
**FOREST INSECT AND DISEASE CONDITIONS
BRITISH COLUMBIA AND YUKON - 1993**

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Abstract

This summary of forest pest conditions in British Columbia and the Yukon Territory in 1993 highlights pests that are, or may become, major forest management problems. It was compiled from field reports of 11 Forest Insect and Disease Survey rangers with contributions from the forest industry, researchers, and government agencies. The status and impact of more than 50 major forest pests are described and some forecasts are made for 1994.

Résumé

Ce résumé de l'état des insectes et des maladies des arbres en Colombie-Britannique et au Yukon en 1993 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 50 insectes et maladies des arbres d'importance et présente certaines prévisions pour 1994.

Introduction

The Forest Insect and Disease Survey (FIDS) of the Canadian Forest Service is responsible for producing an annual national overview of important forest pest conditions and their implications. In the Pacific and Yukon 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 Canadian Forest Service centres across Canada.

This regional report reviews the status and impact of major forest insects and diseases and the effects of environmental factors on coniferous and broadleaf forests in British Columbia and the Yukon Territory in 1993. 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 tree defoliation; these are defined as 1 to 25%, 26 to 65%, and more than 65% defoliated, respectively.

The report is compiled from information obtained largely from field observations and records collected by 11 FIDS rangers during their field assignments from May to October in six provincial forest regions and 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 Janice Hodge
Nelson	- Leo Unger and Alan Stewart
Prince George	- Nick Humphreys and Bob Ferris
Prince Rupert	- Rod Garbutt and John Vallentgoed
Vancouver	- Rod Turnquist and Colin Wood
Yukon Territory	- Rod Garbutt

Other staff of the Forest Insect and Disease Survey (FIDS) project in 1993 were:

Allan Van Sickle	- FIDS Head
Brenda Callan	- Mycologist, Diagnostics and Herbarium Collection
Dennis Clarke	- Technician, Geographic Information System
Bob Duncan	- Biologist, Insectary Diagnostics
Lee Humble	- Entomologist, Insectary and Collection
Nicola Parfett	- Technician (Temp.), Geographic Information System
Fiona Ring	- Technician (Act.), Disease Diagnostics and Data Base
Jane Seed	- Technician, Insectary Rearing and Data Base
Joan Strobbe	- Secretary

Summary

This summary is of pests that were most prominent in the Pacific and Yukon Region in 1993 and most likely to be of interest and concern. 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, they fluctuate little from year to year so they are not surveyed on an annual basis.

The most noteworthy changes in the status of major forest pests in 1993 included continuing populations of **two-year-cycle** and **eastern spruce budworms** and declining populations of **western spruce budworm**, **Douglas-fir tussock moth**, and **western hemlock looper**. The number of European biotype (race) of **gypsy moth** trapped in the southwestern part of the region declined slightly, but two Asian biotype moths were trapped.

Slightly above average **temperatures** (range - 0.6° C to + 1.8° C, average + 0.7° C) occurred at 13 of 15 sites in the region during the growing season, with **precipitation** from 88% to 174% of the 30-year norm. Overall, growing season weather was slightly warmer and wetter, with little effect on pest conditions.

An estimated 2.3 million m³ of mature pine were killed by **mountain pine beetle** in British Columbia in 1993, in 11 900 infestations which covered 49 450 ha in six regions. Infestations were up 10% overall with increases in the Cariboo, Prince George, and Prince Rupert regions, but declines in the Kamloops, Nelson, and Vancouver regions. Infestations will continue in 1994, but at declining levels. **Western pine beetle**, **red turpentine beetle**, **lodgepole pine beetle**, **pine engraver beetle**, and **ambrosia beetle** were again common in weakened trees. **Pinewood nematode** remains very rare. Studies continued to obtain data for an exemption of yellow cedar and western hemlock from the heat treatment requirement for imports to the European Community. Discoloration of year-old and older needles infected by **pine needle diseases** were again very common throughout the interior over 193 000 ha, for a seventh consecutive year in some areas. Special surveys to detect **pine shoot beetle**, recently introduced to North America, were negative. The European **pine shoot moth** is established in ornamental pines in urban areas in the Okanagan Valley and southwest coastal areas, but to date not in native pines. **Pine needle sheathminer** collapsed in previously

defoliated regeneration lodgepole pine in the North Thompson River valley, north of Kamloops.

Mortality of mature Douglas-fir killed by **Douglas-fir beetle** increased in 4600 separate groups, totaling about 13 000 ha in parts of five forest regions. The area affected, nearly double that in 1992, is forecast to increase again in 1994. The area of Douglas-fir defoliated by **western spruce budworm** covered about 43 000 ha in parts of four forest regions, about one-eighth of the area defoliated in 1992. The decline occurred throughout the Kamloops, Nelson and Vancouver regions, with little change in the Cariboo Region. Numbers of egg masses increased 6%, indicating continuing defoliation in 1994. Defoliation of Douglas-fir by **Douglas-fir tussock moth** totaled 1150 ha in the Kamloops Region, down 40% from 1992, the third year of the outbreak. The numbers of adults in pheromone traps declined 35% and, along with fewer egg masses, this indicates declining populations in the Kamloops Region in 1994. **Western false hemlock looper** populations collapsed in previously defoliated Douglas-fir stands in the Kamloops Region.

Spruce beetle was one of the most damaging forest pests in British Columbia in 1993 and killed mature and overmature spruce over about 56 000 ha, down about one-third from last year. This followed three consecutive years of increase, mostly in the Mackenzie, Dawson Creek and Prince George forest districts. Populations in older windthrown and standing spruce in Bowron Lakes Provincial Park declined to endemic levels and pose no immediate threat to healthy stands. Spruce aphid populations were less common than in 1992 in coastal areas, but on the Queen Charlotte Islands **spruce aphid** predisposed trees to attack by beetles.

Defoliation of alpine fir and white spruce by **eastern spruce budworm** in northeastern British Columbia increased 20% to 170 000 ha in 180 patches near Fort Nelson and into Yukon Territory, and defoliation is forecast to continue in 1994. Defoliation by mature "**off-cycle**" **2-year-cycle budworm** totaled 107 000 ha, mostly in the Prince George Region, the eastern part of the Kamloops Region, and the East Kootenay. Immature "**on-cycle**" **2-year-cycle budworm** larvae infested but did not visibly defoliate new buds of alpine fir and spruce forests in four forest regions.

The area of mature alpine fir recently killed by **western balsam bark beetle** covered more than 200 000 ha in parts of six forest regions, up 20% from 1992, mostly in the Prince Rupert Region. Active **balsam woolly adelgid** populations were found on regeneration amabilis fir for the first time near Port Alberni and on mature amabilis fir for the first time southwest of Campbell River, which is outside the quarantine zone.

Defoliation of old-growth western hemlock by **western hemlock looper** declined by half overall to 92 750 ha in 335 patches in four forest regions in the fourth year of outbreak. Most defoliation was in the Nelson Region, where new patches occurred east and south of Revelstoke. Defoliation is forecast to be mostly light but occasionally severe in 1994, particularly in newer infestations. Populations of **western blackheaded budworm budworm** increased in the eastern part of the Nelson Region and lightly defoliated hemlock near Golden.

Declining **larch casebearer** populations very lightly defoliated western larch stands at widely scattered locations throughout the host range in southeastern British Columbia. Parasitism averaged 15% overall, down 19% from the previous year. Exotic larch near Maple Ridge were defoliated by **larch sawfly** which remained endemic elsewhere in native larch stands. Discoloration of western larch by **needle blights** was common and widespread in the southern part of the Nelson Region, but was less widespread and conspicuous in the Kamloops Region. A **larch shoot miner** infested and killed new shoots on immature larch in small patches in the East Kootenay.

Defoliation of seedlings by **black army cutworm** occurred in six recently burned and planted sites in interior British Columbia and on ground cover at an additional three sites. Seedlings were killed by **Rhizina root disease** at two sites in interior British Columbia, and fruiting bodies (but no seedling damage) occurred at sites in the Prince Rupert Region.

The most damaging and most widespread problems found in surveys of 242 young managed stands across the province in 1993 were similar to those in the previous four years. These included locally significant **root diseases**, **terminal and root collar weevils**, and **stem rust cankers**. Less damaging but more common were **native needle diseases** and **shoot insects**.

Feeding by **porcupines** and **squirrels** again damaged young trees over 9400 ha in the southwestern Yukon Territory, north of Mackenzie and Vanderhoof, in the Prince Rupert Region where

stocking levels have been reduced, and increased in the Cariboo and Vancouver regions.

Discoloration of seedlings, young conifers, and mature deciduous stands caused by **climatic factors** was generally less common than last year, but still widespread in parts of the Prince Rupert region and Yukon Territory.

Rusty tussock moth populations collapsed in previously defoliated conifers in mixed stands east of Prince George, and near Quesnel Lake in the Cariboo Region.

Surveys of coastal seed orchards found one of the most damaging pests were **balsam woolly adelgid**, which severely infested and distorted growth on amabilis fir at four of five true fir seed orchards. Hemlock at two orchards were severely infested by high populations of **hemlock woolly adelgid**, which increased at an additional four orchards. **Armillaria root disease** killed two hemlock and infected an additional 15 trees at a coastal orchard.

Infection of seedlings by **foliar diseases** in forest nurseries caused increased losses of western larch, western red cedar, and lodgepole pine seedlings. Storage **mould** and seedling **root rots** were again common on nursery stock.

New tree mortality at 27 Biomonitoring/ARNEWS sample plots surveyed across the province in 1993 totaled 3%. This was attributed to causes other than **acid rain** and occurred mostly in plots on the lower mainland. Samples to determine baseline concentrations of foliar and soil elements were collected at the new 12 sites established in 1992.

The number of adult male **gypsy moths** trapped in British Columbia in 1993 declined to 141 at 15 locations, compared with 166 moths in 24 areas in 1992. This includes two of an Asian biotype, first recorded in North America in Vancouver in 1991. Other defoliators were again numerous and widespread, particularly in trembling aspen forests. Defoliation by **forest tent caterpillar** populations expanded nearly twofold to more than 410 locations totaling 86 000 ha near Prince George, McBride, Quesnel and Horsefly, and in the Peace River area. Increased **Northern tent caterpillar** populations defoliated alder and other deciduous hosts on Vancouver Island and Gulf Islands and near Meziadin in the western part of the Prince Rupert Region, and was common near Terrace. Trembling aspen was defoliated by declining **large aspen tortrix** populations in about 31 areas north of Mackenzie totaling 3000 ha and over 3000 ha in southwestern Yukon Territory. Increasing populations defoliated stands over 3000 ha near Vanderhoof, and for the first time north of Kitwanga in the Prince Rupert

Region on 400 ha. **Satin moth** populations increased for a second year and defoliated deciduous hosts in 54 areas totaling 3000 ha in parts of the Kamloops and Nelson regions. A **poplar leaf rust** recently introduced into North America was found for the first time in British Columbia on hybrid poplars. A **cottonwood sawfly** defoliated native black cottonwood over 730 ha on islands in the Fraser River near Chilliwack, some for the third consecutive year. Increased birch **leafminer** populations severely defoliated birch stands over about 12 000 ha in the northern part of the Nelson Region. Defoliation of deciduous hosts by **winter moth** was again common in the Greater Vancouver and Victoria areas. Garry

oaks in the Greater Victoria area were discolored by **jumping gall wasp** and an introduced **oak leaf phylloxera**, but less severely than in 1992, the seventh consecutive year of infestation.

Four **new disease collections**, one introduced rust and three minor foliage diseases, were recorded within British Columbia or the Yukon Territory in 1993. An additional 15 diseases were recorded for the first time on new hosts. Two **new insect collections** were new species for this region, four collections were significant extensions of their previously known distribution within the region, and one was recorded for the first time on a new host.

Pine Pests

Mountain pine beetle

Dendroctonus ponderosae

The mountain pine beetle continues to be one of the most damaging forest insects in British Columbia. The area of lodgepole pine and some western white pine killed by the beetle increased 10% to about 49 450 ha in 11 900 active infestations (Table 1), extending from the international border in the southeast to northeast of Terrace (Map 1). This is about eleven times the area burned by forest fires in British Columbia in 1993 (4500 ha), and the volume lost (2.7 million m³) represents about 18% of the lodgepole pine annually harvested in British Columbia.

The area of mature pine recently killed in six forest regions in British Columbia increased slightly overall in 1993, and is forecast to continue in 1994. Increases occurred in the Prince George Region over 12 750 ha (up 33%), in the Cariboo Region to

700 ha, and in the Prince Rupert Region over 7700 ha (up 31%). Declines occurred in the Kamloops Region over 19 925 ha (down 5%), in the Nelson Region over 7850 ha (down 12%), and in the Vancouver Region to 525 ha.

Infestations in the Cariboo Region more than doubled to about 700 ha, up from 275 ha in 1992. The increase occurred in more than 1500 widely scattered patches from Clinton to north of Quesnel, and to a lesser extent west of the Fraser River. Populations are expected to continue at similar levels in 1994, but near Chilko Lake they are expected to decline due to reduced host availability.

In the Kamloops Region, the area of mature pine killed by the beetle in 1993 declined slightly to 19 925 ha following two successive years of increase. About 3.5 million mature pine (1.8 million m³) were killed in 4445 pockets, mostly over 16 250 ha in the Okanagan Timber Supply Area (TSA). This included about 1750 ha in Okanagan

Table 1. Number, area and incidence of new and old attack of mountain pine beetle by forest region, based on aerial and ground surveys in British Columbia in 1993.

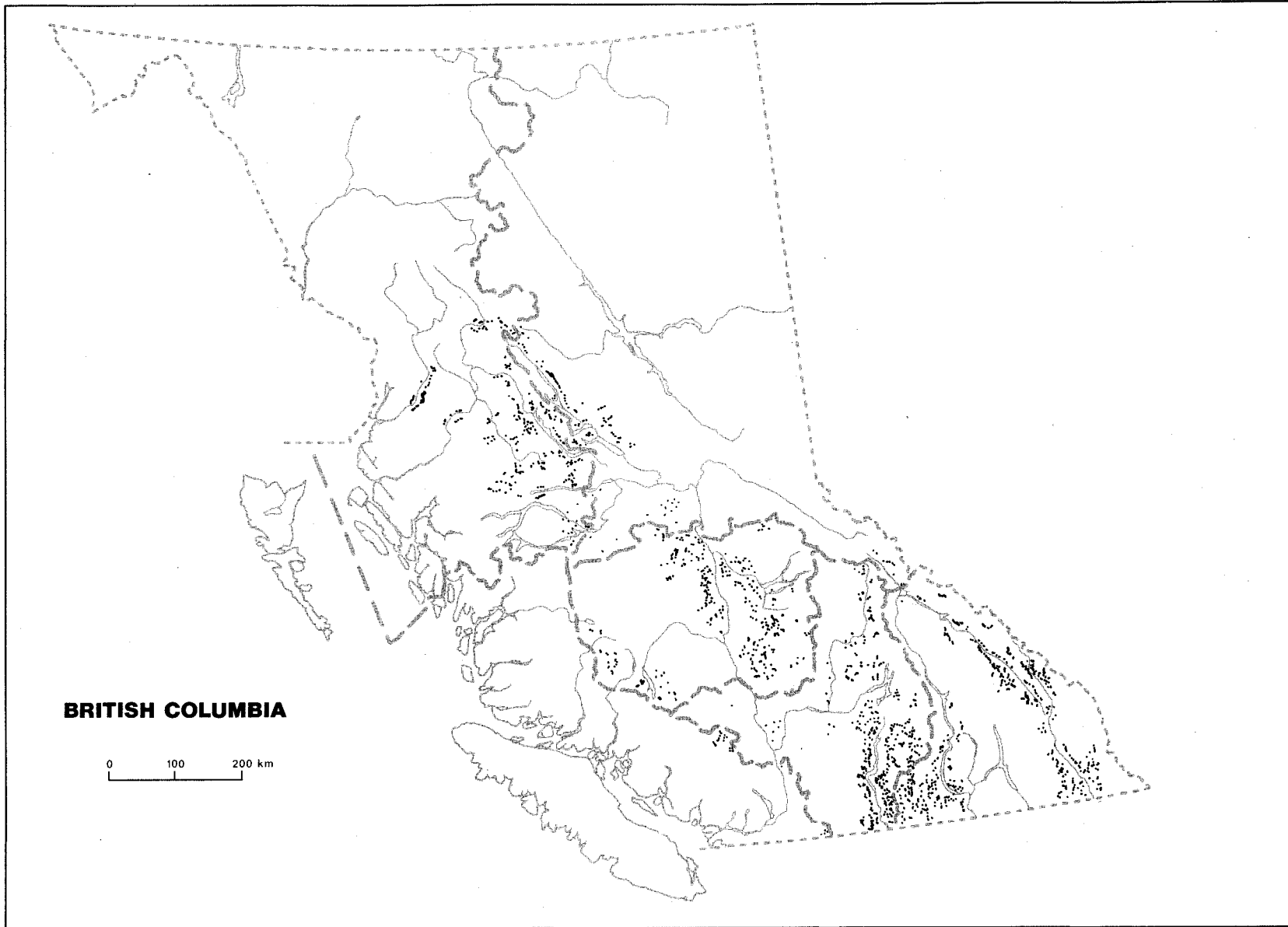
Forest Region	Number of infestations	Area (ha)	Trees killed ^a		Stands cruised ^b		Damage category ^c					
			No. (000)	Vol. (000 m ³)	No.	Avg. yrs. infested	H	C	R	G	P	
Cariboo ^d	1500	700	34	20	7	2	71	10	16	3	0	
Kamloops	4445	19 925	3538	1782	5	3	74	12	9	5	0	
Nelson	4350	7850	654	248	19	5	54	20	17	7	2	
Prince George ^d	451	12 750	660	550	-	-	-	-	-	-	-	
Prince Rupert ^d	1110	7700	73	62	2	6	64	7	3	25	1	
Vancouver	144	525	11	8	1	3	17	28	27	8	20	
Total	11 900	49 450	4970	2670	34	4	4	57	15	13	10	5

^a Trees attacked in 1992, discolored in 1993.

^b Some stands located in younger infestations may not represent average condition.

^c H - Healthy; C - Current, attacked in 1993; R - Red, attacked in 1992; G - Grey, attacked in or before 1991; P - Partial or strip attacked in 1993.

^d Estimates include data from the B. C. Forest Service



Map 1. Areas where recent tree mortality due to mountain pine beetle was detected during aerial surveys in 1993

Mountain Provincial Park. About 2187 pockets of recently killed pine, totaling 2745 ha, were mapped in the Merritt TSA, and 320 pockets totaling 700 ha were mapped in the Kamloops TSA. This included groups of 5 to 10 beetle-killed white pine near Adams and Barriere lakes and from Vavenby to Albreda. Tree mortality is forecast to continue in the Kamloops Region in 1994. This is based on the incidence of current attacks which averaged 12% (range 2%-27%) in five stands in the Okanagan TSA.

An estimated 654 mature pine (248 000 m³) were killed in the Nelson Region in about 4350 separate pockets, totaling 7850 ha. The 12% decline was mostly in the East Kootenay, particularly in the Cranbrook TSA and south of Radium in the Invermere TSA. The declines were due to some overwintering brood mortality and declining host availability. Small pockets of recently killed pine were again numerous in the Boundary TSA in the West Kootenay, but there was little change in the Arrow, Kootenay, and Revelstoke TSAs. Infestations along the British Columbia-Alberta border were generally stable, but doubled in Yoho National Park to 20 ha and were 15% more numerous in Kootenay (700 ha), with a slight decline in Glacier National Park (30 ha). Groups of 5-25 recently killed pine were less common in the Flathead and Elk river valleys than in 1992. An average 20% of the trees were attacked in 19 stands surveyed in the region, indicating continuing tree mortality in 1994. New attacks were highest in the East Kootenay (average 24%, range 3-39%), particularly south of Cranbrook from near Radium to north of Golden, and in Kootenay National Park. In the West Kootenay, current attacks declined 10% on average to 14% (range 6-28%). The highest attacks were at Nancy Greene Lake in the Arrow TSA and lower at Beaverdell (13%) and Boundary (14%) creeks in the Boundary TSA.

Recent pine mortality in the Prince George Region increased in area to about 12 750 ha, up a third from 1992. Most of the 660 000 trees (550 000 m³) in 451 chronically infested stands in the region were over 11 250 ha northwest of Fort St. James near Takla and Trembleur lakes and in the Skeena, Sustut, Middle, and Tachie river valleys. New infestations were mapped near Vanderhoof over 650 ha, and near Prince George (400 ha) and McBride (400 ha). Pine mortality is likely to continue in the region in 1994 northwest of Fort St. James and in the southern part of the Prince George Forest District, based on historical trends. For the second consecutive year in surveys conducted by the British Columbia Forest Service, there were no new

beetle-killed pine located in Mt. Robson Provincial Park and west of Jasper National Park. However, about 85 baited pine recently attacked by the pine beetle are to be cut-and-burned in a control operation ongoing since 1985.

Infestations in the Prince Rupert Region increased about 30% in area to 7700 ha. An estimated 73 800 trees (62 450 m³) were killed in 1110 separate infestations. The increase, which followed a decline in 1992, was mostly in the eastern part of the region in the Bulkley and Morice TSAs. Tree mortality, based on a ratio of three new attacks to one previous attack at four sites, is forecast to continue in the eastern part of the region but mortality is forecast to decline in the west, where only 7% of the trees in the two stands examined were attacked.

In the Vancouver Region, about 144 separate pockets totaling 525 ha contained about 11 000 recently killed trees (8100 m³). This is down a third from 1992, and only slightly more than the lowest level recorded in the region since 1981. Most pockets were in widely scattered parts of the Soo TSA, north and east of Pemberton. Additional pine mortality is expected to occur in 1994, based on the 28% of trees currently attacked.

Pine mortality is forecast to continue throughout many recently infested stands in parts of six forest regions in 1994. This is based on the number of new attacks (average 15%, range 7-28% of the trees) in 34 representative mature pine stands infested by mountain pine beetle on average for 4 years. Current attacks declined overall in the Nelson Region and were similar to or slightly less than 1992 levels in the Kamloops and Prince Rupert regions. New surveys in the Cariboo and Vancouver regions found increased current attacks.

Mortality of western white pine caused by mountain pine beetle increased in parts of the Prince George Region and in Glacier National Park, but declined in the northern part of the Kamloops Region following three consecutive years of increase. Other bark beetles such as western pine beetle, *Dendroctonus brevicomis*, and red turpentine beetle, *D. valens*, were again common in parts of the Kamloops and Nelson regions. Pine engraver beetles, *Ips pini* and *I. emarginatus*, and ambrosia beetle, *Trypodendron* sp., attacks were also common at widespread locations in pines attacked by other beetles.

The increase in harvesting of susceptible and recently killed mature pine continued in four areas in the south Okanagan and Boundary Forest District in the Nelson Region to prevent further spread of the

beetle. Elsewhere, single-tree disposal and salvage of beetle-killed and adjacent susceptible pine continued in most beetle-infested TSAs. More than 30 000 commercially produced semiochemical baits have been used by the British Columbia Forest Service and industry for beetle management through population monitoring, containment and single tree disposal.

Pinewood nematode

Bursaphelenchus xylophilus

New surveys were conducted in 1993 to obtain data for a possible exemption of yellow cedar (Cypress) from the ban on non-kiln-dried softwood exports from Canada to the European Community. The ban was imposed in 1993. Additionally, bait-log trials to obtain data for a possible exemption for western hemlock continued and a product survey was initiated in cooperation with the Council of Forest Industries (COFI).

Samples of yellow cedar were collected from logs at 23 sites, including dry-land sorts and log decks. Most sites were in the Vancouver Region on Vancouver Island (15), and a few were on the lower mainland (2) and the mid-coast (2) and in coastal areas of the Prince Rupert Forest Region (4). None of the 31 extracted samples contained pinewood nematode, but 45% contained other insect-associated or fungal-associated nematodes of the families Rhabditidae and Tylenchidae. New or old insect activity was evident in some of the logs at some of the sites, but the activity was mostly confined to near the cambium and most galleries were incomplete. Woodborer galleries identified in 5% of the logs at 11 sites were caused by *Semanotus ligneus amplus* and other Cerambycidae, but not *Monochamus*. Ambrosia beetle (*Trypodendron* sp.) attacks were found in about 5% of the logs at three sites and cedar bark beetles (*Phloeosinus* sp.) at four sites.

A follow-up bait log survey with western hemlock and lodgepole pine continued. Freshly cut logs from healthy standing hemlock (18) and pine (12) were placed at sites with active woodborer populations in each of the Cariboo, Kamloops, Nelson, and Vancouver regions in late May to early June. To date, there have been far fewer woodborer attacks this year than last year in the Vancouver Region, but there were only slightly fewer in the other regions. Reduced attacks, combined with the occurrence of two-year life cycles in *Monochamus* species may prolong these trials.

Also in 1993, a lumber product survey for pinewood nematode was initiated. Of 578 samples collected and examined during July to September from 50 mills in the Pacific and Yukon Region, none contained pinewood nematode. Only six samples contained other insect-related or fungal-related nematodes of the families Rhabtidae, Tylenchidae, and Monhysteridae. Of all the samples collected at random without regard for intended market or lumber grade, 6% contained sap stain, 5% contained bark, and 3% contained grub holes. Samples included 177 western hemlock, 163 spruce, 118 true fir, and 113 Douglas-fir.

Pine needle diseases

Elytroderma deformans
Lophodermella concolor

Discoloration and premature needle loss of year-old needles of lodgepole and ponderosa pines due to infection by native needle diseases was again severe and widespread over 193 000 ha in the Cariboo, Kamloops, and Nelson regions, parts of the Prince Rupert Region and the southern Yukon Territory, and in the southern part of the Vancouver Region.

In the Cariboo Region, infection by *Lophodermella* needle disease discolored year-old and older needles on 10-90% of the lodgepole pine over an estimated 116 000 ha, up from 1000 ha last year. The most severely affected stands were between Clinton and 100 Mile House, where successive years of severe infection on immature trees has resulted in the "lions' tail" effect in many areas.

Widespread infections in the Kamloops Region, particularly in younger lodgepole pine on plateaus in the Kamloops TSA, were mapped on 5650 ha in the North Thompson, Tranquille, and Bonaparte River drainages and west of Lillooet. Severe infections were also common on up to 100% of the regeneration lodgepole pine throughout the Okanagan and Similkameen valleys, from near Falkland and Vernon to Hedley and Merritt and from Princeton to Manning Park. The most severely affected stands were on the east side of Okanagan Lake from Vaseaux Creek north to Big White Mountain.

Increased light, moderate and severe discoloration of lodgepole pine was widespread over 71350 ha in the Nelson Region throughout the East Kootenay and the southern half of the West Kootenay. Pine were affected over 63 000 ha in the East Kootenay mostly in the Elk, Flathead, and Bull river drainages and near Yahk. Infection was most

severe over 32 000 ha at Hawkins Creek to Bloom Creek for a second consecutive year. Moderate to severely infected regeneration were common near lightly infected mature stands in the Spillimacheen, Bugaboo, and Bobbie Burns drainages, and to a lesser extent in and near Kootenay National Park and near Creston. Increased infection and discoloration of older foliage was more widespread in the West Kootenay, particularly in the Blueberry and Paulson creek drainages.

Infections and premature needle loss were widespread in the northern part of the Prince Rupert Region, but were less severe in the French River and Boya Lake drainages. Young pine in southwestern Yukon, including those in a provenance trial near Watson Lake and roadside trees west to Rancheria and along the Robert Campbell Highway, were lightly or moderately infected, although there was slightly less discoloration than last year. Infection of pines in the Prince George Region was minimal where stands had been severely discolored last year near Mackenzie, in the MacGregor River drainage, and at the Red Rock Seed Orchard.

Elytroderma needle disease again infected Ponderosa pine throughout much of the host range in the Cariboo and Kamloops regions, and to a lesser extent in the Nelson Region. Chronically severe infections occasionally contribute to the predisposition of trees to attack by turpentine beetle, *D. valens*, and to branch flagging and top-kill on younger trees.

Pine shoot beetle

Tomicus piniperda

European pine shoot moth

Rhyacionia buoliana

Surveys of Christmas tree plantings, particularly Scots pine, initiated in 1992 for the pine shoot beetle, were negative again this year in the Pacific and Yukon Region. The surveys followed the recent discovery of the introduction of this pest into North America in Ohio and five Lake States.

Surveys for the shoot moth were intensified in conjunction with the shoot beetle survey. Shoot moth populations and damage remain confined to new shoots of exotic pines in urban areas from Victoria to Courtenay, on the lower mainland, and in the Okanagan Valley. There has been no increase in numbers or spread and there is no evidence of shoot moth populations in native pines in the Pacific and Yukon Region.

On average, about 40% of the new shoots of exotic pines in urban plantings are infested annually, but generally there is little impact on overall tree vigor.

Pine needle sheathminer

Zelleria haimbachi

Following defoliation and needle mining of lodgepole pine by sheathminer in the Kamloops Region in 1992, populations collapsed. There was no apparent reduction of lateral or height growth or evidence of increment reduction, and infested stands are expected to fully recover.

Douglas-fir Pests

Douglas-fir beetle

Dendroctonus pseudotsugae

Increased Douglas-fir beetle populations killed mature Douglas-fir in about 3975 separate pockets totaling 13 000 ha in five regions. This was the sixth year of increase and more than double the area recorded last year. Tree mortality occurred mostly in the Fraser River drainage in the Cariboo, and in the Kamloops, Prince George and Vancouver regions. Lesser damage occurred in the Nelson Region. Most of the beetle-killed trees were in groups of 2 to 15, and occasionally groups of up to 500 trees were killed. Tree mortality in the Cariboo Region increased threefold in 2545 separate pockets, totaling about 6950 ha. The largest increase was in the Chilcotin Military Block near Riske Creek, with over 5320 ha in 240 patches, up fourfold from 1992. Additional patches of recently killed trees were in or near previous infestations from Clinton north to Quesnel and from Horsefly west to Redstone.

In the Kamloops Region, beetle-killed Douglas-fir were widely scattered in about 970 patches of 5 to 20 trees in the Thompson River and North Okanagan drainages over a total of 1175 ha, up fourfold from 1992. Most were in previously and chronically infested stands from Cache Creek to Pavilion, in the Deadman River Valley, north of Kamloops Lake, the Shuswap River Valley, and near Sugar and Mabel lakes.

Mature beetle-killed Douglas-fir in the Nelson Region occurred in about 70 widely scattered groups in the Rocky Mountain Trench totaling about 950 ha. This mortality was similar to the level observed last year and it occurred in previously infested areas south of Cranbrook, near Fairmont, along McNaughton Lake, and near Columbia, Whiteswan and Whitetail lakes, with slight increases in the Lussier River drainage and north of Radium. Patches of ten or fewer beetle-killed trees were common along Kootenay and Slokan lakes and Kootenay River drainages in the West Kootenay, similar to 1992.

Douglas-fir mortality in the Prince George Region continued for the fourth consecutive year in about 300 patches totaling 4500 ha, up 25% from 1992. Most were again north of Fort St. James and along Canoe Reach south of Valemount, with increasing populations over about 1200 ha in the southern part of the Prince George Forest District.

Tree mortality in the Vancouver Region was mapped in about 195 separate patches totaling 360 ha, about double the area of mortality mapped in 1992. These infestations were in the Anderson, Fraser, Chilliwack and Skagit river drainages, and to a lesser extent east of Bella Coola in the Mid-Coast district.

Mortality of mature and overmature Douglas-fir will likely continue in 1994 in the most recently infested stands, particularly in the Cariboo Region. In 10 stands surveyed in the military training area near Riske Creek, an average of 31% (range 4-62%) of the trees were currently attacked.

Western spruce budworm

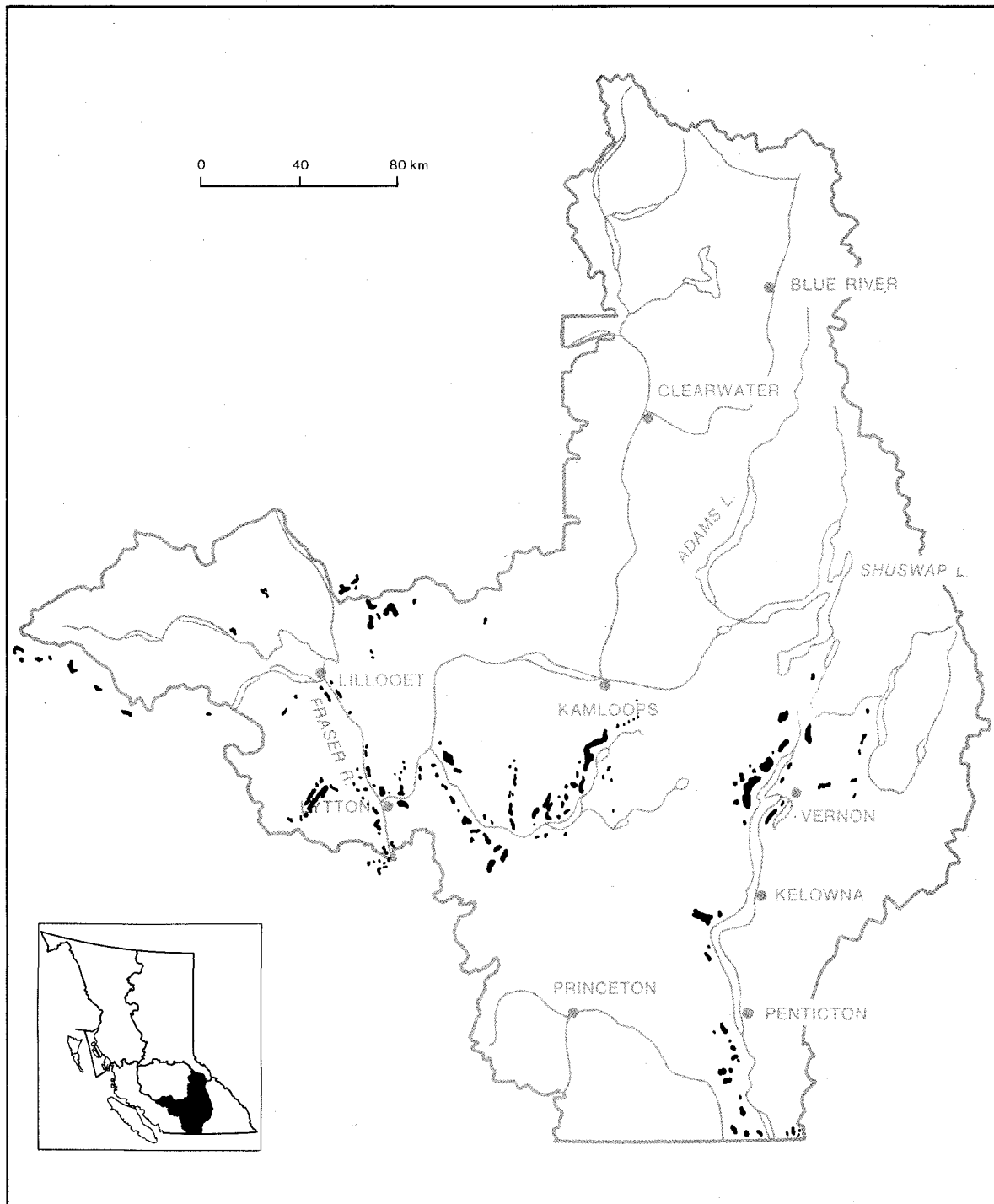
Choristoneura occidentalis

Defoliation of mixed-age interior Douglas-fir by western spruce budworm covered about 43 000 ha in 265 separate infestations, mostly in the Kamloops Forest Region (39 000 ha) and to a lesser extent in the Vancouver (3700 ha) and Cariboo (350 ha) regions (Map 2). This was about one-eighth of the defoliation in 1992 and was the smallest area affected since 1982. Populations in the western part of the Nelson Region remained endemic following a significant decline last year.

Defoliation was light on 95% of the area and moderate on the remainder; in 1992 defoliation was light on 72% of the area, moderate on 27%, and severe on 1%. The area of moderate defoliation (2300 ha) was again west of Lillooet and near Lytton (1775 ha), and Pemberton (525 ha).

As forecast, a major decline in area of defoliation (300 000 ha) occurred throughout all previously infested stands. The largest decline was in the Okanagan, Lillooet and Kamloops TSAs in the Kamloops Region. Declines occurred also in the Cariboo Region, in the Vancouver Region, and in the Nelson Region. Mortality of late-instar larvae due to disease and insects was assessed at 11 locations in two regions. An average of 35% (range 0-88%) were diseased with various entomopathogens, including NPV, bacteria, *Beauvaria* and *Entomophthoraceae*, being isolated from dead larvae. Parasitism of late-instar larvae, by tachinids and hymenopterans, averaged 10% (range 2-19%), similar to 1992.

The number of egg masses per 10 m² of foliage at each site increased 6% overall from 1992,



Map 2. Defoliation by western spruce budworm detected by aerial surveys in 1993

averaging 66 (range 0-379) in 33 infested stands in the Cariboo (2), Kamloops (24), and Vancouver (7) regions. This indicates a slight overall increase in populations in 1994 (Map 3), mostly in the 100 Mile TSA in the Cariboo Region, in the Kamloops and Merritt TSAs in the Kamloops Region and in the Fraser TSA in the Vancouver Region. Defoliation is forecast to be severe at 12% of the sites, moderate at 24%, trace or light at 49%, and no defoliation is forecast at 15% of the sites. At additional sites in the Kamloops Forest District, surveyed by the British Columbia Forest Service, light and moderate defoliation is forecast at 80% of the sites, severe defoliation is forecast at 1% of the sites near Cache Creek, but no defoliation is forecast at the remainder of the sites.

Tree mortality, top-kill, bud mortality, increment loss, and tree deformity due to successive years of severe defoliation were common throughout the Kamloops Region but amounts vary by site. Monitoring of the impacts of defoliation on young open-growing Douglas-fir continued at 64 research plots in the Kamloops Region. Tree mortality in 1993 averaged 1%; cumulative tree mortality from budworm since 1986 averaged 12%. Tree mortality increases with increasing years of defoliation (R. Alfaro, Canadian Forest Service, Victoria, personal communication).

Infested Douglas-fir stands over about 34 000 ha of young managed stands in the Kamloops Region were sprayed aerially with *Bacillus thuringiensis* var. *kurstaki* (Btk) in five forest districts by the British Columbia Forest Service. This followed applications over about 36 000 ha in 1992, when control was considered successful at all but one site where applications were delayed.

A study to improve and calibrate detection methods for western spruce budworm continued in 1993. Adult males were monitored in four regions at 11 sites with low populations but with a history of budworm outbreaks. Larval sampling was discontinued. Up to 1050 male adults/trap (average 154 /trap), were caught in a total of 49 traps similar to last year. The data indicate continuing populations with the potential to very lightly defoliate stands in 1994.

Douglas-fir tussock moth

Orgyia pseudotsugata

The total area of Douglas-fir defoliated by the tussock moth in the fourth year of an outbreak in the Kamloops Region declined 40% to 1150 ha in 64 patches. Declines occurred in previously defoliated

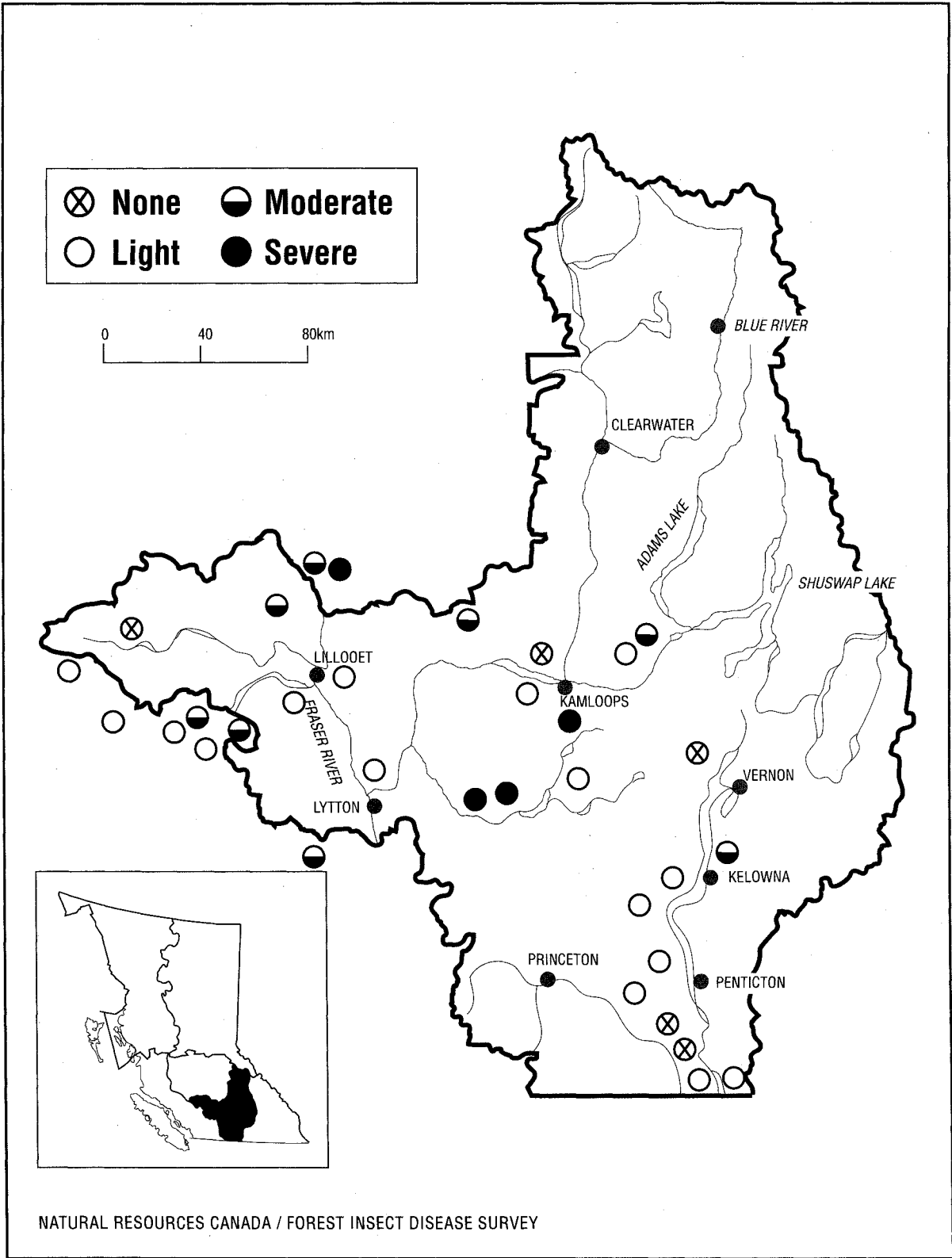
stands west of Kamloops to Spences Bridge and near Hedley in the southern Okanagan, but new patches were observed near Cache Creek, north and east of Kamloops from Heffley Creek to Pritchard, and south of Monte Creek.

Defoliated ornamental Douglas-fir and spruce were again common in urban areas of Kamloops, Vernon, Kelowna, and Penticton, but not near Abbotsford, Chilliwack, and Clearbrook in the Vancouver Region where populations were controlled in 1992. Populations remained at low levels near Christina Lake in the western part of the Nelson Region.

Declines in the number of male adults in pheromone-baited sticky traps placed in selected Douglas-fir stands with the greatest historical frequency of outbreaks occurred for the second consecutive year. About 2717 adult males were trapped in 91% of the 112 traps (average 27, range 0-119) at permanent monitoring sites in the Kamloops and Nelson regions. This is 35% fewer than last year. An average of 25 or more males occurred at 42% of the sites. Egg masses (average 3, range 1-10) were found at 8 of 15 sites surveyed, and none were found at the remainder. This indicates that defoliation of Douglas-fir is likely in 1994 at Battle Creek west of Kamloops where 10 egg masses were found, and little or no defoliation is expected at the remainder of the sites. Numbers declined further at two sites in the western part of the Nelson Region, where only a single male adult was trapped in five traps at Christina Lake and two at Rock Creek. This is down from 54 and 30 males trapped at the same sites in 1992, and is too few to cause damage in 1994.

An additional 1166 male adults were trapped in 31 of 57 traps (average 38/trap), compared to 2195 adults in 1992, placed singly for detection purposes about one kilometer apart in 12 areas in the Kamloops (10) and Nelson (2) regions. A further 4039 male adults were trapped at 152 locations (average 28/location) monitored by the British Columbia Forest Service. This compares with 5119 at 187 locations (average 27/location) last year. This indicates an overall decline, but with a potential for defoliation in 1994 at sites with egg masses.

The trap data and reduced numbers of egg masses in 1993 at 15 sites indicates the potential for very light defoliation of Douglas-fir at only one site near Kamloops, and little or no defoliation at 14 sites elsewhere in the region. No defoliation is forecast near Chilliwack or in the western part of the Nelson Region.



Map 3. Defoliation by western spruce budworm forecast for 1994, based on 1993 egg surveys.

Populations were treated with nuclear polyhedrosis virus (Virtuss®) by the British Columbia Forest Service at six sites totaling about 650 ha (range 20-120 ha) near Savona and Rayleigh in the Kamloops Region. Results indicate effective viral spread and population reduction. A pheromone male confusion trial conducted by the Canadian Forest Service over 30 ha near Kamloops found mating was effectively blocked.

Western false hemlock looper

Nepytia freemani

Populations in Douglas-fir near Premier Lake in the East Kootenay collapsed following an increase in 1992, and remained endemic at Jamieson Creek north of Kamloops.

Spruce Pests

Spruce beetle

Dendroctonus rufipennis

Mature white and Engelmann spruce killed by spruce beetle in British Columbia in 1993 was mapped over about 56 000 ha, down about 35% from 1992. This followed four consecutive years of increase. Most of the tree mortality mapped in aerial surveys was again in the Prince George Region over about 54 000 ha, and the remainder of the mortality occurred in parts of four forest regions. On average, 25% of the trees within these areas were killed by the beetle in 1993.

A one-third change in area to 54 000 ha occurred in the Prince George Region, namely on the east slopes of the Rocky Mountains in the Dawson Creek Forest District, where only 10 000 ha were mapped. Additional changes occurred north and east of Prince George near Carp and Weedon lakes, in the Parsnip and McGregor river drainages, and southeast of Fort Nelson near Kocho Lake, where no new tree mortality was seen this year. Tree mortality north and west of Mackenzie was mapped over 41 000 ha, similar to last year, and increased in the Fort St. James Forest District over 1200 ha and in the McBride District over 400 ha.

Elsewhere in the province, populations were mostly endemic or increased slightly. Small patches of recent tree mortality mostly associated with previously infested stands totaled about 2150 ha, up 20% from 1992.

Populations in Bowron Lake Provincial Park were endemic following two consecutive years of decline in mature and overmature spruce, windthrown in 1990 and 1991. Elsewhere in the Cariboo Region, recent tree mortality totaled only 15 ha in 52 pockets, similar to the mortality observed

the past two years. All mortality occurred near previously infested stands in the northeastern part of the region near Barkerville, in the Mitchell, Matthew, and Cariboo river drainages, and near Towkuh, Big Valley, Rebman, and Alice creeks.

The area of beetle-killed spruce in the Kamloops Region was 2030 ha, up 20% from 1992. Most of the 63 separate patches were generally in or near previously infested stands in Connel and Noel creeks between Anderson and Bridge lakes west of Lillooet, north and west of Barriere lakes, and in the Tulameen River drainage in the Merritt TSA.

About 44 new infestations in the Nelson Region in the Golden TSA totaled about 105 ha; this threefold increase followed a slight increase last year. Most newly killed trees were at Bachelor, Ensign, Sullivan, and Cupola creeks west of Golden, and new pockets of about 50 trees each occurred in numerous drainages north of Golden to the Wood River drainage.

Recent spruce mortality in the Prince Rupert Region totaled about 65 ha, similar to 1992. New attacks in standing green trees occurred in the Toughy Road area in the Bulkley TSA and near Chisholm Lake in the Morice TSA, and these new attacks threaten adjacent susceptible stands. Populations in year-old blowdown near Mitten Lake in the Kispiox TSA, along the Haines Road near the British Columbia-Alaska border and near Haul Lake in the Morice TSA pose no immediate threat to adjacent stands.

There is no evidence of new top-kill of mature and over mature spruce caused by northern spruce engraver beetle, *Ips perturbatus*, which was common last year in the Torpy River drainage north of Prince George and at Indianpoint and Isaac lakes in Bowron Lakes Park.

Spruce aphid

Elatobium abietinum

Declining spruce aphid populations very lightly defoliated older needles of immature and mature Sitka and ornamental spruce in coastal areas of the Vancouver and Prince Rupert regions, some for the fourth consecutive year. Damage on the Queen Charlotte Islands was significantly less widespread than in the previous two years.

Shoreline spruce, particularly near Campbell River and Port Edward, were less severely defoliated than in 1992 when severe defoliation of all age classes covered about 820 ha. This was attributed to

colder than normal late winter temperatures. Elsewhere in the Vancouver Region, declining populations were common from Port Hardy to Hope, and were common on trees in urban areas of Prince Rupert and Terrace.

Populations in regeneration and mature spruce on the Queen Charlotte Islands declined to very low levels. This followed moderate and severe defoliation over about 2950 ha in 1992.

Mortality of 1 of 40 trees at one of two plots being monitored in previously defoliated stands was attributed to successive years of severe defoliation and predisposition to attack by a secondary bark beetle, *Dryocoetes affaber*.

True Fir Pests

Budworms

Choristoneura spp.

Spruce and alpine fir forests in parts of two forest regions were defoliated by eastern budworm over 170 000 ha, and by 2-year-cycle budworms over 107 000 ha (Map 4). This compares with 139 000 ha and 435 000 ha, respectively, in 1992.

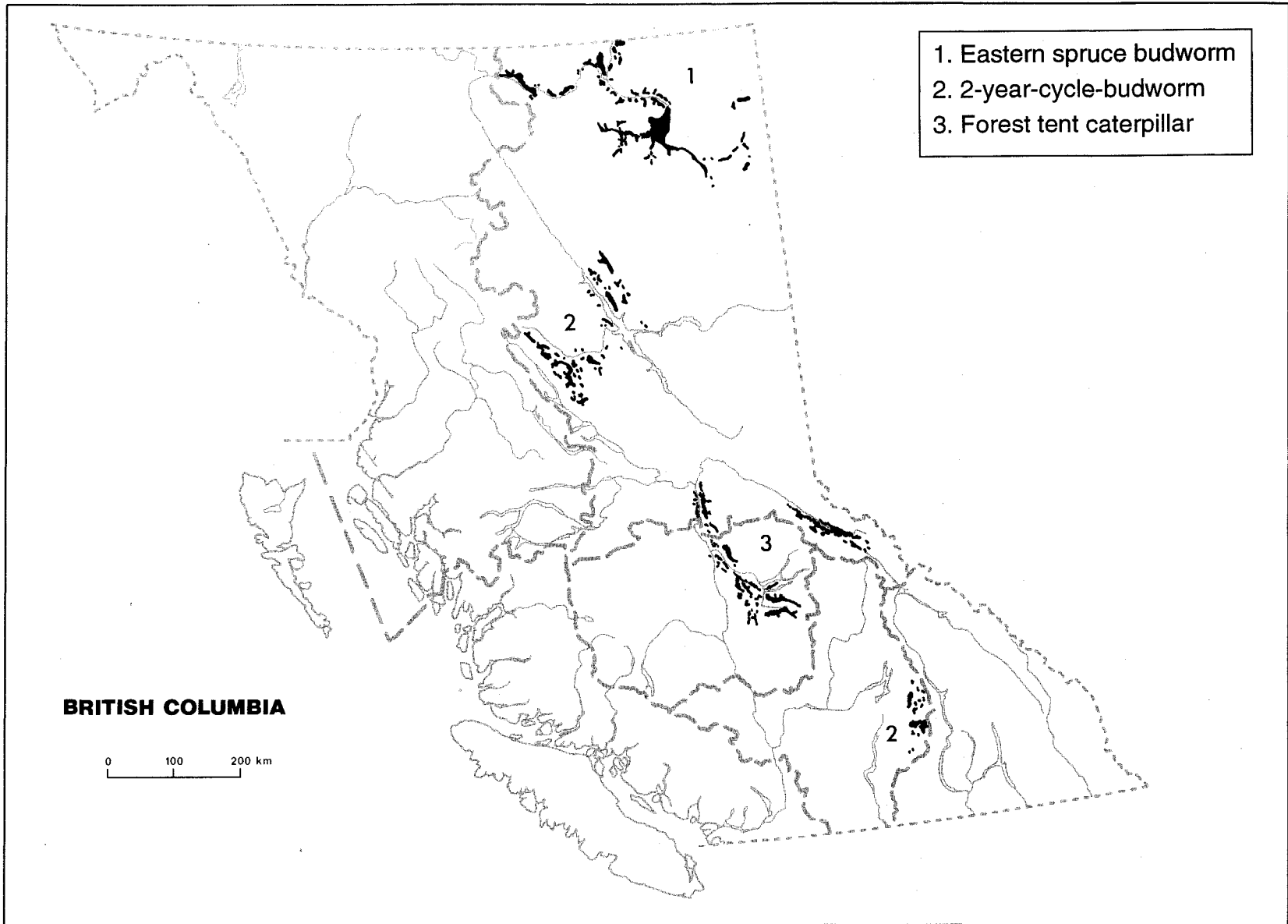
Eastern spruce budworm, *Choristoneura fumiferana*, defoliated mostly current and some older foliage of white spruce and alpine fir over 170 000 ha in the northern part of the Prince George Forest Region. This is 20% more than in 1992, but defoliation was light on 80% of the area and moderate on the remainder. Defoliation occurred in 179 separate patches west and north of Fort Nelson, into the Yukon and Northwest territories, and southeast into the Fort Nelson and Fontas river drainages. Some areas have been defoliated for ten years.

Egg masses averaged 33/m² (range 23-41) at sites sampled by the British Columbia Forest Service in previously defoliated stands near Fort Nelson in the Snake and Liard River drainages. This indicates continuing defoliation by the budworm in these areas in 1994.

Mature 2-year-cycle spruce budworm, *Choristoneura biennis*, lightly and moderately defoliated alpine fir and spruce over 107 000 ha in 135 separate infestations in the Prince George and two other forest regions. Additionally, immature larvae infested new buds in fir-spruce stands in parts of four regions.

Defoliation of alpine fir and spruce by mature "off-cycle" budworm larvae covered 97 000 ha in the Prince George Region, 10 000 ha in the northeast part of the Kamloops Region, and 105 ha in adjacent parts of the Nelson Region. In the Prince George Region, defoliation was mostly light over 88 300 ha and moderate over the remainder in the Fort St. James and Mackenzie forest districts (Map 4). This was up nearly fivefold from 1992, with the largest areas from Kloch Lake in the south to Ferriston Creek in the Omineca River drainage in the north, and northeast to the Ospika River drainage. In the Kamloops Region, defoliation was mapped over 10 000 ha in 23 patches near Keefer and Sugar lakes east of Vernon, similar to the previous two years. After larval mortality from late frost, defoliation by mature larvae was lighter than forecast in Vowell, McMurdo and Bugaboo creeks and in the upper St. Mary River drainage in the East Kootenay. However, populations between Barnes and Plant creeks in the West Kootenay moderately and severely defoliated fir-spruce stands in patches totaling 4300 ha.

Immature "on-cycle" budworm larvae were common in new buds in fir-spruce stands in parts of four forest regions, but there was no visible defoliation in this non-feeding year. Populations in stands southeast of Prince George in the Bowron and Willow river drainages infested 46% (range 16-80%) of the 1993 buds. The highest populations were at Pundata (80%) and at Big Valley and Everett creeks (63%). Populations in Betty Wendle Creek and the Milk River drainages near McBride remained endemic.



Map 4. Areas where defoliation was detected by aerial surveys in 1993

Infested 1993 buds on understory alpine fir and spruce in previously infested stands in the eastern part of the Cariboo Region occurred in patches from north of Barkerville to near Mahood Lake. In the eastern part of the Nelson Region, about 7% of the buds of alpine fir and spruce were infested by immature larvae in the White River drainage and near Marble Canyon. Only new buds were infested in previously infested stands in the Kamloops Region, mostly in the Clearwater District.

Western balsam bark beetle

Dryocoetes confusus

Mature alpine fir recently killed by the bark beetle was mapped over about 200 000 ha in 1980 separate pockets in parts of all six forest regions. This was up about 20% from 1992. Most was in the Prince Rupert (80%) and Prince George (15%) regions.

Infestations in the Prince Rupert Region, which have persisted for many years, totaled 158 500 ha in 220 areas. This was up 22% from the area mapped in 1992, and occurred mostly in chronically infested mature stands in the south-central parts of the region in the Bulkley and Morice TSAs. These included the Bulkley, Telkwa, Morice, Babine, and Nilkitkwa river drainages.

In the Prince George Region, the areas containing recent beetle-killed alpine fir declined slightly to about 29 000 ha in 269 separate areas. Most occurred northwest of Fort St. James, and other areas were in the McBride Forest District.

Recent tree mortality in other regions was also in chronically infested areas and increased in area by about a third overall from 1992. This includes about 2200 ha in the Cariboo Region, 5200 ha in the Kamloops Region, and 4200 ha in the Nelson Region; however, the area of tree mortality declined to 525 ha in the Vancouver Region, mostly in the Fraser TSA.

The fluctuation in the areas containing recently killed mature alpine fir recorded annually in aerial surveys is due in part to beetle-killed trees retaining reddened needles for at least 5 years, and in part to variation in the coverage and amount of aerial surveys.

Balsam woolly adelgid

Adelges piceae

Populations were found on regeneration amabilis fir within the quarantine zone on Vancouver Island for the first time near Port Alberni in several widely scattered patches. Populations were also found outside the quarantine zone and the previously known distribution on mature amabilis fir in the Oyster River drainage west of Campbell River, and on advanced amabilis fir regeneration northwest of Spuzzum in the Fraser Canyon.

Leader dieback, reduced height growth, and gouting of branch nodes caused by increased adelgid populations occurred on 20 to 25 year old regeneration in small 0.5-ha pockets in higher elevation sites throughout the Cameron River drainage southeast of Port Alberni. Damage was moderate to severe on 20% of the trees and light on an additional 15% of the trees at two sites examined in detail. Although the remaining regeneration had no visible damage, 70% and 80% of the trees in each of the two sites had active populations. This was the first record of significant damage to managed young stands on Vancouver Island. Populations on mature trees in the Oyster River drainage near Campbell River were observed for the first time. Adelgids were found on severely gouted branches at tops of trees from which a large cone crop was collected.

In 1992, the Balsam Woolly Adelgid Regulations were revised by an Order-in-Council under the British Columbia Plant Protection Act. The revision included an expansion of the quarantine zone to include infested areas of the mainland and islands previously outside the zone.

Ongoing surveys of grand fir stands along the international border in the Nelson Region still have found no evidence of the adelgid. These stands are north of infested subalpine and grand fir in nearby central Idaho, which totaled 24 000 ha in 1992.

Hemlock Pests

Western hemlock looper

Lambdina fiscellaria lugubrosa

Defoliation of old-growth western hemlock by western hemlock looper declined in area to 92 750 ha in 335 patches in four regions (Map 5). Declines occurred in stands severely defoliated for two or more successive years near Clearwater in the Kamloops Region and near Quesnel Lake in the Cariboo Region. However, increases occurred in younger infestations near McBride and Prince George and in the northwestern part of the Nelson Region.

About half the affected area was severely defoliated, 25% was moderately defoliated, and the remainder was lightly defoliated. This resulted in continuing concerns expressed by land users on the survival and potential utilization of conspicuous, severely defoliated stands, many of which were adjacent to high-use traffic corridors and recreational areas. Earlier infestations resulted in mortality and top-kill of severely defoliated mature hemlock.

More than half of the defoliation was in the Nelson Region over 48 500 ha, up 3% from 1992. Most was north of Revelstoke in stands defoliated for three consecutive years along Revelstoke Lake from Frisby Ridge to Mica, including Albert, Downie, Script, and Bigmouth creek drainages and east of Mica along McNaughton Lake to Wood Arm. Populations continued for a third year east and south of Revelstoke, mostly in the Illecillewaet, Jordan, Tangier, Beaver and Halfway river drainages and near Upper Arrow and Trout lakes and Lardeau Creek.

Defoliation between Prince George and McBride in the Prince George Region covered 43 000 ha, up 50% from 1992, the second year of the outbreak. Defoliation was severe over 80% of the area (37 000 ha), and moderate (5000 ha) or light (1000 ha) on the remainder. The largest area of expansion was 31 000 ha in 70 separate patches east of Prince George from Purden Lake to Walker Creek. Defoliation west of McBride increased slightly to 12 000 ha, but declined along McNaughton Lake.

Populations in the Cariboo Region near Quesnel and Horsefly lakes collapsed. Only a single 100-ha patch of very light defoliation occurred this year, down significantly from 22 750 ha last year, the second year of infestation. Populations collapsed also in most parts of the Kamloops Region, particularly in

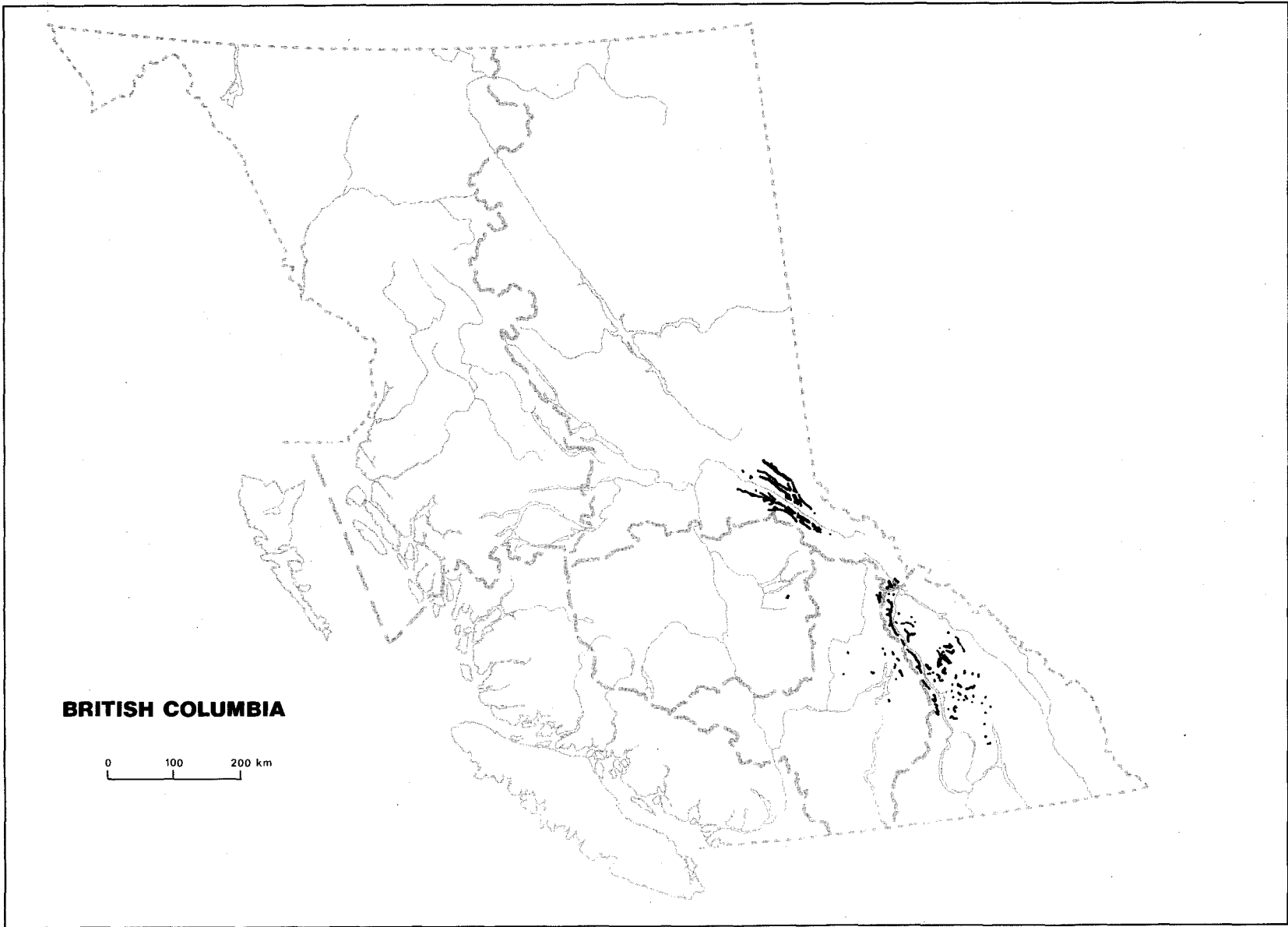
the Clearwater and Raft river drainages from Blue River to the Albreda River, the Adams River drainage, and in Wells Gray Provincial Park. However, 13 areas totaling 1150 ha were lightly defoliated in the Perry River, Ratchford and Scotch creek drainages and near Malakwa. This was down significantly from 88 000 ha defoliated region-wide in 1992.

The cause of the decline is attributed in part to larval mortality caused by disease and parasites. In laboratory rearings, larval parasitism averaged 2% (range 0-5%) at 11 sites in three regions, mostly caused by Hymenoptera and to a lesser extent by Diptera, similar to 1992. Additionally, about 28% (range 0-72%) of the larvae were dead from pathogens, mostly NPV with some Entomophthoraceae. Egg parasitism averaged 21% overall (range 0-28%) at nine sites in the Kamloops Region, 23% (range 8-64%) at 15 sites in the Nelson Region, and 8% (range 0-35%) at six sites in the Prince George Region, but was less than 1% at four sites in the Cariboo Regions. Parasitism was highest at sites where high populations occurred for two or more years.

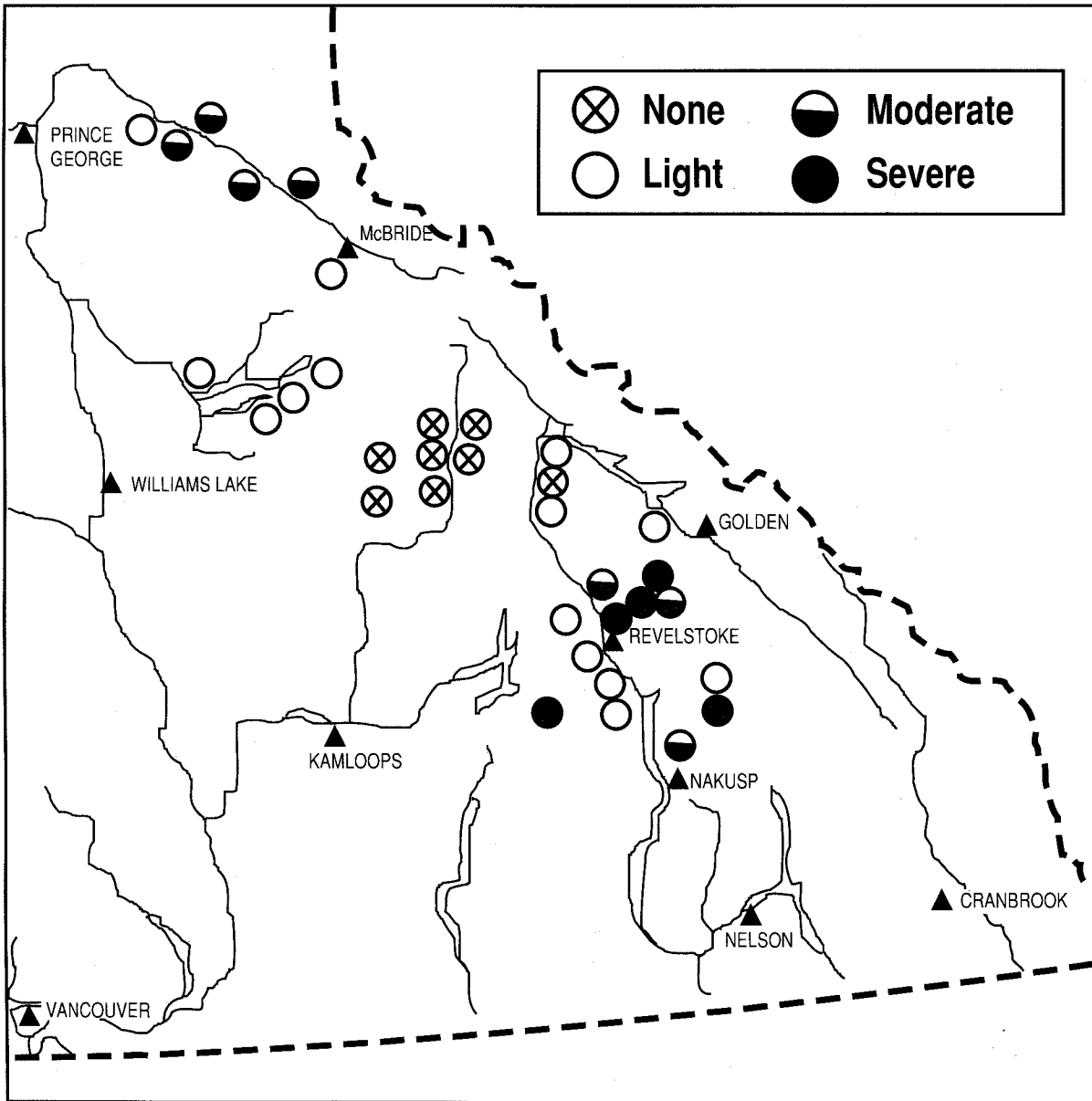
Defoliation is forecast to continue in 1994 in newly infested stands in the Nelson and Prince George regions, but not in older infestations in the Cariboo and Kamloops regions. Overwintering eggs laid this year averaged 20 (range 1-38) eggs per sample (100 grams of lichens/site) at 34 sites in four regions. This indicates severe defoliation at five sites, moderate defoliation at seven sites, light at 14, and none at the remaining 8 sites, (Map 6).

Tree mortality averaged 6% at 13 plots in previously defoliated stands in the Cariboo and Prince George regions and 40% at six areas in the Nelson Region, but no mortality has been observed at two severely defoliated plots in the Kamloops Region.

In the Cariboo Region, about 7% of the trees in four plots were killed by successive years of severe defoliation and an additional 27% were totally defoliated. Tree mortality averaged 5% of only understory cedar and hemlock in nine plots in previously defoliated stands between Prince George and McBride. Tree mortality was estimated at 40% in stands at Downie, Bigmouth, Lardeau, and Pingston creeks and in the Goldstream and Illecillewaet river drainages in the West Kootenay. About 40% of the trees at two plots in the Kamloops Region were



Map 5. Defoliation by western hemlock looper detected by aerial surveys in 1993



Map 6. Western hemlock looper defoliation forecast for 1994, based on 1993 egg surveys.

totally defoliated and the rest of the trees were defoliated from 10 to 90%, some for the second consecutive year, but to date there is no tree mortality.

A cooperative study by Canadian Forest Service and Simon Fraser University initiated in 1992 to develop a pheromone trapping and forecasting system for the western hemlock looper continued in 1993. Three-tree beating sampling, defoliation severity, pupae, trapping of male adults using different trap types and overwintering egg populations were assessed at 27 sites with a history of looper activity in the Cariboo, Kamloops, Nelson, Prince George, and Vancouver forest regions. Preliminary results found that adult and immature populations were interrelated and that trap catches have predictive capability for populations in the succeeding generation. Additional calibration is required.

Western blackheaded budworm

Acleris gloverana

Western hemlock in the eastern part of the Nelson Region near Crawford Bay and near Golden was very lightly defoliated by increased budworm populations in association with western hemlock looper. This was the second year of increased populations in the East Kootenay, where the numbers of larvae indicate continuing populations near Glacier National Park and along the west side of McNaughton Lake with the potential for very light defoliation in 1994.

Larch Pests

Larch casebearer

Coleophora laricella

Casebearer populations in western larch stands in southeastern British Columbia declined to near endemic levels. There was little or no discoloration of new needles in previously infested larch stands in the Nelson Region but discoloration was common east of Vernon in the Kamloops Region.

Generally, only trace defoliation was observed throughout the host range in the West Kootenay (slightly less than last year) and at Cranbrook Reservoir, but not elsewhere in the East Kootenay. Discoloration of larch stands in the eastern part of the Kamloops Region was very light. Lightly infested stands, some also infected by larch needle blight, were common in drainages from Vernon to Cherryville, but a much smaller area was damaged than in 1992.

Discoloration of trees at 16 of 17 long-term parasite release study sites surveyed from Koochanusa Lake west to Anarchist Mountain in the Nelson Region, and at two sites near Cherryville and Penticton in the adjacent Kamloops Region, declined to the point where damage was negligible at these locations. Only one site near Cranbrook had very light discoloration.

Low casebearer populations made widespread assessments of parasitism difficult. Populations were high enough to allow determination of parasitism at only three previously infested sites in the Nelson Region. While parasitism approached 32% in one collection, it was below 3% at the other two locations. The majority of the parasitism resulted from attack by the introduced *Chrysocharis laricinellae*. *Agathis pumila* and the native *Spilochalcis* sp. were not recovered at any locations in 1993.

Larch sawfly

Pristiphora erichsonii

Exotic larch at the University of British Columbia Research Forest near Haney in the Vancouver Region were again defoliated by the sawfly, some for the sixth consecutive year. Populations in previously defoliated native larch stands elsewhere in British Columbia and southwestern Yukon Territory remained endemic.

Larch needle diseases

Hypodermella laricis,
Meria laricis

New infections and discoloration of western larch by larch needle diseases were common and widespread in the southern part of the Nelson Region. In the eastern part of the Kamloops Region there was significantly less new infection and discoloration than in 1992. Infections have fluctuated periodically with weather conditions.

Discoloration of western larch was conspicuous and widespread throughout most previously infected stands in the southern part of the Nelson Forest Region. There was slightly more discoloration than in 1992, and severe infections increased from Yahk to Creston in patches totaling 1500 ha, particularly in the Goat and Yahk river drainages and at Summit, East Arrow and Maryland creeks. Moderate to severe discoloration was common in the southern parts of the Arrow and Kootenay Lake TSAs and in the Boundary TSA in the West Kootenay, where

generally light infection and discoloration occurred in 1992. In the Kamloops Region, lightly infected and discolored stands totaled less than 100 ha, down from about 1540 ha in 1992. Most were in previously infected stands east of Vernon along King Edward Main. Very light discoloration was common in stands near Sugar Lake and Trinity Valley, but discoloration declined east of Enderby and Penticton.

A larch shoot miner

Argyresthia columbiana

New shoots of dominant and codominant western larch in spaced stands over about 100 ha at Brewer Creek near Columbia Lake in the East Kootenay were mined and killed by a shoot miner, but fewer shoots were damaged than in the previous three years. About 5% of the terminal shoots were killed and 10% of the lateral buds on upper whorl branches were mined. About 30% of the trees had multiple leaders.

Multiple Host Pests

Black army cutworm

Actebia fennica

Defoliation of recently planted seedlings and ground cover by cutworm populations in recently burned and planted sites in interior British Columbia have generally remained at low levels since a significant decline in 1989. Defoliation but no seedling mortality occurred at six sites in 1993. Additionally, larvae very lightly defoliated ground cover at three sites where 300 or more male adults were trapped last year.

Recently planted lodgepole pine seedlings and herbaceous ground cover in the Prince George Region were lightly defoliated, but not killed, by increased cutworm populations over about 100 ha at a site in the Murray River drainage south of Tumbler Ridge. This was the first record of damage to conifer seedlings in the region east of the Rockies. Additionally, lodgepole pine and spruce seedlings were lightly defoliated and ground cover severely defoliated in parts of four recently planted sites near Merton and Weedon lakes north of Prince George, and at two wildfire burns near Stoner and the Willow

River. Defoliation of herbaceous growth was very light in a recently burned but unplanted site north of Golden in the Nelson Region. Only a few cutworm larvae but no defoliation were found in 10 sites re-surveyed in the Prince Rupert Region; the number of male adults trapped at these sites in 1992 ranged from 146 to 847.

Population declines are attributed to a reduction of slash burning and natural factors, including diseases, *Verticillium* sp., *Fusarium* sp., and *Paecilomyces*. Usually, Diptera parasites affected less than 10% of the populations.

Seedlings in 1994 plantings on sites slash-burned in 1992-93 may be threatened by cutworm larvae, particularly where the numbers of male adults in pheromone-baited sticky traps exceeded a threshold of 600 or more per trap. This occurred in only 1 of 30 sites trapped in parts of five regions, namely at Cariboo Creek (688) north of Golden in the Nelson Region.

A comparison of 1992 and 1993 lure batches at nine sites in three regions found 9% more male adults in dry "Multiplier" traps baited with the '92 RPC lures. The number of males trapped at 30 sites

in five regions averaged 124 (range 2-902). This indicates the potential for defoliation at Cariboo Creek (902) north of Golden, and possibly near Martin Mountain (384) near Avola in the Kamloops Region.

Rhizina root disease

Rhizina undulata

Some seedling mortality associated with fruiting bodies of *Rhizina* root disease in previously burned areas occurred in eleven sites in five regions in 1993.

Up to 40% of the lodgepole pine and 10% of the spruce seedlings were infected and killed in small patches at two sites near Cariboo Lake. This was the first report of seedling mortality caused by the disease in the region since 1983. Seedling mortality averaged 10% (range 1-30%) at nine sites in the Arrow and Revelstoke Forest Districts in the West Kootenay in the Nelson Region. This is similar to the previous two years (11% in 1992, 12% in 1991), and less than the 27% recorded in the region in 1990. In follow-up surveys of previously infected sites in the West Kootenay, an additional 5% of the seedlings infected last year were dead or dying where up to 50% of the seedlings had been killed last year.

New fruiting bodies in very low numbers, but no seedling mortality, occurred in recently burned sites

in parts of the Prince Rupert Forest Region. There was no evidence of sporophores in the Kamloops and Prince George regions, where seedling mortality and fruiting bodies had been present in recent years.

Pests of Young Managed Stands

Young natural and planted conifer stands were surveyed in British Columbia in 1993, as part of a continuing study to identify and record major pests and environmentally related problems and their impact on young stands. The 242 stands examined averaged 19 years old (range 2 to 99 years), and were established or treated under the Canada/British Columbia Forest Resources Development Agreement program.

A total of about 29 775 trees were examined in at least 10 circular plots at each location. Pines were the major component in about 43% of the sites, spruce in 23%, Douglas-fir in 18%, hemlock in 10%, true firs in 3%, cedar, larch and trembling aspen, poplar, and alder comprised the remainder (Table 2). Sites were located in 9 biogeoclimatic zones. Most (27%) were in the Sub-Boreal Spruce (SBS) zone, 21% in Interior Cedar-Hemlock (ICH), 17% in Coastal Western Hemlock (CWH), 10% in Montane Spruce (MS), 10% in Interior Douglas-fir (IDF), 8% in Engelmann Spruce-Subalpine Fir (ESSF), 4% in

Table 2. Number of young stands by region and species examined in British Columbia in 1993.

Region	Total	Species				
		Pine	Spruce	Douglas-fir	Hemlock	Other ¹
Cariboo	20	18	-	2	-	-
Kamloops	41	24	6	8	-	3
Nelson	50	23	8	9	4	6
Prince George	49	15	30	3	-	1
Prince Rupert	47	22	11	-	9	5
Vancouver	32	1	-	22	9	-
Q.C. Islands	3	-	-	-	3	-
Total	242	103	55	44	25	15
(%)		(43)	(23)	(18)	(10)	(6)

¹ Includes plots in which the major component was true firs, western red cedar, western larch, or where species are equal components.

Boreal White and Black Spruce (BWBS), and the remainder in the Coastal Douglas-fir (CDF) (2%), and Sub-Boreal Pine Spruce (SBPS) (1%).

About 44% of the 242 stands surveyed were either free of pests or contained only insects or diseases of little consequence. About 13% contained pests which caused losses to current growth potential, and 43% contained pests which caused significant damage, although only 5% of the trees have died. Overall, 74% of the trees were pest free. Locally significant and damaging pests were root diseases, terminal and root collar weevils, and stem rust cankers. Less significant but widespread problems included feeding by mammals, new climatic (abiotic) damage, infection of new and older needles by native diseases, and adelgids on new spruce shoots.

Root diseases, mainly *Armillaria* spp. and to a lesser extent *Phellinus weirii* and *Inonotus tomentosus*, were recorded in 25% of the stands. *Armillaria* root disease infected and killed an average of 3% (range 1-22%) of the Douglas-fir in 7% the 44 stands examined, half of which had been spaced. The highest incidence was at Montana Creek, southeast of Revelstoke where 22% of the 40-year-old pruned Douglas-fir and some white pine were infected.

Spruce weevil, *P. strobi*, infested 13% (range 1-50%) of the terminals in 18% of the 55 spruce plantations examined, mostly in the Prince George Region. Half the 8-year-old planted spruce were infested at Cecil Creek in the Kitimat Valley, and 43% and 36% at each of two sites in the McGregor River drainage east of Prince George. Warren's root collar weevil, *Hylobius warreni*, infested 2% (range 1-5%) of the immature lodgepole pine in 9% of the 103 pine plantations. About 5% of the 13-year-old pine were girdled and killed at one of nine infested sites, in the Nelson Region.

Stem and branch diseases including western gall rust, *Endocronartium harknessii*, and blister rusts, *Cronartium* spp., were common in pine plantations, but to date these diseases have had little impact on stocking levels. Tree mortality, frequently the result of perennial stem cankers, was generally less than 1%. Western gall rust, *Endocronartium harknessii*, infected branches and/or stems on an average of 4% (range 1-32%) of the trees in 29% of the pine stands. The highest incidence (32%) was in a 20-year-old spaced stand on the Bowron River Road in the Cariboo Region. Blister rusts, *Cronartium* spp., infected an average of 4% (range 1-22%) of the immature lodgepole pine at 6% of the sites. An average of 5% (range 1-24%) of the white pine in 10% of the sites were infected by white pine blister rust, *C. ribicola*. Stem and branch cankers were

common on 24% of the residual white pine in a spaced stand in the Lardeau River drainage in the West Kootenay. Stem cankers caused by *Atropellis* spp. infected 1-28% of the trees in 6% of the lodgepole pine stands, mostly in the Prince Rupert Region.

Browsing and related damage caused by mammals occurred in 37% of the 242 stands examined in the region. Most of this damage was caused by deer, elk, or moose, although some damage was caused by bear, beaver, cattle, porcupine, squirrels, voles, hares, and occasionally birds. Deer browsed 57% of the 11-year-old trees in Texada Island plantation in the Vancouver Region, and moose damaged 30% of the stems of 18-year-old trees in a Goat River plantation, east of Prince George.

Hail and snow and, to a lesser extent, ice and frost damaged trees in about 34% of the stands examined in the region. Hail severely damaged 39% of the trees in a 5-year-old plantation in the Prince Rupert Region, and 18% of the pine in a pruned site near Prince George were severely damaged by snow press.

Foliar diseases, mostly *Lophodermella concolor*, infected and discolored both new and old needles of half (range 1-100%) the pines in about 22% of the young stands surveyed, particularly in the western part of the Cariboo Region. Fir-fireweed rust, *Pucciniastrum epilobii*, affected most new foliage on true firs in 13% of the plantations.

Dwarf mistletoes, *Arceuthobium* spp., infected on average 4% of the trees in only 6 of 134 pine, hemlock and larch stands surveyed. The most common dwarf mistletoe was *A. tsugense* on western hemlock, and *A. americanum* on lodgepole pine and *A. laricis* on western larch were also prevalent.

The most common pest of Douglas-fir and spruce, Cooley spruce gall adelgid, *Adelges cooleyi*, was common on most trees in 5% (on Douglas-fir) and 33% (on spruce) of the 242 stands surveyed, but tree growth and vigor or tree form were not significantly affected.

Svenska Cellulose Trials

The annual cooperative survey with Svenska Cellulose to determine pest losses on different provenances of lodgepole pine, Scots pine, Siberian larch, and Norway spruce seedlings planted in 1986 continued. Trees at four sites in the Prince George Region and at one site in the Yukon Territory were examined in 1993. The most damaging pests in the

plots were perennial stem and branch rusts on pines. These included Western gall rust, *Endocronartium harknessii*, recorded for the first time at the Takhini plot near Whitehorse on one lodgepole pine. Stems and branches on 10% (range 1-24%) of the lodgepole pine at all four plots in the Prince George Region were also infected, as in 1992. Stem cankers of comandra blister rust, *Cronartium comandrae*, were found for the first time infecting lodgepole pine at Takhini and killed 1 of 12 infected trees, and with stalactiforme blister rust, *Cronartium coleosporioides*, infected 18% of the trees at Nation Bay near Mackenzie, up 8% from 1992. A rust canker, *Cronartium* sp., was found infecting a branch on a Scots pine at Nation Bay and a lodgepole pine at the Teardrop Lake site near Fort St. James, where Western pine aster rust, *Coleosporium asterum*, infected year-old needles on 2% of the lodgepole pine. About 60% of the year-old needles on half the lodgepole pine at the Halfway River plot near Fort Nelson were infected and discolored by a needle cast, *Lophodermella* sp..

Significant damage caused by insects included new attacks by Warren's root collar weevil, *Hylobius warreni*, which girdled and killed 2% of the lodgepole at Nation Bay. Stems on an additional 1% of the pine were infested by northern pitch twig moth, *Petrova albicapitana*, for the third consecutive year in the plot near Mackenzie; 2% of the trees were also infested at Fort Nelson, but none was infested near Fort St. James where damage was recorded last year for the first time. There was no evidence of feeding by eastern spruce budworm, *Choristoneura fumiferana*, on Siberian larch and Norway spruce at the plot near Fort Nelson that was last defoliated in 1991. There were no new attacks of white spruce terminals in the Fort St. John plot, where 1% were killed by spruce weevil, *Pissodes strobi*, last year; this was the first record of spruce weevil in the plot and it is the most northerly record of spruce weevil in British Columbia.

Climatic damage caused by frost, snow, ice, and cold winds was less than in previous years but cumulatively has resulted in multiple tops, bushy form, and bud mortality at all five sites. Damage was most severe at Nation Bay where 52% of the larch and 23% of the pine have poor form. Elsewhere, an average of 10% (range 5-15%) of the lodgepole pine were affected at two sites, as well as 5% of the Siberian larch at two sites and 10% of the Norway spruce near Fort Nelson. About 10% of the Siberian larch at Takhini are barely surviving following frost damage and feeding by snowshoe hares in 1990-91. About 9% of the Scots pine at Teardrop Lake near

Fort St. James have severe basal sweep caused by snow.

Mammal damage

Feeding by a variety of mammals in 1993 again damaged young trees in the Yukon Territory. Mammal damage increased in the Cariboo and Vancouver regions, but declined in the Kamloops and Prince Rupert forest regions. This follows consecutive years of noteworthy damage caused by mammals since a significant increase of this type of injury in 1991.

Porcupines

Young and semimature conifers killed and top-killed by porcupines chewing stem and branch bark were mapped in 228 chronically infested areas totaling 3000 ha in the western part of the Prince Rupert Region. Damage by porcupines increased in the western part of the Cariboo Region. Stocking levels, particularly in spaced lodgepole pine and western hemlock stands in the Prince Rupert Region, have been significantly affected. Increased populations of porcupines severely debarked and top-killed groups of up to five lodgepole pine near Mt. Alex in the Gaspard Creek drainage west of Williams Lake.

Squirrels

Feeding by squirrels was again widespread in lodgepole pine throughout northwestern British Columbia and southwestern Yukon Territory for the third consecutive year, and increased in the Cariboo and Vancouver regions.

Dead and discolored branch tips and partial branch girdling was highly visible in patches of 10-100 trees in the southwestern Yukon and northern part of the Prince Rupert Region. Damaged patches were most common from Pelly Crossing to the south end of the Canol Road, near Atlin, Takhini, Lake Laberge, and Rancheria. Similar damage occurred in the northern part of the Prince Rupert Region at Swift River, and to a lesser extent near Boya and Dease lakes where immature cones were stripped from up to 15 branches on about 40% of the trees.

Increased populations in the Cariboo Region near Gaspard Creek killed the tips on up to 30 branches on semimature and mature lodgepole pine in patches up to 0.5 ha. This was more than last year, but similar to widespread damage in 1991. Increased damage occurred in the Vancouver Region where successive years of feeding damage to 10 to 15 year

old ponderosa pine near Little Lillooet Lake near Pemberton resulted in multiple tops and poor form. Leader and lateral buds in the tops of 7-year-old Douglas fir were clipped in a plantation near Roberts Creek near Sechelt.

Populations declined to endemic levels in stands in the Kamloops Region where young lodgepole pine had been killed in 1992. Alternative food sources including sunflower seeds, distributed aerially in some areas by the British Columbia Forest Service, have successfully reduced damage.

Voles

About 25% and 7% of the recently planted seedlings at each of two sites north of Revelstoke in the Nelson Region were killed due to feeding by meadow voles, *Microtus* sp. Increased populations killed about 20% of the year-old Douglas-fir in a 1993 plantation near Mission in the Vancouver Region. Seedlings at one site in the western part of the Prince Rupert Region were partially damaged, but there was no additional seedling mortality in previously damaged sites in the northern part of the Kamloops Region, and eastern part of the Nelson Region.

Climatic injury

Discoloration of seedlings, young conifers and mature deciduous stands caused by climatic factors, mostly winter drying and frost, was less common than last year but was still most widespread in the Prince Rupert Region and Yukon Territory.

Climatic damage was most severe in the Yukon Territory, where winter drying caused highly visible needle discoloration of immature and mature lodgepole pine on south facing slopes in the Rancheria River Valley. Premature needle loss on some affected trees near Watson Lake resulted in retention of only the current year's needles. In the northern part of the Prince Rupert Region, most trees on south facing slopes over 500 ha near Good Hope Lake were severely discolored. Most 1992 needles on young exposed lodgepole pine were severely affected in the Telkwa River Valley, at Harold Price Creek and at McKendrick Pass north of Smithers. Young spruce were dead at widely scattered sites in plantations, along roadsides and power lines along the Morice-Telkwa road, and in the Lakelse River drainage following severe damage to new growth by late frost last year.

Foliar discoloration and branch dieback, attributed to cold weather and high winds in late winter and early spring, was common on conifers throughout the upper Fraser Valley in the Vancouver Region. Similar damage was common also in higher elevation young stands north of Campbell River on Vancouver Island.

Rusty tussock moth

Orgyia antiqua badia

Populations in parts of the Prince George and Cariboo forest regions collapsed in 1993. White spruce, alpine fir, lodgepole pine, alder and other deciduous shrubs had been defoliated over more than 13 000 ha in 1992.

Seed orchard and nursery pests

Eleven coastal and one interior seed orchard and more than 220 samples from forest nurseries were assessed in 1993 in cooperation with the British Columbia Forest Service and industry.

Balsam woolly adelgid, *Adelges piceae*, currently the most damaging pest in seed orchards, severely infested and distorted growth on up to 90% of the amabilis fir at four of five true fir orchards. This included gouting from previous years attacks on 30% of the trees. Most western hemlock at two seed orchards were severely infested by increased hemlock woolly adelgid, *Adelges tsugae*, 3% of the trees were lightly infested at a third orchard, and light populations were present at three others. Two western hemlock in a coastal orchard were infected and killed by *Armillaria* root disease, *Armillaria ostoyae*, and an additional 15 trees had rhizomorphs. This has resulted in root raking to remove inoculum at a nearby proposed seed orchard site.

The most common pest on Douglas-fir in seed orchards, Cooley spruce gall adelgid, *Adelges cooleyi*, lightly infested 10% of the trees at five Douglas-fir orchards, infested all the trees in an additional two orchards, and infested about 20% of the tips on 20% of the Sitka spruce in four orchards. Douglas-fir needle midge, *Contarinia pseudotsuga*, lightly infested 10% of the trees in five orchards. Fir coneworm, *Dioryctria abietivorella*, lightly infested 2% of the cones at five orchards and mined under the bark of 7 to 10% of the trees at two orchards. About 10% of the year-old needles on 70% of the lodgepole pine at one interior orchard were infected and discolored by needle cast, *Lophodermella concolor*.

Losses of seedlings in forest nurseries due to diseases, included larch needle cast, *Meria laricis*, on 1-year-old and 2-year-old western larch at several nurseries. More than 10% of the seedlings were killed at one nursery previously considered free of the disease. Keithia leaf blight, *Didymascella thujina*, again caused significant losses in western red cedar nursery stock and outplanted seedlings. Increased late-season needle blight, *Sirococcus strobilinus*, resulted in stem cankers and severe culling of lodgepole pine at three nurseries. Grey mould, *Botrytis cinerea*, seedling root rots, *Fusarium* sp., *Cylindrocarpon* sp., and *Pythium* sp., and storage mould, *Septonema* sp., were again common on nursery stock, similar to last year. The Nursery Pest Clinic monitors nursery stock for early recognition of these problems and makes cultural recommendations for their control.

Forest tree seed collected in British Columbia and Yukon Territory for international trade is certified under the Organization for Economic Cooperation and Development (OECD) at the Pacific Forestry Centre in Victoria. In 1992, 1283 kg of seed from eight coniferous species were certified for export with a value in excess of \$750 000 for the extracted seed. In 1993, 2530 kg of cones, twice as much as in 1992, were collected from nine species of conifers.

Biomonitoring and acid rain surveys

The condition of trees and ground cover were monitored in 1993 at 27 permanent sample plots across British Columbia. There were no changes found attributable to acid rain.

The annual plot assessments found 12 dead trees (3%) in eight plots, one near Dawson Creek and the rest in the Vancouver Region. Tree mortality was caused mostly by suppression, although a small amount of mortality was due to storm damage, and one died from a stem canker. None was killed by acid rain.

To better represent the biodiversity of forest types in this region, an additional 12 plots were established in six forest regions in British Columbia and at one site near Whitehorse, Yukon Territory in 1992. Most were in lodgepole pine (4), and ponderosa pine (3), and the remainder in trembling aspen (2), Douglas-fir, Western hemlock, and Sitka spruce (1 each). Foliar and soil samples were collected from each of the new sites this year to obtain baseline knowledge of the concentrations of elements along with foliar condition and tree growth, to detect and monitor possible changes.

The 27 plots have been established across eight biogeoclimatic zones, mostly in the Coastal Western Hemlock (11) and Interior Douglas-fir (5) zones, but also in the Coastal Douglas-fir (2), and Interior Cedar Hemlock (2), two spruce (6) zones and Ponderosa pine (1). Within the national ecozone classification, 13 plots are in the Pacific maritime zone, 11 are in the montane cordillera zone, 2 are in boreal plains, and 1 is in the boreal cordillera. There is also a wide range of elevations, with plots established from almost sea level (100 m) up to 1545 m. Plot locations are representative of areas of sulphate deposition of up to 20 kg/ha/yr and ozone concentrations exceeding 120 ppb.

Deciduous and Ornamental Tree Pests

Gypsy moth

Lymantria dispar

More than 8000 sticky traps were deployed throughout British Columbia to detect gypsy moth populations in the sixteenth year of interagency cooperative surveys with Agriculture and Agrifood Canada (Plant Health), the Canadian Forest Service, and the British Columbia Ministry of Forests.

The number of adult males trapped in British Columbia in 1993 declined to 141 in 100 traps at 15 locations. Mitochondrial DNA analysis confirmed that two of these were of the Asian biotype of gypsy moth, the first since 1991 when the type was first found in British Columbia. This compares with 166 males in 24 areas in 1992, which was the highest number trapped in British Columbia since 1987. Additionally, 10 female gypsy moths and 11 egg masses were found to date during ground searches at Vancouver, Hope, and Victoria.

Most adult males trapped in 1993 (including the two Asian biotypes) were at previously active areas including Hope (32 males, 2 females), Whiskey Creek (32), Vancouver (21 males, 8 females) and Nanaimo (29). Additionally, males were trapped on the lower mainland at Coquitlam (2), Langdale (1), Langley (1), New Westminster (1), Richmond (2), Surrey (4 European, 1 Asian), Vedder (6), and on Vancouver Island at Merville north of Courtenay (2), Victoria (4 European, 1 Asian), and Oak Bay (1), and on Gabriola Island (1).

Low numbers of male moths were caught for the fifth consecutive year in Vancouver, and for the fourth consecutive year at Victoria and Coquitlam. Catches were made for the third consecutive year at Langley, Surrey, and Richmond, and for the second consecutive year at Hope, Whiskey Creek, Nanaimo, Merville, New Westminster, and Oak Bay. New catches were made on the Sechelt Peninsula at Langdale, in the Fraser Valley at Vedder, and on Gabriola Island near Nanaimo. None was caught in 278 traps deployed by the Canadian Forest Service in 153 provincial parks and 91 forested recreation areas in national parks, commercial campgrounds, and north coast ports.

Catches of the European biotype in Richmond (61) in 1992 prompted aerial (640 ha) and ground (70 ha) applications of *Bacillus thuringiensis* var. *kurstaki* (Btk, Foray 48B) in late April and May 1993 in an apparently successful eradication effort.

Additionally, ground treatments and intensified trapping programs were implemented in 1993 in areas where many gypsy moths were trapped in 1992 at Hope, Whiskey Creek, and Salt Spring Island. Post-treatment assessments found continuing populations at Hope and Whiskey Creek, but none at Salt Spring Island.

Tent caterpillars

Malacosoma spp.

Forest tent caterpillar, *Malacosoma disstria*, defoliated trembling aspen and other trees and shrubs in more than 410 separate locations totaling 86 000 ha in the Cariboo and Prince George regions (Map 4), but populations collapsed in the Kamloops Region. The increase, up from 47 325 ha in 1992, was mostly from Horsefly to Prince George, near McBride, and for the first time since 1991 in the Peace River area. Populations declined in the northern part of the Kamloops Region following four years of outbreak.

Increased Northern tent caterpillar, *M. californicum pluviale*, populations defoliated alder on central Vancouver Island for a second consecutive year and for the first time in recent years on southern Vancouver Island and on the Gulf Islands. Populations increased slightly in cottonwood stands in the Prince Rupert Region from Meziadin to Stewart and were common in previously defoliated areas in and near Terrace.

In the Cariboo Region, trembling aspen was defoliated by forest tent caterpillar over 47 000 ha in 238 patches, up from 25 000 ha in 1992, the fifth year of outbreak in the region. Most of this defoliation was severe, and most of it occurred in previously defoliated stands between Quesnel and Horsefly lakes, and from Horsefly to Williams Lake.

Populations in the Prince George Region defoliated trembling aspen and, to a lesser extent, other deciduous trees over 39 000 ha in 175 areas in 1993. Defoliation was mostly severe over 22 000 ha south of Prince George to Quesnel. Areas of moderate and severe defoliation near McBride expanded to 16 000 ha from southeast of Tete Jeune to northwest of McBride. Populations increased in the Peace River area near Taylor and defoliated aspen over several hundred hectares for the first time since 1991.

Populations in the Kamloops Region near Clearwater collapsed in 1993 after four years.

Egg samples from 19 areas in the Cariboo and Prince George regions indicate continuing populations in 1994 and defoliation in most recently infested stands. An average of 23 new egg masses per tree (range 7-42) at four sites near Prince George, 17 (range 6-30) at six sites near McBride, and 18 near Dawson Creek, indicates moderate and severe defoliation in most areas. This is up from an average of 10, region-wide, in 1992. Counts greater than 11 egg masses per tree usually result in moderate and severe defoliation which is also forecast in the Cariboo Region, where an average of 16 egg masses were counted (range 5-58) at eight sites, down slightly from 1992.

Increased larval mortality from parasites and disease averaged 76% (range 51-99%) at four sites in two regions. This is likely to contribute to a decline of populations in some older infestations in 1994.

Increased Northern tent caterpillar populations totally defoliated small patches of alder over about 1 ha at Mira Creek west of Buttle Lake in Strathcona Provincial Park on central Vancouver Island. For the first time since 1986 a variety of trees and shrubs, particularly alder, were severely defoliated in widespread patches in Saanich and on Saturna Island and at widely scattered locations along the east coast to Campbell River. Light and occasionally severe defoliation of deciduous trees and shrubs increased near Meziadin Lake to Stewart in the Prince Rupert Region and was common in and near Terrace. There was no defoliation in the Skeena River Valley following a population decline.

The high numbers (more than 10 per tree) of overwintering egg masses commonly found on many trees and shrubs in the Saanich area and east coastal areas of Vancouver Island and on Saturna Island indicate continuing populations and defoliation in 1994.

Large aspen tortrix

Choristoneura conflictana

Trembling aspen were defoliated by large aspen tortrix over 9000 ha in the Prince George Forest Region and in southwestern Yukon Territory, and over 400 ha in the western part of the Prince Rupert Region in 1993.

Defoliation in the Prince George Region was light, moderate, and severe in 31 patches over about 3000 ha north of Mackenzie and was severe in new patches totaling 3000 ha near Vanderhoof. This is down overall from 24 000 ha in 1992. Defoliation

was severe in about 10 patches in south-central Yukon Territory over an estimated 3000 ha, about one-third the area defoliated in 1992. Most damage occurred near previously defoliated stands from Jakes Corner to Teslin Lake and Stewart Crossing to Mayo and to a lesser extent near Braeburn. Increased populations in the western part of the Prince Rupert Region severely defoliated aspen over about 400 ha north of Kitwanga, and the tortrix was reported for the first time near Telegraph Creek.

Parasitism of larvae in defoliated stands near Teslin Lake in the Yukon reached 71%, and was mostly by Hymenoptera. Parasitism of larval populations in new infestations in the Prince George and Prince Rupert regions was only 6% and 19%, respectively. This indicates a reduction of populations in 3 to 4 year old infestations in 1994, but newer infestations will not decrease.

Satin moth

Leucoma salicis

Defoliation of aspen, cottonwood and willow by satin moth totaled 3000 ha in 54 separate areas in parts of the Kamloops and Nelson regions. This fourfold increase from 1992 occurred mostly in the northern part of the East Kootenay. Declining populations in the Kamloops Region defoliated stands in nine areas totaling only 250 ha.

Populations in the Nelson Region severely defoliated trembling aspen, particularly near Golden and east in the Blaeberry River Valley in nine patches totaling 2650 ha, an increase of 13% from last year. Additionally, defoliation occurred in 32 widespread patches in the West Kootenay between Greenwood and Anarchist Mountain totaling about 250 ha, similar to 1992. Tree mortality was common in stands totaling 170 ha severely defoliated since 1989 in the West Kootenay, and near Golden.

Declining populations in the Kamloops Region lightly to moderately defoliated nine patches of trembling aspen totaling 250 ha. Defoliation occurred for the second consecutive year at Hurley and Cayoosh creeks and for the first time along the north shore of Carpenter Lake, west of Lillooet. Elsewhere, populations totally stripped aspen over about 10 ha near Larcan Creek between Hedley and Keremeos, and lightly and moderately defoliated patches over 5 ha at Keremeos Creek and 2 ha east of Princeton. Populations declined to endemic levels in previously defoliated stands at Lambly Creek and near Mabel Lake.

A Poplar Rust

Melampsora medusae f. sp. *deltoidae*

Surveys to detect the poplar rust *M. medusae* f.sp. *deltoidae*, which is pathogenic to native cottonwood and to many hybrid poplar clones used in plantations, were initiated this year.

The rust was first reported in Oregon and Washington in 1991 on hybrid poplar (*P. trichocarpa* x *deltoides*) plantations on the lower Columbia River. Since its discovery, the rust has caused severe damage on susceptible hybrids, has spread rapidly, and was detected close to the Canadian border in Bellingham, Washington, in the fall of 1992.

The rust was first confirmed in British Columbia in hybrid poplar plantations in the Fraser Valley in October 1993, and a week later in a hybrid poplar nursery on Vancouver Island. Damage in British Columbia plantations was light, since the initial infections occurred late in the growing season. However, severe defoliation and mortality of susceptible clones is likely in the next 2-3 years. Susceptible clones will have to be replaced with the more resistant hybrids such as *P. trichocarpa* x *maximowiczii*. In the plantations in the U.S.A. where the rust has been established for several years, mortality in some of the more susceptible clones has been reported this year. Eurasian poplar rust, *Melampsora larici-populina*, also discovered in Washington State, has not yet been detected in Canada.

Poplar shoot blights

Venturia spp.

Discoloration of trembling aspen and cottonwood by poplar shoot blights was significantly damaging only in the northern part of the Prince Rupert Region and in the Fraser Valley in the Vancouver Region in 1993. This followed severe, widespread damage in three regions in 1992.

Trees were severely discolored mostly along roadsides from Kinaskan Provincial Park north to Todagin Creek in the northern part of the Prince Rupert Region. Hybrid poplars were lightly infected and discolored in plantations on islands in the Fraser Valley in the Vancouver Region, and near Agassiz and Chilliwack.

A cottonwood sawfly

Nematus currani

The area of native black cottonwood defoliated by sawfly populations on islands in the Fraser River near Chilliwack increased to 730 ha in 1993, the third consecutive year of infestation. Defoliation, up from 685 ha in 1992, was severe over 260 ha, moderate over 365, and light over the remainder. Most defoliation occurred again from Herrling Island near Agassiz to Matsqui Island near Mission, within TFL 43. Hybrid poplars in some managed plantations on Herrling Island were severely defoliated, and were very lightly defoliated at Harrison Mills. Defoliated trees later produced new leaves, and a major impact on tree growth is likely to occur only if severely defoliated for additional years.

Aspen leaf rollers

Epinotia sp.
Pseudoexentra oregana,
Anacampsis niveopulvella

Aspen leafrollers moderately defoliated trembling aspen over about 300 ha near Golden and over 50 ha east of Cranbrook in the Nelson Forest Region. This is down from 2300 ha near Golden in 1992, the fourth year of infestation. Defoliation by *Epinotia* sp., *Pseudoexentra oregana*, and *Anacampsis niveopulvella* was again moderate in the Kicking Horse River Valley east of Golden, where consecutive years of defoliation have resulted in dieback of up to 30% of the branches. Populations declined in the Columbia River Valley west of Golden. Aspen over about 50 ha in the lower Bull River Valley east of Cranbrook were again very lightly to lightly defoliated by *Epinotia* sp. Previously, this pest was found only in small numbers on single or small groups of aspen, birch, balsam poplar and other hardwoods, particularly in Alberta.

Birch leaf miners

Lyonetia sp.
Fenusa pusilla,
Profenusa thomsoni

High populations of a birch leafminer, *Lyonetia* sp., severely discolored stands over about 12 000 ha in the West Kootenay in the Nelson Forest Region, and over 5000 ha in the western part of the Prince Rupert Region. Populations of other leaf miners, *Profenusa thomsoni*, and *Fenusa pusilla* caused

widespread light discoloration of stands in the upper Fraser Valley and lower Fraser Canyon in the Vancouver Region similar to 1992.

Leafminer populations increased significantly near Revelstoke for the second consecutive year and severely discolored birch over about 12 000 ha in the Illecillewaet River Valley where high populations and discoloration occurred annually in the 1980s until a decline due to colder than normal winter temperatures. Increased populations elsewhere in the West Kootenay lightly defoliated stands from Kaslo to the Goldstream River drainage north of Revelstoke. Light to severe discoloration of birch was common over about 5000 ha between Echo Lake and Bob Quinn Camp in the Iskut River Valley in the northern part of the Prince Rupert Region. Most severely affected were pure stands near Echo Lake. Patches of moderately discolored birch were also common near Terrace. Populations of a birch leafminer, *F. pusilla*, moderately discolored birch stands for a second consecutive year in the Vancouver Region. Affected stands were common at widespread areas from near Yale to Vancouver, including the upper Fraser Valley, North Shore areas, and along the Lougheed Highway.

Winter moth

Operophtera brumata

Defoliation of deciduous trees by winter moth was again common in urban areas in Vancouver and in the Greater Victoria area.

Defoliation of boulevard trees was common in south Vancouver, particularly near Marine Drive, Point Grey, and other areas in southwest Vancouver. Defoliation was again generally light but occasionally severe. Elsewhere, very light defoliation of scattered fruit and other deciduous trees was common in Ladner and Surrey for a second year, and at widely scattered areas throughout Richmond for the first time in recent years.

Continuing populations in the Greater Victoria area very lightly and occasionally moderately defoliated deciduous hosts, including Garry oak in small patches, particularly in chronically infested areas at Cattle Point and in the Lansdowne area.

The introduction of parasites has greatly reduced winter moth populations overall on Vancouver Island. Parasitism by an introduced parasitoid *Cyzenis albicans*, a parasitic fly, averaged 9% (range 5-13%) at three sites on the lower mainland.

Jumping gall wasp

Neuroterus saltatorius

Garry oaks in the Capital Regional District on southern Vancouver Island were again lightly to severely discolored by the gall wasp, resulting in premature foliage loss. Overall, damage declined slightly for the first time this year following increases annually since first being observed in the area in 1986. However, there was a slight expansion of the infestation area to Ardmore in North Saanich. This followed a significant expansion last year. The area of trees moderately discolored was widespread from Gordon Head in Saanich to Sooke and from Beacon Hill in Victoria north to Ardmore near Sidney. Low numbers of the wasp were again common but not significantly damaging on oak near Duncan and Nanaimo, where they were first found last year. To date, populations have not been recorded on the Gulf Islands.

Gall wasp populations were parasitized by species of Chalcids at 20 sites. Parasitism ranged from 1-40% (average 10%) and was highest in areas where high populations have persisted for up to seven years, particularly near Beaver Lake, Royal Oak, and adjacent areas of Quadra Street. The increased parasitism is considered sufficiently high in some areas to reduce populations slightly in 1994.

An oak leaf phylloxera

Phylloxera sp. nr. glabra

The introduced phylloxera (an aphid-like sucking agent) discolored and subsequently defoliated 25-100% of the foliage on about 10% of the Garry oak trees throughout the Capital Regional District on southern Vancouver Island, similar to previous years. Feeding damage, which has occurred generally on the same trees each year progressively reducing their vigour, resulted in mortality of a small number of trees for the first time in this outbreak. High populations also occur on Garry oaks on the east coast of Vancouver Island north to Comox and on Galiano, Salt Spring, and Saturna Islands. Light populations were found for the first time at Sumas Mountain near Chilliwack in an isolated Garry oak stand. Predators of the phylloxera were again common but are still too few to effectively reduce populations.

New Records of Occurrence and Distribution

Four new disease collections were recorded in the region in 1993. One was an introduced poplar rust, two were minor foliage disorders, and one was a rust hyperparasite. A single collection on an ornamental evergreen and two on herbaceous plants were new records of the diseases within either British Columbia or the Yukon Territory. An additional 15 diseases were recorded for the first time on new hosts: 7 on conifers, 5 on deciduous trees, 2 on shrubs, and 1 a hyperparasite on a conifer rust. The introduced poplar rust, *Melampsora medusae* f. sp. *deltoidae*, was first recorded in British Columbia this year, on hybrid poplars in the Fraser Valley and on Vancouver Island. Pathogenic to native cottonwood and many hybrid poplars, the rust was first reported in the Pacific Northwest in 1991 on poplar hybrids in the Columbia River Valley in Washington and Oregon.

Two insect collections were new species for this region, four collections represented significant extensions of their known distributions within the region, and one was recorded for the first time on a new host. A psyllid, *Cacopsylla peregrina*, was found for the first time in North America, defoliating

hawthorn in Victoria. A webworm, *Clepsis* sp., was recorded for the first time in Canada, feeding on English yew at Saanichton. Significant extensions of previously known distributions included balsam woolly adelgid, *Adelges piceae*, which was found on mature amabilis fir near Campbell River and on amabilis fir regeneration east of the Coast Mountains near Spuzzum. An oak leaf phylloxera, *Phylloxera* sp. nr. *glabra*, was collected for the first time on the mainland at Sumas on Garry oak and at Kelowna on English oak. The discovery of a spruce shoot aphid, *Mindarus obliquus*, feeding on the new growth of white spruce in a plantation northeast of Stewart is the most northerly record for British Columbia. The introduced cherry ermine moth, *Yponomeuta padella*, was found for the first time on the mainland feeding on hawthorn near Ladner. New host records for cherry ermine moth in British Columbia include saskatoon-berry, sweet cherry, damson plums and European mountain ash. An anobiid beetle, *Ptilinus basalis*, was found for the first time at Sooke and Victoria boring into oriented strand board produced from trembling aspen.

Forest Insect and Disease Survey in the Pacific and Yukon Region

Who they are and what they do

The Forest Insect and Disease Survey (FIDS) is a nationally coordinated program of six regional FIDS units with links to the Petawawa National Forest Institute and the Forest Pest Management Institute. The program provides perspectives on insects and diseases including acid rain to forest managers, quarantine agencies, researchers, educators, and the public.

At the Pacific Forestry Centre, there are 17 positions within the FIDS organization headed by Dr. Allan Van Sickle. From May into October, 11 rangers work throughout six forest regions in British Columbia and in the Yukon Territory. Their regular reports are based on ground and aerial observations, egg counts, pheromone traps, plantation examinations, stand cruises, sketch maps and other survey techniques. Most are supported by samples of the damaging agents.

Verification of the damaging agents is performed by Herbarium and Insectary staff. Collections which contain 62 000 disease specimens representing 3300 organisms and 66 000 insects representing 6000 different species, and their associated records, are essential for the correct identification of forest pests causing damage in the Pacific and Yukon region.

A geographic information system (GIS) enables analysis and presentation of insect or disease maps in

combination with major geographic boundaries, biogeoclimatic zones and forest inventory and climatic information. An 'Arc Info' system expanded the 'Overlay' capabilities and provides better analysis capabilities and potential links with other users. The system also links to a data retrieval and query system containing more than half a million insect and disease records from the region's forests.

Communication of information to operational forest managers is an important aspect of FIDS. To alert local managers and the public to new or threatening outbreaks, "Pest Reports" may be issued during the field season. In addition to this regional report, more detailed information for each provincial forest region is compiled and distributed. Contributions are also made to national forestry statistics and to a national report which outlines pest conditions in forests across Canada.

Forest insects and diseases will increasingly influence how forests are managed. Detailed measurements of losses for a range of pests and situations can be combined with survey results to improve statistics and to guide research and forest management. FIDS in the Pacific and Yukon Region is an integral part of the team required to solve major problems and reduce uncertainty in the complex, long-range management of forest crops.