (range 1 to 51%), which is considered too low to significantly reduce the population. An average of 14 eggs per 45-cm hemlock branch were found at 16 sample sites near Holberg; this indicates continuing defoliation of hemlock in the area in 1990. Light defoliation is forecast at ten sites, moderate defoliation is forecast at two sites, and trace defoliation is forecast at the remainder. Actual defoliation could be less than forecast.

Following four consecutive years of defoliation of western hemlock stands on the Queen Charlotte Islands by blackheaded budworm and hemlock sawfly, populations collapsed. Surveys of stands severely defoliated by both pests for at least two successive years found tree mortality to be widespread and patchy; an average of 29% (range 0 to 94%) of the 20- to 45-year-old hemlock were killed.

A commercial formulation of *Bacillus thuringiensis* (B.t.) was applied aerially to budworm larvae in western hemlock in three blocks totaling 108 ha near Holberg. The cooperative study found that an average of 52% of larvae that fed for 6 days on the sprayed foliage were killed. Additional calculations of population reductions are in progress (I. Otvos, Forestry Canada, Victoria, personal communication).

Larch Pests

Larch casebearer

Coleophora laricella

As in the previous two years, populations of larch casebearer generally were low in western larch stands in southeastern British Columbia.

In the Nelson Region, defoliation generally was minimal. Populations in the western part of the host range in the Kamloops Forest Region were also very low and defoliation also was minimal. At most of the 20 long-term parasite release study sites in the Nelson Region, defoliation was nil to light and was moderate only near Castlegar. Larval parasitism at the sites ranged from 0 to 67% (average 20%). About 13% of this parasitism was caused by the introduced *Agathis pumila*, and the remainder was caused by *Chrysocharis laricinellae*. Pupal parasitism at 17 sites averaged 23% (range 0 to 51%); this level of parasitism was similar to that observed in 1988, and was mostly caused by *C. laricinellae*, by *A. pumila*, and by a native parasite, *Spilochalis* sp. (L. Humble and I. Otvos, Forestry Canada, Victoria, personal communications).

With several consecutive years of low populations, attributed in part to the success of the parasite releases, sampling of overwintering larvae to determine populations and to forecast defoliation was discontinued. Results from more than 10 years of assessments are being evaluated. Since the biological control program against larch casebearer was initiated in 1966, more than 15 000 specimens of *Chrysocharis laricinellae* or *Agathis pumila* have been released. No parasites were released in 1989, and additional releases are not anticipated until the results to date can be further assessed.

Larch sawfly

Pristiphora erichsonii

Larch sawfly populations again defoliated stands of western and exotic larch and tamarack in British Columbia and the Yukon Territory; some areas were defoliated for the third consecutive year.

In the Nelson Region, defoliation of western larch at Miller Creek near Grand Forks declined to only trace levels. In 1988, for the first time in 20 years, moderate and severe defoliation occurred over 100 ha. Populations in the East Kootenay were greatly reduced in 1988 by a chalcid parasite, *Dibrachys saltans*, following several years of fluctuations. This resulted in little or no defoliation of larch in the Elk River Valley where patches totaling 400 ha had been lightly or moderately defoliated in 1988.

Mixed-aged tamarack stands in the southwestern part of the Yukon Territory north of Watson Lake from Simpson Lake to Finlayson Lake were moderately defoliated, some for the third consecutive year. Tamarack in the northern part of the Prince Rupert Region south of the Yukon border were also moderately defoliated.

Exotic larch at Terrace were defoliated for the third consecutive year, and tamarack in Prince George were defoliated for the second year. Sawfly populations in exotic larch in the University of British Columbia Research Forest near Haney in the Vancouver Region declined for the second consecutive year, and caused only very light defoliation. Populations were recorded for the first time on larch in Stanley Park, where a small group of trees near Brockton Point were lightly defoliated.

Larch needle blight

Hypodermella laricis

New needle blight infections and discoloration of western larch were generally light, although there were pockets of moderate and severe defoliation at widespread locations in the western and southeastern parts of the host range in the Nelson and Kamloops regions. This defoliation was similar to that observed in 1988, which followed 2 years of severe and widespread infection.

Discoloration was more severe in parts of the West Kootenay, including the Christina Lake area, near Grand Forks, Johnstone Creek east of Bridesville, and in pockets in the lower Kettle River Valley. In the East Kootenay, new infections increased overall; moderate or severe discoloration occurred in patches of up to 5 ha in most western larch stands in the western and southern parts of the Rocky Mountain Trench. Infections in the eastern part of the Trench declined slightly, but severely discolored larch were scattered near Skookumchuck and Dutch Creek. Most western larch in the north Okanagan Valley in the Kamloops Region and near Sicamous and east of Cherryville were lightly and moderately discolored; infections of similar extent and intensity occurred in these areas in 1988.

Larch budmoth

Zeiraphera improbana

Budmoth populations remained endemic in previously infested stands in the West Kootenay part of the Nelson Region after increases in 1988 at Johnstone Creek east of Bridesville.

European larch canker

Lachnellula willkommii

Formal surveys for this potentially damaging canker in western, alpine, eastern and some exotic larch stands in British Columbia were discontinued in 1989. This followed eight successive years of surveys which revealed no evidence of the disease. A native larch canker continues to be found on immature western larch in the West Kootenay. The distribution of the canker in North America remains limited to New Brunswick and Nova Scotia and several eastern states where small-diameter trees have been infected and killed.

Multiple Host Pests

Black army cutworm

Actebia fennica

Cutworm populations in previously infested areas in interior British Columbia declined significantly in 1989. Seedlings and herbaceous ground cover were very lightly defoliated at two sites in the Prince Rupert Region, and only ground cover was affected at one site in the Nelson Region. Larvae but no feeding damage were found at six previously infested sites in the Nelson Region, in very low numbers at widespread sites in the western part of the Prince Rupert Region, and at one site north of Prince George. None was found at an additional twelve sites surveyed in these two regions, or in the Cariboo and Kamloops regions where larvae were present in 1988.

The decline was attributed to natural factors: parasites and an entomopathogen reduced populations by as much as 42% at 11 sites in three regions in 1988. In 1989 additional parasitism, primarily tachinids, affected 53% of the larvae at two sites in the Golden TSA and 47% of the pupae from the Kispiox area in the Prince Rupert Region.

In the Nelson Region, the number of cutworm larvae declined to less than 5 per 1000 cm^2 from 15 per 1000 cm^2 at six areas in the Golden TSA. However, at sites near Redrock Harbour east of Mica Dam in the West Kootenay, about 10% of the spruce seedlings stripped by cutworms in 1988 over about 100 ha were dead, as were 16% of the previously stripped Douglas-fir over about 15 ha near Bush Harbour.

In the Prince Rupert Region, where cutworms were numerous in 1988, cutworm larvae were present at only 2 of 10 sites including sites where up to nine male adults were caught in sticky traps in late 1988. In the eastern part of the region, small numbers of larvae very lightly defoliated white spruce seedlings and ground cover at two sites. Larvae but no feeding damage were common at 1- and 2-year-old burns in the western part of the region.

Near Weedon Lake north of Prince George only very low numbers of cutworm larvae were observed and no damage occurred where ground cover was defoliated in 1988. Larvae were not found elsewhere in the region, including near McBride where seedlings and ground cover had been defoliated over 30 ha in 1988.

Cutworms could pose a threat to seedlings in 1990 plantings following slash burning in 1989. This prediction is based on the numbers of male adults in sticky traps which exceeded a trial threshold of 10 at 31 of 81 sites in parts of four regions, mostly in the Prince Rupert Region. Additionally, non-sticky traps at 7 of 87 sites contained more than a threshold of 500 adult males; five of the sites were in the Prince Rupert Region and two were in the East Kootenay. Each sticky trap was baited with a non-commercial experimental pheromone and was set out with a commercial non-sticky trap containing a commercially produced pheromone for comparison. Additional years of trapping are required before results can be calibrated and used as a forecasting tool.

Building on earlier studies by R. Shepherd in cooperation with FIDS, a contract to develop a predictive warning system linking moth catches in non-sticky

pheromone traps with subsequent defoliation and a seedling and vegetation damage index completed its third and final year of field studies. A report is being compiled.

Rhizina root disease

Rhizina undulata

Rhizina root disease infected and killed newly planted conifer seedlings in 37 of 72 burned sites in parts of the Nelson and Prince Rupert forest regions and at one site in the Cariboo Region; most of these sites were burned in 1988, but a few were burned in 1987. Fruiting bodies were present but seedlings were not affected at an additional 13 sites in the Nelson and Prince Rupert regions and at one site in the Kamloops Region. There was no evidence of Rhizina at an additional 22 recently burned sites. It was the second consecutive year of seedling mortality caused by this disease since it was first recorded in British Columbia 20 years ago.

Seedling mortality was greatest in the Prince Rupert Region, where up to 74% (average 23%, up from 14% in 1988) were killed at 24 sites. Most seedlings were spruce, pine and western hemlock; western red cedar seedling mortality was also recorded in association with the Rhizina root disease for the first time in British Columbia. An additional 17% of the seedlings were killed at one plantation where 6% had been killed by the fungus in 1988.

In the Nelson Region, seedling mortality increased from an average of 9% in eight plantations in 1988 to 17% (range 2 to 39%) in 13 of 48 plantations surveyed by FIDS in 1989. Fruiting bodies without seedling mortality were observed at 13 of the 48 sites and were absent at an additional 22 sites. High mortality occurred at six sites in the West Kootenay: 38% of the Douglas-fir and lodgepole pine were killed at one site; 30% of the Douglas-fir were killed at one site; and up to 25% of the Engelmann spruce, western larch, and Douglas-fir were killed at four sites. At two previously infested sites in the West Kootenay, a total of 34% and 19% of the seedlings have been killed; in 1988, 15% and 6% of seedlings were killed in these areas, respectively. At one site in the East Kootenay up to 60% of the lodgepole and white pine seedlings were killed, and 2 to 21% were killed at five other sites. In two areas in which 33 and 44% of seedlings were killed in 1988, only an additional 1 or 2% of the seedlings were killed.

About 12% of the Douglas-fir seedlings were killed in a 5-ha recently burned site south of Cariboo Lake in the eastern part of the Cariboo Region. This was the first record of seedling mortality linked to the fungus in the region since 1983. Mortality of pine seedlings was reported near Canim Lake by industry personnel.

Fruiting bodies were common and widely scattered over more than 80 ha in a recently burned and planted area west of Clearwater in the Kamloops Region. However, seedling mortality was not attributable to infection by Rhizina, but may have resulted from planting shock.

The abundance of fruiting bodies in 1989 could provide inoculum to infect some recently burned adjacent sites in 1990 and for 1 to 3 years thereafter; however, there is no reliable method of prediction.

Climatic injury

Foliage on most conifers, particularly on hemlock and cedar, was severely discolored and some trees were killed in early 1989 at more than 115 widespread areas totaling 22 700 ha in six forest regions. This follows unusually cold temperatures accompanied by strong winds in late January and early February.

In the Cariboo Region, up to 100% of the foliage of most age classes of hemlock, cedar, and Douglas-fir were discolored in more than 30 areas over 2600 ha in the eastern part of the region from Likely to Horsefly, and from Horsefly to Quesnel lakes. Most of the affected trees later refoliated. Bud mortality was common in young Douglas-fir and spruce plantations in the region east of Highway 97.

In the Bella Coola Valley in the mid-coast part of the Vancouver Region, mixed-aged hemlock, cedar, Douglas-fir and lodgepole pine over 9350 ha in 57 areas from near Bella Coola and along Burke Channel to King Island were severely discolored and defoliated, and many mature and overmature hemlock and Sitka spruce were killed over about 1500 ha near Bella Coola.

Discoloration of most conifer species in the Kamloops Region was widespread over about 800 ha, and was most severe in the Highland Valley south of Kamloops. Less severe discoloration was common elsewhere, including in extensive areas of cedar in the North Thompson River drainage and particularly in Wells Gray Provincial Park and around Vavenby.

In the eastern part of the Nelson Region, up to 60% of the Engelmann spruce and 35% of the lodgepole pine were discolored and dying over 1100 ha, mostly in the Flathead and Elk river drainages. Buds on Douglas-fir and western larch in the area were damaged by frost and wind; this reduced and delayed the bud flush. Whitebark and lodgepole pines on western slopes in the area were severely discolored. Western hemlock in the Bush River Valley and in Glacier National Park were lightly discolored.

In the Prince George Region, most western hem-

Table 2. Number of young stands and species examined in British Columbia, 1989.

Region	Total	Species					
		Pine	Douglas-fir	Spruce	True fir	Hemlock	Other[1]
Cariboo	12	10	-	1	1	-	-
Kamloops	10	3	2	1	-	-	4
Nelson	35	15	3	9	-	1	7
Prince George	32	24	-	8	-	-	-
Prince Rupert	62	12	-	17	-	4	29
Vancouver	27	2	14	-	-	2	9
Total	178	66	19	36	1	7	49
(%)		(37)	(11)	(20)	-	(4)	(28)

[1]Includes plots with equal proportion of two or more hosts, or plots in which the major component is not listed above, e.g., cottonwood or western red cedar.

lock in patches over more than 2700 ha east of Prince George to McBride and in the Bowron River Valley were lightly discolored. Mortality of about 60% of the new buds on spruce was common on most trees in stands east of Highway 97.

Loss of 1988 foliage was common in the Prince Rupert Region where stands over more than 6150 ha were discolored; hemlock was particularly affected on exposed sites along the Skeena River Valley. Lodgepole pine seedlings in some exposed plantations near Fulton Lake in the eastern part of the region lost up to 20% of the 1988 needles. All the lodgepole pine and most trembling aspen and birch over 750 ha at Conglomerate Mountain south of Carmacks in the Yukon were severely discolored.

Inonotus root disease

Inonotus tomentosus

Surveys of mature and overmature lodgepole pine and Engelmann spruce in four drainages in the East Kootenay part of the Nelson Region found the disease in 68% of the pine in 10 of 11 stands and in 59% of the spruce in 10 stands. From 35 to 94% of the pine and 17 to 89% of the spruce were infected in the 21 stands examined in the Spillimacheen, Beaverfoot, and Bull river drainages, and 90 and 93% of the pine at two sites at Dewar Creek were infected. Armillaria root disease, *Armillaria* sp., was also present in three of four pine stands. Schweinitzii butt rot, *Polyporus schweinitzii*, was present in association with *Inonotus* in three areas and in most recent spruce blowdown in parts of Mt. Revelstoke and Glacier national parks.

Pests of young stands

More than 175 young, 2- to 25-year-old natural and planted conifer stands containing more than 15 000 trees were surveyed in British Columbia in 1989. This was part of a continuing study to identify major pests and environmentally related problems and their impact on young stands.

At least seven trees were examined at each of 10 or more circular plots at each location. Pines were the major component in about 37% of the sites, spruce in 20%, Douglas-fir in 11%, and hemlock in 4% (Table 2). The balance contained a mix of at least two conifer species, one site contained mostly cedar, and one was cottonwood.

The most common, damaging and widespread problems included climatic injury, animal feeding, and infection of new and older needles by native diseases. Less common and widespread but locally significant and damaging were terminal and root collar weevils and stem rust cankers.

Bud mortality, foliar discoloration, and premature needle loss were common on most conifers in about 40 young stands in parts of six forest regions. The damage resulted from unusually cold temperatures accompanied by strong winds in late January and early February. Bud mortality ranged from 2 to 75% in Engelmann spruce and alpine fir from the eastern part of the Nelson Region to Tweedsmuir Provincial Park. Foliage of white spruce, lodgepole pine, and alpine fir at 16 sites in the Prince George Region were lightly or moderately discolored, and up to 80% of the buds were killed at three sites near Mackenzie and Manson River. Desicca-

tion of 20 to 50% of the new shoots of cedar, hemlock, and some spruce was common in the North Thompson River Valley. Up to half the Douglas-fir and grand fir were moderately discolored at five sites in the Vancouver Region, and 10% of the 2-year-old Douglas-fir at a site near Yale were killed, and buds were killed on an additional 20%. About 10% of the buds on more than half the young Sitka and white spruce and alpine fir at 18 sites in the western part of the Prince Rupert Region failed to flush due to late winter freezing. In the eastern part of the region, terminal bud mortality resulting in multiple tops affected more than half the white spruce at two plantations in the Telkwa River and Burdock Creek drainages.

Feeding damage to the stems, branches, and foliage of most conifer species by several animal species was common in more than 50 young stands in parts of six forest regions. Stocking levels, however, were not usually reduced. Deer browse of Douglas-fir, hemlock, and cedar was common at 11 plantations on Vancouver Island and throughout the mainland part of the Vancouver Region, but fewer than half the trees were affected. Debarking of stems and branches by squirrels resulted in top-kill but no tree mortality at 10 sites in four regions. About 10% of the western larch at one site in the East Kootenay were top-killed up to 1 m. Seventy percent of the 15-year-old whitebark pine near Tweedsmuir Park and 40% of the lodgepole pine near Horsefly in the Cariboo Region were partially girdled; similar damage occurred near Kamloops and southwest of Prince George. Increased vole, *Microtus* sp., populations clipped the leaders of most western red cedar in a 1988 plantation near Squamish in the Vancouver Region. Voles were less numerous than in recent years in the Prince Rupert Region, but terminal and lateral clipping by hares, *Lepus* sp., affected 60% and 55% of the white spruce at two sites in the western part of the region. At two additional sites in the area, the mid and upper crowns of more than 75% of the exotic larch were killed by porcupines, which have killed significant numbers of conifers and reduced stocking levels in silviculturally treated stands in recent years. Stripping of bark by black bears, *Ursus* sp., killed 12% and 5% of the lodgepole pine and partially girdled 7% at two sites in the Nelson Region.

Infection and discoloration of new and older needles by several foliar diseases on conifer hosts were generally light but occasionally severe in parts of six forest regions. The infections resulted primarily in premature needle loss, but caused little change in vigor or form. A pine needle rust, *Coleosporium asterum*, and a needle cast, *Lophodermella concolor*, lightly infected older needles, resulting in premature loss on most lodgepole pine at six sites in parts of the Cariboo, Nelson, Prince George, and Prince Rupert regions. Rhabdocline needle cast, *Rhabdocline pseudotsugae*, and Swiss needle cast, *Phaeocryptopus gaeumannii*, lightly infected year-old needles resulting in premature needle loss on less than 25% of the trees at only two sites in the East Kootenay and at one site north of Kamloops. Infection of western larch foliage by larch needle blight, *Hypodermella laricis*, and larch needle cast, *Meria laricis*, was generally light at four sites surveyed in the Nelson Region. However, height growth on severely infected immature trees was reduced by 30%. Fir-fireweed rust, *Pucciniastrum epilobii*, discolored up to 60% of the new foliage on up to half of the true firs in plantations near Powell River and east of Stewart, and lightly infected current needles on regeneration alpine fir east of Prince George.

Less than 5% (range 1 to 12%) of the terminals of immature lodgepole pine in 10 plantations were attacked and killed by lodgepole pine terminal weevil, *Pissodes terminalis*, in 1989. The highest incidence, 12%, was in one of five sites infested in the eastern part of the Prince Rupert Region. Spruce terminal weevil, *P. strobi*, was more damaging and more widespread, particularly in the western part of the Prince Rupert Region, east of Prince George, and near Barriere. Terminal mortality averaged 20% in 31 stands surveyed in parts of five forest regions. Current attack in 10- to 20-year-old Sitka spruce in the Prince Rupert Region averaged about 22% (range 2 to 48%); the highest level of damage occurred north of Kitimat. At two sites east of Prince George in the Goat River drainage, new attack was 3% and 2%, but at one site southwest of Prince George, current attack was 17%. East of Barriere in the Kamloops Region 57% of the spruce terminals in one plantation were killed, but only 16% were killed at a site south of Vavenby. Leader mortality in a single plantation in the Cariboo Region and at five sites in the East Kootenay was less than 10%.

Pine root collar weevil, *Hylobius warreni*, infested lodgepole pine in only 5 of 66 pine plantations and spruce at only one site in four forest regions surveyed in 1989. Only 4% of the infested lodgepole pine were killed at a site east of Golden in the Nelson Region. The highest level of damage was basal girdling of 12% of the trees at Hannay Creek in the eastern part of the Prince Rupert Region. In previous years, mortality of immature lodgepole pine in nearby areas reached 15% and more than 75% were girdled. At two sites in the western part of the Cariboo Region, 5 and 8% of the pine were partially girdled, and less than 5% of the pine were girdled at a site in the Prince George Region.

Blister rusts, *Cronartium* spp., infected an average of 6% of the immature lodgepole pine at 13 sites mostly

in the eastern parts of the Nelson and Prince Rupert regions. Tree mortality, frequently the result of perennial stem cankers, generally was less than 1%. The highest incidence of stem infection was 30% at one of six sites in the eastern part of the Prince Rupert Region, but only 3 to 9% (average 4%) of the trees were infected at the other five sites. Stems on 25% of the lodgepole pine at one of four sites in the East Kootenay were infected; an average of 5% were infected at the other three sites. West of Prince George, blister rust infections averaged 11% at two sites, and affected 4% of the pine at one site in the Cariboo Region. Although it was present on lodgepole pine in 32 stands in five forest regions, western gall rust, *Endocronartium harknessii*, infected less than 15% of the trees, except at Jamieson Creek, north of Kamloops, where 43% of the pine was infected. There was no evidence of tree mortality due to stem infection. More than half the trees had galls on the branches, but there was little apparent impact on tree form or vigor. White pine blister rust, *Cronartium ribicola*, infected an average of 28% (range 3 to 55%) of the white pine in nine plantations in three forest regions, particularly in the Nelson Region. These included more than half the trees at one site east of Kimberley, and one-third to one-half of the pine at sites near Creston, New Denver and Nakusp. At two sites north of Kamloops, about 12% of the white pine were infected, and 20% were infected at a site near Sechelt.

Small, superficial unidentified perennial stem and branch cankers were common on Douglas-fir at three plantations in the West Kootenay, but these had little effect on tree growth and development.

Mortality of young lodgepole pine, some Douglas-fir, and occasionally other conifers caused by Armillaria root disease, *Armillaria* spp., occurred at 27 natural and planted sites, mostly in the Nelson and Kamloops regions. Mortality of lodgepole pine ranged from 1 to 25% (average 4%) at 13 sites, mostly in the East Kootenay. The highest incidence (25%) was in 16-year-old trees near Adams Lake in the Kamloops Region and in 14-year-old lodgepole pine in the western part of the Cariboo Region. In the Palliser, Flathead, and Bull river drainages in the East Kootenay, up to 15% (average 6%) of the lodgepole pine were infected in the survey plots, and outside the plots there were an estimated 50 infection centers per hectare. Mortality of Douglas-fir ranged up to 21% (average 7%) at nine sites in two regions; mortality was 21% at Adams Lake in the Kamloops Region and 13% at one site in the East Kootenay. Nine percent of the Engelmann spruce at one site west of Kimberley were killed.

Fewer than 5% of the young lodgepole pine in only four of the 66 pine plantations surveyed in 1989 were infected by dwarf mistletoe, *Arceuthobium americanum*. The 7- to 17-year-old stands, all west of Williams Lake in the Cariboo Region, had severe stem infections.

Douglas-fir cone worm, *Dioryctria abietivorella*, infested the bases of about 60% of the terminals on recently clipped 4-year-old Douglas-fir with multiple leaders in a plantation near Port Alberni. Records indicate that this is the most severe damage recorded in a coastal plantation by this pest, which is more commonly associated with pruning wounds in seed orchards.

Additional forest pests and other natural factors which affected the growth or development of young conifers surveyed in 1989 included adelgids and aphids on new growth of Douglas-fir and spruce, brush competition in white spruce, and a midge and leaf spot fungi in a young cottonwood plantation.

Douglas-fir and spruce were infested by Cooley spruce gall adelgid, *Adelges cooleyi*, in more than 50 stands in parts of five forest regions. Damage did not significantly affect tree growth and vigor, and caused only minimal damage to tree form. Populations on the new growth of Douglas-fir were greatest on southern Vancouver Island and in mainland parts of the region, where more than half the trees were severely infested at 12 of 18 sites. The new tips of Engelmann, white, and Sitka spruce were infested, discolored and swollen by the adelgid at 16 sites in three regions. The most severe tip damage was at two sites in the East Kootenay and at one in the North Thompson River Valley, where most tips on all the spruce were infested. Spruce gall adelgids, *Pineus* sp., lightly infested fewer than half the white and Sitka spruce in seven young stands in the Prince Rupert Region. Giant conifer aphid, *Cinara* sp., lightly infested needles on an average of 13% (range 5 to 38%) of the lodgepole and ponderosa pines, Douglas-fir, Engelmann spruce, and western larch at seven sites in the West Kootenay.

Only one of the more than 160 sites with young conifers surveyed in 1989 was affected by brush. At Toboggan Creek in the eastern part of the Prince Rupert Region, 11% of the 20-year-old white spruce were considered suppressed by willow brush competition.

At the only deciduous tree plantation surveyed, most of the buds on all the 5-year-old black cottonwood on an island site in the Fraser River near Chilliwack in the Vancouver Region were killed by a bud midge, *Dasineura* sp. About 53% and 16% of the trees were lightly infected by leaf spot fungi, *Taphrina populisalicis* and *Mycosphaerella populorum*, respectively.

Lodgepole and some Scots pine and Siberian larch seedlings at four sites in the Prince George Region and at one in the Yukon Territory were examined as part of a cooperative international survey with Svenska Cellulose. At the Takhini Forest Reserve near Whitehorse,

10% of the pine were dead from repeated years of climatic injury and subsequent infection by pathogens including *Sclerophoma* sp. Top-kill of larch was common, and two weak pathogens, *Phoma* sp. and *Epicoccum* sp., were found on larch for the first time in the Yukon. Two parasitic microfungi, *Ascocalyx* sp. and *Didymella* sp., usually associated with stressed seedlings, were found for the first time on Siberian larch near Fort Nelson. Natural pines were competitive near Fort St. John, and a pine adelgid, *Pineus coloradensis*, was common. Elsewhere, trees were generally healthy except for minor winter damage to pine near Fort St. James and to pine and larch near Mackenzie.

Cone, seed, and seed orchard pests

Assessment of cone and seed insects and diseases in the Pacific Region was de-emphasized in 1989. This was due in part to the conclusion of the research study at Pacific Forestry Centre. Some seed orchard pest assessments were done by the British Columbia Forest Service.

Twelve coastal and three interior seed orchards were surveyed. Cooley spruce gall adelgid, *Adelges cooleyi*, lightly infested Douglas-fir in six orchards and Sitka spruce in one orchard; white spruce were infested in two interior seed orchards. Balsam woolly adelgid, *Adelges piceae*, and balsam twig aphid, *Mindarus abietinus*, were common on amabilis fir in four orchards; the aphid severely infested Sitka spruce at one site. A gall midge lightly infested yellow cedar at one of two orchards, and a foliage and cone mite, *Trisetacus* sp., was more numerous than in 1988 and severely infested all the yellow cedar at a second orchard. Hemlock woolly adelgid, *Adelges tsugae*, increased and lightly to moderately infested western hemlock at two of four orchards. In interior orchards, western spruce budworm, *Choristoneura occidentalis*, larvae feeding in lodgepole pine rooted cuttings and seedlings distorted lateral and terminal shoots on 5% of the trees in one orchard. In another orchard, spruce weevil, *Pissodes strobi*, attacked 40% of the leaders, frost damaged 20% of the buds on 90% of the white spruce, and most of the lodgepole pine were lightly infected by a needle disease, *Lophodermella concolor*.

Cone crops at 7 of the 12 coastal seed orchards surveyed were affected by several pests: Douglas-fir coneworm, *Dioryctria abietivorella*, infested up to 80% of the cones in one of four orchards; Douglas-fir cone gall midge, *Dasineura canadensis*, occurred in up to 100% (average 50%) of the cones in four orchards; and Douglas-fir cone scale midge, *Contarinia washingtonensis*, lightly infested cones at two orchards.

Animal damage

Feeding damage to conifers including seedlings by voles, rabbits and porcupines was again common in parts of the Prince Rupert and Vancouver regions and in the Yukon Territory, but vole populations in the western part of the Prince Rupert Region declined.

High numbers of meadow voles, *Microtus* sp., killed about 80% of the hemlock seedlings in one new plantation near Squamish in the Vancouver Region; 2% of seedlings were killed by voles in a nearby plantation, where lateral and terminal leaders on hemlock, cedar, and Douglas-fir were clipped. New vole damage was not present in the western part of the Prince Rupert Region, where seedling mortality caused by feeding was prevalent in 1987-88.

Porcupines chewing patches of stem and branch bark continue to kill young and semimature conifers, especially lodgepole pine in the western part of the Prince Rupert Region and increasingly in parts of the Prince George Region; this is a significant problem in spaced stands. Recent scattered tree mortality was mapped aerially over about 3700 ha in the Prince Rupert Region. For the first time in recent years, tree mortality from porcupine feeding was recorded in the Vancouver Region, where 3% and 5% of the 10-year-old lodgepole pine at two sites east of Boston Bar were killed.

De-barking and girdling of willow stems by rabbits or hares was more common than in 1988 in the Yukon Territory, particularly on roadside trees from Carmacks to Mayo and Dawson City.

Acid rain monitoring

There was no evidence of change in the condition of trees and ground cover at 6 of 15 permanent sample plots across British Columbia monitored in 1989. Tree mortality at nine plots since they were established in 1986-87 included 16 Douglas-fir (12% of the trees) killed by suppression in a plot on Vancouver Island, and 14 Douglas-fir (14% of the trees) killed by Phellinus root rot, *Phellinus weirii*, in a plot on Saltspring Island. A total of 26 trees (6%) in five of seven plots in the lower mainland have died, including hemlock and cedar killed by 'shading out', and some Douglas-fir killed from snow breakage and from root disease suspected to be Armillaria. Engelmann spruce (6% of the plot trees) northeast of Quesnel died from suppression since 1986. Northeast of Prince George, the stem of a recently dead alpine fir was broken by strong winds. Observations for acid rain symptoms, or symptoms which mimic those of acid rain, have been made in the plots annually since 1984. Plots will continue to be monitored closely be-

cause of concerns about potential acid rain and long-range transportation of air pollutants. However, to date no scientific proof of any damage caused by acid rain in western forests has been established.

Deciduous and Ornamental Tree Pests

Tent caterpillars

Malacosoma spp.

Defoliation of trees and shrubs by forest tent caterpillar, *Malacosoma disstria*, was more widespread and severe than in 1988 in parts of three forest regions. Defoliation was mapped at more than 325 locations covering 122 500 ha (Map 4). Colonies of northern tent caterpillar, *M. californicum pluviale*, were common, although defoliation was mostly light in the Kamloops and Prince Rupert regions, near Bella Coola, and in the East Kootenay.

Forest tent caterpillar populations increased in the Prince George Region, in some areas for the fourth consecutive year, and defoliated trembling aspen and to a lesser extent other deciduous trees in 187 infestations over 103 225 ha, more than double the area affected in 1988. Defoliation was moderate and severe north and west of Prince George and within Prince George. In the Peace River area, defoliation occurred over 4800 ha in 22 separate areas near Farmington and Pouce Coupe; this defoliation was similar to that observed in 1988. In the Cariboo Region, trembling aspen near Green and Bridge lakes east of 100 Mile House was defoliated for the second consecutive year over 3215 ha in 26 pockets, an eightfold increase from 1988. In the Nelson Region, the area of defoliation increased fourfold to 9970 ha in 61 pockets from near the international border in the East Kootenay north to near Golden. Populations near Chilliwack declined along with populations of satin moth, *Leucoma salicis*, in the same stands. A high incidence (90%) of a nuclear polyhedrosis virus was present in forest tent caterpillar populations in 1988.

Generally severe defoliation of trembling aspen is forecast to continue in most recently infested stands near Prince George and Farmington in the Peace River area, in the East Kootenay, and in the eastern part of the Cariboo Region. This is based on an average of 38 egg masses per tree from 13 areas in the Prince George Region, 17 per tree at five sites in the East Kootenay, and 22 per tree at three sites in the Cariboo Region. If more than 10 egg masses are found per tree, severe defoliation is usually the result.

Increased northern tent caterpillar populations in the Bella Coola Valley lightly defoliated alder, birch, and other deciduous trees and shrubs following two consecutive years of severe defoliation, mostly near Hagensborg. In the north Okanagan Valley in the Kamloops Region, a variety of deciduous hosts were lightly defoliated from Vernon to Falkland, near Armstrong, Enderby, Pritchard, and south of Clearwater. Populations declined in the central Okanagan in previously defoliated patches of trembling aspen. For the first time in many years, defoliation of mostly black cottonwood was common in the western part of the Prince Rupert Region; light defoliation and patches of moderate and severe defoliation were common in the Skeena River Valley near the Exchamsiks River and near Kitimat. Northern tent caterpillar was present for the second consecutive year in the East Kootenay, in stands defoliated mostly by forest tent caterpillar.

Aspen decay

An average of 86% of the trees and 28% of the wood in 21 stands of trembling aspen in the central and northern interior of the province was either decayed or discolored. In the Prince George Region, 87% (range 60 to 100%) of the aspen were stained or decayed at all 10 sites from west of Prince George to north of Fort St. James. Stain was present in 70% and decay was present in 57% of the trees. At eleven sites surveyed in the Cariboo Region where aspen grows on 3% of the forested area, 74% were discolored (stained), and 60% were infected by decay. Field determinations found that the most common decay fungus was false tinder conk, *Phellinus tremulae* (= *Fomes igniarius*).

Gypsy moth

Lymantria dispar

About 7600 sticky traps were monitored throughout British Columbia in the fourteenth year of a cooperative

program with Agriculture Canada (Plant Health), FIDS, and the British Columbia Forest Service. Only 26 adult male gypsy moths were trapped this year in British Columbia in 26 pheromone-baited sticky traps in 11 areas. This compares with only 12 moths in 12 traps in seven areas in 1988. Male moths were caught near Parksville (8), and Kelowna (1) for the third consecutive year, and in West Vancouver (5) for the second year. New catches were made at Quesnel (1), Manning Provincial Park (1), near Chilliwack (1), Fort Langley (1), Cultus Lake (1), Canadian Forces Base Jericho in Vancouver (1), on the Saanich Peninsula (5), and near Thetis Lake north of Victoria (1). One new egg mass and two female moths were found at Parksville.

The captures at Manning and Cypress provincial parks were in two of 278 traps set out by FIDS in 236 forested recreation areas in national and provincial parks, commercial campgrounds, or near military bases.

There were no aerial or ground applications of *Bacillus thuringiensis* (B.t.) in 1989, following successful controls with B.t. at Kelowna, Colwood, and Parksville in 1988.

Satin moth

Leucoma salicis

Populations of satin moth declined significantly southeast of Chilliwack in the Vancouver Region, where exotic poplar were severely defoliated in 1988. A nuclear polyhedrosis virus reduced the population by 90%, and the remaining population lightly defoliated only the upper crowns over about 25 ha; defoliation is not expected to occur in 1990.

Large aspen tortrix

Choristoneura conflictana

Tortrix populations in southwestern Yukon Territory increased for the second consecutive year and defoliated trembling aspen over about 10 000 ha, ten times the area affected in 1988. Defoliation was moderate and severe over more than 75% of the area west of Takhini and southwest of Lake Laberge. Patches of mostly light defoliation were also widespread in northeastern British Columbia along the Alaska Highway, between Fort St. John and Pink Mountain, and on Steamboat Mountain. Populations are expected to decline next year, based on the incidence of larval parasitism by *Glypta conflictanae*, *Agathis* sp., and *Phytodietus* sp., which was about 89% at Takhini.

Birch leaf miners and a skeletonizer

Lyonetia sp., *Fenusa pusilla*, and *Bucculatrix canadenissiella*

Discoloration of native birch by leafminers continued in the northern and western parts of the Nelson Region, in some places for the fifteenth year. Increases also occurred in the Vancouver Region, on ornamental birch in Terrace, and on native birch in the Kispiox and Skeena river valleys.

In the Nelson Region, populations in birch in the Golden and Donald areas in the East Kootenay declined to the lowest level in 15 years, due to mortality of most early instar larvae. In the West Kootenay birch were again lightly defoliated near Kaslo and birch were defoliated for the first time near Watshan Lake west of Lower Arrow Lake. Also for the first time in recent years, leafminer populations increased in the lower mainland and discolored birch over about 20 ha in the Coquitlam watershed, as well as a small patch of ornamental birch at the south end of Alouette Lake. In Terrace, ornamental birch in urban areas were lightly discolored for the second consecutive year by increased leafminer populations which had not been recorded in birch in the area before 1988.

Western winter moth

Erannis tiliaria vancouverensis

Defoliation of broadleaf and vine maples and other deciduous hosts by western winter moth was more severe and widespread in the Vancouver Region in 1989, the third consecutive year of defoliation. Populations declined in the Kamloops Region, where numerous scattered patches of defoliated maple and birch occurred in 1988.

Maples, birch, and to a lesser extent alder and willow were defoliated in widely scattered patches, some for the third consecutive year, in the Vancouver Region from Chilliwack to Boston Bar. The largest and most severe defoliation was, for the second consecutive year, in Sasquatch Provincial Park north of Harrison Hot Springs. Additional patches were scattered from Sardis to Boston Bar, and along the Coquihalla Highway. High numbers of adults in flight near Hope for the second consecutive year indicate continuing populations in the upper Fraser Valley in 1990. An entomopathogen, historically the cause of population declines, was present at very low levels in small numbers of larvae for the first time in this outbreak.

After three successive years of defoliation, populations in the Shuswap Lake area and in the Turtle, Clearwater, and North Thompson river valleys declined as predicted due to natural control factors.

Winter moth

Operophtera brumata

In southwestern British Columbia, winter moth populations increased in the lower mainland, but remained at very low levels on southern Vancouver Island for the fifth consecutive year.

The first reported defoliation in the lower mainland occurred in birch stands near Highway 99 and the New Westminster Highway, and on scattered fruit and oak trees from Ladner to Tsawwassen. Blueberry had been defoliated in the area previously, and male moths had been caught in pheromone-baited sticky traps. On southern Vancouver Island where defoliation of deciduous trees, mainly Garry oak, has occurred for more than 15 years, populations remained at very low levels for the fifth consecutive year. The reduced population levels were attributed to periodic releases of introduced parasites since 1979.

Discoloration and premature loss of foliage on individual Garry oak in the Victoria area increased during the past 3 years; this damage was caused by an oak leaf phylloxeran, *Phylloxera* sp. nr. *coccinae*, and a jumping gall wasp, *Neuroterus saltatorius*.

For the first time in recent years, small numbers of a native defoliator, Bruce spanworm, *Operophtera bruceata*, were collected on broadleaf and vine maples on the lower mainland in North Vancouver and near Hope; however, defoliation was minimal.

Apple ermine moth

Yponomeuta malinella

The known distribution of this introduced pest of crabapple and old orchard trees increased significantly in southern and southwestern British Columbia. Since first detected in British Columbia in 1981 in a nursery on Vancouver Island, larvae have been detected throughout southern Vancouver Island, Vancouver, and the lower Fraser Valley. Surveys in 1989 detected populations on the Gulf Islands, in east coastal areas of Vancouver Island, on the Sechelt Peninsula, in the Fraser Canyon to Boston Bar, from Lytton to Hat Creek, and from Kamloops north to Little Fort and east to Malakwa. Defoliation was most severe in the Vancouver Region at Pemberton and Agassiz, where single trees were totally stripped. The high numbers of pupae at most sites indicate that significant populations will be present in 1990.

New Records of Occurrence and Distribution

Nineteen disease and seven insect collections in 1989 were new records within either British Columbia or the Yukon Territory. Most of the new disease records were relatively minor foliage or bark disorders or saprophytes. *Rhizina undulata* was for the first time associated with western red cedar seedling mortality. Seven collections were on conifer hosts, eight on deciduous hosts and the remainder on soil and duff. An additional 48 diseases were recorded for the first time on new hosts; 35 of these were conifers, and 13 were deciduous trees and shrubs.

European pine shoot moth found on Douglas-fir in a plantation in the lower mainland was a first North American record. A cone beetle collected at two sites in the Vancouver Region was a first Canadian record, and six insect collections represented significant extensions of their known distributions within the region.

Forest Pest Leaflets

A series of 66 Forest Pest Leaflets (FPLs) have been compiled and maintained by the Pacific Forestry Centre and are available on request. The leaflets describe the biology and damage and occasionally recommend controls for many of the major forest and ornamental pests of concern to the forest manager and home owner. A list of the insects and diseases covered by the leaflets is provided for reference.

Forest Insect and Disease Survey - Forest Pest Leaflets

No.	Title	Date
1.	Balsam woolly aphid	Revised 1978
2.	Spruce weevil	Revised 1983
3.	Poria root rot of Douglas-fir	Replaced by Forest Technical Report 12
4.	Western tent caterpillar	Revised 1978
5.	Silver-spotted tiger moth	Revised 1982
6.	Cooley spruce gall aphid	Revised 1977
7.	Poplar-and-willow borer	Revised 1981s
8.	Juniper webworm	Replaced by FPL 70
9.	Douglas-fir tussock moth	Revised 1978
10.	Boxelder bug	*
11.	Fall webworm	Revised 1983
12.	Larch sawfly	Revised 1977
13.	Spruce beetle	Revised 1978
14.	Douglas-fir beetle	Revised 1977
15.	Annosus root rot in Douglas-fir and Hemlock	Revised 1979
16.	Spruce aphid	Revised 1983
17.	Tent caterpillars	Revised 1978 Reprinted 1989
18.	European pine shoot moth	Revised 1975
19.	Woolly aphids on conifers	Revised 1986
20.	Engraver beetles	+
21.	Western hemlock looper	Revised 1984
22.	Greenstriped forest looper	Revised 1978
23.	Saddleback looper	*
24.	Western blackheaded budworm	Revised 1978
25.	Atropellis canker of lodgepole pine	Revised 1985
26.	White pine blister rust	1983
27.	Elytroderma disease of pines	1978
28.	Needle blight of western larch	Replaced by FPL 71
29.	Insects found in and near the home	1975
30.	A hemlock needle miner	*
31.	Spruce budworm	Revised 1986
32.	Rhabdocline needle cast of Douglas-fir	+
33.	Spruce spider mite	+
34.	Larch casebearer	+
35.	Armillaria root rot	Replaced by Information Report BC-X-203
36.	Balsam twig aphid	Replaced by FPL19
37.	Stem rusts of western Canada	Revised 1977

No.	Title	Date
38.	Satin moth	Revised 1984
39.	Common needle diseases of spruce	Revised 1989
40.	Pine needle and black pineleaf scales	*
41.	Needle rust of lodgepole pine	1972
42.	Poplar shoot blight	1978
43.	Pine needle casts and blights	1986
44.	Dwarf mistletoes	+ Replaced by Information Report BC-X-72
45.	Needle rusts of true firs	Revised 1981
46.	True fir blights	Revised 1978
47.	Needle rusts of spruce	Revised 1989
48.	Broom rusts of conifers	Revised 1989
49.	Melampsora foliage rusts	Revised 1978
50.	Spruce cone rusts	Revised 1978
51.	A conifer seedling weevil	*
52.	Lophodermium needle cast of pines in nurseries and plantations	Revised 1977
53.	Corky root disease of Douglas-fir nursery seedlings	1972
54.	Introduction to forest disease problems	Revised 1985
55.	True heartrots	Revised 1978
56.	Rhizina root rot of conifers	1972
57.	Termites	Revised 1978
58.	Carpenter ants	1973
59.	Western false hemlock looper	Revised 1983
60.	Phomopsis (Diaporthe) canker of Douglas-fir	1973
61.	Fusarium root rot of Douglas-fir nursery seedlings	1973
62.	Wound parasites causing tree decay	Revised 1978
63.	Common pests of arbutus	Revised 1983
64.	Western balsam bark beetle	1981
65.	Canker disease of spruce	1978
66.	Western red cedar borer	1979
67.	Blackstain root disease	1979
68.	Golden buprestid woodboring beetle	1981
69.	Common pitch moths of pine	1982
70.	Common insects damaging junipers, cedars and cypress	1983
71.	Foliage diseases of western larch	1984
72.	Ambrosia beetles	1985
73.	Terminal and root collar weevils of lodgepole pine	1986

*FPLs out of print and pest not recently of much significance.
+FPLs currently being revised.