Forest Insect and Disease Conditions

British Columbia and Yukon, 1986

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Abstract

This summary of forest pest conditions in British Columbia and the Yukon Territory in 1986 highlights pests that are or may become major forest management problems. It was compiled from records and field reports of 11 Forest Insect and Disease Survey rangers with contributions from forest agencies, researchers and industry. More than 37 forest pests are discussed and some predictions made for 1987.

Résumé

Le présent résumé sur les ravageurs des forêts de la Colombie-Britannique et du Yukon, en 1986, porte sur ceux qui posent ou peuvent poser de graves problèmes aux aménagistes. Il synthétise les observations et les rapports de 11 techniciens du RIMA, en intégrant les contributions des chercheurs, des organismes et de l'industrie forestière. Plus de 37 ravageurs font l'objet de discussion et de prévisions pour 1987.

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Introduction

The six Forest Insect and Disease Survey (FIDS) units of the Canadian Forestry Service (CFS) are responsible for producing an annual national overview of important forest pest conditions and their implications, maintaining surveys and records in support of quarantines, supporting forestry research through maintenance of records, herbaria and insect collections, and providing advice concerning forest insect and disease conditions. In 1986 FIDS is celebrating 50 years of service to the needs of forestry in Canada. General surveys to detect and monitor important forest insects, diseases and environmental factors are conducted annually in the Pacific Region with the cooperation of the B.C. Forest Service and other federal, provincial and municipal agencies and industry. The close cooperation with research programs and staff at the Pacific Forestry Centre and other CFS centres continues to be an important contribution.

This regional report reviews the status and impact of the major insects and diseases and effects of environmental factors on conifer and broadleaf forests in British Columbia and the Yukon Territory in 1986, and forecasts some pest conditions for 1987. Tables, estimates of damage and maps of major insect infestations are included. Damage trends and locations of infestations can be determined by comparison to previous years' reports. The information is compiled largely from observations and field records of 11 FIDS rangers collected during their field assignments from late May to October. More detailed information on the status of forest pests for six provincial forest regions and the Yukon Territory is available in reports compiled by the following FIDS rangers:

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

Other staff of the 1986 Forest Insect and Disease Survey project were:

Allan Van Sickle, Head, Forest Insect and Disease Survey
Lee Humble, Entomologist i/c Insectary and Collection
Bob Duncan, Insectary Technician
Erika Pass, Insectary Technician
John Hopkins, Pathologist i/c Disease Identification
Daphyne Lowe, Herbarium Technician
Colin Wood, Chief FIDS Ranger
Joan Strobbe, Secretary

Summary

Weather in late 1985 and early 1986 was highly variable. Record low temperatures in late November 1985 killed overwintering mountain pine beetle broods in thin-barked stems, particularly in the Cariboo Region. Spruce beetle broods in the Prince Rupert Region were also affected. Late spring frost in April, following above-normal temperatures in March, killed new flush on conifers in coastal and interior British Columbia. Unsettled weather in April and early May, with slightly below-normal temperatures in some areas, contributed to a reduction of western spruce budworm larvae in higher-elevation Douglas-fir stands north of Clinton, mortality of black army cutworm larvae in the Cariboo and Nelson regions, and delays of up to two weeks in the development of blackheaded budworm larvae in north coastal areas. However, development of larch casebearer and larch budmoth in the East Kootenay was slightly accelerated by high temperatures in late May. Record high temperatures, consecutive days of sunshine and rainless days from mid-July were conducive to successful development of many major forest pests in most parts of the province.

Mountain pine beetle killed mature pine over more than 94 100 ha in five regions, but populations collapsed in the Cariboo Region due to mortality of most overwintering broods. Infestations expanded in the Nelson Region for the first time in recent years, and continued to cause significant volume losses and adjustments to harvesting plans in most regions. Secondary beetles, including *Ips* spp., were very common in parts of the Cariboo, Prince George, Prince Rupert and Nelson regions. New shoots on young and some older lodgepole pine were severely defoliated by increased numbers of **pine needle sheathminer** in widely scattered parts of three forest regions, some for the second consecutive year. **Pine sawfly** populations near Vavenby in the Kamloops Region collapsed after defoliating older needles of lodgepole pine over 100 ha in 1985. **Pine needle diseases** were inconspicuous for the second consecutive year, but **stem and branch diseases** were common and widespread. Preliminary examinations indicate that **pine wood nematode** was isolated for the first time in British Columbia from branch and stem samples from three species of pine at eight locations in three forest regions. Other nematodes were isolated from 31 of 190 samples from four conifer hosts and from 4 of 55 woodborer adults.

More than 413 000 ha of immature and mature Douglas-fir mainly in the Kamloops Region were defoliated by the **western spruce budworm** in 1986, nearly double the area defoliated in 1985. Defoliation was visible in the Vancouver Region for the first time since 1981. The expansion occurred mainly in the North Thompson River Valley and adjacent parts of the Cariboo Region, in drainages west of the Okanagan Valley and near Anarchist Mountain in the Nelson Region where some stands have been lightly defoliated for 9 consecutive years. Populations in higher elevation, infested stands in the southern part of the Cariboo Region declined for the first time in 4 years due in part to colder temperatures in May. Mortality of understory regeneration is variable in stands severely defoliated for up to eight consecutive years, and height growth loss is evident in surviving trees. Defoliation is forecast to be widespread and severe in 1987 in most currently infested areas, but expansion into new areas is expected to be minimal. As predicted, there was no evidence of **Douglas-fir tussock moth** populations in previously infested stands in the interior. Conspicuous mortality of previously defoliated Douglas-fir occurred over 5100 ha, the same area defined in 1985. Pheromone-baited traps attracted 75 male adults in nine previously active tussock moth areas, up from five in 1985 but too few to be of significance in 1987.

The area of mature spruce killed by **spruce beetle** declined fourfold to 3800 ha which occurred mostly in remote parts of the Kamloops Region. The decline, due in part to improved utilization, occurred for the fourth consecutive year in the Prince Rupert, Cariboo and Prince George regions. Colder than normal temperatures in late 1984 and 1985 killed overwintering broods in windthrown trees in parts of the Prince Rupert Region, and erased a significant threat to large, remote areas of mature spruce. Populations at the south end of Glacier National Park were re-

duced by salvaging or by treatment of infested stems to accelerate drying. The general population decline is forecast to continue in 1987.

The extent and intensity of defoliation of alpine fir and spruce forests by **two-year cycle budworms** increased tenfold to 60 000 ha in the Willow and Bowron river valleys in the Cariboo and Prince George regions and in the North Thompson River drainage in the Kamloops Region. Significantly increased numbers of **eastern spruce budworm** larvae consumed new foliage on alpine fir and white spruce over 94 700 ha mainly northwest of Fort Nelson to the borders of the Yukon and Northwest Territories, and to a lesser extent west to the Coal River Valley.

More than 55 000 ha of mature and some immature western hemlock were defoliated by **western blackheaded budworm** on the Queen Charlotte Islands and near Kitimat. This was nearly double the area defoliated in 1985, the first year of this outbreak. Tree mortality and top-kill of advanced second-growth trees occurred in localized stands severely defoliated for 2 consecutive years. Greatly reduced populations are forecast in 1987 and only trace to light defoliation is expected to occur in most areas. Infestations in the Cariboo, Kamloops and Nelson regions and the lower mainland part of the Vancouver Region collapsed after 2 successive years of defoliation in most areas.

Defoliation of western larch in southeastern British Columbia by **larch casebearer** declined in severity for the second consecutive year and was generally light, with only isolated pockets of severe defoliation. A biological control program initiated in 1966 continued with the release of more than 5000 parasites. **Larch budmoth** populations collapsed in the western part of the host range after 4 consecutive years of defoliating western larch. There was no evidence of **larch sawfly** in the southern Yukon during limited surveys.

Newly planted conifer seedlings were killed or severely defoliated and large areas of herbaceous ground cover totally stripped by **black army cutworm** in parts of the Prince Rupert, Prince George and Cariboo regions. Populations were not as evident in extensive areas of 1985 wildfires in drier parts of the Nelson Region. High numbers of adults, despite the variable incidence of parasites and virus, indicate a potential for damage to seedlings in or near recently infested sites and in newly burned sites in the Cariboo, Kamloops, Prince George and Prince Rupert regions in 1987. The **variegated cutworm**, found in high numbers in a newly planted site in the Cariboo Region, is not expected to survive the winter in its pupal stage.

Defoliators of deciduous forest trees were common. **Forest tent caterpillar** severely defoliated trembling aspen over more than 92 000 ha in the Peace River area for the fourth consecutive year and in pockets near Trail in the Nelson Region for the third consecutive year. Populations collapsed in aspen stands between Hazelton and Moricetown in the Prince Rupert Region after three years of defoliation. Defoliation of a variety of trees and shrubs by **western tent caterpillar** was the most severe and widespread since populations increased in 1981 in the Fraser Valley, Sunshine Coast, Lower Mainland, Gulf Islands and eastern Vancouver Island. New infestations developed near Penticton in the Kamloops Region. High numbers of tent caterpillar larvae are forecast in the Nelson Region in 1987, but slightly fewer are expected in the Peace River area, in southwestern British Columbia and near Penticton. Although trembling aspen stands in parts of the Kamloops Region were defoliated by **satin moth** for the first time in 1986, populations in previously defoliated stands elsewhere in the region collapsed. Populations declined or collapsed in the Nelson and Cariboo regions and near Victoria. **Winter moth** populations in mixed deciduous stands on southern Vancouver Island were very low following a significant decline in 1985. Winter moth parasites from infested stands were released in other stands.

Gypsy moth has not yet caused detectable defoliation or become established in British Columbia. However, 24 male moths were trapped in 19 pheromone-baited sticky traps in eight areas in British Columbia in 1986, up from 14 in 13 traps in three areas in 1985. About 7000 traps were monitored in the twelfth year of a cooperative interagency quarantine-related program.

Six permanent study plots were established and sampled in 1986, in addition to nine established in 1984-85, as part of a national program to monitor tree condition and possible effects of **acid rain**.

Pine Pests

Mountain pine beetle
Dendroctonus ponderosae

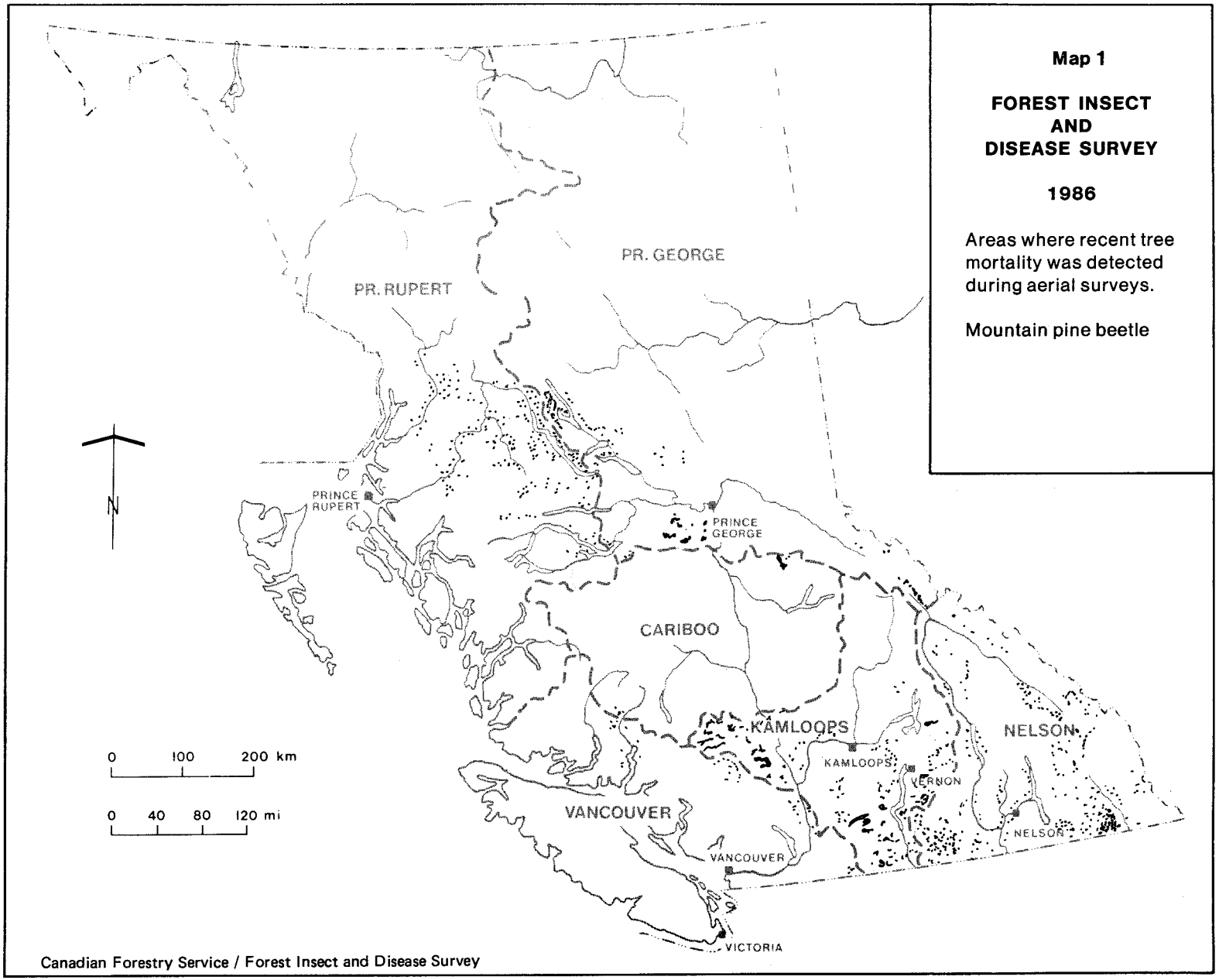
For the second consecutive year, the area and volume of mature lodgepole pine and lesser amounts of western white pine killed by mountain pine beetle in British Columbia declined. However, the beetle continued to be the most damaging forest insect in the province. More than 8500 infestations covered 94 135 ha (Table 1) from the international border south of Cranbrook to north of Terrace (Map 1), about six times the area burned by forest fires in 1986. This is less than a third of the area killed in 1985. Additionally, more than 228 000 ha in the Cariboo and Kamloops regions were killed in 1984 and earlier. The most significant decline occurred in the Cariboo Region where below-normal temperatures in late 1984 and 1985 virtually eradicated beetle populations over the nearly 190 000 ha infested in 1985. Elsewhere, the area of pine killed by the beetle more than doubled in the Nelson Region to 28 000 ha and increased 22% to 8500 ha in the Prince Rupert Region. In the Prince George Region the increase was 16% to 1225 ha, but in the Kamloops and Vancouver regions the areas, 47 900 ha and 4160 ha respectively, were similar to 1985.

Assessments of overwintering mountain pine beetle broods in 44 representative major infestations early in 1986 showed that sufficient numbers survived to threaten remaining areas of susceptible mature lodgepole pine in four forest regions, but brood survival declined in the Cariboo and Prince George regions. Based on the ratio of

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, British Columbia, 1986

Forest region	No. of infestations	Area (ha)	Trees killed[a] No. (000)	Trees killed[a] Vol. (000 m³)	Stands[b] cruised	Avg. % of trees[c] H	C	R	G	P
Cariboo	–	–	–	–	14	90	0	0	10	0
Kamloops	2165	46 750	4790	2294	11	71	4	13	9	3
Nelson	3323	28 000	1222	448	11	66	10	7	11	6
Prince George	440	1225	13	7	0	–	–	–	–	–
Prince Rupert	2393	14 000[d]	946	689	11	47	32	15	5	1
Vancouver	191	4160	127	101	5	32	8	21	25	14
TOTAL	8512	94 135	7098	3539	52	61	11	11	12	5

[a] Trees attacked in 1985, discolored in 1986
[b] Some stands located in younger infestations may not represent average condition
[c] H = Healthy; C = Current, attacked in 1986; R = Red, attacked in 1985; G = Grey, attacked in or before 1984; P = Partial, or strip attack
[d] Estimates include data from B.C. Forest Service.



Map 1

FOREST INSECT AND DISEASE SURVEY

1986

Areas where recent tree mortality was detected during aerial surveys.

Mountain pine beetle

Canadian Forestry Service / Forest Insect and Disease Survey

surviving overwintering progeny to parent beetles, population trends ('R' values) in all six regions ranged from 0 to 12.6; a value of 4.1 or greater indicates static to increasing populations. The regional average 'R' value ranged from 0 in the Cariboo Region to 8.9 in the Nelson Region and averaged 3.4, 4.2, 5.1 and 5.4 in each of the Prince Rupert, Kamloops, Prince George and Vancouver regions, respectively.

The average incidence of 1986 attack in 52 representative mature pine stands in five forest regions declined to 11% from 17% in 1985. This indicates generally declining populations, particularly in the western part of the Cariboo Region and adjacent parts of the Kamloops and Prince George regions. In other regions populations will continue with significant variation among stands. The highest regional average of current attack was in the Prince Rupert Region at 32% (range 14 to 47%). Elsewhere current attack declined 8% in the Kamloops Region and 14% in the Vancouver Region. The only successful current attack observed in the Cariboo Region was associated with pheromone-baited traps in one of 14 stands surveyed.

In the Cariboo Region mountain pine beetle attack averaged less than 2% in 1985 cruises and with 'pitch-outs' and overwintering mortality the number of recently killed pine is even lower. Cruises in 14 stands in late 1986 found limited mountain pine beetle activity. However, engraver beetles, *Ips* spp., had attacked less than 2% of the trees, of which about half had been previously but unsuccessfully attacked by mountain pine beetle. Because of the significant reduction in 1986 attacks by mountain pine beetle in the Cariboo Region and because of harvesting and control operations, pine mortality in the region is expected to be greatly reduced in 1987.

In the Kamloops Region, 2165 mountain pine beetle infestations covered 46 750 ha, slightly more than in 1985, and contained 4.8 million trees (2.294 million m^3), mainly in the Lillooet and Okanagan Timber Supply Areas (TSAs). An additional 38 350 ha were killed prior to 1984. The infestations occurred generally throughout chronically infested stands in the Lillooet and Okanagan TSAs including the following areas: from Gold Bridge to French Bar Creek and in the Stein River Valley near Lytton; east of Kelowna in Mission, Daves and Belgo creeks; west of the Okanagan Valley in Hayes, Trout and Short creeks; and in the Ashnola River Valley south of Keremeos. Smaller scattered pockets of mortality covered 4000 ha in the Merritt TSA and 350 ha in the Kamloops TSA. The 1986 attack in green standing pine decreased overall but in Hydraulic Creek, east of Kelowna in the Okanagan TSA, 17% of the pine were attacked this year and tree mortality is expected to increase. In the Lillooet area, where current attack was less than 5%, tree mortality is forecast to decline, particularly in the McKay and Leon Creek drainages.

The number of infestations in the Nelson Region nearly doubled to 3323 and covered 28 000 ha which contained 1.2 million recently killed pine (448 500 m^3) in seven TSAs and three national parks. Following 4 consecutive years of region-wide decline, localized increases occurred in the Boundary, Cranbrook and Invermere TSAs and in Kootenay National Park. Along the B.C.-Alberta border, infestations continued to decline due to weather and harvesting. Tree mortality is forecast to continue in most currently infested stands in the region but will vary between stands and TSAs. Current attack declined by nearly half overall to 10% (range 2 to 17%) with increases at Sinclair Creek in Kootenay National Park, north of Invermere, and at Larson Lake near Skookumchuck in the Invermere TSA.

The area of lodgepole pine recently killed by the beetle in the Prince George Region in 1986 doubled to 1225 ha. Most of the 440 infestations were near Fort St. James, southwest of Vanderhoof and southwest of Prince George, north of the Cariboo-Prince George regional border and southeast of Valemount. In control operations in Mt. Robson Provincial Park, 259 beetle-attacked pines were treated in 1985, and 26 trees attacked in 1986 were found, including 12 'pitch-outs.' Further control programs are being considered. South of Valemount, host depletion and harvesting contributed to a further decline in the western white pine killed by the beetle. Populations are predicted to continue in the region in 1987 primarily in the Fort St. James area and, based on limited B.C. Forest Service data, southwest of Prince George.

The overall area of lodgepole pine killed by 1985 attacks in the Prince Rupert Region increased to 14 000 ha mainly in the western part of the region. Groups of 2 to 20 mature lodgepole pine

near Terrace Airport, were significantly west of recently recorded beetle-infested stands in the region. Current attack remained at 32% overall (range 14 to 47%) in 11 representative stands, similar to 1985. Slightly increased tree mortality is expected in 1987, mainly in the western part of the region, and in the Telkwa River Valley, Trout Creek and Coffin Lake areas, but little overall change is expected in most of the eastern part of the region.

Although the number of infestations in the Vancouver Region increased 11% to 76, the area, 4160 ha, was the same as in 1985 and contained 127 000 trees (101 500 m^3). Most were in the Homathko River drainage west of previously active infestations in the Cariboo Region. Small localized infestations continued in mixed stands in the Pemberton area. Infestations in and adjacent to the eastern part of Manning Provincial Park declined slightly due largely to containment programs in their fourth consecutive year. Current attack in five beetle-infested stands near Manning Park and Birkenhead Lake averaged 8% (range 0 to 14%) down from 22% in 1985, indicating declining tree mortality in the southwestern part of the region in 1987.

Secondary beetles including *Ips* spp., *Dendroctonus murrayanae*, and *Trypodendron* spp. were very common in predisposed pines in the northwestern part of the Cariboo Region, in adjacent parts of the Prince George Region and in localized areas in the East Kootenay part of the Nelson Region. Monterey pine ips, *Ips mexicanus*, attacked mountain pine beetle-killed pine near Cedarvale in the Prince Rupert Region. Scolytid beetles, including *Hylurgops rugipennis*, were numerous on root collars of mature pine south of Vanderhoof earlier in the year.

Warren's root collar weevil, *Hylobius warreni*, killed small patches of mature pine adjacent to mountain pine beetle salvaged stands in the eastern part of the Prince Rupert Region.

A pine needle sheathminer
Zelleria haimbachi

New shoots of lodgepole pine were infested and severely discolored by increased numbers of the sheathminer in the Kamloops, Nelson and Vancouver regions. Near Salmon Arm in the Kamloops Region, young pine on 500 ha in the Fly Hills were discolored for the second consecutive year. Pine stands in the North Thompson River Valley, from Birch Island to McMurphy, were also severely discolored in the same area infested by the sheathminer in 1979-80. Increased populations between Yahk and Cranbrook and near Kimberley in the Nelson Region moderately and severely discolored new shoots on most roadside regeneration as well as 30- to 60-year-old lodgepole and some ponderosa pine. Near Fernie, between 30% and 100% of the current year's pine shoots were defoliated over several hundred hectares. Populations increased significantly in the Vancouver Region where about 17% of the new shoots on about 9% of the immature lodgepole pine along the east side of Lillooet Lake were infested. In scattered pockets of pine on Texada Island and near Sechelt, 10% of the new shoots on up to 16% of the 10-year-old trees were infested.

A needle miner, *Coleotechnites* sp., was associated with the sheathminer at most locations.

Parasite and overwintering population assessments were inconclusive. However, based on historical data, populations are expected to be high in most newly infested areas but they will probably decline in the Fly Hills.

Squirrel damage

Cone stripping by squirrels killed the leaders and branches in the upper crowns of many thousands of young lodgepole pine in the southern Yukon between Watson Lake and Jakes Corner and north of Johnsons Crossing. In early 1986, mature cones were stripped from three or four locations on the stem near the apex of the 1984 shoot. This killed 40% of the leaders in a 40-year-old stand over 10 ha near Jakes Corner. Less severely damaged pine were common throughout the surrounding 1000 ha, and 5 to 20% of the trees in intermittent patches along the Alaska Highway were also damaged. The damage, which has not been previously reported to this extent in the Yukon Territory or British Columbia, is likely to result in development of multiple tops.

Pine needle diseases

Elytroderma deformans
Lophodermella concolor
Scirrhia pini

Infection of lodgepole and white pines by native needle diseases declined for the second consecutive year in the Nelson and Prince George regions, but systemic infections in ponderosa pine in the Kamloops Region continued high, similar to the past 3 years.

Most ponderosa pine stands in the Kamloops Region are infected by *E. deformans*. Needle discoloration and brooms on most infected trees in patches up to 100 ha, affect from 10 to 60% of the crowns.

In a long-term damage assessment plot at Summit Lake near New Denver in the Nelson Region, 1-year-old white pine needles were lightly infected by *S. pini*; this compared with moderate infection in 1985. Overall, about 70% of the needles have been cast prematurely as a result of consecutive years of infection by red band needle disease. Most 2-year-old and some 3-year-old needles on 80% of the pine along Cusson Creek west of Nakusp were also infected and cast prematurely.

At Red Rock south of Prince George, less than 5% of the year-old needles on 10% of the seed orchard trees were infected, the lowest level of infection in 3 years. West of Summit Lake on the Alaska Highway, severe infection of 1985 and older needles by an unidentified needle disease killed five localized pockets of regeneration lodgepole pine. Most 1985 needles in the upper third of the crowns of other surviving pines were lightly or moderately infected and cast prematurely.

Pine sawfly

Neodiprion nanulus contortae

Populations of pine sawfly in mature lodgepole pine stands between Wire Cache and McMurphy in the Kamloops Region, where moderate defoliation occurred in 1985, collapsed. Parasitism affected 68% of the 1986 cocoons and 70% of those more than 1 year old. Previous outbreaks in the area lasted for 3 years and affected nearly 10 000 ha. Populations also collapsed at Brandywine Falls Provincial Park in the Vancouver Region where older needles of 65% of the young lodgepole pine were defoliated in 1985.

Pine wood nematode

Bursaphelenchus xylophilus

Preliminary examination of 207 branch and stem samples, from symptomatic dying conifers and from 69 adult woodborers, indicates that the pine wood nematode was isolated for the first time in British Columbia from three species of pine at eight locations in three forest regions. Lodgepole pine samples from five sites in the Prince Rupert Region from Houston to Terrace and at Cassiar are suspected of containing the nematode, as are lodgepole pine near Christina Lake, ponderosa pine near Skookumchuck in the Nelson Region, and western white pine at the Pacific Forestry Centre in Victoria. Wood chips collected by Agriculture Canada at five interior mills, mainly in the Cariboo Region, also contained pine wood nematodes.

Native bacterial or insect-associated nematodes including *Aphelenchoides* sp., *Cryptaphelenchus* sp., *Deladenus* sp. and *Acrobeles* sp., which occur commonly across Canada, were found in 32 samples from lodgepole, western white, whitebark and ponderosa pines, and from four adult woodborers including Buprestidae and Cerambycidae.

Lodgepole pine terminal weevil

Pissodes terminalis

Mortality of lodgepole pine terminals in young stands increased significantly this year in parts of the Prince Rupert, Cariboo and Kamloops regions.

Leader damage from cumulative attacks in 1984 and 1985 in 12 young stands (age 8 to 15 years) in the eastern part of the Prince Rupert Region averaged 13%, up from 4% in 1984. Similar levels occurred in three regeneration stands in the western part of the Cariboo; an average of 22% (range 16 to 28%) of trees had damaged leaders. At Dean River all overwintering broods were dead, presumably killed by abnormally cold temperatures in May. Brood mortality was also high in two dense immature pine stands near Lil-

looet in the Kamloops Region where 25% and 30% of the terminals were infested and dying.

European pine shoot moth
Rhyacionia buoliana

No male adults were caught in 45 pheromone-baited sticky traps at nine locations in the Okanagan Valley from Hedley to Vernon in the second year of a 2-year quarantine-related trial. In 1985 an average of seven males (range 0 to 30) were caught at five locations, all in Kelowna, but none was caught in traps at Penticton and Vernon. Rigorous pruning and removal of infested, mainly exotic pines in urban areas, initiated in 1961, were maintained during annual surveys until 1981. Damage to native pines was never apparent.

Douglas-fir Pests

Western spruce budworm
Choristoneura occidentalis

More than 413 000 ha of mature and immature Douglas-fir forests in four forest regions (Map 2) were defoliated by the budworm in 1986. This was nearly double the area defoliated in 1985 and was the most expansive budworm infestation recorded in British Columbia during 50 years of CFS-FIDS surveys. Most defoliated stands were in the Kamloops Region. Less extensive defoliation was recorded in the Cariboo and Nelson regions; defoliation occurred for the first time since 1981 in the Vancouver Region.

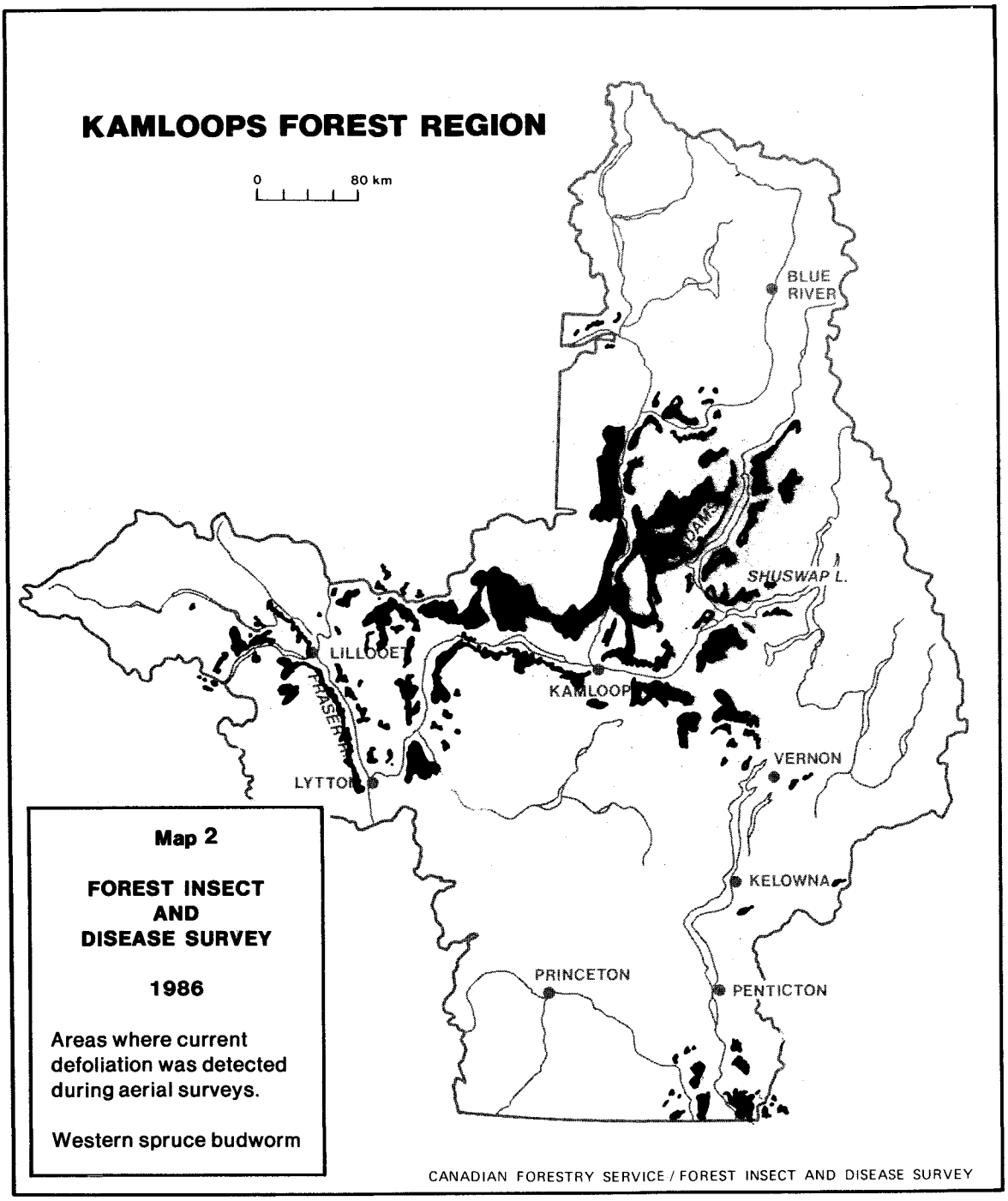
The major expansion occurred in the Kamloops Region where 74% of the 408 000 ha of Douglas-fir were lightly defoliated; 25% was moderately defoliated, and 1% severely defoliated. Major expansions occurred to the northern limits of the host range near Avola in the North Thompson River Valley, around Falkland, Westwold, Salmon Arm, Chase and west of Osoyoos to near Summerland. Light defoliation occurred for the second consecutive year and expanded along the north shores of Anderson and Seton lakes and the south side of Carpenter Lake west of Lillooet.

The area of mainly lightly defoliated Douglas-fir in the Nelson Region expanded from 60 ha to 3700 ha between Rock Creek and Anarchist Mountain. Pockets of Douglas-fir at Johnston Creek east of Anarchist Mountain have been defoliated to varying degrees for about 9 successive years.

Light and moderate defoliation of the current year's foliage occurred in the Vancouver Region for the first time since 1981 over about 1250 ha in the Blackwater Creek drainage near D'Arcy. The last major outbreak in the Vancouver Region started in this area in 1970 and continued until 1980.

In the southern part of the Cariboo Region near Clinton budworm populations in previously defoliated stands declined due to mortality of young larvae caused by below-normal temperatures in the late spring. This resulted in no visible defoliation where Douglas-fir had been moderately or severely defoliated over 29 500 ha in 1985. In the eastern part of the region, however, half the current year's needles on Douglas-fir and some alpine fir were very lightly defoliated for the first time in recent years over 180 ha in five pockets near Mahood Falls and Bowers Lake.

Larval mortality was 44% in an interagency experimental spray trial which applied *Bacillus thuringiensis* over about 200 ha of newly infested Douglas-fir in Paul Lake Provincial Park near Kamloops. Rainfall both before and after applica-


KAMLOOPS FOREST REGION
0
80 km
BLUE RIVER
SHUSWAP L.
LILLOOET
KAMLOOPS
VERNON
LYTTON
KELOWNA
PRINCETON
PENTICTON
Map 2
FOREST INSECT AND DISEASE SURVEY
1986
Areas where current defoliation was detected during aerial surveys.
Western spruce budworm
CANADIAN FORESTRY SERVICE / FOREST INSECT AND DISEASE SURVEY

tion may have reduced efficacy.

As a first approach to tree condition assessment, the FIDS aerial sketch maps for the last 6 years of the budworm infestation were compared by computer overlays. Of the total area infested to date, most (66%) had been visibly defoliated 1 year, with 26% defoliated for 2 consecutive years and 7% for 3 consecutive years. Less than 1% of the total area had received either 4, 5 or 6 years defoliation.

Mortality of understory trees is evident but variable (0, 8 and 95%) in three stands defoliated for four to seven consecutive years. Preliminary assessments of moderately and severely defoliated mature trees showed an average 6% tree mortality in 38 of 63 plots and none in the remainder. There was no mortality of trees in plots with up to 2 years of defoliation, but tree mortality of 1.2% and 4.6% occurred after 3 and 4 years of defoliation, respectively.

Egg sampling at 54 locations in four forest regions, to determine potential larval populations and related defoliation in 1987, indicates severe defoliation at 72% of the areas throughout the Kamloops Region and in adjacent parts of the Nelson and Cariboo regions (Map 3). Light or moderate defoliation is forecast mainly near D'Arcy in the Vancouver Region and in isolated parts of the other three regions. Additionally, sampling by the B.C. Forest Service in the Kamloops and Nelson regions indicates similar levels of expected defoliation. Defoliation is forecast to continue but at reduced levels in the southern part of the Cariboo Region near Clinton and near Mahood Falls.

Parasitism of early and some late instar larvae occurred at 39 of 41 stands, mainly in the Kamloops Region, but averaged only 8% (range 0 to 50%) down from 11% in 1985, and is too low to effectively reduce populations.

Pheromone-baited sticky traps were used to monitor male adult populations in six Douglas-fir stands in the Kamloops and Vancouver regions, and catches averaged 5 to 117 adults per trap. This indicated the budworms' presence, but numbers cannot yet be correlated with population potential and damage. Non-sticky traps were also tested for the second year since sticky traps were discontinued in most areas in 1984, but the results are pending.

Douglas-fir tussock moth

Orgyia pseudotsugata

There was no evidence of larval populations of this economically important defoliator of Douglas-fir in 1986. This follows a major population collapse in 1984 after a 3-year outbreak which covered 23 500 ha, mainly in the Kamloops Region. Conspicuous mortality of previously defoliated Douglas-fir was evident over 5100 ha in 1986, the same area defined by aerial surveys in 1984.

There was little change in tree mortality and top-kill caused by the 1982-83 outbreak in 61 Douglas-fir stands assessed in the Kamloops Region. Most mortality (80%) occurred during the infestation, 11% occurred one year after (1984), and 9% occurred in 1985. Top-kill occurred on 17% of the mature surviving trees defoliated for 1 to 3 years and on 2% of the immature trees.

Endemic populations of Douglas-fir tussock moth are forecast in 1987, based on the number of male moths in pheromone-baited sticky traps and the absence of larvae in standard FIDS collections. At 9 of 19 previously active tussock moth areas mainly in the Kamloops Region, 75 adults were trapped in 25 of 114 traps, up from four moths at the same locations in 1985.

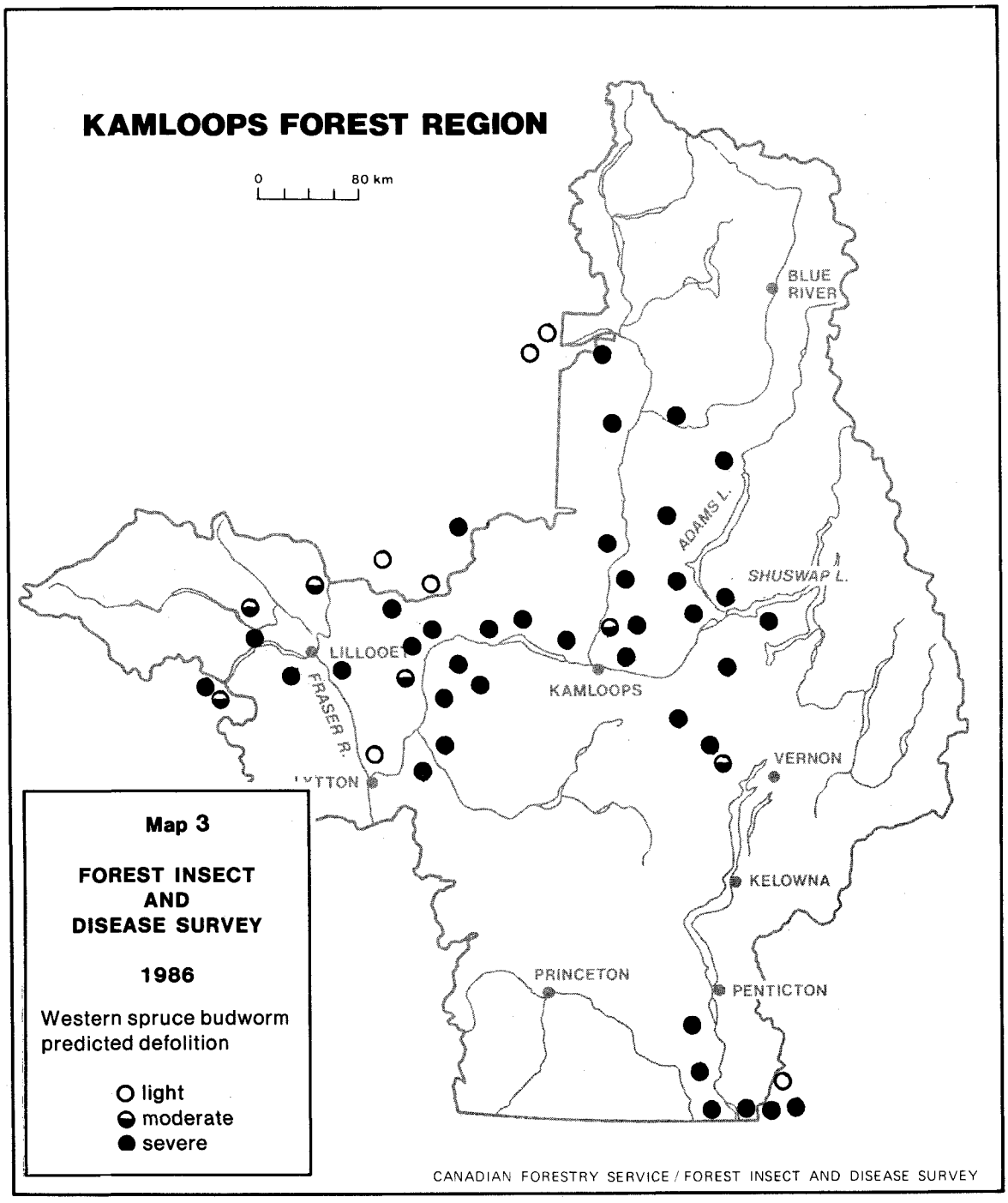
Growth loss in Douglas-fir stands near Keremeos which were defoliated by the tussock moth in 1981 and sprayed with *Bacillus thuringiensis* in 1982 is currently being evaluated by the Damage Appraisal group.

Douglas-fir beetle

Dendroctonus pseudotsugae

The area containing recently killed mature and mainly predisposed Douglas-fir trees declined sevenfold to 240 ha in widely scattered pockets mostly in the Kamloops and Prince George regions, and declined to a lesser extent in the Nelson, Vancouver and Cariboo regions.

In the Kamloops Region 12 pockets of one to five mature trees were killed over about 95 ha. Most were associated with stands severely defoliated by tussock moth in the north Okanagan Valley in 1982-83.


KAMLOOPS FOREST REGION
0
80 km
BLUE RIVER
ADAMS L.
SHUSWAP L.
LILLOOET
FRASER R.
KAMLOOPS
VERNON
KELOWNA
PRINCETON
PENTICTON
Map 3
FOREST INSECT AND DISEASE SURVEY
1986
Western spruce budworm predicted defolition
light
moderate
severe
CANADIAN FORESTRY SERVICE / FOREST INSECT AND DISEASE SURVEY

About 20 small groups of Douglas-fir veterans were killed over 75 ha in the Prince George Region, mostly in the Averil and Eaglet lake areas northeast of Prince George. Tree mortality declined in the Blackwater River Valley due to recent trap tree and selective tree removal programs.

Tree mortality remained at very low levels in the Nelson Region where only single trees or small groups of two to five trees were killed in 29 pockets totalling 17 ha, mostly east of the southern end of Kootenay Lake and north of Arrowhead on the Arrow Lakes.

The number of beetle-killed Douglas-fir in the Vancouver Region declined for the second consecutive year due mainly to harvesting of pockets of recent attack in the North Bend area of the Fraser Canyon. Only three inaccessible pockets of Douglas-fir totalling 55 ha were recorded in the region in 1986, all in Hannah Creek southwest of Lytton.

In the Cariboo Region, groups of two to five beetle-killed Douglas-fir occurred at scattered locations on both sides of the Fraser River from Marguerite south to near Clinton. Harvesting of scattered beetle-killed trees particularly in the Springhouse, Gaspard, Meadow and Loon supply blocks reduced populations to endemic levels.

Little change is expected to occur in the status of the Douglas-fir beetle in interior Douglas-fir stands in 1987.

Spruce Pests

Spruce beetle

Dendroctonus rufipennis

Although active in all six forest regions, the area and volume of mature white and Engelmann spruce killed by spruce beetle in British Columbia declined for the fourth consecutive year to 298 infestations over 3800 ha (Table 2). Most (55%) of the recent beetle-infested stands were in remote areas in the Kamloops Region. Significant declines occurred in the Cariboo, Prince George and Prince Rupert regions due to factors including salvage and sanitation, host depletion, and abnormally low temperatures in late 1984 and 1985. Brood mortality in standing and windthrown spruce in parts of the Prince Rupert Region averaged 70% (range 40 to 95%) with only low populations remaining, mainly in butts of standing trees.

Areas of recently killed spruce in the Kamloops Region increased for the third successive year to 2100 ha, more than double the area recorded in 1985. Infestations over 715 ha in the upper Tulameen River drainage west of Princeton, and over 570 ha in Noel Creek south of Gold Bridge, mapped for the first time this year, contributed to the increase. Infestations at Connel, Whitecap and McGillivray creeks north of Anderson Lake declined 20% to 790 ha. Infestations are expected to continue in 1987 with some reduction by harvesting in the Princeton and Gold Bridge areas.

The significant decline in the area and number of recently killed mature spruce in the Prince George Region to 32 infestations on 150 ha, from 135 on 4000 ha in 1985, was due largely to harvesting and brood mortality mostly in the McGregor and Bowron river drainages. The decline is forecast to continue for the sixth consecutive year in 1987.

Tree mortality declined in the Prince Rupert Region to 950 ha from 7400 ha in 1985, as forecast. The apparent decline was due largely to the deletion in 1986 of 'grey' standing trees killed by

Table 2. Number and area of spruce beetle infestations and volume of mature spruce killed, by forest region, based on recently killed trees observed during aerial and limited ground surveys, British Columbia, 1986

Forest region	No. of infestations	Area (ha)	Volume killed (000 m^3)	Stands cruised	Avg. % of trees[a]				
					H	C	R	G	P
Cariboo	29	240	5	2	61	0	0	36	3
Kamloops	41	2100	508	0	—	—	—	—	—
Nelson	4	40	1	0	—	—	—	—	—
Prince George	32	150	2	0	—	—	—	—	—
Prince Rupert	183	940[b]	13	1	38	42	3	15	2
Vancouver	9	325	8	0	—	—	—	—	—
Total	298	3795	537	3	50	21	2	25	2

[a] H = Healthy, C = Current, attacked in 1986, R = Red, attacked in 1985, G = Grey, attacked prior to 1984, P = Partial 1986 attack.
[b] Estimates include data from B.C. Forest Service.

the beetle prior to 1984, which had been included in 1985 data. Most of the beetle-killed trees were in remote parts of the upper Kispiox River Valley and in the Telkwa area. In the Walcott area 42% of the green standing trees in a cruise strip were attacked in 1986 by beetles which emerged from 1984 windthrow. This high incidence is very localized as windthrow in most parts of the region has been salvaged. Populations are expected to continue in these areas with most maturing in 1988.

In the northern part of the Prince Rupert Region, 20 mature spruce in pockets along 9 km of the Haines Road north of the British Columbia and Alaska border were infested. About 300 beetle-infested spruce near this new road construction were removed or felled and peeled in 1983.

At the south end of Glacier National Park in the Nelson Region a potential increasing population in and adjacent to recent salvage and harvesting operations was treated by cutting the trees into short lengths to accelerate drying. Elsewhere in the Nelson Region, populations declined significantly to only 40 ha in four pockets in high-elevation stands northeast of Canal Flats, west of Kimberley and northeast of Creston. Little change is expected in 1987.

Only very light populations were found in two cruise strips in mature spruce stands in the northeastern part of Bowron Lake Provincial Park near Wolverine Creek in the Cariboo Region. Earlier aerial observations had indicated a potential for population buildup and a threat to stands outside the park; however, tree mortality mapped in 1986 in about 24 pockets over 240 ha, mostly in or near the park, occurred in 1985 or earlier and did not contain any living broods.

The area of beetle-killed spruce in the Vancouver Region increased by half to 325 ha, all of which was at Smokehouse Creek southeast of Rivers Inlet. Previously infested stands in the Fraser Canyon area at Mowhokam and Log creeks were harvested. Two-year-cycle broods at Phantom

Creek on Graham Island in the Queen Charlotte group are expected to continue at low levels in spruce windthrow, a minor component of the mainly hemlock-cedar forest.

The province-wide decline is expected to continue in 1987. However, broods are expected to persist in most regions at endemic levels in stumps, slash and decked logs and in standing trees in parts of the Prince Rupert Region.

Northern spruce engraver
Ips perturbatus

The upper crowns of about 500 mature spruce were killed by the engraver beetle in the Prince George Region in 1986; this is the third consecutive year of high beetle populations, but damage is down from 1985 when 4000 tops were killed. Most killed tops, up to 20 m long, were in the Torpy River Valley. The remainder were widely scattered throughout the McGregor, Parsnip and Bowron river drainages and near Stephanie Creek south of Stoney Lake. Field observations of the biology and parasitoids of the declining populations are being analyzed.

Spruce aphid
Elatobium abietinum

Populations of spruce aphid remained at very low levels for the second consecutive year in Sitka spruce stands on the Queen Charlotte Islands, near Prince Rupert and in east coastal areas of Vancouver Island. Abnormally low temperatures during the 1984-85 winter contributed to the decline. Severe defoliation, which has occurred periodically since 1982, has resulted in mortality of up to 67% of the mature spruce (60 to 65 cm dbh) near Miller Creek on Graham Island. Populations are forecast to remain low in 1987 when tree mortality and growth loss will be further assessed.

Spruce weevil
Pissodes strobi

Leader mortality of immature Sitka spruce caused by spruce weevil at 10 sites in the western part of the Prince Rupert Region ranged from 0 to 45%. At one of three sites in the Kitimat River Valley, where Sitka spruce comprised 67% of the stands, only 2% of the terminals on 8- to 15-year-old trees were killed and none were killed at the other two sites. At five sites elsewhere in the Kitimat and Skeena river valleys, 34 to 45% (average 38%) of the leaders were killed.

Spruce bud insects

Damage to flushed new growth in young Sitka spruce plantations increased in the western part of the Prince Rupert Region. Spruce budmoths, particularly *Zeiraphera canadensis*, damaged an average of 80% of the new buds of 9- to 14-year-old spruce in eight plantations in the Kitimat, Skeena and Nass river drainages. In six of the plantations, spruce gall aphid, *Pineus similis*, and pineleaf chermid, *P. pinifoliae*, infested new shoots on 10 to 72% (average 43%) of the spruce.

True Fir Pests

Budworms
Choristoneura spp.

The intensity of defoliation and area of true fir and spruce forests in the Cariboo, Kamloops and Prince George regions (Map 4) infested by one- and two-year cycle budworms increased to 94 700 ha and 60 000 ha, respectively.

Mature two-year cycle populations of *Choristoneura biennis* defoliated mainly current foliage of alpine fir and spruce over 60 000 ha in the Cariboo, Kamloops and Prince George regions. This was a more than fourfold increase from 1984, the last year of mature larval populations. Increased populations were present also in localized areas in the Nelson Region, but none were found in previously defoliated stands in the Prince Rupert Region.

The largest increase was in the northern part of the Kamloops Region where mainly light defoliation occurred, for the first time since 1980, over 22 950 ha. Most of the increase was in the North Thompson River Valley southwest of Albreda and near Clearwater and Mahood Lakes in Wells Gray Provincial Park.

West of Wells Gray Park in the Cariboo Region, 21 000 ha of alpine fir and spruce stands were defoliated, mainly in the Quesnel Lake, Bowron and Willow river drainages, up more than threefold from 1985. The most severely defoliated stands, with up to 95% of the 1986 needles on most trees defoliated, were in Big Valley Creek and the Willow River Valley; these were contiguous with budworm-infested stands in the Prince George Region. From 2% to more than 50% of the new buds on most trees in six stands from the Horsefly River south to Hendrix Lake were defoliated.

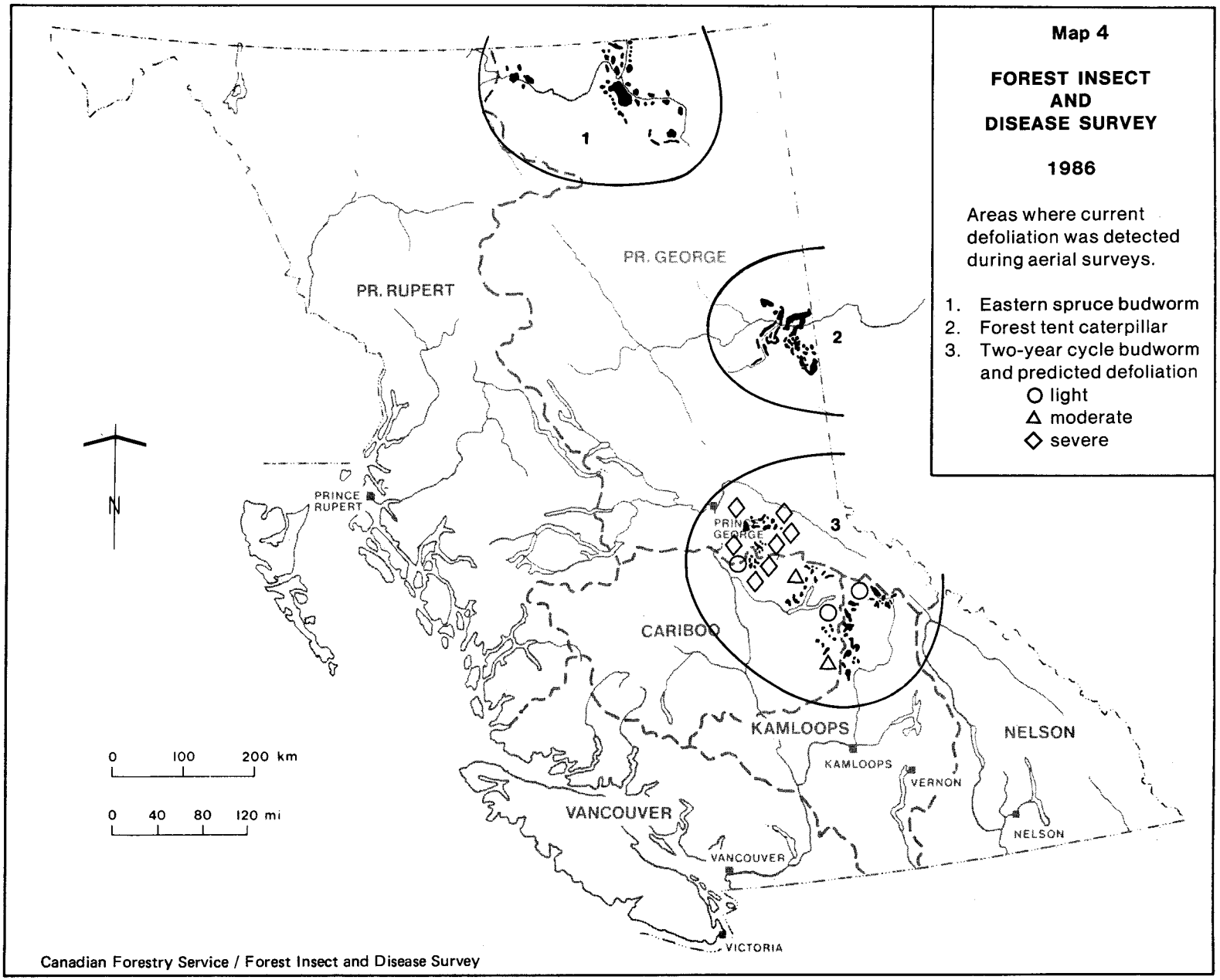
Southeast of Prince George, mature larvae lightly and moderately defoliated alpine fir and spruce over 15 670 ha, up from 580 ha by early instar larvae in 1985. Major increases occurred near the Cariboo regional border near Stoney Lake; however, the largest infestation of mainly light defoliation covered 5400 ha along the Bowron 'Coal' Road, where populations were first recorded over 300 ha in 1985. Mostly moderate defoliation was widespread in the Everett Creek and Tumuch Lake areas, and in Spruce and Centennial creeks.

Three high-elevation alpine fir-spruce stands totalling 500 ha in the St. Marys River drainage west of Kimberley were lightly defoliated for the first time in recent years. Endemic populations continued at Bugaboo Creek and 'off-year' cycle larvae infested most new buds of alpine fir and spruce in a remote part of Baker Creek west of Kimberley. Defoliation in this area is expected to intensify in 1987 when larvae mature. Moderate defoliation of the upper crowns of roadside spruce west of Castlegar to the junction of Highways 3 and 3B was attributed to two-year cycle budworm; this was the first observation of the budworm in the West Kootenay in 30 years.

Populations remained at very low levels in previously infested stands in the western part of the Prince Rupert Region. There were no larvae evident Map 4 in fir-spruce stands in the Wedeene, Kispiox or Skeena river valleys and little change is expected in 1987.

The increased number of two-year cycle budworm egg masses in and adjacent to 13 widespread stands in three regions indicates that early instar larvae are expected to be numerous in 1987 buds (Map 4), but defoliation should not be visible until larvae mature in 1988.

One-year cycle eastern spruce budworm, *C. fumiferana*, defoliated mainly current year's needles of alpine fir and white spruce over 94 700 ha in the northeastern part of the Prince George Region, up 13-fold since 1984. Light and moderate defoliation extended from north and west of Fort Nelson along the Fort Nelson and Liard river valleys to the Yukon and Northwest Territories border. Pockets of mostly light defoliation occurred west of Fort Nelson in the Coal River Valley and near Liard Hot Springs. Infestations have occurred in the Fort Nelson area periodically since 1957, most recently in the mid-1970's when 27% of the trees examined in infested


Map 4
FOREST INSECT AND DISEASE SURVEY
1986
Areas where current defoliation was detected during aerial surveys.
1. Eastern spruce budworm
2. Forest tent caterpillar
3. Two-year cycle budworm and predicted defoliation
O light
△ moderate
◇ severe
PR. RUPERT
PR. GEORGE
PRINCE RUPERT
PRINCE GEORGE
CARIBOO
KAMLOOPS
NELSON
VANCOUVER
VICTORIA
VERNON
1
2
3
N
0 100 200 km
0 40 80 120 mi
Canadian Forestry Service / Forest Insect and Disease Survey

stands in the Liard and Smith river valleys had an average of 1.2 m of top-kill. Although the average number of adult male moths in pheromone-baited sticky traps in two sites west of Fort Nelson and one in the Yukon ranged from 20 to 96, counts were inconclusive due to trap saturation and data were used primarily for taxonomic purposes. However, based on historical trends, one-year cycle budworm populations are expected to continue in the Fort Nelson area in 1987.

Western balsam bark beetle
Dryocoetes confusus

Mature high-elevation alpine fir were killed by the beetle-fungus complex over more than 128 750 ha in 585 separate infestations in six forest regions in British Columbia in 1986, up threefold from 1985. The increase, from 45 000 ha across the province in 1985, was the result of more intensive aerial mapping of higher elevation stands in the Prince Rupert Region.

Most tree mortality occurred in about 720 widespread stands over 120 500 ha in the Prince Rupert Region, mainly in the Bulkley and Morice TSAs in the eastern part of the region. The area containing beetle-killed trees in the Kamloops, Nelson and Prince George regions averaged 2540 ha (total 7615 ha) in more than 300 widely scattered areas. In the Cariboo and Vancouver regions, tree mortality occurred over 370 ha and 235 ha in 130 and 38 stands, respectively.

In the Spillimacheen River Valley, including McMurdo Creek in the Nelson Region, up to 47% of the mature alpine fir component in mixed stands were killed by the complex to date. An additional 3% were killed by Armillaria root disease, *Armillaria* sp., but there was no apparent relationship between beetle-attacked trees and those infected by root disease.

Balsam woolly aphid
Adelges piceae

For the second consecutive year, aphids were found in the Vancouver Region beyond the 1976 infestation zone but within the quarantine zone. An ornamental true fir at Powell River was severely infested by high numbers of aphids and gouting was common on branch tips. An average of 5% of *Abies amabilis* stock at three nurseries on southern Vancouver Island were lightly infested. There was no evidence of the pest in true fir stands along the international border in the Nelson Region north of infested stands in Idaho.

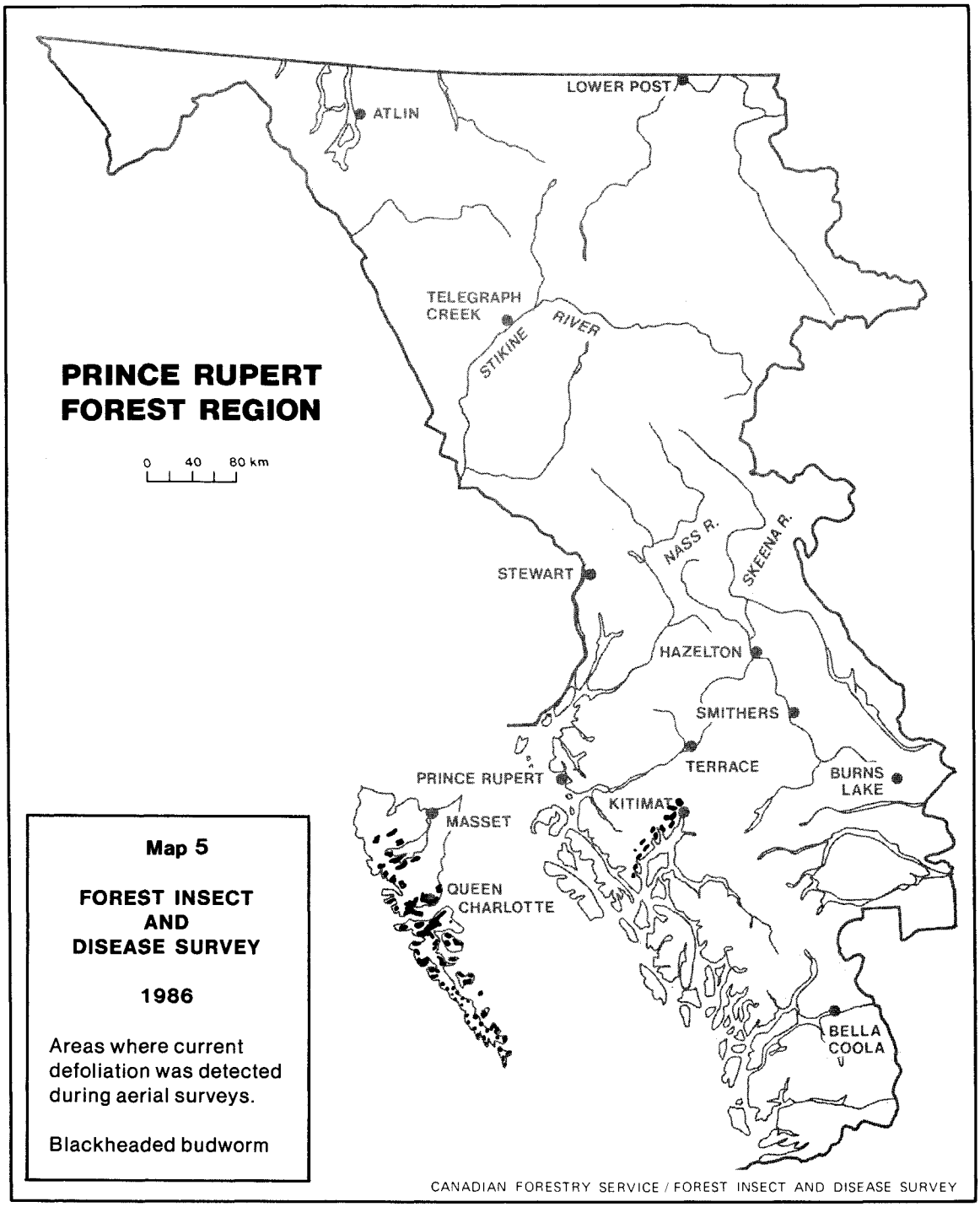
Hemlock Pests

Western blackheaded budworm
Acleris gloverana

Increased blackheaded budworm populations defoliated mainly mature and some immature western hemlock over an estimated 56 200 ha on the Queen Charlotte Islands and near Kitimat (Map 5) in the second year of the outbreak. Populations collapsed, however, in 12 500 ha of old-growth hemlock in the interior defoliated in 1985, and over 2150 ha west of Harrison Lake in the Vancouver Region. The collapse was attributed to cool moist weather in late spring.

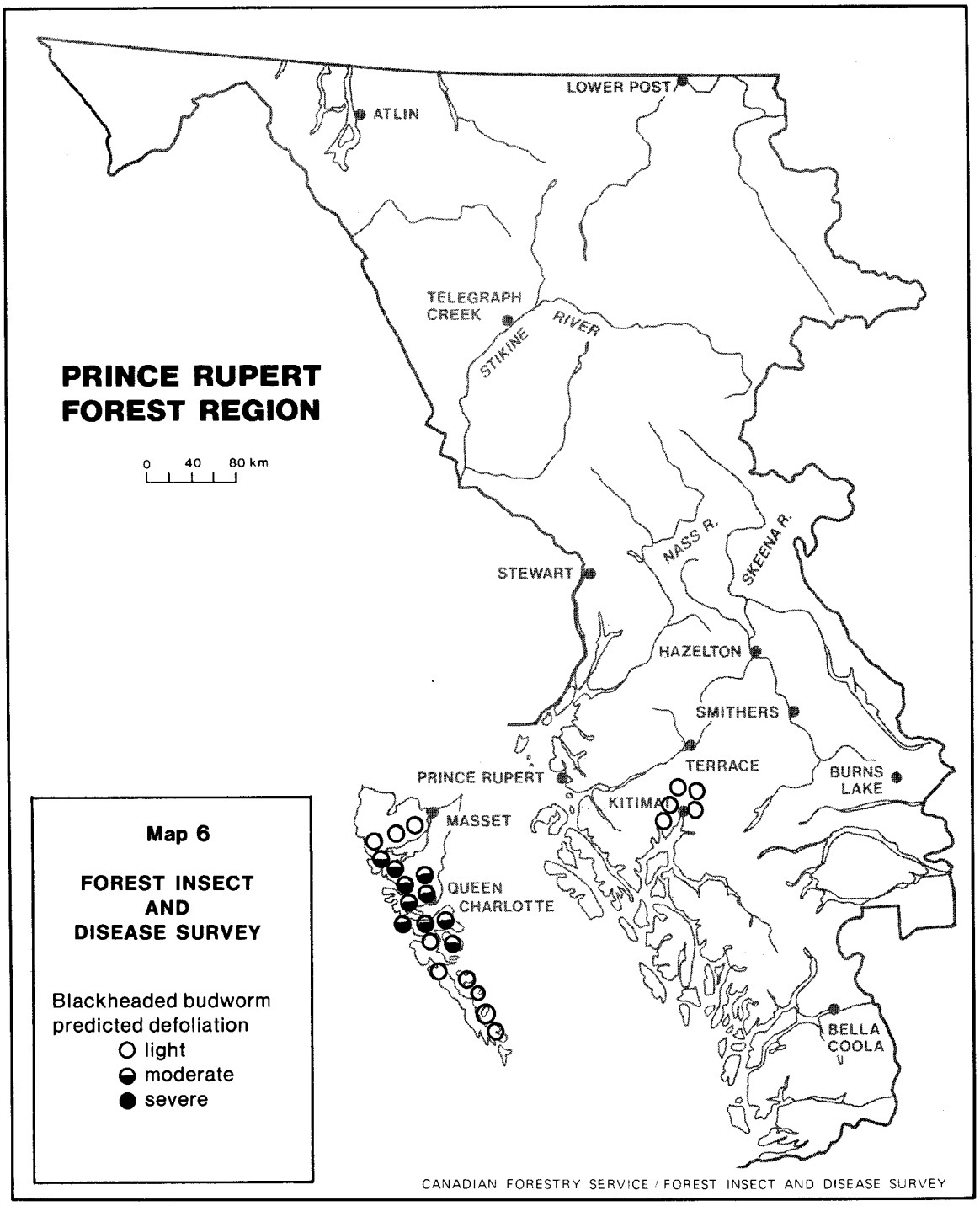
The major increase, as predicted in 1985, occurred on the Queen Charlotte Islands where 44 300 ha were defoliated (31% lightly, 57% moderately, and 12% severely), up from 28 600 ha of mainly moderate defoliation in 1985. Near Kitimat the area of mainly moderate defoliation expanded more than fivefold to 11 900 ha. Most (75%) of the stands defoliated were 100 years old or older; 19% were between 20 and 100 years old and only 6% were less than 20 years old.

A greatly reduced population is forecast for most areas in 1987 based on the reduced number of



eggs per sample (average of 18 compared to 118 in 1985) on 50-cm branch samples from 33 sites mainly on the Queen Charlotte Islands (Map 6). Assistance in sampling was provided by B.C. Forest Service and industry personnel. Trace or light defoliation is predicted for 25 sites including the southern end of Moresby Island as well as the Lyell Island and Kitimat areas; moderate defoliation is expected at eight sites including the north end of Moresby Island as well as parts of Masset Inlet and Louise Island.

Larval parasitism in three areas averaged 16% (range 2 to 23%); this was not high enough to sig-



nificantly reduce populations. Diseases, weather and starvation are natural factors which contribute significantly to population collapses.

Following 2 successive years of severe defoliation, 12% mortality of second-growth hemlock (20 to 100 years old) occurred in representative plots over 3100 ha on the Queen Charlotte Islands, and top-kill averaged 8 m on 75% of the surviving trees. Top-kill averaged 4 m on 56% of the trees on 4400 ha of moderately defoliated second growth. About 80% of the moderately to severely defoliated mature hemlock over 18 700 ha averaged 3 m of top-kill.

Based on 15 dominant or codominant western hemlock cut shortly after the last blackheaded budworm infestation at Jeune Landing, average radial growth from 1972 to 1974 was 69% less than pre-infestation growth. During recovery (1975-76), average radial growth still averaged only 55% of previous rates (Fig. 1). Defoliation among trees (average 28 years old) ranged from 42 to 82%.

Hemlock sawfly
Neodiprion sp.

High numbers of sawfly larvae, up to 2600 per three-tree beating sample, were common in numerous stands on the Queen Charlotte Islands infested by western blackheaded budworm, *Acleris gloverana*, and contributed to the overall defoliation.

Reduced populations lightly defoliated mainly older foliage of western hemlock over about 400 ha along Boundary Creek near the B.C.-Idaho border where stands had been severely defoliated in 1985.

Populations declined in immature and some mature hemlock stands at Dore River near McBride in the Prince George Region which were lightly defoliated for the first time in 1985.

Sawfly outbreaks collapse, usually with little or no tree mortality, unless associated with *A. gloverana*. Radial growth was probably reduced in the Nelson infestation but there was no current evidence of top-kill.

Terminal crook disease
Colletotrichum sp.

After 4 consecutive years of inspection revealed no evidence of terminal crook disease on hemlock seedlings, quarantine-related surveys of four plantations near Northwest Bay on Vancouver Island were discontinued. Follow-up inspections will be done periodically to monitor the seedlings which were outplanted following the discovery of this introduced disease in nursery stock in 1981.

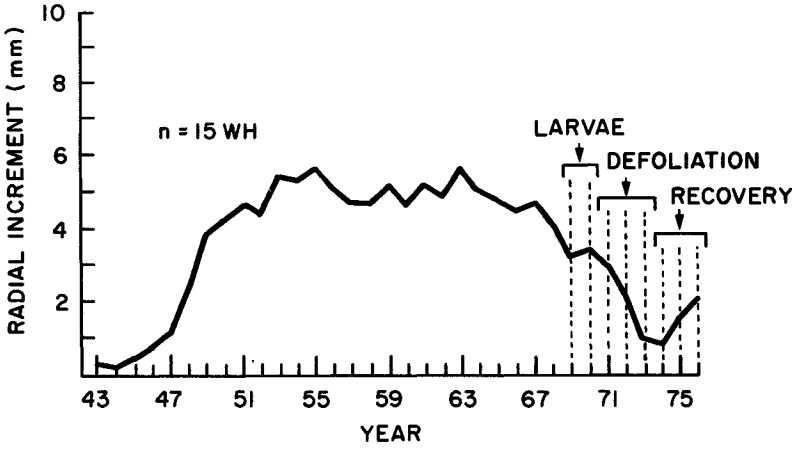


Fig. 1. Radial increment of western hemlock defoliated by western blackheaded budworm, Jeune Landing, Vancouver Island, 1971-1973.

Larch Pests

Larch casebearer
Coleophora laricella

Casebearer populations and defoliation of western larch in the Nelson and Kamloops regions declined in intensity for the second consecutive year. Defoliation was generally light and limited to the lower crowns of immature trees, particularly in the East Kootenay between Koocanusa Lake and Creston. However, isolated pockets of severe defoliation occurred in parts of the West Kootenay near Castlegar, Fruitvale and Montrose.

Isolated stands east of Okanagan Falls and near Vernon in the Kamloops Region were very lightly defoliated by declining populations which remained endemic elsewhere throughout the region from Anarchist Mountain to near Salmon Arm.

Pupal parasitism, mainly by *Chrysocharis laricinellae*, was generally low and variable: parasitism averaged 5% (range 1 to 24%) in 16 of 17 sites, similar to the previous 2 years.

More than 5300 adult *C. laricinellae* parasites were released in four infested stands near Castlegar in the West Kootenay, as part of a biological control program continued by CFS-FIDS since 1966. Adults were introduced from Austria and Switzerland and released in six batches of 200 to 1600 from late July to early August.

The average number of male adult casebearers in pheromone-baited sticky traps in 16 parasite release areas in the Nelson Region declined to 49 (range 1 to 277) from 69 at six sites in 1985 and 89 in 1984, the first year of the monitoring program. Traps to monitor the spread of casebearer populations beyond the known distribution limits in the Nelson and Kamloops regions attracted an average of 11 male adults per trap at two locations north of Nakusp and one male adult per trap near the south end of Kootenay National Park. These results indicate a slight expansion of adult populations beyond the previously known limits of casebearer larval populations. However, there were no adults caught in traps in western larch stands east of Elko, near Sparwood, in the Flathead River Valley, or near Salmon Arm and Vernon in the Kamloops Region.

Overwintering larvae per 100 fascicles at 19 permanent sample sites averaged 18 (range 0.1 to 64.3) indicating negligible to moderate defoliation of western larch stands in parts of the Nelson and Kamloops regions in 1987.

Larch budmoth
Zeiraphera improbana

After 4 consecutive years of defoliation of western larch stands, mainly in the western part of the host range in the Nelson and Kamloops regions, populations collapsed in early 1986. In areas where populations had defoliated larch stands over 14 800 ha in 1985, abnormally low temperatures in May contributed to the mortality of overwintering early instar larvae. Up to 70% of the larvae (average 31%) in the West Kootenay were parasitized by Diptera and Hymenoptera in 1985, which may also have contributed to the decline.

There was no evidence of larvae in previously infested stands at Hanna, Springer and Grizzly creeks and the Blueberry Summit area nor in eight areas from Skookumchuck to Yahk. However, endemic populations occurred near Castlegar, Johnstone Creek and Anarchist Mountain in the West Kootenay and in Redding Creek in the East Kootenay.

Populations also declined significantly in the eastern part of the Kamloops Region. Current defoliation was very light and limited to small higher-elevation stands on the eastern side of the Okanagan Valley from Okanagan Falls to northeast of Vernon, where about 52 areas totalling 9000 ha were defoliated in 1985.

In a second year of testing, pheromone-baited sticky traps at 12 locations in the Kamloops and Nelson regions attracted an average of 24 male moths per trap (range 7 to 97) at four sites east of

the Okanagan Valley, 14 in the West Kootenay, and 50 in the East Kootenay.

Larch needle diseases

Hypodermella laricis
Meria laricis
Melampsora sp.

Infection of western larch foliage by larch needle diseases was common but variable in intensity in the western part of the host range in the Nelson and Kamloops regions.

In the West Kootenay, infection by *M. laricis* and *H. laricis* increased slightly following a general decline in the Nelson Region in 1985. Between Stagleap Park and Christina Lake north of Castlegar an average of 37% (range 5 to 95%) of the needles on most roadside larch in pockets of 2 to 5 ha were infected. Similar infections were common between Nakusp and Fauquier and along the Inonoaklin River Valley. A conifer needle rust, *Melampsora* sp., infected an average of 40% of the western larch in a 2-ha stand near Keenleyside Dam in the West Kootenay.

Larch stands of 2 to 200 ha in the Kamloops Region were lightly defoliated by *H. laricis* near Vernon and Cherryville. Infections in these areas have fluctuated periodically with weather conditions. Successive years of moderate or severe infection have been most damaging to understory trees and have resulted in premature needle loss.

Larch sawfly

Pristiphora erichsonii

Western, eastern, Japanese and Polish larch in 20- to 30-year-old plantations in the UBC Research Forest near Haney were defoliated for the second consecutive year. Western larch were the most severely defoliated by larch sawfly and 4% of the leaders were dead. Exotic larch were only lightly defoliated.

Populations in larch stands in the East Kootenay remain at endemic levels following a decline in 1985. Tamarack in the La Biche River Valley in the Yukon Territory, where cocoons were collected in 1985, were not defoliated this year.

European larch canker

Lachnellula willkommii

For the sixth consecutive year, surveys for this potentially damaging canker in western, alpine, eastern and some exotic larch stands throughout British Columbia were negative. To date, its distribution in North America is limited to New Brunswick, Nova Scotia and some eastern States where small diameter trees have been infected and killed.

Multiple Host Pests

Black army cutworm
Actebia fennica

Mortality, bud damage and severe defoliation of conifer seedlings and herbaceous ground cover by the cutworm were variable in recently burned and planted sites in parts of the Prince Rupert, Prince George and Cariboo regions, some for the fifth consecutive year. Larvae were not found in the Kamloops Region and only very few were found in three sites in the Nelson Region. Planting programs were delayed in some regions.

In the interior part of the Prince Rupert Region where larvae have been common for the last 5 years, an estimated 6000 newly planted white spruce and some lodgepole pine seedlings, fewer than in 1985, were killed in parts of at least 10 of 13 recently planted sites. At Harold Price Creek, 10% of the white spruce seedlings were killed and surviving seedlings and most herbaceous ground cover were severely defoliated. Elsewhere, defoliation of ground cover was light over 10% of a planted site at Burdick Creek and very light to moderate at most of the remaining sites. The average number of pupae in 1000-cm^2 duff samples in July ranged from 1 to 20 (average 10), indicating declining populations at the 'Pop' Fire and static to increasing populations at Burdick, Harold Price and Torkelson creeks.

Larvae were more numerous and widespread in the Prince George Region than last year and totally defoliated an estimated 10 000 lodgepole pine seedlings and most ground cover over about 10 ha in a recently planted site in the Bowron River Valley. Within the 'Pink' Fire in the Haggen Creek area, 60% of the white spruce seedlings on a 10-ha area were defoliated, 30% moderately or severely, and most of the ground cover was severely defoliated. White spruce seedlings in a 20-ha site nearby were also lightly defoliated. North of Prince George, larvae were numerous in a site planted in 1985 in the Missinka River Valley, but only patches of ground cover were lightly defoliated.

Larvae were common in the Cariboo Region for the third consecutive year, but damage to seedlings was minimal. A small number of newly planted Douglas-fir seedlings were very lightly defoliated at a site near Cariboo Lake; lodgepole pine seedlings were not affected. Ground cover at three sites near Likely was severely defoliated but seedlings had not been planted. At 11 other recently burned but unplanted sites in the northeastern part of the region, very few larvae were present and defoliation of ground cover was minimal.

Although a few larvae were found in parts of the extensive 1985 burns in the East Kootenay in early May, none were found during extensive surveys in June. Suspected feeding damage, but no larvae, was found in 1 of 12 sites in five fires near Canal Flats. There was no evidence of larvae or feeding in the 'Lost Ledge' Fire near Kootenay Lake.

Parasitism, which along with environmental factors, predation, and virus has contributed to reducing populations, ranged from 1 to 65% (average 22%) of the larvae from 10 areas in three forest regions; most of the parasites were tachinid flies and ichneumonid and braconid wasps. Parasitism of pupae from two sites in the Prince George Region averaged 37% (range 27 to 50%). There was no evidence of virus.

The potential for damage to conifer seedlings in 1987 spring planting exists in some parts of the Prince Rupert and Prince George regions and in the Cariboo and Kamloops regions where the number of slash burns in susceptible areas increased significantly in 1986. Sticky traps with experimental pheromone attracted up to 30 male adults at 78 sites in five forest regions, indicating continuing populations in 1987. At Torkelson Creek in the Bulkley TSA in the Prince Rupert Region, non-sticky traps baited with experimental attractant caught an estimated 35 000 male moths from early August to early September. For the first time in recent years up to 11 moths were caught in sticky traps at three sites in the North Thompson River Valley in the Kamloops Region.

High numbers of the variegated cutworm, *Peridroma saucia*, severely defoliated most of the

ground cover and a small number of newly planted seedlings in part of a plantation at the north end of Quesnel Lake in the Cariboo Region. This resulted in the rescheduling of the planting program and was the first time this primarily agricultural and forest nursery pest has been found causing damage in a forested site in British Columbia. However, the high numbers of pupae overwintering in gravel and earth adjacent to and throughout the site are not expected to survive sub-zero winter temperatures.

Cone, seed and seed orchard pests

Cone crops were heavy in north coastal areas, but generally light and spotty elsewhere, similar to 1985. Cone and seed pests were also variable in 39 cone-bearing stands examined across the province. Major pests included Douglas-fir seed chalcid, *Megastigmus spermotrophus*, which infested up to 45% of the cones in parts of the Nelson Region and in four coastal seed orchards. A spiral spruce cone borer, *Delia anthracina*, infested up to 75% of the white and Engelmann spruce cones in six interior stands and Sitka spruce in a seed orchard on Vancouver Island, and 78% of the cones in 18 natural Sitka spruce stands in the western part of the Prince Rupert Region. Western hemlock cones in five north coastal areas were healthy as were yellow cedar cones from Rennell Sound on the Queen Charlotte Islands.

Surveys of provincial and industrial seed orchards identified several pests, generally at low levels, in twelve coastal and three interior seed orchards. Cooley spruce gall aphid, *Adelges cooleyi*, severely infested Douglas-fir in 11 coastal orchards and lightly infested white and Engelmann spruce in one interior orchard; balsam woolly aphid, *Adelges piceae*, infested twigs on about 5% of the amabilis fir in three orchards on Vancouver Island, all within the known infestation zone. Swiss needle cast, *Phaeocryptopus gaeumannii*, was less severe and extensive than in 1985 but infected 10% and 50% of the Douglas-fir in two coastal orchards. White and Engelmann spruce in two orchards near Kamloops were again lightly infested by western spruce budworm, *Choristoneura occidentalis*, which has been epidemic in adjacent Douglas-fir stands. Stem rusts, *Cronartium coleosporioides* and *Endocronartium harknessii*, persist and pine needle disease, *Lophodermella concolor*, infected about 10% of the needles in provenance trials south of Prince George.

Pests of young stands

Several important insects and diseases were identified in numerous young stands throughout the province. As part of a disease resistance trial, recently planted second generation lodgepole pine from Sweden, Scots pine and adjacent mature native lodgepole pine were surveyed for native pathogens at four locations in the Prince George Region and one near Whitehorse.

Currently active and potentially damaging pathogens occurred at varying levels at all sites and included lodgepole pine dwarf mistletoe, *Arceuthobium americanum*, near the Fort St. James and Mackenzie sites, and western gall rust, *Endocronartium harknessii*, at Fort St. James, Mackenzie, Fort St. John, Fort Nelson and Whitehorse. Potentially damaging pests include needle diseases, *Lophodermella* spp., stem and branch diseases, *Cronartium* spp. and *Atropellis* spp., Warren's root collar weevil, *Hylobius warreni*, pine terminal weevil, *Pissodes terminalis*, a pitch twig moth, *Petrova* sp., and bark-feeding mammals including snowshoe hares, porcupines and squirrels.

Tomentosus root rot
Inonotus tomentosus

Only mature and overmature lodgepole pine were killed by the fungus in 9 of 18 stands in the interior of the Prince Rupert Region. Tree mortality was highest (50%) in overmature pine at White Eye Lake south of Ootsa Lake and ranged from 1 to 20% (average 5%) at eight other locations. Tree mortality was frequently associated with, and accelerated by, woodboring insects including mountain pine beetle, engraver beetles, Warren's root collar weevil and long-horned woodborers. An average of 80% (range 60 to 100%) of the trees were infected but not killed at five mainly overmature stands; immature pines at four sites were not infected.

Near Averil Lake, northeast of Prince George, 15% of the semimature white spruce over about 5 ha were lightly infected but there was no evidence of tree mortality.

Porcupine feeding damage

The increased extent and intensity of feeding by porcupines in young and semimature stands in the western part of the Prince Rupert Region is expected to result in increased widespread tree mortality, particularly in spaced stands in the Kitsumkalum River Valley.

Numerous patches of bark were chewed from the stems and branches of trees in 41 stands, including 31 which were spaced, along the West Kalum Forest Road. Of the 5- to 37-year-old (average 20 years) stands affected, half were lodgepole pine; the remainder were equal numbers of western hemlock, amabilis fir and Sitka spruce. Additionally, 49 European larch in three plantations near km 40 were severely damaged. Less severe bark stripping occurred elsewhere including unthinned 20- to 25-year-old hemlock stands along the Copper River Forest Road, 30- to 40-year-old lodgepole pine near Lakelse Lake in the Copper River Valley, near Lava Lake and in the Tseax River Valley to the Nass River and near Aiyansh. Western red cedar and broadleaf trees were not affected.

Acid rain monitoring

Establishment of a nationally standardized series of long-term study plots in forested areas was initiated in British Columbia in 1984 as part of the CFS-FIDS Acid Rain National Early Warning System (ARNEWS). This was in response to recognition of the potential for damage to forested areas in British Columbia from low-pH rainfall and the presence of soils with low buffering capacity. Baseline knowledge from the 1/25-ha plots includes the concentration of foliar and soil elements, foliar condition, tree growth and, on selected plots, the detection and monitoring of possible changes on sensitive lichens and liverworts.

Six permanent plots were established in B.C. in 1986 for a total of 15. Ten plots are in the Vancouver Forest Region: one on Saltspring Island; two on Vancouver Island; five on the lower mainland; and two in the Fraser Valley. There is one plot in each of the other five regions near Penticton, Castlegar, Quesnel, Prince George and Terrace.

Since 1984 observations for possible acid rain or other mimicking symptoms have been made across the province at 592 permanent sample stations (PSS), by CFS-FIDS rangers. About 20 tree species and numerous ground cover species were observed within various soil sensitivity and wet sulphate deposition zones. Symptoms directly attributable to acid rain, including premature needle discoloration and loss of needles, have not been seen. Trees were generally healthy in more than 90% of the PSSs and damage observed was usually attributable to previous or current pest conditions.

Fume damage

Premature loss of older needles in mature western hemlock over about 240 ha on the east side of Neroutsos Inlet about 1 km north of the mill was attributed to emissions of sulphur dioxide from the pulp mill at Port Alice on Vancouver Island .

Five sites north of the mill on the east side of the inlet were examined by provincial and federal agency specialists in mid-June. Needle loss and foliar discoloration occurred at sites nearest the mill with slight browning of foliage on deciduous trees 5 km from the mill. There was also an apparent absence of lichens and liverworts on stems of conifers in all five areas up to 9 km away. Monitoring of affected hosts will continue in 1987.

Deciduous and Ornamental Tree Pests

Tent caterpillars
Malacosoma spp.

Trembling aspen stands and some black cottonwood and other deciduous trees were defoliated over more than 93 425 ha in the Prince George Region, and to a lesser extent in the Nelson Region (Map 4), nearly double the area defoliated in 1985.

More than 169 areas of trembling aspen and balsam poplar totalling 91 700 ha were defoliated by *M. disstria* in the Peace River area of the Prince George Region, some for the fourth consecutive year. Light, moderate and severe defoliation occurred over 18 550, 27 000 and 18 240 ha, respectively, in or adjacent to previously defoliated stands in the Kiskatinaw and Peace River valleys and in scattered shelterbelts and woodlots from Tupper north and west to Fort St. John along the Pine River Valley south of Fort St. John. In the Salmon River Valley north of Prince George, only six patches of trembling aspen over 580 ha were lightly and moderately defoliated following a major collapse of populations in 1985.

In the Nelson Region, infestations expanded tenfold and severely defoliated 37 areas totalling 1200 ha, some for the third consecutive year. Defoliated areas occurred from Rossland east to Montrose including Trail, and north to near Castlegar. Isolated 1- to 20-ha patches were defoliated near Crescent Valley, Eholt and Crawford Bay. Similar patches near Kitchener were the first to be recorded in that area.

Between Kitwanga and Moricetown in the Prince Rupert Region populations collapsed in the third year of an outbreak in which stands over 900 ha had been lightly defoliated in 1985. The collapse in the overwintering stage, as forecast, was due in part to greatly reduced egg hatch from smaller, less healthy egg masses.

Based on egg mass samples at nine locations, moderate and severe defoliation is forecast for most previously infested stands in both the Prince George and Nelson regions, with some localized expansions. There was little evidence of naturally occurring parasites or virus at sufficient levels to reduce populations.

Colonies of western tent caterpillar, *M. pluviale*, were more numerous and widespread in southwestern British Columbia in mainly urban and some forested and park areas in 1986. Light to severe defoliation of deciduous trees and shrubs was common for the sixth consecutive year in many areas from the Fraser Valley to the Sunshine Coast, and from Victoria to Campbell River, and was most severe on the Gulf Islands, particularly in older stands on Galiano and Sidney islands. A variety of deciduous trees and shrubs were lightly defoliated near Penticton for the first time in recent years.

Egg-mass surveys indicate declining populations in the Victoria area and generally static high populations and continuing variable defoliation elsewhere. Severely defoliated hosts usually recover and refoliate by late summer; long-term growth loss is likely to occur.

Satin moth
Leucoma salicis

Small new areas of trembling aspen defoliated by the satin moth occurred in the Kamloops Region in 1986, but most of the previously active populations elsewhere in the region and in the Nelson Region declined significantly, or collapsed.

South of Kamloops small pockets of aspen were lightly defoliated for the first time, but populations collapsed in previously defoliated stands near Merritt and Chase where consecutive years of severe defoliation killed 10% of the aspen. Near Moyie in the Nelson Region, regeneration black cottonwood was killed and the upper crowns of overstory trees were moderately defoliated over 5 ha, down from 15 ha severely defoliated in 1985. Pockets of aspen were moderately defoliated for the second consecutive year in the West Kootenay, mainly in the Bridesville area.

Defoliation is expected to continue in 1986 in

most currently infested stands. Many natural enemies including parasitic wasps, flies, mites and a polyhedrosis virus usually reduce populations in the third or fourth year of infestations.

Gypsy moth
Lymantria dispar

In a continuing cooperative interagency program about 7000 pheromone-baited sticky traps were distributed province-wide: 24 adult male moths were caught in 19 traps at eight locations in 1986, compared with 14 moths in 13 traps in three areas in 1985. New catches were near Kelowna (7), Clinton (2), south of Kamloops (1), Point Roberts (1), in Vancouver (1), at Goldstream Provincial Park near Victoria (1), Canadian Forces Base (CFB) Esquimalt, at Belmont Park (3) and at CFB Chilliwack (8). Near Chilliwack small areas had been sprayed in May 1986 with *Bacillus thuringiensis* following discovery of egg masses and larvae. In the 268 traps set out by CFS-FIDS in 233 forested recreation areas in national and provincial parks, one moth was trapped.

Gypsy moth populations have not yet become established in British Columbia, nor has defoliation been observed. Should it become established, the major concern of the forestry sector continues to be potential quarantine restrictions, which could require large costly control programs such as those in Oregon in 1984.

Pheromone trapping programs and, if necessary, egg-mass surveys will continue in 1987 in cooperation with Agriculture Canada and the B.C. Forest Service.

A birch leaf skeletonizer
Lyonetia saliciella

High populations defoliated stands in the northern part of the Nelson Region for the twelfth consecutive year, but declined in the eastern part of the Prince George and Kamloops regions.

Scattered patches of western white birch were severely discolored in the Illecillewaet River Valley in Glacier National Park and in the Tangier River Valley west to Revelstoke. Most of the birch over 900 ha in the West Kootenay were severely defoliated by increased populations near Kaslo, Meadow Creek and from Rapid Creek to Trout Lake.

Populations declined significantly in the Prince George Region between Tete Jaune Cache and Mt. Robson. Only 5% of the leaves on 80% of the trees were discolored in 1986; in 1985, all trees were severely discolored. There was no evidence of the leaf skeletonizer in birch stands in the North Thompson River Valley in the Kamloops Region, where severe discoloration occurred over 3100 ha from Barriere east to Adams Lake in 1985, and populations have fluctuated since 1979.

Poplar leaf diseases
Venturia spp.

Infection and discoloration of trembling aspen and some black cottonwood by poplar leaf and shoot blights, *Venturia* spp., declined significantly after 9 successive years in the western part of the Prince Rupert Region, but increased in the Nelson Region.

Moderate to severe infection of scattered pockets of aspen by *V. macularis* occurred between Kitwanga and Cedarvale in the Prince Rupert Region, where widespread infections in 1985 caused premature leaf drop over 12 000 ha. A similar decline in infection of black cottonwood by *V. populina* occurred in the Skeena and Kitimat river valleys.

Increased infection of aspen by *V. macularis*, due largely to moist conditions in early summer, killed about 60% of the shoots on 30% of the immature aspen in a provincial park near Cranbrook in the Nelson Region. Aspen groves between Kimberley and Ta Ta Creek were lightly infected, as were 25 to 60% of the crowns in scattered pockets between Nakusp and Fauquier. Between Castlegar and Slocan Lake, including Winlaw and Crescent Valley in the West Kootenay, an average of 70% of the trees were infected.

Winter moth
Operophtera brumata

Populations were low on southern Vancouver Island following a significant decline in 1985

when larval parasitism, mainly by *Cyzenis albicans*, averaged 44% for the second consecutive year.

Only very light or light defoliation of deciduous trees and shrubs, mainly Garry oak and maple, occurred in Greater Victoria, the Saanich Peninsula and in the Western Communities for the fifteenth consecutive year. Defoliation was not visible at Duncan, on Saltspring Island or at Nanaimo, where larvae and adults were collected for the first time in 1984. Parasitism, mainly by the introduced parasitic fly, *C. albicans*, and the wasp, *Agrypon flaveolatum* is being evaluated but preliminary assessments indicate a reduced incidence.

Pheromone-baited traps were deployed for the third consecutive year to detect male adult populations at 26 locations on southern Vancouver Island where the moth was not found in 1985. Results showed that moths (average 17 per trap, range 0 to 61) were present at 16 sites from Sooke to south of Nanaimo; none were trapped at 10 sites at Nanaimo, Lantzville, Parksville and Coombs.

Dogwood leaf blotch (Anthracnose)

Gloeosporium sp.

Despite a wet spring, infection of dogwood trees in east coastal areas of Vancouver Island and the lower mainland was generally light or moderate and similar to 1985; however, single, heavily shaded trees in the Greater Victoria area were more severely infected. Infected, discolored foliage was contained largely within the lower crowns. Tree, twig and branch mortality, mostly in urban areas, has occurred following successive years of severe infection.