FOREST INSECT AND DISEASE CONDITIONS BRITISH COLUMBIA AND YUKON - 1994

C.S. Wood
G.A. Van Sickle

Natural Resources Canada
Canadian Forest Service
Pacific and Yukon Region
Pacific Forestry Centre
Victoria, B.C.

Information Report
BC-X-354
1994

Canadian Forest Service
Pacific and Yukon Region

Pacific Forestry Centre
506 W. Burnside Road
Victoria, British Columbia
V8Z 1M5
Phone (604) 363-0600

ISSN 0830-0453
ISBN 0-662-22830-8
Cat No. Fo46-17/354E
Printed in Canada

Additional copies of this publication are available in limited quantities
at no charge from the Pacific Forestry Centre

Microfiches of this publication may be purchased from:

MicroMedia Inc.
Place du Portage
165, Hôtel-de-Ville
Hull, Quebec
J3X 3X2

The National Library of Canada has catalogued this publication as follows:

Forest insect and disease conditions, British Columbia & Yukon

(Information report, ISSN 0830-0453)
1979-
Annual
Title from cover varies slightly.
Vols. 1979-1984 issued as Information report/Pacific Forest Research Centre; BC-X-
Vols. 1985- Information report/Pacific Forestry Centre; BC-X-
Includes abstracts in French.
ISSN 0837-6530

1. Trees -- Diseases and pests -- British Columbia. 2. Forest insects -- British Columbia. 3. Trees -- Diseases and pests -- Yukon Territory. 4. Forest insects -- Yukon Territory. I. Pacific Forestry Centre. II. Pacific Forest Research Centre.

SB605.C32W66 634.9'6'09711 C88-070584-1

CONTENTS

Abstract

This summary of forest pest conditions in British Columbia and the Yukon Territory in 1994 highlights pests that are, or may become, major forest management problems. Estimates of losses due to forest insects and diseases for the period 1988-1992 are included. The summary 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 1995.

Résumé

Ce résumé de l'état des insectes et des maladies des arbres en Colombie-Britannique et au Yukon en 1994 donne les grandes lignes de ce que sont ou pourraient être les grands problèmes d'amenagement forestier. Il a été compilé a 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 1995.

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, 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 1994. Damage trends and expansion of infestations can be determined by comparison to previous years' reports. Estimates of the growth loss and tree mortality caused by major forest pests in British Columbia between 1988 and 1992 are presented.

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 66% and more 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 the Yukon Territory. More detailed information on the status of forest pests is available in regional reports compiled by the following rangers:

Cariboo	- Bob Erickson and Bob Ferris
Kamloops	- Peter Koot and 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 1994 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

The most noteworthy changes in the status of major forest pests in 1994 included increasing populations of **spruce bark beetle, phantom hemlock looper, satin moth, poplar rusts and pine needle cast**, and continuing populations of **mountain pine, Douglas-fir** and **western balsam bark beetles, western, two-year-cycle** and **eastern spruce budworms, forest tent caterpillar** and **large aspen tortrix**, and **root rots** and **dwarf mistletoes**. **Black army cutworm** and **rhizina root disease** and **western hemlock looper** declined and the number of **gypsy moth** trapped in the southwestern part of the region declined significantly.

Slightly above average **temperatures** (range +1.0 C to + 1.8 C, average +1.3 C) during the growing season, occurred at all 15 sites in the region with **precipitation** from -20 to +23% of the 30-year norm. Overall, the growing season weather was slightly warmer and wetter, with localized effects on tree condition including drought stress and foliar disease infections.

The volume of mature pine killed by **mountain pine beetle** in British Columbia in 1994 was an estimated 1.74 million m^3 in 9340 infestations which covered about 36 000 ha in six regions. This was down 27% overall but with increases in the Cariboo and Prince George regions and declines in the Kamloops, Nelson, Prince Rupert, and Vancouver regions. Infestations will continue in 1995, but at declining levels. **Red turpentine beetle, western pine beetle, pine engraver beetle**, and **ambrosia beetle** were again common in weakened trees, particularly ponderosa pines. **Pine needle diseases** discolored year-old and older needles throughout the interior over 870 000 ha, in some areas for the eighth consecutive year. Pinewood nematode remains very rare. Studies continue to obtain data for an exemption of western hemlock from treatment required for imports to the European Community. Surveys to detect **pine shoot beetle**, recently introduced to North America, were negative for the third year. There has been no increase in the numbers or spread of **European pine shoot moth** and no evidence of populations in native pines. Most are confined to ornamental pines in urban areas in the Okanagan Valley and southwest coastal areas.

Mature Douglas-fir were killed by **Douglas-fir beetle** in about 3421 separate groups, totaling about 7665 ha in parts of five forest regions. The area affected was a third less than in 1993 and declined for the first time in six years; populations are forecast to continue in 1995, mostly in the Cariboo Region. Douglas-fir was defoliated by **western spruce budworm** over about 16 000 ha in 144 separate areas in parts of three forest regions, down 60% from 1993 and the smallest area defoliated in 12 years. Defoliation is forecast in 1995 in three regions where overall numbers of egg masses increased 9%. There was no defoliation by **Douglas-fir tussock moth** in the Kamloops Region, as forecast following the decline to 1150 ha in 1993, the fourth year of the outbreak. Defoliation is not likely to occur in the Kamloops Region in 1995, since 65% fewer male adults were captured in pheromone traps and egg masses are absent. Increased **phantom hemlock looper** populations severely defoliated Douglas-fir in several residential areas in Burnaby; this was the first outbreak in the area since 1982.

Spruce beetle was again one of the most damaging forest pests in British Columbia in 1994 and became a major concern for the first time in recent years in the Yukon Territory. Mature and overmature spruce were killed over about 110 000 ha; this is similar to the damage that occurred in three of the past four years. Most damage was in the Prince George Region again and in new infestations in and near Kluane National Park.

Alpine fir and white spruce defoliated by **eastern spruce budworm** in northeastern British Columbia covered about 173 000 ha in 154 patches near Fort Nelson and into Yukon Territory; this level of damage is similar to that which occurred in 1993, and it is forecast to continue in 1995. Mature **"on-cycle" 2-year-cycle budworm** defoliated stands over 200 000 ha. Half of the damaged area was in the eastern part of the Cariboo Region and the remainder was in adjacent parts of the Prince George and Kamloops regions; no damage occurred in previously defoliated stands in the East Kootenay. Immature **"off-cycle" 2-year-cycle budworm** lightly defoliated alpine fir and spruce forests over more than 8000 ha mostly in the Prince George Region and to a lesser extent in the Kamloops and Nelson regions.

Mature alpine fir recently killed by **western balsam bark beetle** were mapped over 180 000 ha in parts of all six forest regions, mostly in the Prince Rupert Region; this damage is similar to that recorded in 1993. Regeneration amabilis and alpine fir infested by **balsam woolly adelgid** were found near Pemberton just outside the quarantine zone but in only 1 of 40 young managed stands surveyed elsewhere throughout the Vancouver Region.

Old-growth western hemlock and western red cedar were defoliated by declining **western hemlock looper** populations over 8000 ha in the Prince George and Nelson regions, and tree mortality resulting from up to four consecutive years of outbreak was mapped over more than 60 000 ha. Populations are forecast to decline further in 1995, with only light defoliation likely in reduced areas. Increased **western blackheaded budworm** populations defoliated hemlock in 18 separate infestations totaling 6000 ha; some of this damage occurred in parts of the Nelson Region for a second year and some occurred in new infestations in the Kamloops Region. Predators of the introduced **hemlock woolly adelgid** in British Columbia are being evaluated as a biological control for woolly adelgid populations in hemlock forests in eastern North America.

Western larch were defoliated by **larch casebearer** in four patches totaling 285 ha east of Vernon but this pest remained at endemic levels in the Nelson Region for the fifth consecutive year. **Larch sawfly** lightly defoliated exotic larch near Maple Ridge, some for the seventh consecutive year, but this pest remained endemic elsewhere in native larch stands. Discoloration of western larch by **needle blights** was significantly less widespread and conspicuous than in 1993 in previously infected stands in the Kamloops and Nelson regions. Increased **larch bud moth** populations defoliated 18 separate western larch stands totaling 680 ha in the eastern part of the Nelson Region, where new shoots on immature larch in small patches were also infested and killed by a **shoot miner** for the fourth consecutive year.

Recently planted seedlings and ground cover were defoliated by **black army cutworm** at a few recently burned and planted sites in interior British Columbia; which is similar to the generally low levels observed over the past five years. **Rhizina root disease** killed about 12% of the seedlings at seven sites surveyed in each of the West Kootenay and eastern part of the Prince Rupert Region, which is similar to the levels of damage observed in the previous three years.

In surveys of 252 young managed stands across the province in 1994, the most damaging and widespread problems were similar to those in the previous five years. These included locally significant **root diseases, terminal and root collar and terminal weevils**, and **stem rust cankers**. Less damaging but more common were **native needle diseases**. Feeding by **porcupines** again damaged conifers in the Prince Rupert Region where stocking levels have been reduced. Damage by **squirrels** was less common and widespread than last year, but debarking by **bears** increased. Damage to young conifers caused by **climatic factors**, mostly frost, was common but less widespread than last year.

Foliar diseases, including Keithia leaf blight on cedar, damaged fewer seedlings at fewer forest nurseries than last year, due largely to a hotter, drier, and sunnier late spring and summer. Losses due to storage **mould** and most seedling **root rots** also declined but a Fusarium root rot was common on some nursery stock. Surveys of **seed orchards** previously conducted by the Forest Insect and Disease Survey of the Canadian Forest Service were continued by the British Columbia Ministry of Forests.

Less than 1% of the trees at 10 of 27 Biomonitoring/ARNEWS plots across the province were killed in 1994; all of this mortality was attributed to causes other than **acid rain**. Most died from shading, mostly at plots on the lower mainland. A total of 10% of the trees have died in the plots since 1986.

Only 39 adult male **gypsy moths** were recovered in British Columbia in 1994 in 34 traps in nine municipalities. This compares with 141 at 15 locations in 1993, and 166 moths in 24 areas in 1992. Six male adults were of the Asian biotype. Other defoliators of deciduous host trees were again numerous and widespread, particularly in trembling aspen forests. **Forest tent caterpillar** defoliated aspen at 650 locations totaling 93 600 ha (up slightly from last year) again mostly 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, the Gulf Islands, near Meziadin and in the Nass River drainage in the western part of the Prince Rupert Region. Defoliation of trembling aspen by **large aspen tortrix** increased

to about 23 000 ha, mostly in the southwestern Yukon Territory (12 000 ha), near Vanderhoof (3000 ha), and north of Kitwanga in the western part of the Prince Rupert Region (about 8000 ha). Increased **satin moth** populations defoliated deciduous hosts in 127 areas totaling 5350 ha in parts of the Kamloops and Nelson regions and for the first time in the Chilcotin, in the Cariboo Region. A **poplar leaf rust**, recently introduced into North America and found for the first time in British Columbia on hybrid poplars last year, was again found but has not yet caused measurable damage on native poplars. Black cottonwood were again defoliated by reduced populations of a **cottonwood sawfly** on islands in the Fraser River near Chilliwack. Birch **leafminer** populations again severely defoliated birch stands over about 3800 ha in parts of three forest regions, down two-thirds from 1993.

Winter moth was more common on ornamental trees in the Greater Vancouver area than in Victoria, where Garry oaks were again discolored by **jumping gall wasp** and by an introduced **oak leaf phylloxeran**.

Ten fungi were **collected for the first time** in British Columbia or the Yukon Territory in 1994, including leaf rusts on hybrid poplar and alder, and 29 were recorded on new hosts for the first time in the region. Four insects were collected for the first time in this region and bark beetles and woodborers native to Europe were intercepted in dunnage aboard a freighter. Three collections were significant extensions of their previously known distribution within the region, and four were recorded for the first time on new hosts.

Growth Loss and Mortality Caused by Major Forest Pests in British Columbia 1988 - 1992

The average annual mortality and loss of growth caused by forest insect and disease pests in British Columbia from 1988 to 1992 exceeded an estimated 26.8 million m^3 (Table 1, Figure 1). This is equivalent to 36% of the annual allowable cut, and to the extent that such losses can be salvaged or prevented, it can substantially offset reductions in available wood supplies.

Growth loss is estimated to be twice that of mortality. The biggest depletion is by stem and butt decay in mature and overmature trees at 13.7 million m^3 per year. Root rots, at 5.5 million m^3 per year, comprise 20% of the total loss, and losses to dwarf mistletoes comprise about 7%. While losses to bark beetles (11.5%), particularly mountain pine beetle, have been decreasing in recent years, they, along with western hemlock looper, were the most significant forest insect pests. Defoliating insects during this period included the western budworm, Douglas-fir tussock moth, gray spruce looper, other budworms, larch pests and forest tent caterpillar, and accounted for 10.4% of the total loss.

Despite the simplicity of the final numbers and graphs, deriving such estimates is very complex, involving the acquisition and use of forest inventory statistics, annual pest surveys and distributions, GIS

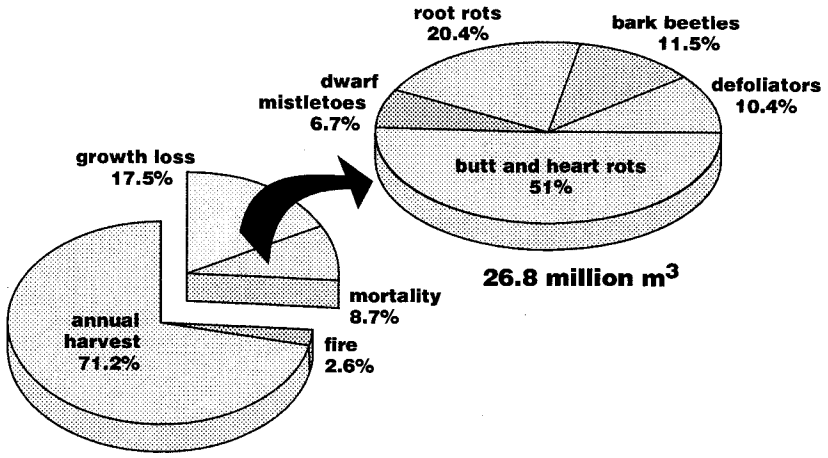
Table 1. Annual mortality and growth loss from forest pests in British Columbia,1988-1992.[1; 2]

	Average annual loss (000 m^3)		
Pest	Mortality	Growth loss	Total
Mountain pine beetle	2054.8		2054.8
Spruce beetle	734.1		734.1
Douglas-fir beetle	81.4		81.4
Balsam bark beetle	215.2		215.2
Western budworm	225.4	769.8	995.2
Hemlock looper	1186.7	68.4	1255.1
Blackheaded budworm	2.2	11.6	13.8
Douglas-fir tussock moth	72.2	0.7	72.9
Two-year budworm		24.7	24.7
Grey spruce looper	184.6	3.1	187.7
Larch casebearer		0.5	0.5
Larch sawfly		0.3	0.3
Eastern spruce budworm		89.5	89.5
Forest tent caterpillar		144.4	144.4
Large aspen tortrix		17.3	17.3
Subtotal - Insects	4756.6	1130.3	5886.9
Butt and heart rots		13680.0	13680.0
Dwarf mistletoes		1797.4	1797.4
Root rots	4127.7	1349.8	5477.5
Sub total - Diseases	4127.7	16827.2	20954.9
Total	8884.3	17957.5	26841.8

[1] Does not include nursery and regeneration losses, numerous foliar pests of hardwoods and softwoods, earlier losses from balsam woolly adelgid or white pine blister rust which continue to affect the management of these valuable tree species, and other impacts which could not be expressed as volumes such as quarantine matters, spruce leader weevil, aesthetics, recreational or water values, or increased fire hazards.

[2] Fires caused depletions, 1989-1990 - 25 000 ha burned, 1.8 million m^3 lost (British Columbia Ministry of Forests Annual Report 1991).

Figure 1. Annual pest losses in British Columbia,1988-1992.



overlays, mortality and growth reduction factors, pest biologies, and numerous assumptions. Further work is required to better quantify loss estimates, particularly in the development of loss factors and pest incidence and intensity data.

While many pests such as dwarf mistletoes and root rots are perennial, infestations of others like defoliators and bark beetles fluctuate greatly over time. Also, impacts are not always immediate; tree mortality often continues for several years after an infestation. Therefore, these loss estimates are presented as an average annual figure rather than as an estimate for a single year.

The general methodology involved creating a composite of annual outbreak or distribution maps for each pest which was then overlaid on forest inventory information (Canada Forest Resources Data System - CFRDS) to obtain the host volume affected. From scientific literature, research plots, and discussions, data on the impact of each pest on each host tree species were summarized. Average mortality or growth loss factors were then applied and regional and provincial losses tabulated.

For the major defoliating insects, annual aerial survey sketch maps for each insect were overlaid for the six-year period and mortality factors were applied to the associated host volume according to the number of years of infestation. Growth loss was estimated using reduction factors applied to the host mean annual increment (MAI) calculated from the BC Ministry of Forests inventory zone data.

For the bark beetles, annual aerial survey maps identified areas within which recent faders were mapped and classified by number or percentage of host trees attacked. Average trees per ha or volume per ha and average volume per attacked tree were derived from the British Columbia Ministry of Forests summaries and FIDS fall cruises were used with the level of attack and area to calculate annual mortality volumes.

The recorded distribution maps for each dwarf mistletoe or root rot were intersected with the CFRDS inventory to obtain an area of host type within the range of each disease for each region. The average MAI per ha for each host was calculated from the British Columbia Ministry of Forests inventory zone data. Factors of percent host affected (i.e., incidence among stands) and mortality and MAI reductions were averaged from available literature, unpublished records and personal communications.

Butt and heart rot decay was estimated separately from root rot and root disease. Factors for decay only (K. Richardson, personal communication) were obtained from the extensive sampling done for the British Columbia Ministry of Forests' "Decay, waste and breakage factors" and averaged for each major species and region. The net volumes for each species and region from the CFRDS inventory were multiplied by the decay conversion factor to obtain gross volume from which the net volume was subtracted to obtain the present decay volume. This was divided by 100 to convert to an annual volume (assuming a 100-year rotation).

Pine Pests

Mountain pine beetle
Dendroctonus ponderosae

The area of lodgepole pine and some western white pine killed by mountain pine beetle, one of the most damaging forest insects in British Columbia, decreased by about 25% to about 36 000 ha in more than 9340 active infestations (Table 2). These extended from southeast of Cranbrook near the international border to northeast of Terrace (Map 1). This area is about 25% more than the area burned by forest fires in British Columbia in 1994 (27 465 ha), and the volume lost (1.74 million m^3) represents about 8% of the lodgepole pine annually harvested in British Columbia.

Increases occurred in the Cariboo Region to 1650 ha (up from 700 ha) and in the Prince George Region over 16 975 ha (up 25%). Declines occurred in the Kamloops Region over 8860 ha (down 55%), in the Nelson Region over 2750 ha (down 65%), in the Prince Rupert Region over 5300 ha (down 30%), and in the Vancouver Region to 465 ha (down 10%), but infestations are forecast to continue overall in 1995.

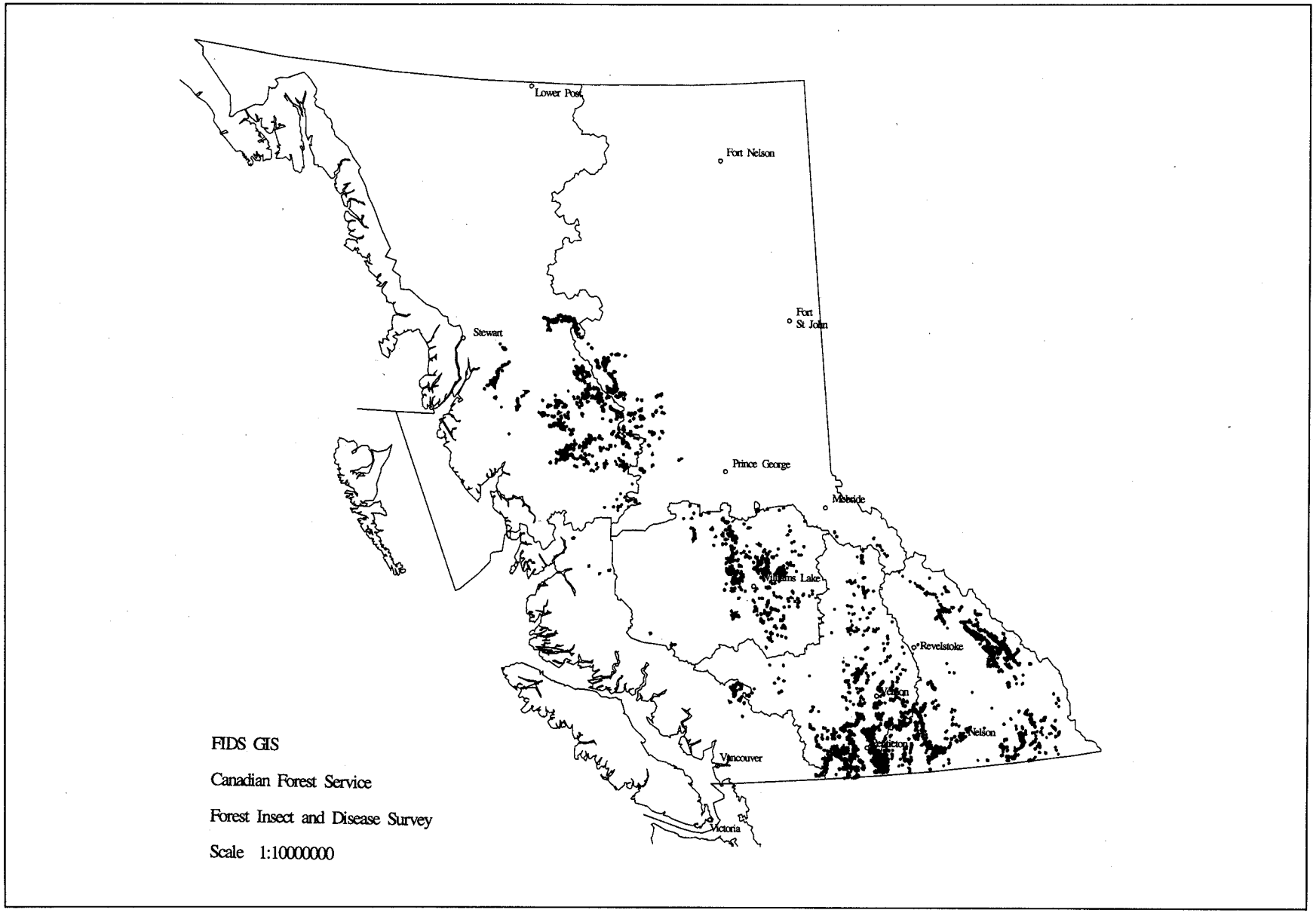
Infestations in the Cariboo Region more than doubled for a second year to 1650 ha, up from 700 ha in 1993. Most of the more than 1660 widely scattered patches were from 100 Mile House north to Quesnel, particularly in the Chilcotin Military Block near Riske Creek west of the Fraser River. Populations are expected to continue to increase generally in 1995, especially near the Military Block.

The area of mature pine killed by the beetle in the Kamloops Region in 1993 declined more than 50% to 8860 ha, following a slight decline in 1993. Most of the 2911 pockets which contained about 1.4 million mature beetle-killed pine (494 000 m^3) were in the Okanagan Timber Supply Area (TSA) over 6500 ha, including about 1550 ha in Okanagan Mountain Provincial Park. In the Merritt TSA, about 981 pockets of recently killed pine totaling 1975 ha and 151 pockets totaling 330 ha in the Kamloops TSA were mapped. 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 1995. This is based on the incidence of current attacks which averaged 5% (range 2-11%) in four stands in the Okanagan TSA.

Table 2. 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 1994.

			Trees killed[a]		Stands cruised[b]		Damage category[c]				
Forest Region	No. of Infestations	Area (ha)	No. (000)	Vol. (000 m^3)	No.	Avg. yrs. Infested	H	C	R	G	P
							% of trees				
Cariboo[d]	1174	1 650	122	55	10	2	72	15	10	2	1
Kamloops	2911	8 860	1391	494	4	3	78	5	8	7	2
Nelson	3313	2 750	330	123	10	4	46	27	19	4	4
Prince George[d]	280	16 975	760	645	-	-	-	-	-	-	
Prince Rupert[d]	1506	5 300	156	143	1	5	57	12	6	22	3
Vancouver	156	465	23	17	-	-	-	-	-	-	-
Total	9340	36 000	2782	1477	25	4	64	15	10	9	2

[a] Trees attacked in 1993, discolored in 1994.
[b] Some stands located in younger infestations may not represent average condition.
[c] H - Healthy; C - Current, attacked in 1994; R - Red, attacked in 1993; G - Grey, attacked in or before 1992; P - Partial or strip attacked in 1994.
[d] Estimates include data from the British Columbia Ministry of Forests.



Map 1. Area where recent tree mortality due to mountain pine beetle was detected during aerial surveys in 1994.

In the Nelson Region, an estimated 330 000 mature pine (123 600 m^3) were killed in about 3313 separate pockets, totaling 2750 ha. This was down 65%, mostly in the East Kootenay, particularly in the Cranbrook TSA and south of Radium in the Invermere TSA, due mainly to 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 again generally stable, except in Kootenay and Glacier parks where pockets of recently killed pine totalled 900 ha and 25 ha, respectively, as in 1993. Recently killed pine were less common in the Flathead and Elk river valleys for a second consecutive year. Tree mortality is forecast to continue in the region in 1995, based on an average of 27% of the trees newly attacked in 10 representative stands. New attacks were highest in the East Kootenay (average 27%, range 24-39%), particularly south of Cranbrook, near Invermere and Radium to north of Golden, and in Kootenay and Yoho National Parks. In the West Kootenay, current attacks averaged 21% (range 12-36%), up 7% from 1993. The highest attacks were at Gem Hill (36%), near Nancy Greene Lake (15 and 23%) and at Blaeberry Creek (12%) in the Arrow TSA.

The area of recent pine mortality in the Prince George Region increased for a second year to 16 975 ha, up 25% from 1993. Most of the 760 000 trees (644 500 m^3) in more than 280 chronically infested stands in the region were over 13 600 ha northwest of Fort St. James near Takla and Trembleur lakes and in the Skeena, Sustut, Middle, and Tachie river valleys. Infestations were mapped for a second year near Vanderhoof over 215 ha, and near Prince George (3000 ha) and McBride (150 ha). Infestations northwest of Fort St. James and in the southern part of the Prince George Forest District are likely to continue in 1995, based on historical trends. There were no new beetle-killed pine in Mt. Robson Provincial Park and west of Jasper National Park in surveys conducted by the British Columbia Ministry of Forests. However, about 68 pheromone-baited and recently attacked pine are to be cut and burned in a control operation ongoing since 1985.

About 1506 separate infestations totaling 5300 ha were mapped in the Prince Rupert Region, down one-third from 1993. These contained an estimated 156 000 trees (143 000 m^3), mostly in the Bulkley and Morice TSAs in the eastern part of the region. Tree mortality is forecast to increase throughout the region in 1995, particularly in the east, where current attack increased.

About 156 separate pockets totaling 465 ha contained about 23400 recently killed trees (17 160 m3) in the Vancouver Region in 1994. This is down 12% from 1993, and the lowest level recorded in the region since 1991. Tree mortality was again mostly in widely scattered pockets in the Soo TSA, north and east of Pemberton. Tree mortality is likely to continue in the region in 1995, particularly in the Soo TSA, where beetle populations and areas of susceptible lodgepole pine persist.

Mortality of mature lodgepole pine is forecast to continue in 1995, in most recently infested stands in six forest regions. The number of new attacks averaged 15% (range 2-39%) of the trees in 25 representative stands infested by mountain pine beetle on average for four years. Overall, new attacks were unchanged from last year, but slight increases occurred in the Cariboo and Nelson regions, and decreases occurred in the Kamloops and Prince Rupert regions.

Numbers of mature western white pine killed by mountain pine beetle increased slightly again in Glacier National Park, but continued to decline in the northern part of the Kamloops Region and adjacent parts of the Prince George Region. Red turpentine beetle, *D. valens*, killed mature ponderosa pine in parts of the Kamloops and Nelson regions. Also common in the same trees were western pine beetle, *Dendroctonus brevicomis*, and pine engraver beetles, *Ips pini* and *I. emarginata*. Attacks by ambrosia beetles, *Trypodendron spp.*, in trees predisposed by other beetles were also common at widespread locations.

The salvage of beetle-killed and adjacent susceptible mature pine remains a priority in most beetle-infested TSAs, particularly in the Kamloops and Nelson regions. More than 30000 commercially produced semiochemical baits were again used for beetle management through population monitoring, containment, and single tree disposal by the British Columbia Ministry of Forests and industry.

Pinewood nematode

Bursaphelenchus xylophilus

Discussions on the ban on green lumber exports from Canada to the European Union because of the possible, although very low, occurrence of pinewood nematode have shifted more to the trade and political levels. Dissatisfaction with the trade ban by the European Union has been expressed by both federal and provincial ministers. A joint federal government-industry mission met with seven member countries and reviewed aspects of risk, focusing on the vector, *Monochamus*, and on a physical inspection program. The Plant Health Committee of the European Union then met October 20, 1994 and, with the review of Canada's scientific evidence, agreed to undertake a detailed pest risk assessment.

A bait log survey to obtain data for a possible exemption for western hemlock from the ban on non-kiln dried softwood exports is continuing. Western hemlock and lodgepole pine logs from healthy standing trees were placed at single sites with active woodborer populations in each of the Cariboo, Nelson, and Vancouver regions in early 1993. Woodborers in bait logs have been monitored periodically; however, with the two-year life cycle of any *Monochamus* beetle, final results from these trials may not be available for some time. Preliminary results found insect-related or fungal-related nematodes of the orders Rhabitida, Tylenchida, and Dorylaimida in 58% of 90 subsamples from western hemlock and lodgepole pine from the Cariboo, Nelson, and Vancouver regions.

Pine needle diseases

Lophodermella concolor
Elytroderma deformans
Leptomelanconium cinereum

Native needle diseases again severely discolored year-old needles of lodgepole and ponderosa pines resulting in premature needle loss in stands over 870 785 ha in the Cariboo, Kamloops, and Nelson regions, in the southern part of the Vancouver Region, and also in parts of the Prince Rupert Region and southern Yukon Territory.

Increased infection by Lophodermella needle cast severely discolored year-old and older needles on 10-90% of the lodgepole pine in all age classes over an estimated 495 350 ha in the Cariboo Region, up fourfold from last year. Stands were most severely affected, some for the fifth consecutive year, in the 100 Mile House TSA from Bridge Lake to the Fraser River and in the Williams Lake TSA from Riske Creek west to Tatla Lake. Successive years of severe infection on immature trees has resulted in a "lions' tail" effect with only current foliage remaining on trees in many areas.

Increased light but conspicuous infections in the Kamloops Region were mapped on 148 355 ha, particularly in younger and semimature lodgepole pine, in the Merritt, Penticton, and Vernon forest districts. Infections were also common on most of the regeneration lodgepole pine in the North Thompson, Tranquille, and Bonaparte river drainages. Lodgepole pine were moderately to severely discolored over about 227 000 ha in the southern two-thirds of the Nelson Region, some for the fourth consecutive year.

Infections and premature needle loss in the lower crowns of regeneration and mature lodgepole pine were widespread in parts of the Prince Rupert Region for a third consecutive year. Up to 100% of the year-old needles on most trees were affected in patches of discolored pine between Endako and Burns Lake, Moricetown to New Hazelton, from Kitwanga to near Terrace, and between Good Hope Lake to the Yukon Territory border.

Severely discolored pines were common in the southeastern part of the Yukon Territory, in some areas for the fourth consecutive year. Immature trees in a provenance trial near Watson Lake were again moderately infected similar to 1993, as well as roadside trees along the Robert Campbell Highway and South Canol Road.

Infections by Elytroderma needle disease of ponderosa pine were again common and widespread throughout much of the host range in the Cariboo, Kamloops, and Nelson regions. Chronic infections occasionally predispose trees to attack by turpentine beetle *D. valens*, and cause branch flagging and top-kill on younger trees. Increased moderate to severe discoloration of ponderosa pines by a needle blight, *Leptomelanconium cinereum*, commonly causing premature needle loss, was common in the southern part of the Rocky Mountain Trench in the Nelson Region in about 17 separate patches totaling 3100 ha.

Pine shoot beetle

Tomicus piniperda

European pine shoot moth

Rhyacionia buoliana

Special surveys for pine shoot beetle were initiated in Christmas tree plantings (particularly of Scots pine) in this region after this insect was recently discovered in Ohio, the adjacent United States, and Ontario. To date, none has been found in surveys of more than 2000 trees at six sites on the lower mainland and one on Vancouver Island.

Surveys for the pine shoot moth, in conjunction with surveys for the shoot beetle, found that damage (up to 40% annually) remains confined to new shoots of exotic pines (mostly Scots pine) in urban areas from Victoria to Courtenay, the lower mainland, and Okanagan communities including Penticton. There is still no evidence of shoot moth populations in native pines in the Pacific and Yukon Region.

Douglas-fir pests

Douglas-fir beetle

Dendroctonus pseudotsugae

Douglas-fir beetle killed mature Douglas-fir in about 3421 separate pockets totaling 7665 ha in five regions (Map 2). This was down a third from 1993, and was the first decline in six years. Most of the recent tree mortality again occurred in the Cariboo Region, and to a lesser extent in parts of the Kamloops, Nelson, Prince George and Vancouver regions. Most of the beetle-killed trees were in groups of 2 to 15, although occasionally there were groups of up to 250 trees.

The area of tree mortality in the Cariboo Region totaled about 5235 ha in 1728 separate pockets, down 25% from last year. Most of the damage was again in the Chilcotin Military Block near Riske Creek, with over 4100 ha in 190 patches, down about 1220 ha from 1993. Patches of recently killed trees occurred elsewhere in the region in or near previous infestations mostly west of the Fraser River, and north of the Military Block to Quesnel, and in widespread scattered patches near Clinton, 100 Mile House, Williams Lake, and Horsefly.

Beetle-killed Douglas-fir in the Kamloops Region declined by half to about 775 patches of 5 to 20 trees totaling 595 ha, mostly near Lillooet, Kamloops, and Sicamous. The decline was in the Thompson River, west of Kamloops Lake to Spences Bridge, in the Shuswap River drainage, and near Sugar and Mabel lakes.

Mature Douglas-fir were killed in 585 widely scattered groups in the Rocky Mountain Trench in the Nelson Region, totaling about 235 ha. This was down nearly fourfold from last year, and the damage occurred near Premier Lake and on Steamboat Mountain near Invermere, and again in small patches of ten or fewer beetle-killed trees along the Kootenay and Slocan lakes and in Kootenay River drainages in the West Kootenay, similar to 1993.

In the Prince George Region, Douglas-fir mortality declined in area by 30% to 2500 ha, following four consecutive years of increases. About 775 patches of recently killed Douglas-fir were mapped from north of Fort St. James to south of Prince George and near McBride. Major declines occurred mostly north of Fort St. James (down 1300 ha to 500 ha) and along Canoe Reach south of Valemount in the McBride Forest District (down by half to 750 ha).

About 241 separate patches of beetle-killed Douglas-fir totaling 250 ha, about a third less than in 1993, were mapped in the Vancouver Region in 1994. The decline was mostly in infestations in the Anderson, Fraser, Chilliwack and Skagit river drainages, and to a lesser extent near Pemberton. Increases were mapped east of Bella Coola in the Mid-Coast district.

Mortality of mature and overmature Douglas-fir is likely to continue in 1995 in recently infested stands, but at slightly reduced levels particularly in

the Cariboo Region. Surveys of 10 beetle-infested stands in the military training area near Riske Creek found an average of 20% (range 7-33%) of the trees were currently attacked, down 11% from last year.

Western spruce budworm

Choristoneura occidentalis

Western spruce budworm populations defoliated mixed-age interior Douglas-fir over about 16 145 ha in 144 separate infestations in two forest regions (Map 3). This was 60% less overall than in 1993 and was the least defoliated by the budworm in 12 years. As forecast, defoliation was mostly in the Kamloops Forest Region over 14 235 ha and, to a lesser extent, in the Vancouver Region on 1900 ha. Populations declined in the southern part of the Cariboo, and remained endemic in the western part of the Nelson Region.

Defoliation was mostly light (52% of the area), moderate (47%), and severe on the remainder; in 1993, defoliation was mostly light. Most of the moderate defoliation (7650 ha) was again west of Lillooet with patches in the Okanagan TSA, near Merritt, and north of Boston Bar.

As forecast, the major decline in areas of defoliation (27 000 ha), for a third consecutive year, was in the Okanagan and Kamloops TSAs in the Kamloops Region and near Pemberton in the Vancouver Region; some decline also occurred in the Cariboo Region.

Bacteria, virus, disease and insects reduced late-instar larvae populations on average by 45% in five representative areas sampled, 10% more overall than last year. Most larval mortality was caused by Diptera and Hymenoptera parasites, and averaged 26% (range 12-57%), up 16% from last year. An average of 19% of the larvae (range 7-31%) were infected by bacteria and virus and an entomopathogen, *Entomophthoraceae*, was isolated from larvae in a collection in which 20% were killed.

Defoliation is forecast to continue in most previously defoliated areas, based on egg and pheromone surveys (Map 4). The number of egg masses per 10 m^2 of foliage at each of 26 sites in three forest regions increased 10% overall from 1993. An average of 74 (range 0-219) egg masses per site indicates a slight overall increase in populations in 1995, particularly near Clinton in the Cariboo Region, at Trepanier Creek in the Okanagan TSA, near Lillooet and Lytton, Pritchard and Merritt in the Kamloops Region and north of Boston Bar in the Fraser TSA in the Vancouver Region. These data suggest that defoliation will be severe at 15% of the sites mostly near Merritt, moderate at 35%, trace or light at 46%, and that no defoliation will occur at only 4% of the sites.

Up to 423 male adults were caught in a total of 140 traps (average 68/trap) monitored at 28 sites beyond the current infestation in four regions. This compares with up to 1050 males (average 154/trap) in 49 traps at 11 sites last year. The data indicate continuing populations with the potential to very lightly defoliate Douglas-fir in 1995, particularly near Clinton, Knutsford, and Penticton.

Defoliation is forecast to be light and moderate at 91% of the sites surveyed in the Kamloops Forest District by the British Columbia Forest Service; severe defoliation is forecast at 2% of the sites near Barnhartvale, Pritchard, and Cache Creek, and no defoliation is forecast at the remainder.

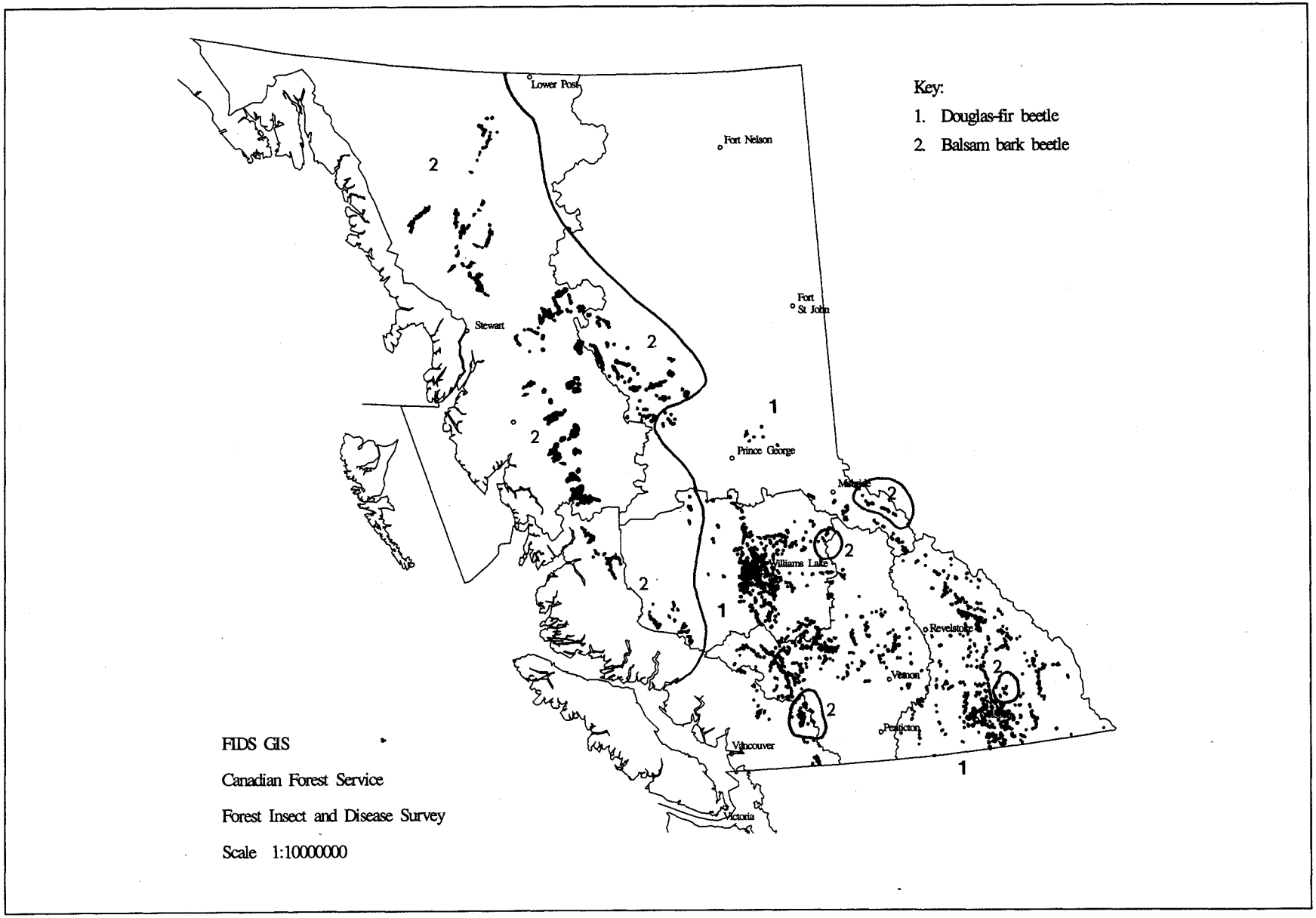
Tree mortality, top-kill, bud mortality, increment loss, and tree deformity due to successive years of severe defoliation were common throughout the Kamloops Region, although amounts vary by site. Monitoring of the impacts of defoliation on young open-growing Douglas-fir continued at 64 research plots in the Kamloops Region. Tree mortality in 1994 averaged 1%; cumulative tree mortality from budworm since 1986 averaged 13%. A trend of increasing tree mortality with increasing years of defoliation has been determined (R. Alfaro, Canadian Forest Service, Victoria, personal communication).

Aerial applications of *Bacillus thuringiensis* var. *kurstaki* (B.t.k.) by the British Columbia Ministry of Forests contributed to the successful reduction of budworm defoliation of young managed Douglas-fir stands over 21 500 ha in parts of four forest districts in the Kamloops Region. This followed successful applications over about 34 000 ha in 1993.

Douglas-fir tussock moth

Orgyia pseudotsugata

There was no defoliation of Douglas-fir by tussock moth in the Kamloops Region in 1994. This followed the forecast decline in 1993, the fourth year of outbreak. The population decline saw reduced numbers of adults and egg masses and reduced larval



Map 2. Areas of recent tree mortality due to bark beetles in 1994.

populations due to infection by a nuclear polyhedrosis virus in 1992 and 1993.

Populations remained at low levels on ornamental Douglas-fir and spruce in previously defoliated urban areas of Kamloops, Vernon, Kelowna, and Penticton in the Kamloops region, at Abbotsford, Chilliwack, and Clearbrook in the Vancouver Region, and near Christina Lake in the Nelson Region.

The number of male adults in pheromone-baited sticky traps placed in Douglas-fir stands with the greatest historical frequency of outbreaks declined for the third consecutive year. An average of 10 adult males (range 0-95) were trapped in 96 traps at 18 permanent monitoring sites in the Kamloops (16 monitoring sites) and Nelson (2 monitoring sites) regions. This is two-thirds less than the number trapped in 1993 when 34 males were caught per trap, and indicates that little or no defoliation of Douglas-fir is likely in or near previously defoliated stands in 1995. Despite the higher numbers of adults at Battle Creek west of Kamloops (average 95/trap), Monte Creek (74), Duck Range (59, range 46-71) and Heffley Creek (52), indicating continuing populations (an average of 40 or more per trap indicates a potential for defoliation), the absence of egg masses indicates that defoliation is not likely to occur in these areas in 1995.

Numbers of male moths at two sites in the western part of the Nelson Region declined: only single adults were trapped in six traps at Cascade and Rock Creek. This compares with only one and two at these locations, respectively, in 1993, and five and nine males at the same locations in 1992. Trapping near previously defoliated trees near Chilliwack, Abbotsford, and Clearbrook in the Fraser Valley was discontinued following successful treatments in 1992, when no males were trapped.

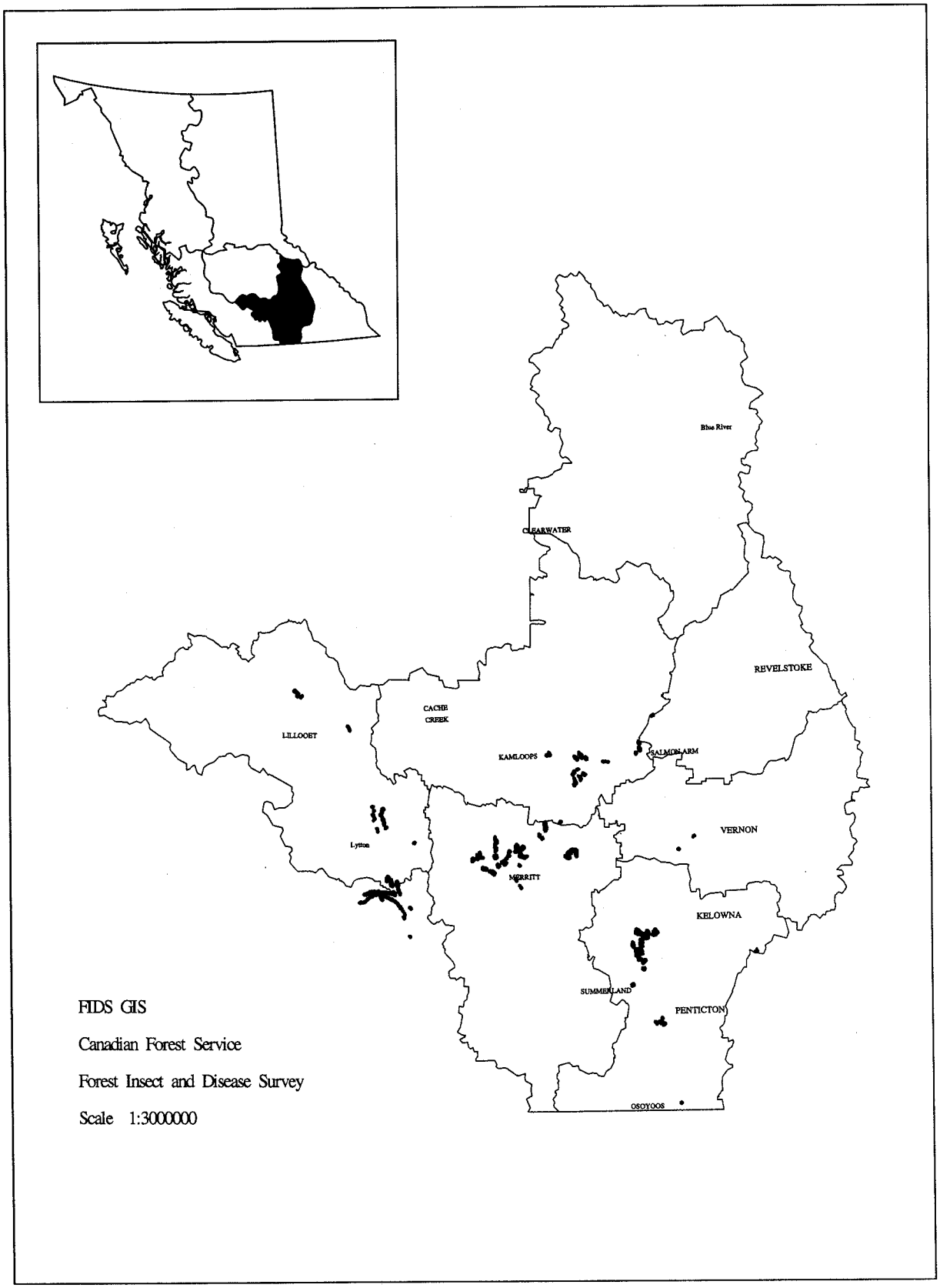
In an additional 25 traps placed about 1 km apart for detection purposes in the Kamloops Region, 343 male adults were trapped (average 14/trap, down from 38/trap in 1993). An additional 30 traps in two areas near Winfield and Kelowna contained only nine adult males, four more than last year, and none was trapped at two sites in the Nelson Region. A further 3401 male adults were trapped at 143 locations in a comparison of lures from different suppliers (average 10 and 14 per location with the PheroTech and Canadian Forest Service lure, respectively) monitored by the British Columbia Ministry of Forests in the Kamloops Region. This compares with an average of 28 last year. These data indicate non-threatening endemic populations in 1995.

Treatments of tussock moth populations by the British Columbia Ministry of Forests with Nuclear Polyhedrosis Virus (Virtuss®) were discontinued this year. This followed treatments at six sites totaling 650 ha in the Kamloops Region in 1993, when post spray observations in control areas found a population reduction due to infection by a residual virus. Although populations were in decline, a pheromone confusion trial continued by the Canadian Forest Service over about 30 ha near Kamloops found mating was effectively blocked. No males were caught in pheromone-baited traps in two treated stands, compared with an average of 70 male adults per trap in three untreated stands.

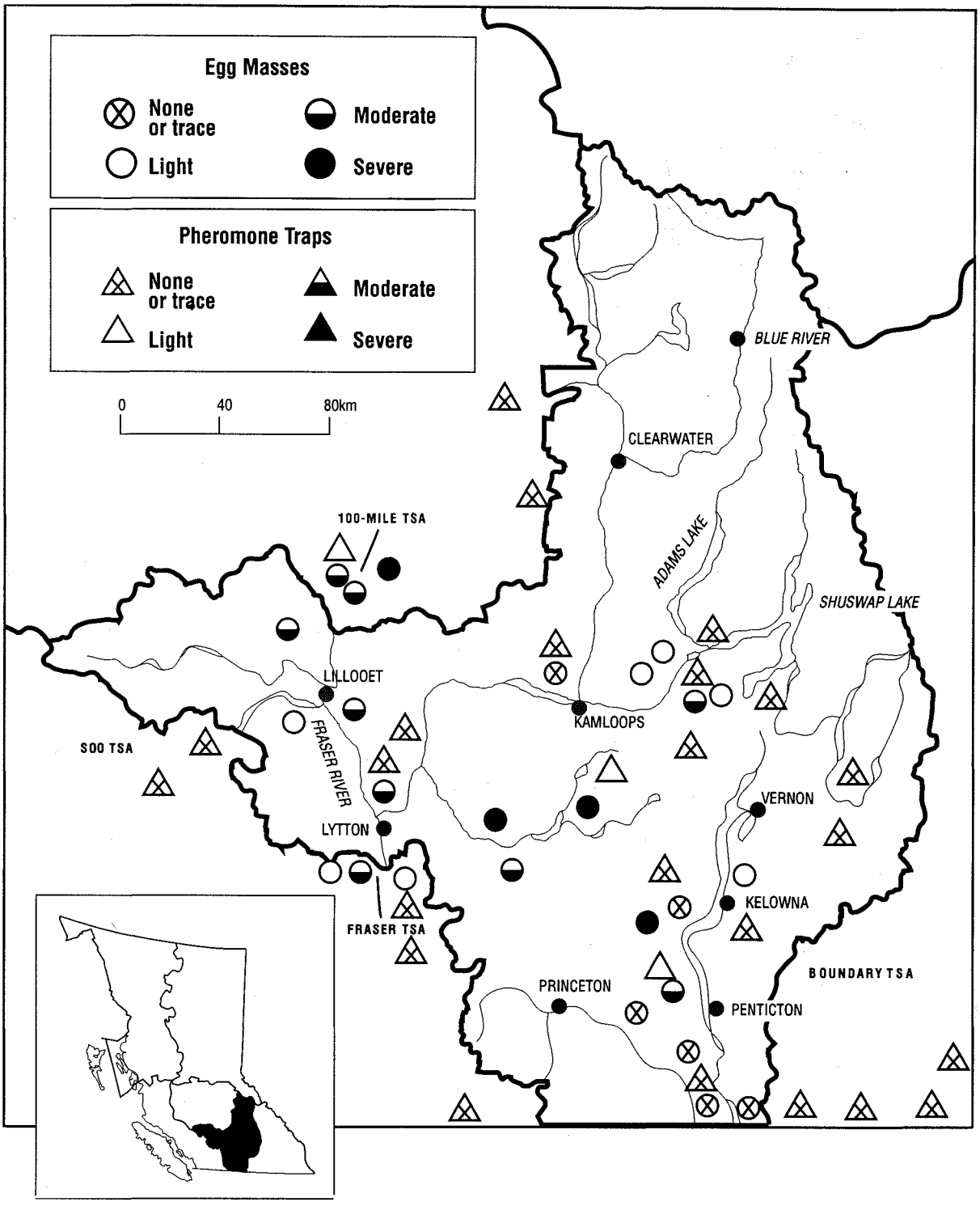
Phantom hemlock looper

Nepytia phantasmaria

Increased populations defoliated Douglas-fir in several residential blocks in Burnaby near Vancouver, the first outbreak in the lower mainland since 1982. Defoliation was moderate and occasionally severe and there was top-stripping on many trees. This pest is native to British Columbia, and outbreaks have been recorded since 1956. Outbreaks usually last two years and occasionally cause tree mortality. Based on the historical trend, populations are likely to defoliate Douglas-fir in the same area in 1995.



Map 3. Defoliation by western spruce budworm detected by aerial surveys in 1994.



Map 4. Defoliation by western spruce budworm forecast for 1995, based on egg and pheromone surveys in 1994.

Spruce Pests

Spruce beetle

Dendroctonus rufipennis

The area of mature white and Engelmann spruce killed by spruce beetle in British Columbia in 1994 increased to about 110 000 ha, up 75% from 1993. Most of the beetle-killed trees were in the Prince George Region over 72 000 ha, up 25% from 1993, and in new outbreaks in the southwestern part of the Yukon Territory over 33 000 ha; the remainder were in about 275 separate patches in parts of four forest regions (Map 5).

The area of major increase was in southwestern Yukon Territory, including Kluane National Park where new outbreaks in mature and overmature white spruce covered about 14 000 ha, and in the adjacent Shakwak and Alsek River valleys. This was the largest outbreak recorded in the Yukon and the first significant spruce beetle activity since 1977. Ground surveys at three infested sites found high numbers of larvae and pupae in trees attacked this year; these are likely to emerge and attack the remaining standing green trees in 1996. Up to 25% of the broods are expected to emerge in 1995, in some areas.

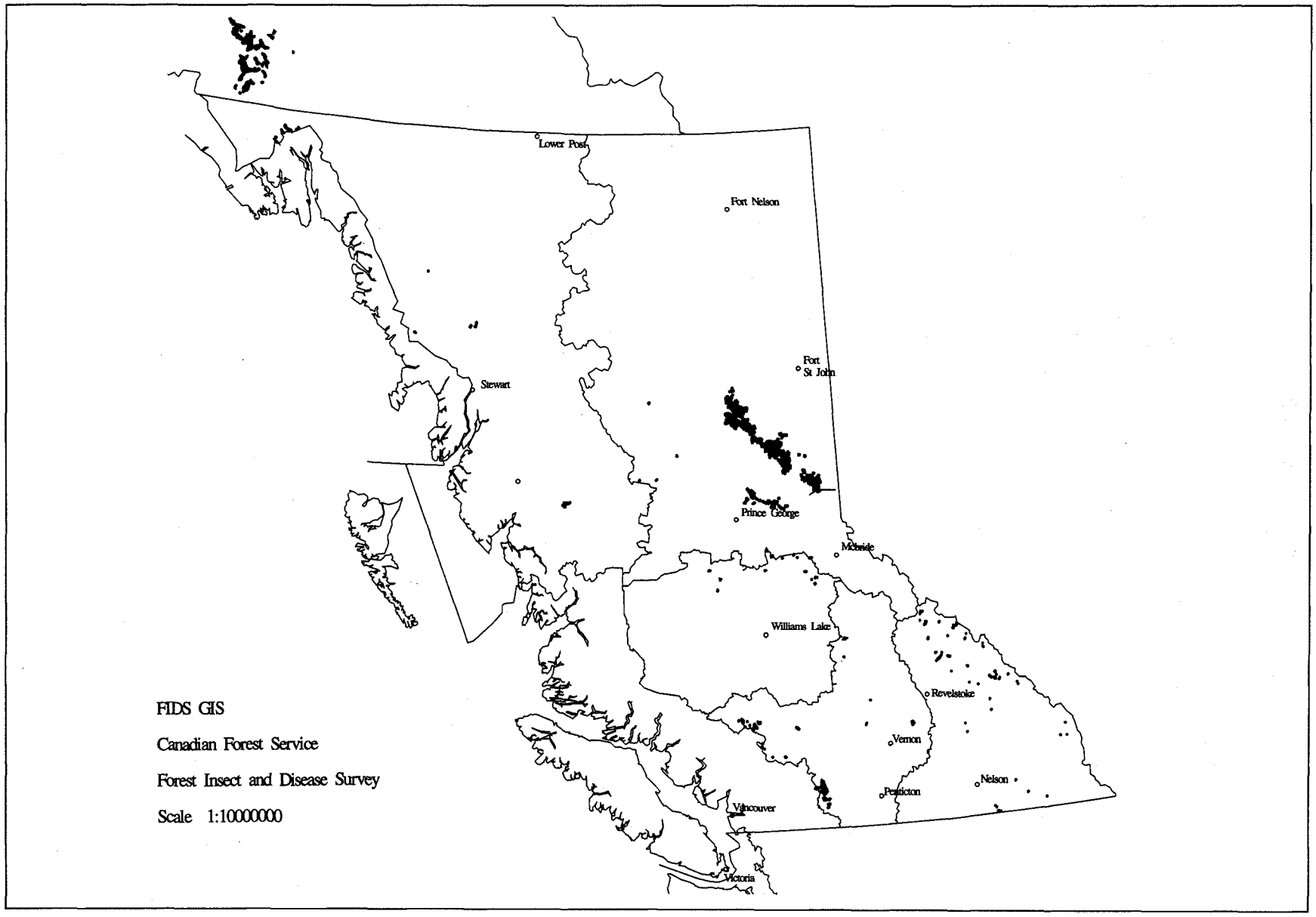
Recent tree mortality in the Prince George Region was mapped in numerous pockets totaling about 72 000 ha, mostly in previously infested areas north of Mackenzie in the Chunamen, Blackwater, and Philips creeks drainages over 53 500 ha, up 12 500 ha from last year. Additional areas of tree mortality occurred over about 5500 ha on the east slopes of the Rocky Mountains in the Dawson Creek Forest District, down 20% from 1993, and in the Fort St. James (5225 ha) and Prince George (7900 ha) forest districts, up significantly from 1993, and near McBride (25 ha).

Beetle populations elsewhere in the Pacific and Yukon Region were mostly endemic or increased slightly. Small patches of recent tree mortality mostly associated with previously infested stands totaled about 4000 ha, about double the area in 1993. This was due mostly to increases in the Haines Road area in the northwestern part of the Prince Rupert Region, and adjacent to major infestations in Yukon Territory totaling about 1300 ha. Small patches were again common south of Houston in the Morice TSA, similar to 1992, but attacks in standing green trees were less common in the Bulkley TSA.

Populations remained generally endemic in the Cariboo Region, including Bowron Lake Provincial Park. Recent tree mortality totaled only 60 ha in 40 pockets, similar to the past three years. All were 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.

In the Kamloops Region, the area of beetle-killed spruce totaled 2500 ha, up 500 ha from 1993. Most of the 106 separate patches were generally in or near previously infested stands south of Merritt between Thynne and Granite mountains, west of Lillooet in Connel, Noel, Whitecap and McGillivray creeks, north and west of Barriere lakes and in the Myrtle River drainage. New tree mortality was mapped east of Vernon in Torrent and Smythe creeks over 240 ha, and near Spences Bridge at Blue Earth Lake on 100 ha.

Infestations in the Nelson Region increased for the third consecutive year to 107 separate patches totaling 295 ha. Most were in the Golden TSA over about 120 ha, up slightly from last year. Most newly killed trees were at Bachelor Creek and Bush River, north of Golden, with new pockets of about 5 to 25 trees each in numerous drainages north of Golden to the Wood River drainage and at McMurdo Creek. New patches were mapped near Creston over about 120 ha and over seven hectares in Yoho National Park.



Map. 5. Area where recent tree mortality due to spruce beetle was detected during aerial surveys in 1994.

True Fir Pests

Budworms

Choristoneura spp.

Eastern spruce budworm defoliated spruce and alpine fir forests over 173 425 ha near Fort Nelson, and defoliation by 2-year-cycle budworms was mapped in 414 separate areas totaling 200 000 ha in parts of four forest regions (Map 6). This compares with 170 000 ha and 107 000 ha, respectively, in 1993.

Defoliation of mostly current and some older foliage of white spruce and alpine fir by Eastern spruce budworm, *Choristoneura fumiferana*, was mapped in 154 separate patches near Fort Nelson in the northern part of the Prince George Forest Region This defoliation occurred west and north of Fort Nelson into the Yukon and Northwest Territories, and southeast into the Fort Nelson and Fontas river drainages. The level of damage was similar to that observed in 1993. Like last year,. defoliation severity was light over the entire area.

Defoliation has occurred in some areas for more than ten years, and, in addition to growth loss and reduced cone crops, this has resulted in top-kill and some tree mortality particularly in the Liard and Muskwa river drainages, at Kledo and Steamboat creeks, and near Fort Nelson.

Defoliation is forecast to decline in the Fort Nelson area in 1995. This is based on the reduced number of egg masses (average 18, range 15-23) per square metre of foliage sampled at sites in previously defoliated stands near Fort Nelson and Snake and Liard River drainages by the British Columbia Ministry of Forests. Protection of mature seed production stands and adjacent young stands near Fort Nelson with *Bacillus thuringiensis* var. *kurstaki* (Dipel 132 (R)), was discontinued in 1993.

Alpine fir and spruce forests were defoliated by 2-year-cycle spruce budworms, *Choristoneura biennis*, in 414 areas totaling 200 000 ha mostly in the Cariboo Region and to a lesser extent in the Prince George and Kamloops forest regions. Most of the damaged area was defoliated by mature larvae, although immature larvae defoliated over 8720 ha in parts of the Prince George, Kamloops, and Nelson regions.

Defoliation of fir-spruce stands by mature ("on-cycle") budworm larvae in the Cariboo Region covered 110 595 ha; 62 675 ha were defoliated in the Prince George Region and 18 200 ha were defoliated in the northeast part of the Kamloops Region, but no defoliation occurred in adjacent parts of the Nelson Region. Defoliation was mostly light and occasionally moderate in the Cariboo Region over 110 595 ha in 260 patches from Canim Lake north to the Willow River drainage. Defoliation was most severe in the Swift and Little Swift river valleys and between Pinegrove and Barkerville. Successive years of defoliation in these areas have resulted in mortality of 20-40% of the advance regeneration, top and branch dieback, and growth loss of all age classes. Defoliation in the Prince George Region was light over 62 675 ha in about 100 patches southeast of Prince George in the Bowron and Willow river drainages near Narrow and Stoney lakes and Haggen and Everett creeks, and near McBride in the Goat, Dore, Morkill and Milk river drainages. This was down a third from 1992 in the same general areas. Defoliation in the Kamloops Region was also mostly light and occasionally moderate over 18 600 ha in about 34 patches in the upper North Thompson River drainages near Clearwater and in Wells Gray Provincial Park; the defoliated area was down from 160 000 ha in 1992. There was no defoliation of fir-spruce by mature on-cycle budworms in previously infested stands in the East Kootenay part of the Nelson Region.

Immature "off-cycle" budworm larvae lightly defoliated fir-spruce stands over about 8720 ha in parts of four forest regions. Most of this damage was in the Prince George Forest Region over about 8000 ha, north of Fort St. James near Tsayta and Tchenilo lakes. This defoliation was about one-tenth that caused by mature larvae in 1993, and 5000 ha less than that caused in by immature larvae in 1992. There was no defoliation mapped elsewhere in the region in previously defoliated stands west of Mackenzie and in the Omineca and Ospika river drainages. In the Kamloops Region, defoliation was mapped over only 400 ha in patches near Keefer and Holmes lakes in the upper Kettle River drainage and near Sugar Lake north of Cherryville, down significantly from the previous two years and the smallest area recorded since defoliation was first

recorded in the area in 1987. Populations in adjacent parts of the Monashee Range in the West Kootenay very lightly defoliated fir-spruce stands in patches totaling 280 ha, down 4000 ha from last year. Defoliation by immature larvae was light at Bugaboo Creek west of Spillimacheen in the East Kootenay, but none occurred at Vowell and McMurdo creeks and in the upper St. Mary River drainage following larval mortality from late frost early last year.

Based on historical trends, defoliation of fir-spruce stands by 2-year-cycle budworms is likely to occur in 1995 in parts of four forest regions, particularly by mature "off-cycle" larval populations in parts of the Prince George, Kamloops, and Nelson regions. Defoliation is not expected to cause significant damage in stands defoliated this year by "on-cycle" budworm populations.

Western balsam bark beetle

Dryocoetes confusus

Mature alpine fir killed by the balsam bark beetle were mapped over about 180 000 ha in 1884 separate patches in parts of all six forest regions, down 10% from 1993. The majority was again in the Prince Rupert (75%) and Prince George (18%) regions (Map 2).

In the Prince Rupert Region, infestations which have persisted for many years totaled 137 000 ha in 397 areas, down 13% from the area mapped in 1993. Most infestations occurred 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 and McDonnel and Trout creeks. Increased numbers of recently killed alpine fir were mapped in 140 patches totaling about 7000 ha in the Cassiar TSA, near Mt. Edziza Park and in the Iskut, Stikine, Dease, Cottonwood, Klappan, and Eagle river valleys.

In the Prince George Region, areas containing alpine fir recently killed by the balsam bark beetle increased slightly to about 33 300 ha in 206 separate areas, up about 12% overall from 1993. Increased numbers of killed trees were mapped northwest of Fort St. James in the Salmon, Mosque, and Nation river drainages, and damage continued east of Takla Lake and the Mitchell Range. The area of tree mortality in the McBride Forest District, mostly south of Moose Lake near Mt. Robson and in the Holmes River drainage, declined fourfold to 650 ha.

Elsewhere in the Pacific and Yukon Region, recent tree mortality continued in chronically infested areas over about 10 000 ha, down 17% overall from 1993. This includes about 2525 ha in the Cariboo Region, 2870 ha in the Kamloops Region, 3300 ha in the Nelson Region. However, there was an increase to 1300 ha in the Vancouver Region, for a second consecutive year, mostly in the Mid-Coast TSA.

The annual fluctuation in the areas of recently killed mature alpine fir mapped 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 of aerial surveys.

Balsam woolly adelgid

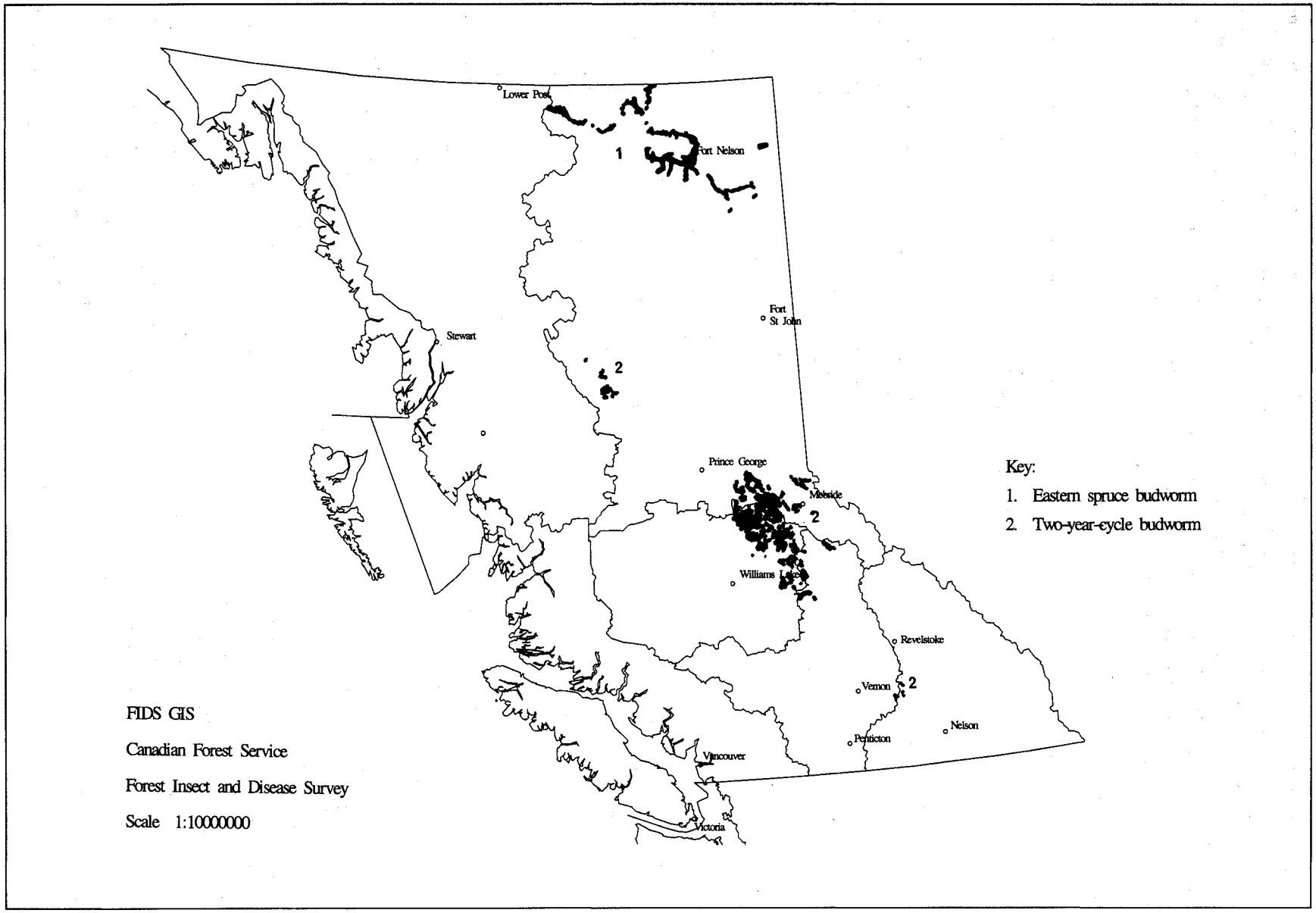
Adelges piceae

Surveys to determine the distribution of balsam woolly adelgid in mature and immature stands in southwestern British Columbia were initiated this year in cooperation with the British Columbia Ministry of Forests and the forest industry.

Additionally, mature amabilis fir were found to be infested within the quarantine zone in the Caycuse River drainage west of Cowichan Lake. Recent mortality of overmature amabilis fir, attributed to the adelgid, was also mapped over about 10 ha southwest of Mt. Arrowsmith near Port Alberni. Additional sampling near mature amabilis fir stands in the Oyster River drainage west of Campbell River, where infested trees were identified outside the quarantine zone last year, have been negative so far.

Additional surveys of immature *Abies* in 40 randomly selected stands in the Vancouver and Kamloops regions, part of a region-wide survey of pests of young stands, found evidence of damage by balsam woolly adelgid at a site near Port Alberni within the quarantine 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 which totaled 24 000 ha in 1992, in nearby central Idaho.

Research to determine the potential for adelgid crawlers to infest and be dispersed to the field on



Map 6. Areas where defoliation by fir-spruce budworms was detected by aerial surveys in 1994.

containerized nursery stock were established at two locations in co-operation with the British Columbia Ministry of Forests. Seedlings (1+0 and 2+0 nursery stock) grown under operational conditions were artificially infested with balsam woolly adelgid to determine if they can survive nursery watering and fertilization regimes and lifting and cold storage treatments over a two-year trial period. Results will be available in 1995.

The balsam woolly adelgid regulations were revised by an order in council under the British Columbia Plant Protection Act in 1992, and included an expansion of the quarantine zone to include infested areas of the mainland and islands previously outside the zone.

Hemlock pests

Western hemlock looper

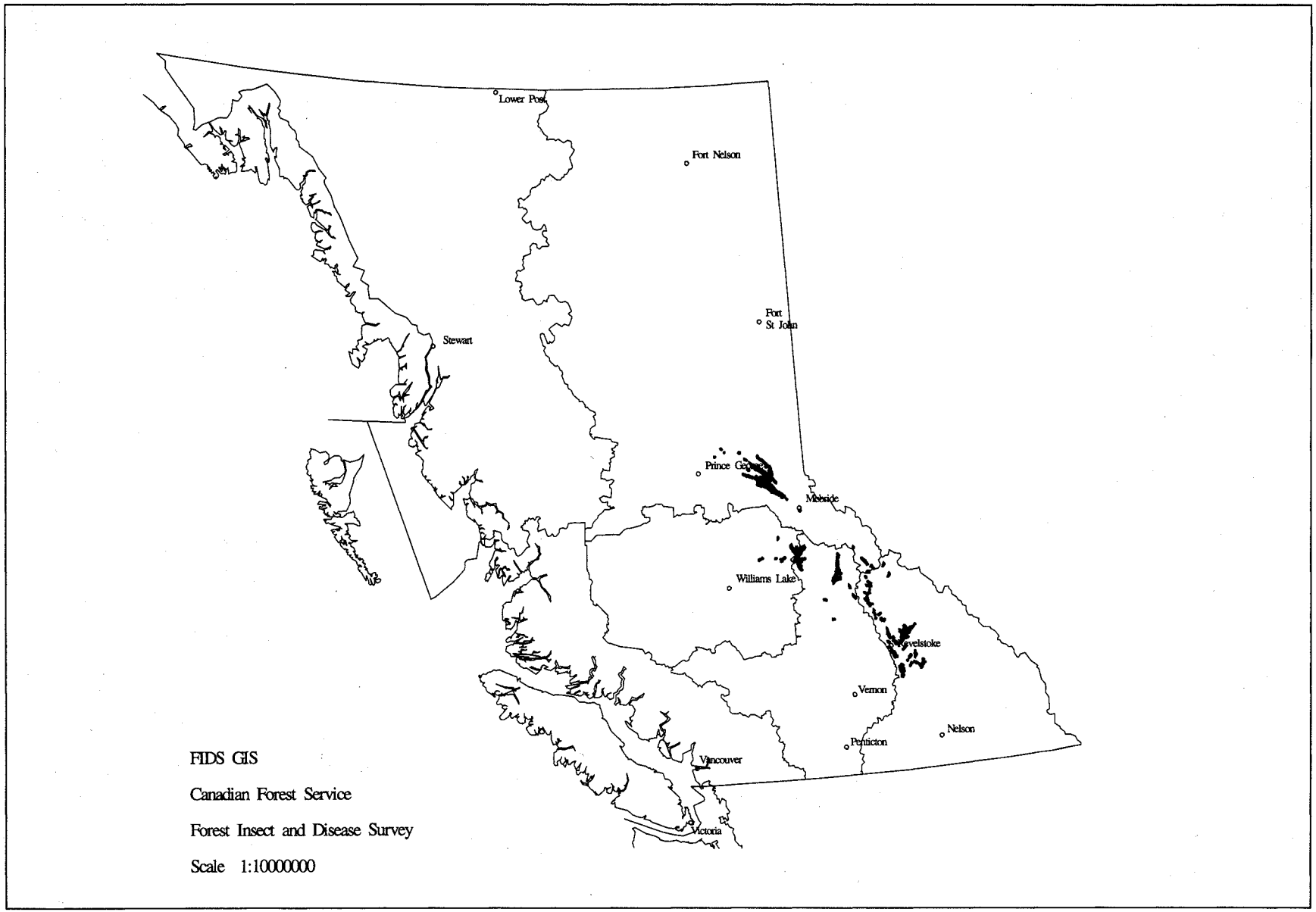
Lambdina fiscellaria lugubrosa

Populations declined significantly following defoliation by the looper for up to five successive years in old-growth western hemlock and western red cedar in parts of four forest regions in interior British Columbia. The area of defoliation totaled about 8000 ha in the Nelson (3000 ha) and Prince George (5000 ha) regions, down from 92 750 ha in 1993. Defoliation was mostly light on 2755 ha, moderate on 4635 ha, and severe over the remainder. Tree mortality resulting from successive years of severe defoliation was mapped over about 64 000 ha in parts of the Cariboo (4000 ha), Kamloops (15 500 ha), Nelson (9150 ha), and Prince George (35 550 ha) regions (Map 7).

Patches of defoliation between Prince George and McBride in the Prince George Region, mostly in white spruce and alpine fir adjacent to previously defoliated hemlock and cedar, totaled about 5000 ha, down from 43 000 ha in 1993, the third year of the outbreak. Most of the defoliation was light or moderate (88% of the area, 4400 ha), and defoliation was severe on the remainder. Defoliation in the Nelson Region declined in area to 3000 ha (down from 48 500 ha in 1993) south of Revelstoke near Arrow and Trout lakes in the western part of the region, down from 48 500 ha in 1993. Populations in previously defoliated areas near Quesnel Lake in the eastern part of the Cariboo Region and in the Clearwater, North Thompson and Adams river drainages in the Kamloops Region collapsed following major declines last year.

Tree mortality in long-term plots in previously defoliated stands in the Cariboo, Kamloops, and Prince George regions averaged 38% (range 9-63%) of the trees at 15 plots after successive years of severe defoliation. In the Cariboo Region, about 35% of the trees in four plots were killed, and an additional 40% of the trees were killed in stands over about 4000 ha; a further 10% are not expected to survive. About 40% (range 34-44%) of the western hemlock and western red cedar trees at three plots near Blue River in the Kamloops Region were killed following consecutive years of moderate and severe defoliation. Additional tree mortality and top-kill ranged from an estimated 10 to 60% of the stands in 58 patches totaling 15 550 ha. In the Nelson Region north of Revelstoke, mortality of western hemlock was 48% and 38% at Downie and Bigmouth creeks, respectively. At an additional three sites where defoliation had previously been light to moderate, mortality of mostly smaller understory trees averaged 9% (range 4-17%). Additional tree mortality was common elsewhere in the Nelson Region in the Illecillewaet, Tangier, and Goldstream river valleys and at Woolsey, Jumping, Lardeau, and Pingston creeks. Tree mortality averaged 40% (range 10-90%) over 35 000 ha of the cedar and hemlock between Prince George and McBride, particularly at the Torpy River, Walker, Ptarmigan, and Catfish creeks, and near LaSalle Lake.

The significant decline, as forecast, was due to naturally occurring factors which severely affected population development in late 1993 and early 1994. These included overwintering egg parasitism which averaged 21% overall at 34 sites in four regions. Infection of larvae by disease (mostly Entomphthoraceae, and some *Beauvaria bassiana*)



Map 7. Defoliation and tree mortality due to western hemlock looper detected by aerial surveys in 1994.

killed about 18% (range 0-72%) of the larvae. Parasites (mostly Hymenoptera and to a lesser extent Diptera) killed an average of 10% (range 0-15%) of the larvae at 11 sites in three regions. Additionally, the decline was due in a part to starvation of larvae caused by competition between their extremely high numbers and reduced foliage on severely defoliated trees.

Populations are forecast to decline further in 1995, with only light defoliation in reduced areas of cedar-hemlock stands in the Nelson, Prince George, and Kamloops regions, and none in the Cariboo Region where populations collapsed this year (Map 8). This forecast is based on egg and pheromone surveys. The numbers of overwintering eggs laid this year averaged three (range 0-25) eggs per sample (100 grams of lichens/site) at 25 sites in four regions; this indicates only very light defoliation at five of nine sites in the Nelson Region, very light defoliation at only one site in each of the Kamloops and Prince George regions, and no defoliation at the remaining 18 sites, all at or near previously defoliated stands. This compares with an average of 20 (range 1-38) eggs per sample at 34 sites last year. Only four healthy eggs were extracted from samples from six additional sites with a history of population activity (but no recent activity) in the Prince Rupert (4) and Vancouver (2) forest regions; this is too few to be of any significance.

In the development of a pheromone trapping and forecasting system for western hemlock looper, Universal® and Multipher® traps were compared. Traps of both types were baited with 10µg lures and placed at 31 locations throughout British Columbia. On average, the Universal® traps attracted significantly more moths (average 136 per trap, range 1-795) than the Multipher® traps (average 61, range 0-422). Such differences did not occur in a companion study with eastern hemlock looper in Newfoundland. Similarly, comparisons were made of 10 and 100µg lures in Universal® traps. Not surprisingly, the 100µg lures attracted more moths (average 407, range 2-2162) than the 10µg lures (average 150, range 0-795). These results along with earlier studies in cooperation with Simon Fraser University suggest that the 10µg lure should become the standard for further calibration. Defoliation based on pheromone trap results forecast declining populations with only light defoliation at 4 of 23 sites, mostly in the Nelson Region, and none at the remainder.

Western blackheaded budworm

Acleris gloverana

Increased populations of western blackheaded budworm defoliated western hemlock in the Nelson Region for a second consecutive year and in the Kamloops Region for the first time in 10 years.

Western hemlock stands over 4600 ha in 11 separate patches near Golden in the Nelson Region were lightly defoliated for a second consecutive year by budworm populations in association with western hemlock looper. The defoliation as forecast was mostly in and near Glacier National Park, and some defoliation occurred along the west side of McNaughton Lake. Budworm populations in association with increased numbers of hemlock sawfly, Neodiprion tsugae, moderately defoliated hemlock stands in the Beaver River Valley south of Rogers Pass for the first time, and for a third consecutive year over 50 ha at Gray Creek near Crawford Bay on Kootenay Lake.

A new outbreak in old growth western hemlock was mapped in the Kamloops Region over 1400 ha in seven patches mostly in the Eagle River Valley, south of Three Valley Gap in the Salmon Arm Forest District. Defoliation, the first in the region since 1985-1988, was light over 90% of the area and moderate over the remainder at Hound Creek near Mabel Lake northeast of Lumby. Light defoliation in six patches occurred at Craigellachie, Crazy, Wap, and Noisy creeks and at Victor Lake.

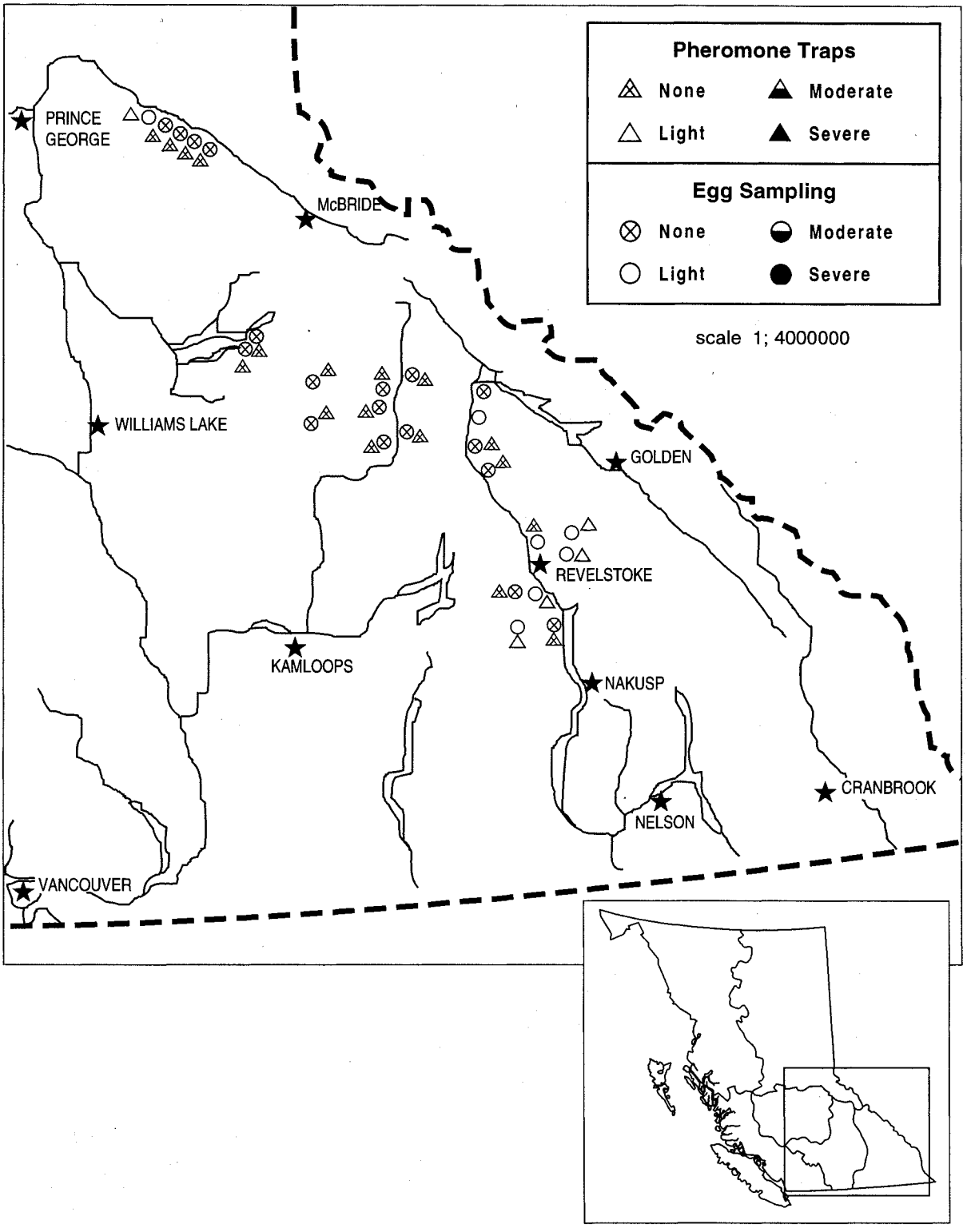
Overwintering egg samples assessed at Glacier National Park and at Wap Creek indicate trace to light defoliation in these areas in 1995. Based on historical trends, similar defoliation is likely in other recently defoliated stands in the Kamloops Region,.

Hemlock woolly adelgid

Adelges tsugae

Hemlock woolly adelgid occurs at low levels throughout the range of western hemlock in British Columbia, but occurs at damaging levels occasionally in some coastal seed orchards.

A native predator beetle, *Laricobius nigrinus*, often found associated with high populations of hemlock woolly adelgid in British Columbia. Specimens of this beetle, which is native to British



Map 8. Defoliation by western hemlock looper forecast in 1995, based on egg and pheromone surveys in 1994

Columbia, were collected to evaluate their potential as a biological control for the adelgid in eastern North America.

More than 200 overwintering adults were shipped under permit to the United States Forest Service quarantine facility at the Northeastern Center for Forest Health Research in Pennsylvania. The adelgid, an introduction from Asia, is causing severe damage and increasing mortality to eastern hemlock, and its range is expanding northward in the northeastern United States. The introduction of native predators and their successful establishment in eastern North America might reduce the damage and slow the rate of spread of the adelgid before it reaches hemlock forests in Canada.

Larch Pests

Larch casebearer
Coleophora laricella

Larch casebearer populations moderately defoliated western larch in four patches totaling 285 ha east of Vernon in the Kamloops Region, but this pest remained at endemic levels elsewhere in the host range in southeastern British Columbia.

Discoloration of larch stands in the eastern part of the Kamloops Region increased to moderate in four areas along King Edward Main access road east of Vernon, where lightly infested stands were common in 1993, and light discoloration occurred at Shuttleworth Creek east of Penticton. There was no noteworthy feeding or discoloration by generally endemic casebearer populations throughout the host range in the Nelson Region. At most of the 18 long-term parasite release study sites surveyed in the Nelson Region from Koocanusa Lake west to Anarchist Mountain, there was either no discoloration or only trace discoloration; however, light to moderate discoloration did occur at two sites near Cherryville and Penticton in the adjacent Kamloops Region.

Populations at previously infested sites in the Kamloops and Nelson regions were too few to determine parasitism. During a biological control program against larch casebearer from 1966 to 1987 more than 15 000 specimens of *Chrysocharis laricinellae* and *Agathis pumila* were released. Since then, parasitism of casebearer by the introduced parasites (and to a lesser extent by native parasites including *Spilochalcis* sp.) has successfully maintained populations at acceptable levels.

Larch sawfly
Pristiphora erichsonii

Sawfly populations again defoliated exotic larch at the University of British Columbia Research Forest near Haney in the Vancouver Region, some for the seventh consecutive year. Populations remained endemic in previously defoliated native larch stands elsewhere in British Columbia and southwestern Yukon Territory.

Larch needle diseases
Hypodermella laricis
Meria laricis

Discoloration of western larch by larch needle diseases, which have fluctuated periodically with weather conditions, declined to endemic levels in previously infected stands throughout the host range in the Nelson and Kamloops regions. This followed a significant decline in 1992 from widespread severe discoloration the previous year.

Larch budmoth
Zeiraphera improbana

Western and alpine larch were moderately to severely defoliated by larch budmoth in 18 patches totaling about 680 ha in the East Kootenay part of the Nelson Region. Most damage occurred on western larch in the Elk River Valley near Fernie, with smaller patches in alpine larch in the St. Mary, Perry, and upper Kootenay river drainages. This was about the fourth significant outbreak of the budmoth in the region since the first outbreak was recorded over about 70 000 ha in 1965. Previously, defoliation has occurred for at least two consecutive years, and is likely to occur again in 1995.

A larch shoot miner
Argyresthia columbiana

The shoot miner killed about 12% of the new terminal shoots of dominant and codominant western larch in spaced stands over about 100 ha at Brewer Creek near Columbia Lake in the East Kootenay, about 7% more than last year. Additionally, about 6% of the lateral buds on upper whorl branches were mined. Follow-up surveys of trees with terminals killed in 1991 found that 15% have multiple leaders.

Multiple Host Pests

Black army cutworm
Actebia fennica

Recently planted seedlings and ground cover were defoliated by black army cutworm populations at a few recently burned and planted sites in parts of three forest regions in interior British Columbia, where populations have generally remained at low levels since a significant decline in 1989. In the Cariboo Region, recently planted spruce and Douglas-fir seedlings were moderately defoliated and ground cover was severely defoliated in a plantation east of Horsefly. About 10% of the spruce seedlings were defoliated and killed, but western larch and lodgepole pine seedlings were less severely affected in patches over about 17 ha at a site on the east side of McNaughton Lake north of Golden in the Nelson Region. Herbaceous growth was severely defoliated over about 135 ha where 688 adult males were caught in a pheromone-baited trap last year, and planting was intentionally delayed. Recently planted lodgepole pine seedlings and herbaceous ground cover were lightly and occasionally severely defoliated by cutworm in widely scattered patches over about 100 ha in the Stoner Creek drainage south of Prince George, where only 14 to 65 male adults were trapped last year. This damage is similar to that which occurred in 1993, when defoliation but no apparent mortality of defoliated seedlings occurred in the Murray River drainage south of Tumbler Ridge.

Cutworm larvae lightly to moderately defoliated ground cover but not seedlings at two of five sites resurveyed in the Prince Rupert Region this year. Last year traps at those sites, mostly in the Bell-Irving River Valley, contained fewer than 150 trapped adults on average.

Seedlings scheduled to be planted in 1995 on sites slash-burned in 1994-95 may be threatened by the cutworm, particularly where the numbers of male adults in pheromone-baited Multipher® traps exceeded a threshold of 600 or more per site. This occurred only at one site in the Prince Rupert Region (635) in the Bell-Irving River drainage north of Kitwanga. An average of 144 males per trap (range 10-302) were caught at the remaining 19 sites. Elsewhere in the 48 sites trapped in four regions moths averaged 143 per trap (range 10-370), up slightly from 124 in 1993. Numbers of trapped males averaged 122 per trap (range 10-326) at 15 sites in the Nelson Region, and 106 per trap (range 12-320) at seven sites in the Kamloops Region. This indicates the potential for very light defoliation in the Columbia River drainage north of Golden in the Nelson Region and at Cayene Creek (320) east of Vavenby in the Kamloops Region, based on a threshold of about 350 per trap. Little or no defoliation is likely at the remainder of the sites in the Nelson and Kamloops regions or at seven sites in the Prince George Region (average 137, range 12-253; too few to cause significant damage in 1995).

A comparison of 1993 and 1994 lure batches at 13 sites in parts of four forest regions found an average overall of 113 male moths per trap using "94" lures, compared with 116/trap with "93" lures. This indicates consistency of lures produced in subsequent years.

Rhizina root disease

Rhizina undulata

Rhizina root disease killed seedlings at seven sites in each of the West Kootenay and eastern part of the Prince Rupert Region, but not in previously infected sites in the Cariboo Region. This low level was similar to the previous three years, and was the seventh consecutive year of seedling mortality by this pathogen in the Pacific and Yukon Region.

In follow-up surveys of four previously infected sites in the West Kootenay, 1 to 5% of the seedlings were infected and killed this year; up to 30% of the seedlings were killed last year. Surveys of an additional seven sites found new seedling mortality averaged 14% (range 1-45%), the highest mortality occurred at Goldstream River north of Revelstoke. Fruiting bodies were present in an additional two unplanted sites. New seedling mortality averaged 13% (range 4-30%) at seven sites burned in late 1993 in the eastern part of the Prince Rupert Region, mostly in the Nilkitkwa River drainage near Smithers. Surveys for the pathogen at an additional seven nearby sites were negative. There was no evidence of new sporophores at two sites in the Cariboo Region, where seedling mortality occurred last year.

Pests of young managed stands

A study to identify and record major pests and environmentally related problems and their impact on young stands in British Columbia continued in 1994. The 252 young natural and planted conifer stands examined by the Forest Insect and Disease Survey of the Canadian Forest Service in cooperation with the British Columbia Ministry of Forests and the forest industry were 16 years old on average and were established or treated under the Canada/British Columbia Forest Resources Development Agreement program.

A total of about 36 665 trees were examined. At each location, trees in at least 10 circular plots were examined. Spruce were the major component in about 34% of the sites, pine in 31%, true firs in 15%, Douglas-fir in 11%, hemlock in 7%, cedar, larch and trembling aspen, poplar, and alder comprised the remainder (Table 2). Sites were located in 12 biogeoclimatic zones. Most (26%) were in the Sub-Boreal Spruce zone, 25% in the Interior Cedar-Hemlock zone, 23% in the Coastal Western Hemlock zone, 10% in the Montane Spruce zone, 8% in the Engelmann Spruce - Subalpine Fir zone, 4% in the Boreal White and Black Spruce zone, 2% in the Interior Douglas-fir zone, and the remainder (2%) in the Alpine Tundra, Coastal Douglas-fir, Ponderosa Pine, and Sub-Boreal Pine - Spruce zones.

Table 3. Number of young stands by region and species examined in British Columbia in 1994.

		Species				
Region	Total	Pine	Spruce	Douglas-fir	Abies	Other[1]
Cariboo	23	9	12	2		
Kamloops	46	12	22	1	8	3
Nelson	45	16	10	13	2	4
Prince George	47	16	30	1		
Prince Rupert	47	26	11	-	1	9
Vancouver	41	-	1	10	26	4
Q.C. Islands	3		3			
Total	252	79	89	27	37	20
(%)		(31)	(35)	(11)	(15)	(8)

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

About 61% of the 252 stands surveyed were either free of pests or contained only insects or diseases of little consequence. About 11% contained pests which caused losses to current growth potential, and 28% contained pests which caused significant damage. Overall, 64% 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 pine needle cast, feeding by mammals, new climatic (abiotic) damage, and tree competition.

Root diseases, mainly *Armillaria* spp., and to a lesser extent, *Inonotus tomentosus*, *Phellinus weirii*, and occasionally *Rhizina undulata* were recorded in plots in 17% of the stands. *A. ostoyae* infected and killed 12% (range 1-50%) of the Douglas-fir in 70% of the 27 stands examined, about half of which had already been spaced. The highest incidence of Armillaria was at Kwikoit Creek near Shuswap Lake where half of the 20-year-old Douglas-fir and some western hemlock were infected. Only 1% (range 1-4%) of the trees in 9% of the spruce stands and 4% of the lodgepole pine in a single stand were infected by *I. tomentosus* in parts of the Prince George and Nelson regions.

Spruce weevil, *Pissodes strobi*, infested 25% (range 1-100%) of the trees in all 89 spruce plantations examined, mostly in the Prince George Region. All the 20- to 35-year-old spruce in plots at Cecil and Schulbuckhand creeks in the Kitimat Valley and 94% in the Little Wedeene River drainage were infested. Weevil attacks were highest in other regions at Hazeltine Creek and Mitchell Bay near Quesnel Lake (82% and 81% of the spruce infested), Sugar Bowl Creek east of Prince George (46% of the spruce infested), Paxton Valley near Monte Creek in the Kamloops Region (53% of the spruce infested), Blackwater River drainage near Golden in the Nelson Region (28% of the spruce infested), and at Cypress Creek near Gold River on Vancouver Island (71% of the spruce infested).

Lodgepole terminal weevil, *P. terminalis* infested only 3% (range 1-20%) of the terminals in 14% of the lodgepole pine stands examined, mostly in the Kamloops Region. Warren's root collar weevil, *Hylobius warreni*, infested only 4% (range 1-9%) of the immature lodgepole pine, mostly already spaced in 11% of the 79 pine plantations. About 7% of the 4- to 22-year-old pine were girdled and killed at three infested sites in the Nelson Region, 9% were killed at one of two sites in the Prince George Region, and about 2% were killed at three sites in the Cariboo Region.

Stem and branch diseases including western gall rust, *Endocronartium harknessii*, and blister rusts, *Cronartium* spp., were again common in pine plantations, but to date these 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 or stems on an average of 7% (range 1-50%) of the trees in 62% of the pine stands, most frequently in the Prince Rupert Region. The highest incidence (25%) was in a 19-year-old spaced stand northeast of Tzenzaicut Lake, west of Quesnel in the Cariboo Region. Blister rusts, *Cronartium* spp., infected an average of 3% (range 1-12%) of the immature lodgepole pine at 30% of the sites. Half (range 3-100%) of the white pine in 28% of the sites were infected by white pine blister rust, *C. ribicola*. Stem cankers caused by *Atropellis* spp. occurred on 1 to 22% (average 7%) of the trees in 11 lodgepole pine stands in the Prince Rupert Region.

Pine needle cast, *Lophodermella concolor*, discolored both new and old needles of two-thirds (range 3-100%) of the pines in about 60% of the young stands surveyed, particularly in the Kamloops Region and to a lesser extent in the Cariboo and Nelson regions. Other needle diseases, including fir-fireweed rust, *Pucciniastrum epilobii*, affected most new foliage on more than half the true firs in 78% of the 37 true fir plantations.

Damage caused by mammals including bark removal and browsing occurred in 27% of the 252 stands examined region-wide. Most damage was caused by deer, elk, or moose, and some minor damage was caused by bear, porcupine, squirrels, cattle, and hares. Moose damaged trees at 13 sites in four regions, including up to 31% of the 16-year-old trees in a plantation at Lunate Creek east of Prince George and 1 to 20% of the trees at an additional four sites elsewhere in the region. Bear damage occurred at nine sites in the East Kootenay, but less than 5% of the residual trees in the spaced stands were affected. Damage to conifers by porcupines at eight mostly spaced sites in parts of the Nelson and Prince George regions averaged less than 4%.

Climatic factors, mostly snow, ice, frost, and occasionally drought, damaged trees in about 28% of the stands examined in the regions, slightly less than in 1993. The impact of this damage is likely temporary and recovery will be good. Frost damaged about 11% of the trees in 15% of the sites in five forest regions, including half of the trees in one of three affected sites in the East Kootenay, up to 42% of the trees at 11 frost-damaged sites in the Kamloops Region, and 72% of the trees at one of nine sites in the western part of the Prince Rupert Region. Snow and ice damaged trees at 11% of the sites.

Only 3 of 96 pine, hemlock, and larch stands surveyed were infected by dwarf mistletoes, *Arceuthobium* spp. Infections by *A. tsugense* averaged 3% of the hemlock at Cecil and Schulbuckhand creeks in the western part of the Prince Rupert Region, and 1% of the lodgepole pine were infected by *A. americanum* at a site near Whipsaw Creek west of Princeton. None of the western larch in plots surveyed this year was infected by *A. laricis*.

The most common insect pest, Cooley spruce gall adelgid, *Adelges cooleyi*, was common on about 60% of the trees in 37% of the Douglas-fir and 94% of the spruce stands, but tree growth and vigor or tree form were not significantly affected. Balsam woolly adelgid, *A. piceae*, infested 9% of the amabilis fir regeneration at Yellow Creek near Port Alberni; none was found in an additional 36 true fir young stands surveyed in southwestern British Columbia.

Svenska Cellulose trials

In an annual cooperative survey with Svenska Cellulose, trees at four sites in the Prince George Region and one site in the Yukon Territory were examined in 1994 to assess pest losses on different provenances of lodgepole pine, Scots pine, Siberian larch, and Norway spruce seedlings planted in 1986.

Perennial stem and branch rusts on pines caused the most damage in the plots. Western gall rust, *Endocronartium harknessii*, infected 17% (range 1-35%) of the stems (4%) and branches (13%) of the lodgepole pine at all four plots in the Prince George Region, and 1% of the Scots pine at two sites. This was up 7% overall from 1993, and it was the first record on Scots pine in the plots. Stem cankers of comandra blister rust, *Cronartium comandrae*, found for the first time on lodgepole pine at Takhini in 1993, killed 8 of 28 infected trees examined. Stalactiforme blister rust, *Cronartium coleosporioides*, infected 4% of the trees at Nation Bay near Mackenzie. Lodgepole pine at the Liard Hot Springs plot near Fort Nelson were again infected by *Lophodermella concolor*, which discolored about 60% of the year-old needles on half the trees, and foliage on 7% of the trees near Fort St. James was infected.

Insect damage included new attacks by Warren's root collar weevil, *Hylobius warreni*, which girdled and killed 1% of the lodgepole pine at Nation Bay; this level of damage is similar to that observed last year. Northern pitch twig moth, *Petrova albicapitana*, infested stems on 1% of the pine at Fort Nelson (also similar to last year) but not in previously infested plots near Mackenzie and Fort St. James. Feeding by eastern spruce budworm, *Choristoneura fumiferana*, was very light in the buds of less than 1% of the Norway spruce at the plot near Fort Nelson that was last defoliated in 1991. There were no further attacks of white spruce terminals by spruce weevil, *Pissodes strobi*, in the Fort St. John plot where 1% were killed in 1992; this was the first record of the pest in the plot and one of the most northerly records of weevil damage in British Columbia. A Gouty pitch midge, *Cecidomyia* sp., newly infested about 5% of the leaders on 10% of the lodgepole pine at Teardrop Road near Fort St. James.

There was no new damage caused by frost, snow, ice, and cold winds in 1994. Climatic damage to plot trees in previous years had resulted in multiple tops, bushy form, and bud mortality at all five sites. Damage was still most evident (although less so than in 1993) at Nation Bay where 25% of the larch and 15% of the pine have poor form. About 9% of the Scots pine, 5% of the lodgepole pine, and 2% of the Siberian larch at Teardrop Lake near Fort St. James still have pronounced forks, multiple tops, and basal sweep. About 10% of the lodgepole pine at Fort Nelson had multiple tops and crooks, but Siberian larch and Norway spruce showed signs of recovery from climatic damage, as did Siberian larch and Scots pine at Fort St. John. About 10% of the Siberian larch at Takhini are barely surviving following frost damage and feeding by snowshoe hares in 1990-91.

Mammal damage

There were significantly fewer reports of feeding damage to conifers by mammals in 1994 than in the previous three years.

Porcupines

Mortality of young and semimature lodgepole pine and western hemlock caused by porcupines chewing stem and branch bark were mapped in 77 chronically infested areas totaling about 700 ha in the western part of the Prince Rupert Region. Stocking levels, particularly in spaced lodgepole pine and western hemlock stands, have been significantly affected. There was no additional significant damage reported in other regions; last year in the Cariboo Region, groups of lodgepole pine near Mt. Alex drainage west of Williams Lake were severely debarked and top-killed.

Squirrels

There were no new reports of feeding damage by squirrels in lodgepole pine in northwestern British Columbia and the southwestern Yukon Territory, or in the Cariboo and Vancouver regions; in the three previous years, widespread damage was recorded in these areas.

Voles

Populations of meadow voles, *Microtus* sp., declined in areas where seedlings were killed last year at sites near Revelstoke in the Nelson Region, in a plantation near Mission in the Vancouver Region, and at one site in the western part of the Prince Rupert Region. No new or additional seedling mortality was reported in previously damaged sites in the northern part of the Kamloops Region and the eastern part of the Nelson Region.

Climatic injury

This year there was little or no discoloration of seedlings and young conifers caused by climatic factors, mostly winter drying and frost. This followed widespread, highly visible needle discoloration of lodgepole pine on south-facing slopes in the Rancheria River Valley and near Watson Lake, and in the Prince Rupert Region near Good Hope Lake, in the Telkwa River Valley, and at McKendrick Pass north of Smithers, and mortality of young spruce due to frost along the Morice-Telkwa road and in the Lakelse River drainage.

Foliar discoloration but no bud mortality was common on regeneration true fir conifers in higher-elevation young stands west of Campbell River on Vancouver Island. This discoloration was attributed to cold weather in early summer.

Nursery and seed orchard pests

The Nursery Pest Clinic assessed 173 samples from forest nurseries in 1994 and provided early recognition of problems in nursery stock and cultural recommendations for their control. Surveys of coastal and interior seed orchards previously conducted by the Forest Insect and Disease Survey of the Canadian Forest Service were implemented by the Forest Health Branch of the British Columbia Ministry of Forests. Forest tree seed collected in 1994 in British Columbia and Yukon Territory for international trade totaled 580 kilograms from four species of conifers. The seed, valued at an estimated $464,000, is certified under the Organization for Economic Cooperation and Development (OECD) at the Pacific Forestry Centre in Victoria.

The incidence of shoot and foliage diseases, including *Sirococcus strobilinus* and *Meria laricis*, was reduced by a hot, dry late spring and summer. Keithia leaf blight, *Didymascella thujina*, caused fewer losses in western red cedar stock than last year, due in part to changes in sowing and growing regimes. Grey mould, *Botrytis cinerea*, was common at some nurseries due to cultural or environmental conditions. The dry, hot weather conditions encouraged a seedling root rot, *Fusarium* sp., which caused severe damping-off and hypocotyl rot in both Douglas-fir and spruce at nurseries where shade protection was not used. Other seedling root rots, *Cylindrocarpon* sp., *Pythium* sp., and storage mould, *Septonema* sp., were significantly less common on nursery stock than last year.

Biomonitoring and Acid rain surveys

There were no changes in the condition of trees and ground cover attributable to acid rain at 27 permanent sample plots monitored across British Columbia in 1994.

Plot assessments found 13 dead trees (less than 1% of all trees) in nine plots; one was found in each of the plots near Hope, Clinton, Whitehorse, and on Saturna and Salt Spring islands, and the remainder were found in north shore watersheds in the Vancouver Region. New tree mortality was caused mostly by suppression (10) and storm damage (3). Since establishment, 10% of the plot trees have died, mostly due to natural succession or insects and diseases.

The 27 plots have been established since 1984 across seven 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) zones, two spruce (6) zones and Ponderosa pine (1) . An additional plot is proposed to be located in the newly established Long Beach Model Forest near Tofino on Vancouver Island. Within the national ecozone classification, 13 plots are in the Pacific maritime, 11 are in the montane cordillera zone, two are in boreal plains, and one is in the boreal cordillera. There is also a wide range in elevation, plots have been 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.

A study to expand the knowledge of biodiversity and to assess trapping methodology was initiated at plots near Shawnigan Lake near Victoria and near Monte Creek north of Kamloops. A pitfall trap system, (cups in the ground at ends of four metal barriers at right angles to a central cup) and a screen flight interceptor trap with two containers were established at each site. Traps were monitored every two weeks from mid-May to late September.

About 515 beetle specimens and 1990 ant specimens were collected in the traps and sorted and mounted for identification. Preliminary results indicate that the addition of flight interceptor traps to a monitoring program greatly expanded the diversity of species and families captured at both sites. The relative efficiency of flight interceptor traps and the pitfall traps varied between the two sites. At Shawnigan Lake the pitfall traps captured almost three times the number of beetles as the flight interceptor trap, but at Monte Creek captures of beetles were almost equal.

Deciduous and Ornamental Tree Pests

Gypsy moth

Lymantria dispar

Surveys to detect introductions of gypsy moth and to monitor populations in previously infested areas in British Columbia continued for the seventeenth year with the deployment of more than 8700 sticky traps, in an interagency cooperative survey with the Plant Health Division of Agriculture Canada, the Forest Insect and Disease Survey of the Canadian Forest Service-and the British Columbia Ministry of Forests.

Only 39 adult males (33 of the introduced European strain, six of the Asian strain) were recovered from 34 traps in nine municipalities in British Columbia in 1994. This was down from 141 in 100 traps at 15 locations in 1993, and was the lowest total number trapped in British Columbia since 1989. Six moths trapped in 1994 were confirmed to be of the Asian biotype by mitochondrial DNA analysis. Only two Asian gypsy moths were trapped in British Columbia in 1993. The Asian biotype was first found in the province in 1991.

Most of the adult males trapped in 1994 were at previously active areas including Chilliwack (15), Hope (8), Nanaimo (5, including two Asian), Oak Bay (2), and Gabriola Island (2). Additional males were trapped at Surrey (3 Asian), Burnaby (2), Langley (1 Asian), and New Westminster (1).

Male moths were caught for the fourth consecutive year at Langley and Surrey, for the third consecutive year at Chilliwack, Hope, Nanaimo, New Westminster and Oak Bay, and for the second consecutive year on Gabriola Island near Nanaimo. New catches were made at Burnaby (2).

Increasing catches of males of the European strain during 1993 at Hope (32), Whiskey Creek west of Parksville (32) and Nanaimo (29), and continuing captures at Victoria (5), prompted aerial applications of *Bacillus thuringiensis* var. *kurstaki* (Foray 48B) in late April and May 1994 over a total of 680 ha at five locations in an effort to eradicate populations. One 14-ha site in south Vancouver was treated from the ground with the same product. No males were caught in post-treatment assessments at Whiskey Creek, Victoria, and south Vancouver; however, additional males were trapped at Hope (8) and Nanaimo (2).

There were no males caught in 278 traps deployed by the Forest Insect and Disease Survey of the Canadian Forest Service in 157 provincial parks and 89 forested recreation areas in national parks, commercial campgrounds, and north coast ports.

Tent caterpillars

Malacosoma spp.

Trembling aspen and other trees and shrubs were defoliated by the forest tent caterpillar, *Malacosoma disstria*, in more than 650 separate locations totaling 93 600 ha in the Cariboo and Prince George regions (Map 9). The increase, up 10% from 1993, was mostly from Horsefly to Quesnel and to a lesser extent south of Prince George, near McBride, and in the Peace River area. Populations remained endemic in the northern part of the Kamloops Region following a collapse last year.

Defoliation of trembling aspen in the Cariboo Region was mostly severe over 52 000 ha in 471 patches, up from 47 000 ha in 1993. This was the sixth year of outbreak in the region. Defoliation occurred mostly in stands between Quesnel and Horsefly lakes, and to a lesser extent from Horsefly to Williams Lake.

In the Prince George Region, trembling aspen and other deciduous trees were defoliated over 41 500 ha in 180 areas, similar to 1993. Increased populations south of Prince George to Quesnel severely defoliated stands over 33 000 ha, up from 22 000 ha in 1993. Near McBride, defoliation was severe over 4500 ha from Valemount to Rider, down from 16 000 ha in 1993. The area of mostly severe defoliation near Taylor in the Peace River area increased to 1500 ha from several hundred hectares in 1993.

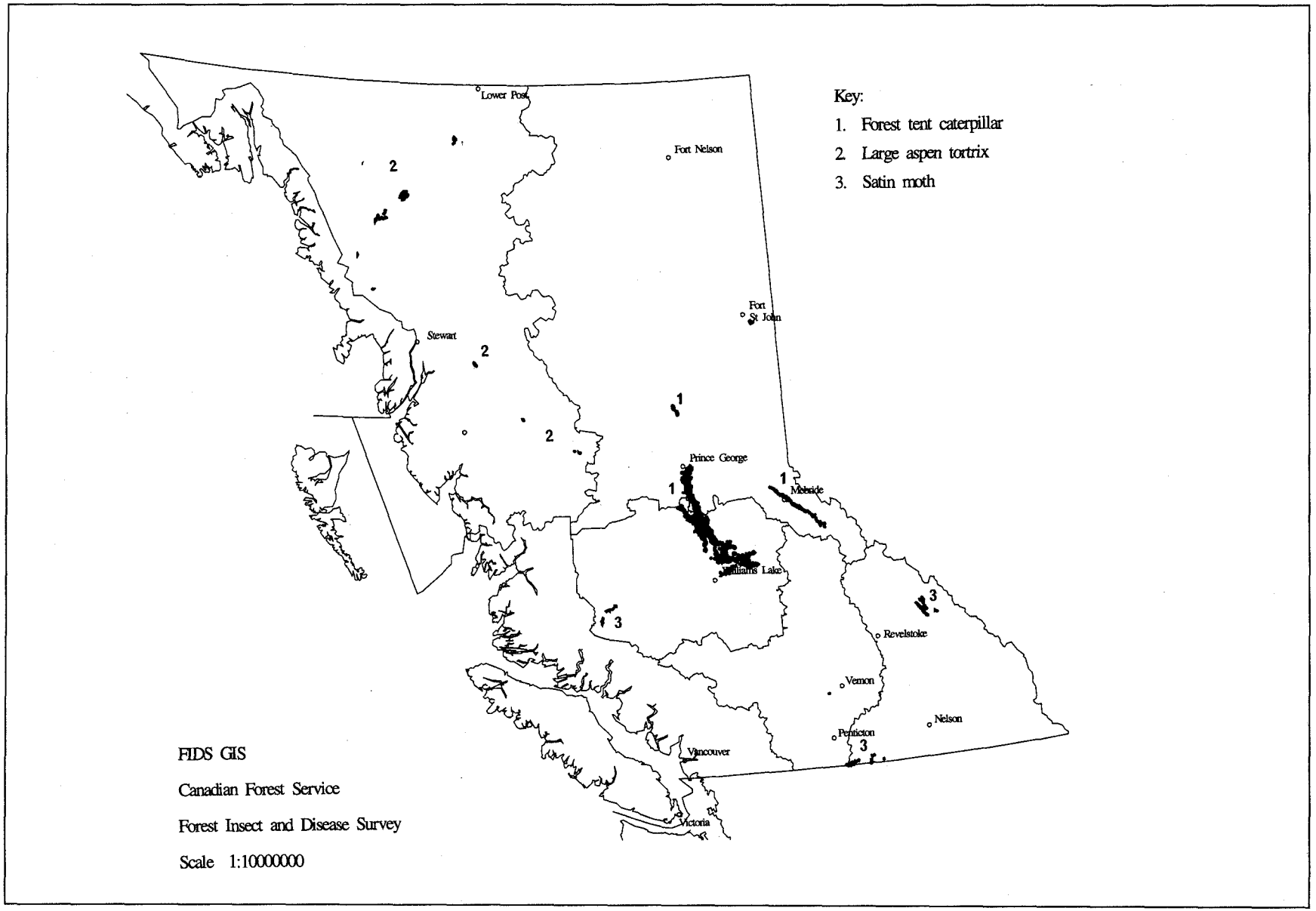
Egg samples from 21 areas in the Cariboo and Prince George regions indicate continuing populations in 1995 and defoliation in most recently infested stands. Moderate and severe defoliation is forecast in most areas. An average of 21 new egg masses were found per tree (range 7-64) at five sites near Prince George, 10 (range 6-15) at five sites near McBride, and an average of eight egg masses per tree was found near Dawson Creek. This is down from an average of 23 for the entire region in 1993. In the Cariboo Region an average of 26 egg masses were counted per tree (range 0-85) at 10 sites, up from 16 in 1993. Counts greater than 11 egg masses per tree usually result in moderate and severe defoliation.

Larval mortality from parasites and disease averaged 85% (range 51-99%) at seven sites in the Cariboo Region. This was up from 76% last year, and is enough to reduce populations at some of these locations in 1995.

Northern tent caterpillar, *M. californicum pluviale*, populations increased for the second consecutive year and defoliated alder and other trees and shrubs in east coastal areas of Vancouver Island, some Gulf Islands, and for the first time on Texada Island, near Powell River and Boston Bar. Willow and other deciduous shrubs were severely defoliated in the western part of the Prince Rupert Region near Meziadin Junction for a second year, and in the Nass River drainage, but populations near Terrace remained endemic.

Defoliation of a variety of trees and shrubs, particularly alder, was again severe in widespread patches in the Victoria area and on Saturna Island. Increased numbers of larval colonies occurred at widely scattered locations from Sooke to Campbell River, particularly in the Cowichan River estuary and from Buttle Lake to Gold River, near Powell River and on Texada Island. Small patches of alder were again totally defoliated over about one hectare at Mira Creek west of Buttle Lake on central Vancouver Island. High elevation alder in the lower Nahatlatch River drainage and at Mohokum Creek northwest of Boston Bar was lightly defoliated. This was the first record of defoliation in these areas in many years.

Increased populations severely defoliated mostly willows and scrub alder in three patches totaling about 100 ha, and along roadsides between Van



Map 9. Areas where defoliation of aspen was detected by aerial surveys in 1994.

Dyke Camp to north of Meziadin Junction in the Prince Rupert Region for a second year. Light defoliation occurred for the first time in many years near Smithers. Northern tent caterpillars were common but less damaging near Aiyansh in the Nass River Valley, but remained endemic following a population decline in and near Terrace and in the Skeena River Valley.

The numbers (more than five per tree) of overwintering egg masses commonly found on many trees and shrubs in the Saanich area, east coastal areas of Vancouver Island, on Saturna Island and at Meziadin Junction, indicate continuing populations and defoliation in these areas in 1995, but no defoliation is forecast at Aiyansh.

Large aspen tortrix

Choristoneura conflictana

The area of trembling aspen defoliated by large aspen tortrix in the southwestern Yukon Territory, the Prince George Region, and the western part of the Prince Rupert Region in 1994 totaled more than 23 000 ha, up from 9400 ha in 1993 (Map 9).

Defoliation was mostly moderate and severe over 10 000 ha in about 10 patches in southcentral Yukon Territory near Mayo (up threefold from 1993) and between Stewart Crossing and Dawson. Defoliation was less severe in stands near Teslin Lake and Braeburn. In the Prince George Region, defoliation increased to severe in the third year of outbreak in the western part of the region in the Nechako River Valley in patches totaling about 3000 ha west of Vanderhoof to Fort Fraser. This damage is similar to that recorded in 1993 but is less than the 24 000 ha recorded in 1992. Increased populations in the western part of the Prince Rupert Region severely defoliated aspen over about 7875 ha for a second year north of Kitwanga in the Cranberry River Valley, near Telegraph Creek, northeast of Dease Lake, in the Iskut River Valley, and near Telkwa. Defoliation near Burns Lake in the eastern part of the region adjacent to infestations in the western part of the Prince George Region totalled about 150 ha.

Larval mortality from parasitism and disease averaged 55% at three sites in the Yukon near Teslin, Mayo, and Dawson City, mostly by Hymenoptera. This indicates a reduction of populations in 3- to 4-year-old infestations in 1995, but a likely continuance of newer infestations, mostly in the Prince George Region, will likely continue.

Satin moth

Leucoma salicis

Satin moth defoliated trembling aspen, cottonwood, and willow in parts of the Kamloops and Nelson regions, and for the first time in the Cariboo Forest Region over 5350 ha in 127 separate areas in 1994, up from 3000 ha in 1993 (Map 9). Most of the damage was in the East Kootenay part of the Nelson Region over 4650 ha and the remainder was in the southwestern part of the region and adjacent areas in the southeastern part of the Kamloops Region, and in the Chilcotin. Satin moth adults, but as yet no larvae, were detected in Prince George Region for the first time.

Increasing populations of satin moth in the northern part of the East Kootenay in the Nelson Region severely defoliated trembling aspen particularly near Golden and in the Blaeberry River Valley in 23 patches totaling 4600 ha, up from 2650 ha last year; this was the second year of increased satin moth damage in this area. Defoliation in the West Kootenay between Greenwood and Anarchist Mountain declined to mostly light over about 80 ha, down from 250 ha in 1993. Mortality of aspen severely defoliated since 1991 was widespread in stands totaling 360 ha between Anarchist Mountain and Greenwood.

Populations in the southeastern part of the Kamloops Region declined for a second consecutive year and lightly to moderately defoliated only four patches of trembling aspen totaling 170 ha, down from 250 ha last year. Defoliated stands were near Anarchist Mountain, Yankee Flats, and Shorts Creek. None occurred west of Lillooet where, in 1993, defoliation was light at Hurley and Cayoosh creeks and along the north shore of Carpenter Lake. Populations also declined between Hedley and Keremeos, and east of Princeton, following two years of light defoliation. Increased populations defoliated aspen in 13 patches totaling 165 ha near Tatla Lake in the Chilcotin area of the Cariboo Forest Region, about 150 km from previously known satin moth

population centres. This was the first record of defoliation by this pest in this region.

Moth flights indicating continuing populations occurred at Golden to Cranbrook, and for the first time on record in the Robson Valley in the Prince George Region from Valemount to McBride. Defoliation near Avola in the Kamloops Region south of Valemount in 1986 was previously the most northern recorded infestation.

A poplar rust

Melampsora medusae f. sp. deltoidae

The poplar rust, *M. medusae* f.sp. *deltoidae*, is pathogenic to many hybrid poplar clones used in plantations, but has not yet caused measurable damage on native *P. trichocarpa*. It was found again on hybrid poplars in the Fraser Valley and on Vancouver Island, where it was first found in British Columbia in 1993.

Damage in British Columbia plantations was severe on susceptible *P. trichocarpa* x *P. deltoides* clones which were repeatedly defoliated. Commercial nurseries removed susceptible clones and replaced them with more resistant hybrids. Mortality of susceptible clones has not yet been reported in British Columbia, but was reported last year in U.S. plantations where the rust has been established since 1991.

The Eurasian poplar rust, *Melampsora larici-populina*, was discovered in Oregon and California in 1991 and in Washington state in 1993, but it is still not known to occur in Canada. Since its discovery on hybrid poplar (*P. trichocarpa* X *deltoides*) plantations on the lower Columbia River in Oregon and Washington, the rust has caused limited damage to susceptible hybrids.

A cottonwood sawfly

Nematus currani

Native black cottonwood on islands within Tree Farm License (TFL) 43 in the Fraser River near Chilliwack were defoliated by cottonwood sawfly over about 600 ha. This was down from 730 ha in 1993, the third consecutive year of infestation. Defoliation was severe over 100 ha, moderate over 200 ha, and light over the remainder, mostly from Herrling Island near Agassiz to Matsqui Island near Mission. Hybrid poplars in some managed plantations on Carey Island and at Harrison Mills were again very lightly defoliated. These defoliated trees later produced new leaves; tree growth is likely to be seriously affected only if severe defoliation occurs for additional years. The decline, mostly in the Herrling Island group was attributed in part to infection by insect pathogens, *Beauvaria* sp. and *Entomophthora* sp., isolated from larvae in 1993.

Aspen leaf rollers

Epinotia sp.
Pseudexentera oregonana
Anacampsis niveopulvella

Aspen leafroller populations in trembling aspen in the Nelson Forest Region declined significantly but increased near Terrace. Only trace defoliation was observed in small patches in parts of the East Kootenay from Windermere to Fairmont. This was down from moderate defoliation over about 300 ha in the Columbia and Kicking Horse river valleys near Golden, and over 50 ha in the lower Bull River Valley east of Cranbrook in 1993, the fifth year of infestation. The defoliator, *Epinotia* sp. previously had been found only in small numbers on single or small groups of aspen, birch, balsam poplar and other hardwoods, particularly in Alberta. Increased leaf roller population defoliated 5-80% of the foliage on 10-40% of the aspen throughout the Terrace area.

Birch leaf miners

Lyonetia speculella
Fenusa pusilla
Profenusa thomsoni

Birch leafminer, *Lyonetia speculella*, populations discolored stands over about 3800 ha in parts of three forest regions, down from 12 000 ha in two regions last year. Most damage was in the West Kootenay in the Nelson Forest Region over 2650 ha and some lesser damage occurred in the western part of the Prince Rupert Region over 660 ha. In the eastern part of the Kamloops Region, the area damaged by the birch leafminer increased over 495 ha. Other leaf miners, *P. thomsoni*, and *F. pusilla*, caused widespread moderate to severe discoloration of most birch stands in the upper Fraser Valley and lower Fraser Canyon in the Vancouver Region for the third consecutive year.

Leafminer populations declined near Revelstoke following two years of increase, but they moderately or severely discolored birch over about 2650 ha in 10 patches in the West Kootenay near Castlegar and Harrop. Discoloration of birch was severe over about 660 ha between Echo Lake and Bob Quinn Camp in the Iskut River Valley in the northern part of the Prince Rupert Region, down from 5000 ha last year. Patches of moderately discolored birch were also common near Terrace. Birch stands in parts of the Vancouver Region were moderately discolored for a third consecutive year by a birch leafminer, *F. pusilla*. Most birch stands in the lower mainland to near Yale were affected, including those in the upper Fraser Valley, along the North shore, and along the Lougheed Highway.

Winter moth

Operophtera brumata

Defoliation of deciduous trees by the winter moth in urban areas of Vancouver declined overall, but very light defoliation was again common at a few locations in the Greater Victoria area.

Boulevard trees, particularly near Marine Drive, Point Grey, and other areas in southwest Vancouver, were very lightly to lightly defoliated, following more common and severe defoliation last year. Very light defoliation of fruit and other deciduous trees was again common in Ladner, Cloverdale, and Surrey for a third year, and at widely scattered areas throughout Richmond and Delta for a second year.

Very light defoliation of deciduous hosts, including Garry oak in small patches, was again common in the Greater Victoria area, mostly in chronically infested areas at Cattle Point and in the Lansdowne area.

Parasitism has effectively maintained winter moth populations at reduced levels on Vancouver Island. A cooperative program between Natural Resources Canada and the City of Vancouver was implemented to introduce additional parasites to the lower mainland. Parasitism at three sites on the lower mainland by *Cyzenis albicans*, an introduced parasitic fly, averaged 9% (range 5-13%) in 1993.

Jumping gall wasp

Neuroterus saltatorius

Discoloration and premature foliage loss of Garry oaks by the gall wasp on southern Vancouver Island declined slightly in most areas for a second consecutive year. This decrease followed annual increases in damage since 1986 when the gall wasp was first observed in the area. Severe leaf scorch occurred, however, for the first time at Deep Cove, Duncan, and Maple Bay. Elsewhere, the area of trees moderately discolored was widespread from Sooke to Oak Bay and from Beacon Hill Park in Victoria, north to Deep Cove in North Saanich. Very light damage by low numbers of the wasp was again common north of Duncan and at Nanaimo, and very light damage was recorded for the first time on Salt Spring Island.

The continued decline in gall wasp populations, particularly south of Brentwood Bay, was likely due to increased parasitism, predation, and host resistance. Parasitism of gall wasp populations by chalcids averaged about 10% at six sites, similar to 1993. Populations are expected to decline further in 1995, mostly where high populations have persisted for up to seven years, particularly near Beaver Lake, Royal Oak and areas of high Quadra Street.

An oak leaf phylloxeran

Phylloxera sp. nr. glabra

From 25 to 100% of the foliage on 10% of the Garry oak trees throughout southern Vancouver Island was discolored and subsequently defoliated by the introduced phylloxeran (an aphid-like sucking insect). This damage is similar to that observed previous years, and occurs chronically on the same trees each year. This damage has progressively reduced tree vigour, and has resulted in branch and occasional tree mortality. Garry oaks have also been damaged by the phylloxeran on Galiano, Salt Spring, Saturna, Hornby, and Thetis Islands, in east coastal areas on Vancouver Island north to Comox, and in an isolated stand at Sumas Mountain near Chilliwack. Ornamental oak at Kelowna are also damaged. Predators of the phylloxeran were common, but are still too few to effectively reduce populations. Movement of English oak nursery stock from coastal nurseries has likely facilitated establishment of the phylloxeran in new areas.

New Records of Occurrence and Distribution

Ten species of fungi were collected in the Pacific and Yukon Region for the first time in 1994. These included blue stain fungi on spruce and Douglas-fir, leaf rusts on hybrid poplar and alder, a saprophyte on alder, leaf spots on herbaceous plants, canker fungi on alder and ornamental shrubs, a saprophytic fungus, and two mushrooms. Additionally, 29 diseases were recorded on new hosts for the first time in this region. These included a needle blight and casts on native pines and on Pacific yew, leaf diseases on poplar, alder and Garry oak, wood decay and blue stain on spruce, and heart and butt rot in an ornamental tree.

Four insects were collected for the first time by the Forest Insect and Disease Survey of the Canadian Forest Service in this region, three collections were significant extensions of their known distributions within the region, and four were recorded for the first time on a new host. In addition, several bark beetles, including *Hylurgus ligniperda* and *Xyleborus affinis*, and a round-headed woodborer, *Arhopalus* sp., were intercepted in dunnage on a freighter. Arbor-vitae weevil, *Phyllobius intrusus*, was found for the first time in the region, feeding on ornamental western red cedar and eastern white cedar in Langley. An unidentified species of a tortricid moth, *Clepsis* sp. was found for the first time in British Columbia on ornamental yew at Saanichton. A lady beetle, *Harmonia axyridis*, was recovered for the first time in British Columbia, on Vancouver Island, the Gulf Islands, and in the Fraser Valley; this followed its release against aphids and scale insects in Washington State in the 1970s. A predacious lady beetle, *Chilocoris bipustulatus*, was collected on ornamental cedar at Langley. Extensions of previously known distributions included balsam woolly adelgid, *Adelges piceae*, found on regeneration amabilis and alpine fir north of Pemberton, yew big bud mite, *Cecidophyopsis psilapsis*, on Pacific yew near Bella Coola, jumping gall wasp, *Neuroterus saltatorius*, on Garry oak for the first time on Salt Spring Island, and satin moth, *Leucoma salicis*, defoliated aspen near Tatla Lake in the Chilcotin about 150 km west of the closest moth populations at Williams Lake. New host records in British Columbia in 1994 included another species of *Clepsis* on ornamental cedar at Coquitlam, a leaf roller, *Herpteogramma pertextalis*, on black cottonwood at Harrison Mills, ambermarked birch leafminer, *Profenusa thomsonii*, on beaked hazelnut near Mica Creek, and an aphid, *Rhopalosiphon* sp., on ornamental spruce at Ladner.

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, and links with the Petawawa National Forest Institute and the Forest Pest Management Institute. The program provides perspectives on forest health (insects and diseases) including biomonitoring to regional and national forest managers, quarantine agencies, researchers, educators, the public and international cooperators.

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

Verification of the damaging agents is performed by herbarium and insectary staff. The FIDS collections contain 62 000 disease specimens representing 3300 organisms, and 66 000 insects representing 6000 different species. These and their associated records are essential for the correct identification of forest pests affecting forest health in the Pacific and Yukon Region.

Analysis and presentation of insect or disease maps and data, in combination with major geographic boundaries, biogeoclimatic zones and forest inventory and climatic information, utilizes a computer-based geographic information system (GIS). 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 and enjoyment of forest ecosystems.