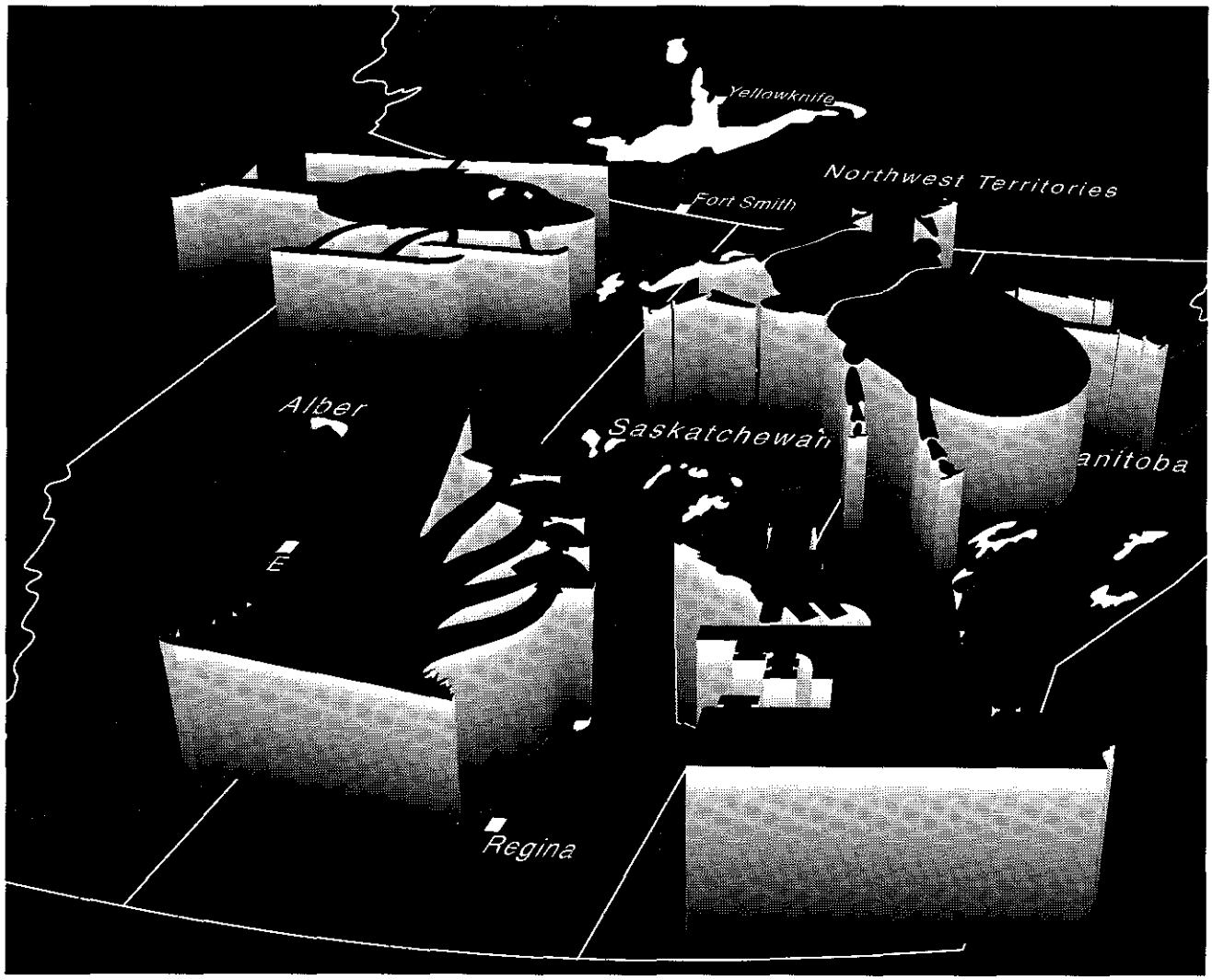
Forest insect and disease conditions in west-central Canada in 1993 and predictions for 1994

J.P. Brandt

Northwest Region • Information Report NOR-X-335



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The Canadian Forest Service's Northwest Region is responsible for fulfilling the federal role in forestry research, regional development, and technology transfer in Alberta, Saskatchewan, Manitoba, and the Northwest Territories. The main objectives are research and regional development in support of improved forest management for the economic, social, and environmental benefit of all Canadians. The Northwest Region also has responsibility for the implementation of federal–provincial forestry agreements within its three provinces and territory.

Regional activities are directed from the Northern Forestry Centre in Edmonton, Alberta, and there are district offices in Prince Albert, Saskatchewan, and Winnipeg, Manitoba. The Northwest Region is one of six regions and two national forestry institutes of the Canadian Forest Service, which has its headquarters in Ottawa, Ontario.

Service canadien des forêts, région du Nord–Ouest, représente le gouvernement fédéral en Alberta, en Saskatchewan, au Manitoba et dans les Territoires du Nord–Ouest en ce qui a trait aux recherches forestières, à l'aménagement du territoire et au transfert de technologie. Cet organisme s'intéresse surtout à la recherche et à l'aménagement du territoire en vue d'améliorer l'aménagement forestier afin que tous les Canadiens puissent en profiter aux points de vue économique, social et environnemental. Le bureau de la région du Nord–Ouest est également responsable de la mise en oeuvre des ententes forestières fédérales–provinciales au sein de ces trois provinces et du territoire concerné.

Les activités régionales sont gérées à partir du Centre de foresterie du Nord dont le bureau est à Edmonton (Alberta); on trouve également des bureaux de district à Prince Albert (Saskatchewan) et à Winnipeg (Manitoba). La région du Nord–Ouest correspond à l'unedes six régions de Service canadien des forêts, dont le bureau principal est à Ottawa (Ontario). Elle représente également deux des instituts nationaux de foresterie de ce Ministère.

FOREST INSECT AND DISEASE CONDITIONS IN WEST-CENTRAL CANADA IN 1993 AND PREDICTIONS FOR 1994

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ABSTRACT

Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories are summarized for 1993. Spruce budworm, forest tent caterpillar, large aspen tortrix, aspen leafroller, mountain pine beetle, Douglas-fir beetle, spruce beetle, spruce gall midge, and Dutch elm disease infestations are discussed. Forecasts of spruce budworm, jack pine budworm, and forest tent caterpillar populations are reported for 1994. Other pests specifically affecting forests, young stands, aspen forests, and a forest nursery are also discussed. An update of surveys for acid rain symptoms in permanently established ARNEWS (Acid Rain National Early Warning System) plots is also reported. Other noteworthy insects, diseases, and tree damage agents are presented in tabular form.

RÉSUMÉ

La situation des insectes et des maladies des arbres en Alberta, en Saskatchewan, au Manitoba et dans les Territoires du Nord-Ouest est résumée pour 1993. Les infestations de la tordeuse des bourgeons de l'épinette, de la vivrée des forêts, de la tordeuse du tremble, de l'enrouleuse du tremble, du dendroctone du pin ponderosa, du dendroctone du douglas, du dendroctone de l'épinette, de la cécydomyie gallicole de l'épinette et de la maladie hollandaise de l'orme sont traitées. Des prévisions sur l'état des populations en 1994 sont présentées dans le cas de la tordeuse des bourgeons de l'épinette, de la tordeuse du pin gris et de la livrée des forêts. D'autres ravageurs attaquant spécifiquement les forêts, les jeunes peuplements, les tremblaies et une pépinière forestière sont également étudiés. Une mise à jour des relevés sur les symptômes des pluies acides dans les parcelles permanentes du DNARPA (Dispositif national d'alerte rapide pour les pluies acides) est également donnée. D'autres insectes, maladies et agents de dommages dignes de mention sont présentés sous forme de tableau.

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NOTE

The exclusion of certain manufactured products does not necessarily imply disapproval nor does the mention of other products necessarily imply endorsement by Natural Resources Canada.

The Forest Insect and Disease Survey (FIDS) unit at the Northern Forestry Centre (NoFC) of the Canadian Forest Service, Natural Resources Canada is responsible for conducting and reporting insect and disease surveys of forests in Alberta, Saskatchewan, Manitoba, and the Northwest Territories (Fig. 1). In addition to NoFC staff, aid is received from various other federal, provincial, and industrial agencies in the collection of survey data. In particular, the assistance of the following agencies is gratefully acknowledged: Abitibi-Price Inc., Manitoba; Agriculture and Agri-Food Canada; Alberta Environmental Protection; Manitoba Natural Resources; Northwest Territories Renewable Resources; Parks Canada; Saskatchewan Environment and Resource Management; and Weyerhaeuser Canada Ltd., Saskatchewan Division.

In type and scope, the forest insect and disease surveys have included aerially mapped pest infestations, ground plot observations for pest collection and identification, measurement of damage intensity, updates of pest distributions and their hosts, and descriptions of pest control projects throughout the Northwest Region, which includes Alberta, Saskatchewan, Manitoba, and the Northwest Territories.

This report summarizes forest insect and disease conditions and other tree-damaging agents within the three prairie provinces and the Northwest Territories in 1993. Collections of insect and disease specimens made during the surveys are maintained at NoFC; they provide continuity for the historical records of both a permanent insect collection and a herbarium, and for the national

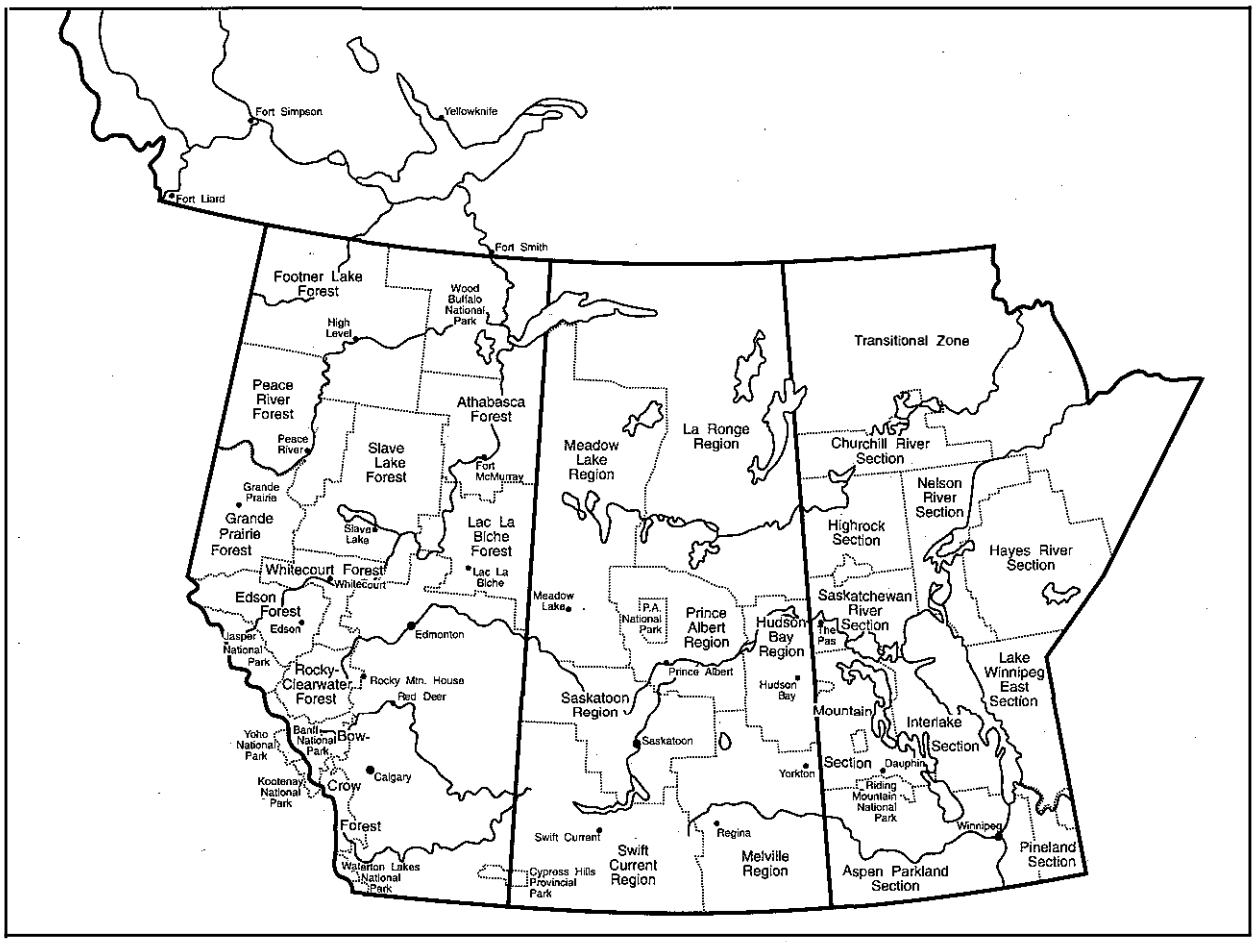

Figure 1. Forest districts and regional boundaries of the three prairie provinces and the Northwest Territories.

FIDSINFOBASE (the Forest Insect and Disease Survey Information System). The collections contain information to support plant quarantine, special forest surveys, and research projects. Two national surveys in which FIDS staff participate are the gathering of tree-damage-related information to develop pest depletion loss estimates, and a program of acid rain symptom detection and monitoring known as ARNEWS (Acid Rain National Early Warning System). Results from special surveys, such as those conducted in nurseries, seed orchards, and plantations, and in permanent sample plots (PSPs) are also reported. Other tree-damaging agents that affect shelterbelts, and shade and ornamental trees in urban and high-use areas are summarized in tabular form.

Information in this report is based on forest insect and disease surveys and collections made from May to September, 1993, by the following FIDS ranger staff: Roger Brett, Mike Grandmaison, Howard Gates, Colin Myrholm, and Daryl Williams. At the NoFC, other contributors to this report were Dr. Herb Cerezke, entomologist; Dr. Yasu Hiratsuka, mycologist; Dr. David Langor, entomologist; Dr. Ken Mallett, pathologist; Paul Maruyama, mycology technician; Dr. Jan Volney, entomologist, FIDS Head, and Project Leader for Forest Insect and Disease Survey and Management Systems; and Andu Yohannes, entomology technician.

SPRUCE BUDWORM *Choristoneura fumiferana* (Clem.)

In the Northwest Region during 1993, spruce budworm infestations occurred in nearly all the same locations reported in 1992. Infestations are shown in Figure 2. Infestation areas in Alberta, Saskatchewan, and Manitoba decreased substantially in 1993, by about 66, 35, and 43%, respectively. In the Northwest Territories, spruce budworm defoliation area increased by 92%. Spruce budworm infestations in the Northwest Region covered a composite area estimated at 293 331 ha, compared to the 345 906 ha in 1992; this is a decrease of about 15% (Table 1).

In 1993, aerial spraying programs using the biological insecticide, *Bacillus thuringiensis* var. *kurstaki* (*Bt*) were implemented to suppress spruce budworm populations and protect foliage. The total area treated in Alberta was 8230 ha in three administrative forests (Table 2). In Saskatchewan, 34 017 ha were treated in the Big River area.

In **Alberta**, several small infestations on white spruce (*Picea glauca* [Moench] Voss) with defoliation classed as light[1] in 1992 did not occur in 1993. These small infestations were west of Bowden, near Millett, in Big Knife Provincial Park, in Elk Island National Park, in Cypress Hills Provincial Park, and near Morningside. A small infestation along the Saskatchewan River in Edmonton continued from 1992 into 1993. No aerial spraying program was considered for this infestation.

Major infestations in the administrative forests were monitored with air and ground surveys by staff of the Alberta Land and Forest Services and FIDS. These infestations continued in the Footner Lake, Peace River, Athabasca, and Lac La Biche forests. The combined total area was 48 546 ha, of which 96% was rated as moderate, moderate-to-severe, and severe. The remaining area, 2073 ha, was rated as light.

In the Footner Lake Forest, the total area of infested white spruce forests mapped in 1993 was 43 616 ha. Most of this occurred in the same areas reported in 1992, but the infested area has decreased substantially. The main infestation area, first reported in 1987, occurred adjacent to the Chinchaga River west of High Level and east along both sides of Highway 58 (28 249 ha). Another large infestation occurred along the Sousa Creek and up onto the Zama ridge (10 036 ha). Other mapped infestation areas with defoliation classed as moderate-to-severe were along the Hay River near

[1] Subjective terms are used in this report to describe defoliation classes. There are six defoliation classes: nil, light, light-to-moderate, moderate, moderate-to-severe, and severe.

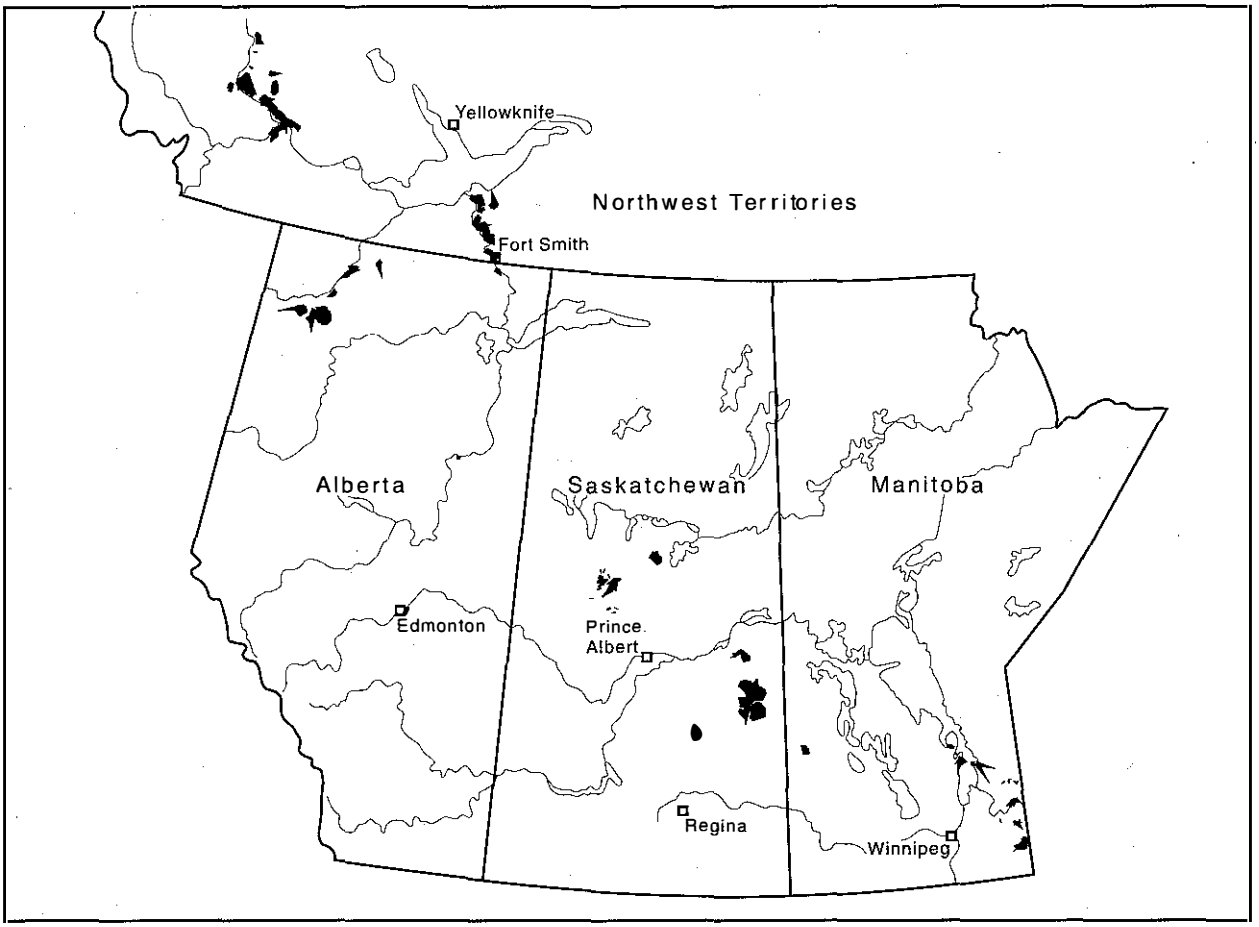

Figure 2. Areas of moderate-to-severe defoliation caused by spruce budworm in 1993.

Table 1. Summary of spruce budworm defoliation in the Northwest Region, determined from aerial and ground surveys in 1992 and 1993

Location	Area of defoliation (ha) 1992	1993	Change (%)
Alberta	142 650[a]	48 546[a]	–66
Saskatchewan	87 000[b]	56 617[a]	–35
Manitoba	26 256[a]	15 051[a]	–43
Northwest Territories	90 000[a]	173 118[a]	+92
Total	345 906	293 331	–15

[a] Includes all areas with visible defoliation.

[b] Includes defoliation classes rated from moderate to severe. Some additional areas had defoliation classed as light but the area is unknown.

Table 2. Spruce budworm control operations in Alberta and Saskatchewan in 1993 using aerial applications of *Bacillus thuringiensis* var. *kurstaki* (*Bt*)

Location	Area treated (ha)	Host tree species	*Bt* product	Application rate (BIU)[a] and volume/ha
Alberta				
Footner Lake Forest	4 652	White spruce	Dipel 132[b]	25.4 BIU; 2.0 L[c]
Athabasca Forest	3 146	White spruce–balsam fir	Dipel 132[b]	25.4 BIU; 2.0 L[c]
Lac La Biche Forest	432	White spruce–balsam fir	Dipel 132[b]	25.4 BIU; 2.0 L[c]
Saskatchewan				
Prince Albert Region (Weyerhaeuser Canada Ltd.)	34 017	White spruce–balsam fir	Foray 48B[d]	30.0 BIU; 2.4 L[e]

[a] BIU = Billion International Units.

[b] Oil-based formulation.

[c] Indicates two applications at the same rate, 5 days apart.

[d] Water-based formulation.

[e] Some spray blocks (total area 28 518 ha) had two applications.

Meander River (1090 ha), and along the Steen (3110 ha) and Yates (1131 ha) rivers. No spruce budworm defoliation was observed during aerial surveys west of Zama Lake along the Hay River or north of Zama Lake along the Zama and Amber rivers.

An aerial spraying program using *Bt* was conducted in an area west of High Level along Highway 58 (Table 2). This was the fourth consecutive year of *Bt* application in the Footner Lake Forest. In addition to aerial spraying to manage spruce budworm populations, the province is targeting severely damaged stands for harvesting to reduce the risk of timber losses.

In the Athabasca and Lac La Biche forests the combined area of infested white spruce–balsam fir (*Abies balsamea* [L.] Mill.) forests was 3930 ha. About 47% of this area (1857 ha) had defoliation classed as moderate. The remainder, about 2073 ha, was classed as lightly defoliated. All infestations occurred along the Athabasca River in about the same locations as in 1992. *Bacillus thuringiensis* was applied over several spray blocks totaling 3146 ha in the Athabasca Forest and 432 ha in the Lac La Biche Forest in 1993. It appears that populations in both of these forests are collapsing (i.e., the population is dropping from epidemic to low endemic levels).

In the Peace River Forest, spruce budworm infestations occurred over 1000 ha of white spruce forests near Hawk Hills, the same area reported in 1992. Most of the area had defoliation classed as moderate. No spraying applications were conducted in 1993.

Alberta Land and Forest Services deployed pheromone-baited traps[2] at many locations throughout the administrative forests in the province to monitor spruce budworm population levels[3] (Fig. 3). Moth counts >500 moths/trap were observed at nine locations in the Athabasca, Footner Lake, Peace River, and Slave Lake forests. Second instar larvae (L_2) surveys[4] were conducted at two of these forests, Footner Lake (Fig. 4) and Athabasca (Fig. 5), based on 1993 defoliation and

[2] A listing of insects, the chemical component(s) of the pheromones used to attract them, the lure types, and trap type is provided in Appendix 1. This appendix details all pheromones referred to in this report.

[3] Details of the pheromone trap survey are summarized in Appendix 2.

[4] Details of the survey are provided in Appendix 3.

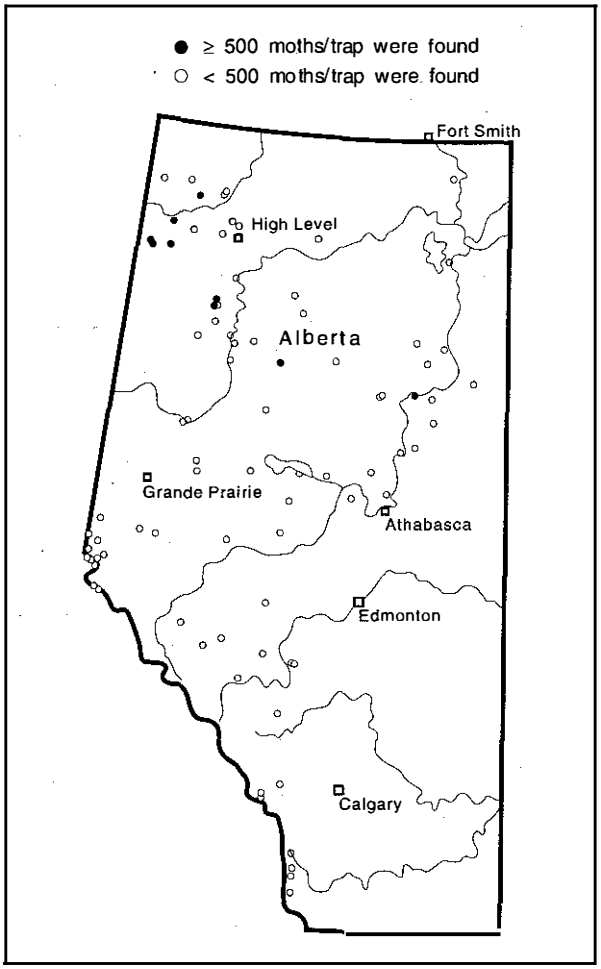

Figure 3. Spruce budworm pheromone trap locations in Alberta in 1993.

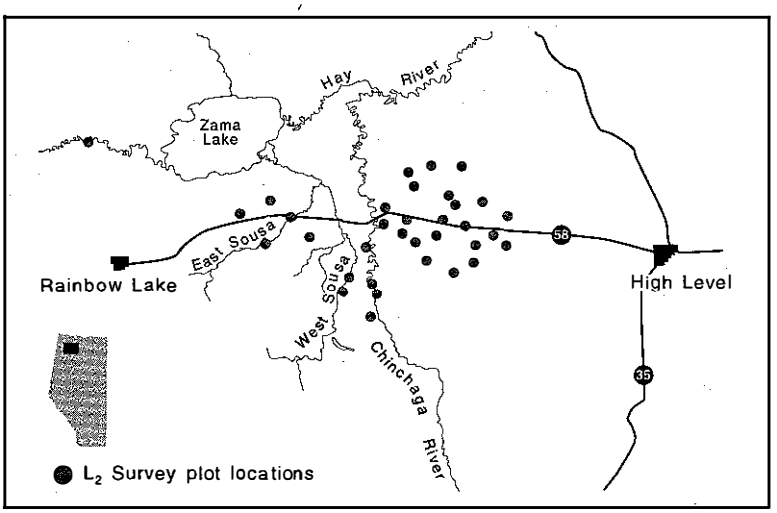

Figure 4. Survey locations of spruce budworm second instar larvae in the Footner Lake Forest in 1993.

pheromone trap results. The results indicate that light to severe defoliation will occur in the main infestation area along the Chinchaga River and east along Highway 58 in the Footner Lake Forest in 1994. In Athabasca Forest, light and moderate defoliation is expected in 1994.

In **Saskatchewan**, the total area of white spruce–balsam fir forests defoliated by spruce budworm and mapped by Saskatchewan Environment and Resource Management and FIDS was 56 617 ha, a decrease of 35% from the area reported in 1992 (Table 1). Infestations continued in three of the same outbreak areas reported in 1992: north of Big River, near Red Earth, and southwest of Hudson Bay. A new infestation was observed at Morin Lake near La Ronge. About 60% of the area was lightly defoliated in 1993; this defoliation occurred in those areas north of Big River where aerial applications of *Bt* were applied to control the infestation. Defoliation in the remaining infested area, 22 600 ha, was rated as moderate-to-severe.

In the Prince Albert Region, the spruce budworm infestation near Big River covered 41 717 ha. Most of the infestation was rated as light (34 017 ha), and the remainder (7700 ha) was rated as moderate-to-severe defoliation and occurred in eight patches ranging in size from 100 to 2800 ha. The infestations occurred west and northwest of Sled Lake, near Bazill Bay and the South Bay of Doré Lake, east of Taggart Lake, south of Mirasty Lake, southeast of Beaupré Lake, and south of Mooswu Lake. Some areas have been defoliated for up to 7 consecutive years, and white spruce mortality is evident.

In 1993, an aerial spraying program using *Bt* was completed by Saskatchewan Environment and Resource Management over 34 017 ha of white spruce–balsam fir forests in the Big River area to suppress spruce budworm populations and reduce the risk of timber losses (Table 2). Sixty blocks of timber near Delaronde Lake, Hackett Lake, Sled Lake, Taggart Lake, and Green Lake were selected for spray treatment. Some blocks (a total area of 28 518 ha) received two applications of *Bt* while the remainder received only one application. Additional management strategies used included salvage cutting of severely damaged sawlog

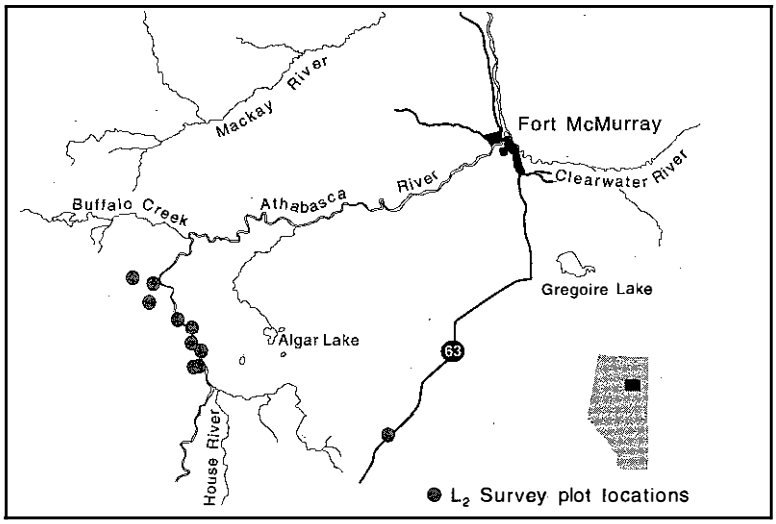

Figure 5. Survey locations of spruce budworm second instar larvae in the Athabasca Forest in 1993.

timber and containment (i.e., using adjacent non-host stands and bog areas) to reduce the rate of spread of spruce budworm.

In the Hudson Bay Region, two major spruce budworm infestations were active in 1993, one near Red Earth (1300 ha) and the other south of Hudson Bay (10 000 ha). The infestation near Red Earth consisted of three smaller patches: two along the Carrot River and one south of Red Earth south of Highway 55. The Hudson Bay infestation consisted of two large patches and three smaller ones; many of the infested spruce stands in this area were scattered. High populations of spruce budworm have been reported in both the Hudson Bay and Red Earth infestation areas since 1982. No aerial spraying programs have been conducted in either area, but salvage logging in both areas has been ongoing for several years and continues to be the main strategy in spruce budworm management.

In 1993, 408 pheromone-baited traps were deployed at 136 sites by Saskatchewan Environment and Resource Management[5]. This was the third consecutive year of trap deployment. Data gathered from pheromone traps help assess budworm population densities adjacent to infested forests and in other susceptible forests (Fig. 6). The trap catches indicated relatively high population densities throughout Saskatchewan's commercial forests and helped to identify areas of concern for follow-up L_2 surveys. Second instar larvae (L_2) surveys[6] were conducted in the Hudson Bay, Meadow Lake, and Prince Albert regions (Fig. 7). The results indicate that light defoliation is expected in the Hudson Bay Region and at most locations in the Meadow Lake and Prince Albert regions in 1994. At one location in Meadow Lake Region and three locations in Prince Albert Region moderate defoliation is expected. These forecasts are based on an average larval density per 10 m^2 of foliage for stands in each 100 km^2 map sheet area.

In **Manitoba**, spruce budworm infestations surveyed by Manitoba Natural Resources occurred in four administrative sections. A total of 15 051 ha of white spruce and spruce–balsam fir forests were infested (Table 1). In the defoliated areas, 1287 ha were classed as light and light-to-moderate, and 13 764 ha were classed from moderate to severe. The infestations occurred in the following sections: Pineland, Lake Winnipeg East, Interlake, and Mountain. The largest affected areas, where spruce budworm infestations have persisted since 1979, were within the Forest Management Licence of Abitibi-Price and included areas of tree decline (i.e., reduced growth or crown dieback) and mortality. Other areas where defoliation ranged from moderate to severe included infestations near Long, Happy, Manigotagan, Quesnel, Oiseau, Booster, Flanders, Star, Bernic, Tulabi, Lone Island, Malloy, Meditation, Dorothy, Beauchemin, Big Whiteshell, Crowduck, West Hawk, and Falcon lakes in the Lake Winnipeg East Section; near Ebb and Flow Lake and Washow Bay, and on Hecla and Black islands in the Interlake Section; and near Noses and Drugstore lakes in the Mountain Section. The infestation near Falcon Lake in the Lake Winnipeg East Section extended into the Pineland Section. No aerial spraying programs were conducted in 1993 for spruce budworm control, but some salvage harvesting is planned in severely damaged forests.

[5] Details of the survey are provided in Appendix 4.

[6] Details of the survey are provided in Appendix 5.

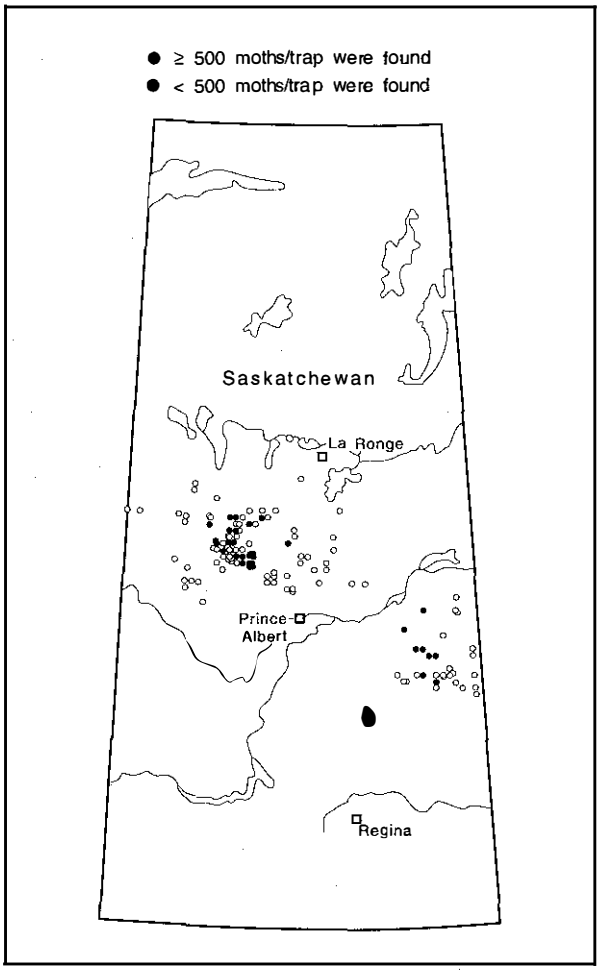

Figure 6. Spruce budworm pheromone trap locations in Saskatchewan in 1993.

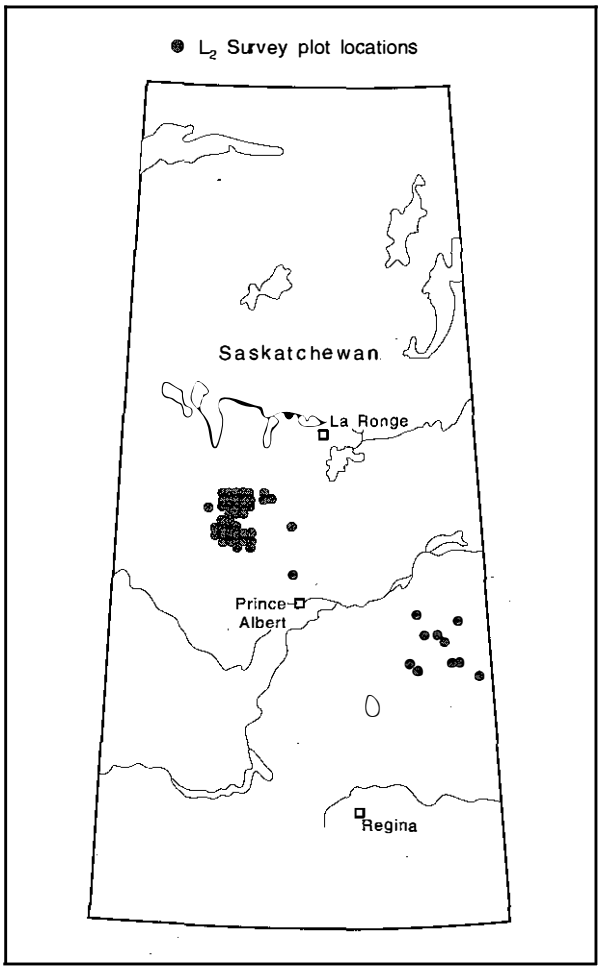

Figure 7. Survey locations of spruce budworm second instar larvae in Saskatchewan in 1993.

Surveys used to forecast spruce budworm populations and predict defoliation levels in 1994 were completed by Manitoba Natural Resources. Light and light-to-moderate defoliation is expected in 1994 (Table 3). In addition, spruce budworm pheromone-baited traps were placed at 13 locations by FIDS staff. This is the ninth consecutive year in which male moths were trapped. Mid-crown foliage samples were also collected from the same locations for estimates of egg-mass densities and defoliation levels in 1993 (Table 4).

In the **Northwest Territories,** aerial surveys to map infested areas of spruce budworm were conducted jointly by Northwest Territories Renewable Resources and FIDS. Infestations occurred in about the same locations as 1992, but the area of defoliation has increased significantly (Fig. 2). In 1992, 90 000 ha were defoliated, while in 1993, 173 117 ha were defoliated, an increase of 92% (Table 1). Most defoliation was rated from light to light-to-moderate (119 507 ha), and the remainder was rated from moderate to severe (53 611 ha). Defoliation was rated from light to severe along the Slave River from Great Slave Lake to Fort Smith. Along the Taltson River east of the Slave River, defoliation was rated from light to moderate. Light defoliation occurred in white spruce stands along the Liard River near Fort Liard. Additional areas of infestation extended along the Liard River near its confluence with the Mackenzie River. Along the Mackenzie River, from Wrigley to Wallace Creek, light to severe defoliation occurred, including adjacent areas along the North Nahanni River and in the Ebbutt Hills. A small, light-to-moderate infestation occurred in Nahanni National Park. Some tree

Table 3. Spruce budworm egg-mass densities in Manitoba in 1993, and forecasted 1994 defoliation

Section	Location (Management Unit)	No. of plots	Egg masses/ 10 m^2 of foliage	Predicted defoliation in 1994[a]
Lake Winnipeg East	Abitibi-Price F.M.L. (31)	26	33	Light-to-moderate
Lake Winnipeg East	Nopiming Provincial Park (31)	19	28	Light-to-moderate
Lake Winnipeg East	Whiteshell Provincial Park (30)	20	11	Light
Mountain	Duck Mountain Provincial Park (13)	21	47	Light-to-moderate

Note: Egg-mass density surveys were conducted by Manitoba Natural Resources.

[a] Based on egg-mass densities where light = ≤35% defoliation (1–30 egg masses), moderate = 36–70% defoliation (60–110 egg masses), and severe = ≥71% defoliation (220+ egg masses) (modified from Dorais and Kettela 1982, and Morris 1954).

Table 4. Summary of spruce budworm moths caught in pheromone-baited traps, defoliation levels, and egg-mass density counts in Manitoba in 1993, and defoliation forecasts for 1994

Site location	Numbers of moths captured[a]	Defoliation in 1993 (%)	Number of egg masses/10 m^2 of foliage	Predicted defoliation for 1994[b]
Birds Hill Provincial Park	321	10	0	Nil
Spruce Woods Provincial Forest	4156	10	417	Severe
Red Deer River	67	<1	0	Nil
Duck Mountain Provincial Park	2	4	0	Nil
Riding Mountain National Park	33	16	0	Nil
Northwest Angle Provincial Forest	152	0	0	Nil
Whiteshell Provincial Park	2522	33	169	Moderate-to-severe
Wanigipow	2326	75	71	Moderate
Hecla Provincial Park	532	5	0	Nil
Red Rose	153	<1	0	Nil
Rocky Lake	1243	4	17	Light
Simonhouse	131	14	0	Nil
Pisew Falls	17	7	0	Nil

[a] These values represent an average count from three traps deployed at each location.

[b] Based on egg-mass densities where light = ≤35% defoliation (1–30 egg masses), moderate = 36–70% defoliation (60–110 egg masses), and severe = ≥71% defoliation (220+ egg masses) (modified from Dorais and Kettela 1982, and Morris 1954). The predicted defoliation levels for 1993 apply only to the immediate area where traps were deployed.

mortality resulting from several years of spruce budworm feeding injury occurred near the south end of the Kotaneelee River and along the Liard River south of Fort Liard. An additional area of infestation was reported in the Martin Hills west of Antoine Lake, but its size and intensity of defoliation were not estimated in 1993.

JACK PINE BUDWORM *Choristoneura pinus pinus* Free.

Jack pine budworm has not caused significant defoliation to pine stands in the Northwest Region since the last major outbreak, which collapsed in 1987. Jack pine budworm populations have been monitored through the ongoing efforts of FIDS in Alberta and Saskatchewan, and Manitoba Natural Resources in Manitoba. Detection surveys have concentrated on pheromone traps for male moths and egg-mass surveys. The locations of survey sites are shown in Figure 8. Based on these surveys[7], populations of jack pine budworm are anticipated to remain low across the Northwest Region and very little defoliation is expected.

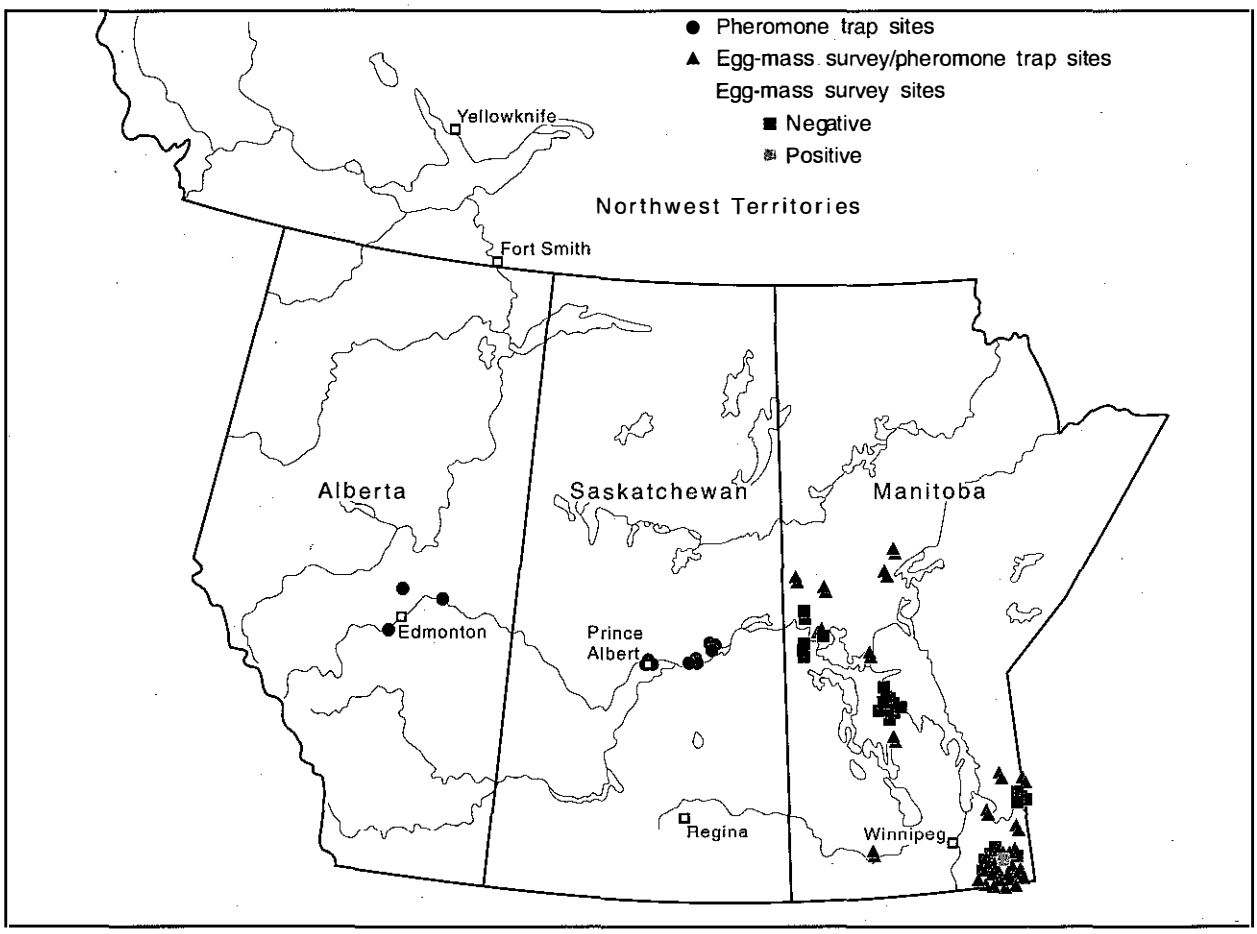

Figure 8. Jack pine budworm pheromone trap locations and egg-mass survey sites in the Northwest Region in 1993.

[7] Details of the surveys are provided in Appendixes 6 and 7.

ASPEN DEFOLIATORS
Forest tent caterpillar, *Malacosoma disstria* Hbn.
Large aspen tortrix, *Choristoneura conflictana* (Wlk.)
Aspen leafroller, *Pseudexentera oregonana* (Wlsm.)

In the Northwest Region aspen was defoliated by forest tent caterpillar, large aspen tortrix, and aspen leafroller. The total area defoliated by aspen defoliators was 607 690 ha in 1993 (Table 5). The area defoliated increased significantly since 1992 in Alberta and Saskatchewan. In Manitoba the area defoliated decreased by 86%. Defoliation area was determined from ground surveys in Alberta. In Saskatchewan and Manitoba, aerial surveys were conducted by provincial staff and FIDS.

In **Alberta,** most aspen defoliation was caused by forest tent caterpillar and aspen leafroller (Fig. 9). Large aspen tortrix was active at many locations throughout the province but caused only light defoliation in 1993. Forest tent caterpillar defoliation occurred at three locations in the province: north and south of Cooking Lake (10 948 ha), the Peace River valley near the town of Peace River (7995 ha), and a few kilometres north of Guy along Highway 34 (39 ha). Defoliation within these infestations was rated from moderate to severe. Other areas of aspen near Cooking Lake had light defoliation (113 685 ha).

Egg-band surveys were completed at 19 locations around infested areas. The results of these surveys indicate that severe defoliation is expected in 1994 just north and south of Cooking Lake and light defoliation is predicted at Tofield, Miquelon Lake Provincial Park, and Elk Island National Park. Light defoliation is expected north of the Peace River townsite. South of the townsite, along both sides of the Peace River to the Shaftesbury ferry, defoliation will probably range from moderate to severe. North of Guy, moderate-to-severe defoliation is expected.

In the spring of 1993, aspen leafroller caused light, light-to-moderate, and moderate defoliation in the Peace River, Grande Prairie, and Slave Lake forests. Most of this defoliation occurred along the Little Smoky River from just east of Highway 34 to the Smoky River confluence, and then along the Smoky River to the Peace River confluence. Some aspen leafroller defoliation was observed south of the Little Smoky–Smoky River confluence. About 27 350 ha of aspen was defoliated.

Large aspen tortrix caused light defoliation at several locations in Alberta. Locations included northwest of Peace River, around Red Earth Creek, and south of Grande Prairie (Fig. 9). No Bruce spanworm (*Operophtera bruceata* Hulst) defoliation was observed in Alberta in 1993.

In **Saskatchewan,** all aspen defoliation was caused by large aspen tortrix (Fig. 9). Defoliation classed as light and light-to-moderate occurred on 5187 ha and 59 736 ha, respectively. There were 16 398 ha of moderately defoliated aspen and 359 434 ha of aspen that received moderate-to-severe defoliation. This defoliation occurred predominantly in the area bounded by Meadow Lake, Horse Head, Cater, Big River, and Green Lake. Smaller areas of defoliation rated as moderate were observed east of Hackett Lake, and near Meeting Lake. Defoliation rated from light to moderate was observed in several small patches northwest of Big River, in Prince Albert National Park, Red Earth Indian Reserve, and southwest of Hudson Bay near the Piwei Lakes and the Etomami River. At one location southwest of Hudson Bay aspen twoleaf tier (*Enargia decolor* [Wlk.]) caused defoliation in association with large aspen tortrix.

In **Manitoba,** areas of defoliated aspen forests decreased from 51 153 ha in 1992 to 6918 ha in 1993. There were 3334 ha of lightly defoliated aspen, 2770 ha of moderately defoliated aspen, and 814 ha of severely defoliated aspen. Forest tent caterpillar was responsible for this defoliation in the Interlake Section in management units 40, 41, and 42. Large aspen tortrix was detected near Wabowden and north of Fairford (Fig. 9). Bruce spanworm was not found in any of the surveys. Forest tent caterpillar egg-band surveys were completed at 8 locations throughout Manitoba. The results of these surveys indicate that light defoliation is expected in 1994 near Manigotagan and Red Rose. No defoliation is expected in 1994 in Duck Mountain Provincial Park and Riding Mountain National Park, or near Mafeking, Big Whiteshell Lake, Landry Lake, or Flin Flon.

No aspen defoliation was observed in the **Northwest Territories** in 1993.

Table 5. Summary of aspen defoliation in the Northwest Region, determined from aerial and ground surveys in 1992 and 1993

Location	Area of defoliation (ha) 1992	1993	Change (%)
Alberta	0	160017	–
Saskatchewan	N/A[a]	440 755	–
Manitoba	51 153	6 918	–86
Northwest Territories	0	0	–
Total	51 153	607 690	+875

[a] Some defoliation was present in 1992 but was not mapped.

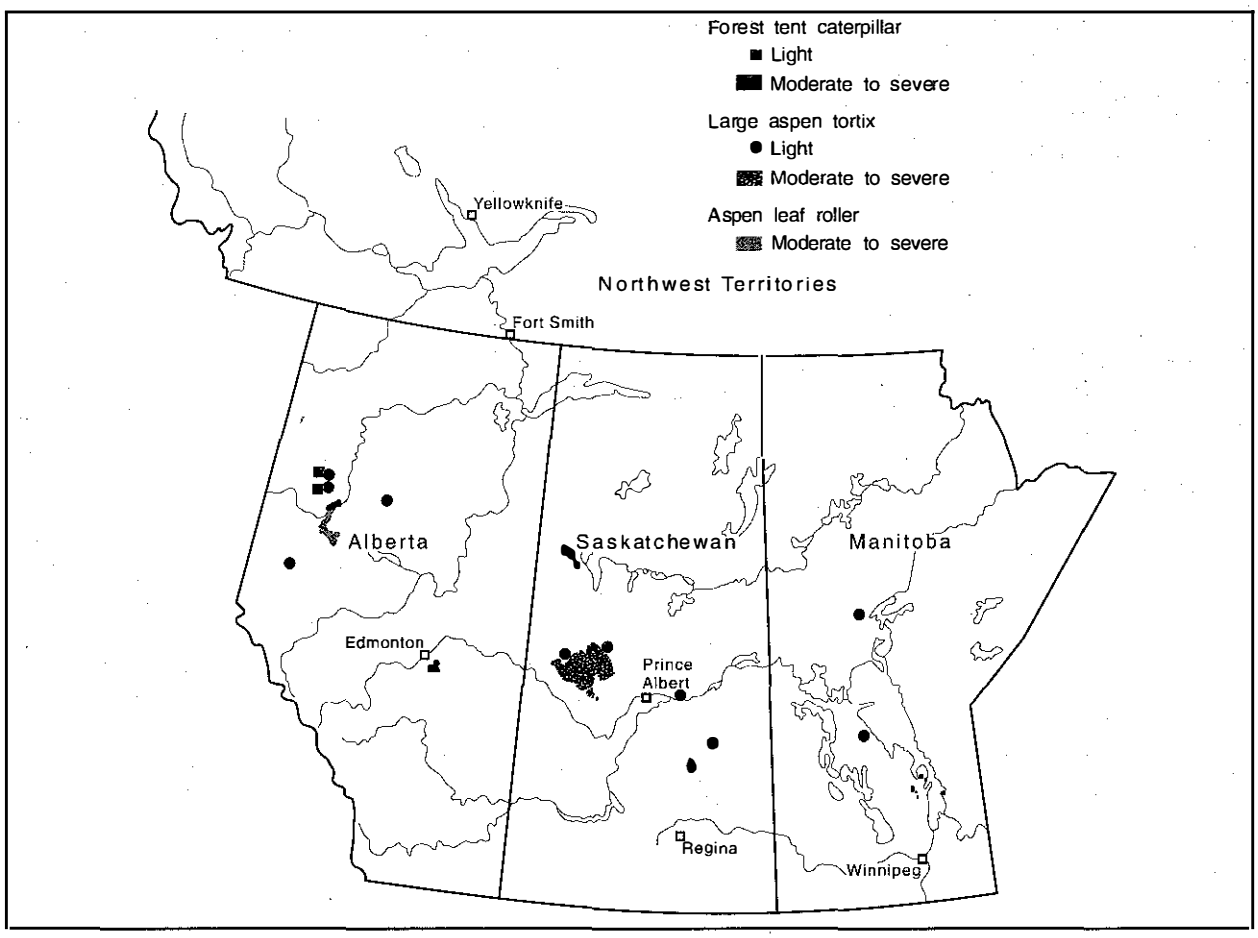

Figure 9. Areas, incidence, and severity of defoliation caused by forest tent caterpillar, large aspen tortrix, and aspen leafroller in 1993.

BARK BEETLES
Mountain pine beetle, *Dendroctonus ponderosae* Hopk.
Spruce beetle, *Dendroctonus rufipennis* (Kby.)
Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopk.

Mountain pine beetle infestations remained very low in the Northwest Region in 1993. Beetle presence was detected at several locations only by means of pheromone-baited trap trees. Aerial and ground surveys to detect recent mountain pine beetle-killed trees were conducted by personnel of FIDS, Alberta Land and Forest Services, and Parks Canada. Survey efforts were conducted in areas where dispersing beetles might invade. Areas of concern in southwestern Alberta included the foothills region from Willmore Wilderness Provincial Park to the Canada–U.S. border and Jasper, Banff, and Waterton national parks. Cypress Hills Provincial Park in southeastern Alberta was also surveyed.

No mountain pine beetle-killed trees were observed in Bow-Crow Forest. Pheromone baits were deployed on trap trees at 30 sites throughout the forest: three in the Turner Valley District (DB1), five in the Elbow District (DB2), three in the Ghost District (DB4), and 19 in the Blairmore District (DB6). Mountain pine beetle attacks occurred on baited trap trees at two sites near Tent Mountain and two sites near Allison Creek northwest of Coleman in the Blairmore District. These areas are near those between Coleman and the British Columbia border in which beetle attacks were reported in 1991 and 1992. Mountain pine beetle attacks also occurred on baited trees in the Oldman River area of the Blairmore District and at the Spray Lakes Reservoir and Lower Kananaskis Lake sites in the Elbow District. Lodgepole pine beetle (*D. murrayanae* Hopk.) and red turpentine beetle (*D. valens* Lec.) were also found attacking some of the baited trap trees near the Spray Lakes Reservoir. All mountain pine beetle attacks were unsuccessful in the Bow-Crow Forest.

No mountain pine beetle-killed trees were observed in the Rocky-Clearwater Forest. Pheromone baits were placed on trap trees at six locations along the forest's boundary with Jasper and Banff national parks. No baited trees were attacked.

In the Edson Forest, pheromone baits were placed on trap trees at 23 locations, mainly along the boundary with Jasper National Park and in Willmore Wilderness Provincial Park. Mountain pine beetle attacks occurred near Morkill Pass, Beaverdam Pass, and the confluence of Jackpine River and Spider Creek in Willmore Wilderness Provincial Park. None of these attacks were successful. Both the bait sites and the aerial surveys failed to detect any mountain pine beetle-killed trees in the Edson Forest.

In the Grande Prairie Forest, no mountain pine beetle-killed trees were detected. No attacks were noted at three sites where pheromone baits were placed.

In 1993, Parks Canada provided an aircraft and assisted in aerial surveys over portions of Banff and Jasper national parks to sketch map areas of dead and dying lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.). No recently killed trees were observed in Banff National Park in the Healy Creek, Brewster Creek, Spray River, and Bow River valleys or in Jasper National Park. Mountain pine beetle attacks occurred at two of 12 locations in Jasper National Park: the Whirlpool River valley and the Miette River valley west of Jasper. None of these attacks were successful.

In the Alberta portion of the Cypress Hills, 201 pheromone baits were deployed on trap trees at 67 sites by park staff. No beetle attacks were observed in 1993.

The Alberta Land and Forest Services conducted a detection survey for **spruce beetle** in a number of forests using Lindgren funnel traps baited with pheromones. Traps were set up at one location in the Athabasca Forest, five locations in the Bow-Crow Forest, three locations in the Footner Lake Forest, eight locations in the Peace River Forest, and two locations in the Slave Lake Forest. Results of this survey were inconclusive. In the Peace River Forest where several patches of recently killed or dying trees were observed in 1992, large numbers of beetles were captured in traps, which indicates that a population still exists in the area. The province uses three strategies to control the spruce beetle outbreak: deployment of pheromone-baited trap trees, felled trap trees, and

salvage logging. During the winter of 1992–93, 9829 m^3 of spruce were salvaged in the Hawk Hills area. More salvage cutting has been approved for the winter of 1993–94: 11 136 m^3 of spruce in the Hawk Hills area, and 70 831 m^3 of spruce in the Nina Lake area.

The infestation of **Douglas-fir beetle** in **Alberta**, which was initially reported in 1991 in Jasper National Park, continued to expand in 1993. Concern over this infestation has led park staff to conduct intensive aerial and ground surveys to detect Douglas-fir beetle activity. The results of these surveys indicate that about 383 Douglas-fir trees (*Pseudotsuga menziesii* [Mirb.] Franco) were killed in 1990 and 1991, 528 trees in 1992, and 685 trees in 1993. The killed trees were located in patches scattered along the Athabasca River valley, in areas adjacent to the Jasper townsite and Jasper Park Lodge, and at several locations up to 15 km north and south of the town of Jasper. Traps baited with experimental pheromones were deployed at several locations by Parks Canada in cooperation with FIDS to attract and collect adult Douglas-fir beetles. Beetle catches at these traps were higher than expected.

SPRUCE GALL MIDGE *Mayetiola piceae* (Felt)

In 1992, an infestation of spruce gall midge was detected in northern Alberta and adjacent areas in the Northwest Territories. In 1993, an intensive survey was conducted for this pest throughout the Footner Lake Forest, in the northwest region of Athabasca Forest along the Birch River, and in the Northwest Territories (Fig. 10). Thirty-two plots were examined for spruce gall midge. Galls formed by spruce gall midge cause mortality to young shoots on which they occur. On trees that were moderately or severely infested, twig mortality may have reduced radial growth. Tree terminals were not attacked. The sampling regime used during the survey involved taking branch samples at three crown levels: upper, middle, and lower. No differences were observed in the intensity of damage at any of the three crown levels. Midge incidence and damage were evaluated on both the 1993 and 1992 shoots.

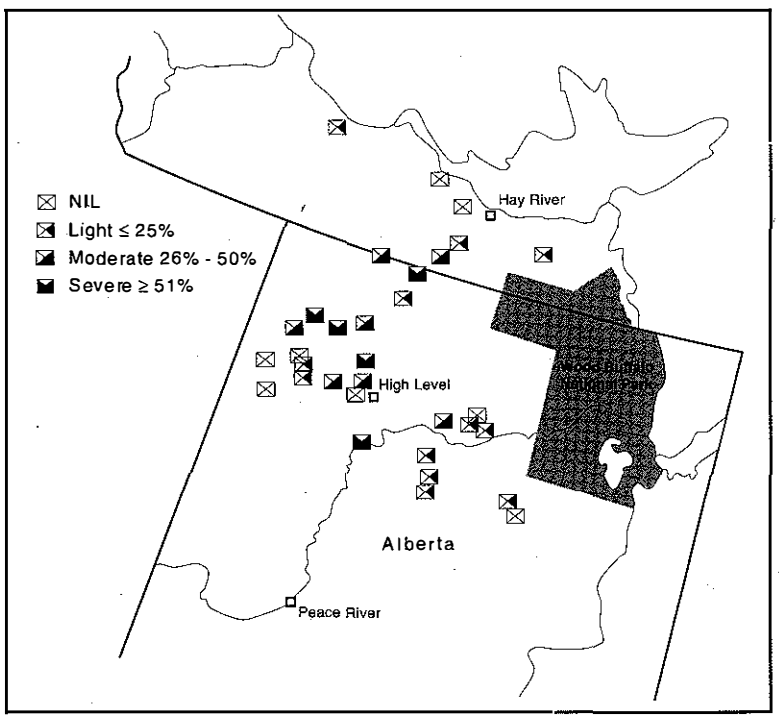

Figure 10. Spruce gall midge survey locations and damage intensity in 1993.

In 1993, at eight sample plots no spruce gall midge was found. Twelve plots were lightly infested (<25% of current shoots infested), seven plots were moderately infested (26–50% of current shoots infested), and 5 plots were severely infested (>50% of current shoots infested). Moderate-to-severe infestations were located in plots from Paddle Prairie north through High Level into the Northwest Territories just south of Enterprise, northwest of High Level to Zama Lake, and southeast of High Level to just south of Fort Vermilion. Light infestations were located southwest of High Level near Rainbow Lake, near Wadlin Lake and east to the Birch River, and in the Northwest Territories near the communities of Hay River and Trout River. Although spruce budworm infestations along

the Chinchaga River and on the Zama ridge included spruce gall midge damage, spruce gall midge damage had decreased in these areas. Spruce gall midge was also found in 1993 shoots at less intensively sampled sites west of Zama Lake along the Hay River and northeast of High Level as far north as the Yates River.

Some samples showed evidence that spruce gall midge infestations began as early as 1991, but damage in that year was insignificant. Based on the ratio of shoot damage for 1992 to that for 1993, it appears that spruce gall midge populations are now static.

GYPSY MOTH
Lymantria dispar (L.)

Gypsy moth trapping surveys were conducted in all the prairie provinces in 1993 by Agriculture Canada in conjunction with other agencies. In **Alberta**, 480 pheromone-baited traps were placed at various locations throughout the province: in Banff, Jasper, and Waterton Lakes national parks; in Calgary, Drumheller, Edmonton, and Red Deer; and in provincial parks. No male gypsy moths were captured. The recent closing of Canadian military bases in Germany, where a current gypsy moth outbreak exists, made it necessary for Agriculture Canada staff to conduct inspections of all incoming cargo from those bases. One egg mass was found in a military cargo container in Red Deer. The eggs were destroyed.

In **Saskatchewan**, Agriculture Canada placed 132 traps throughout the province. No moths were captured at any of the trap sites. As in Alberta, Agriculture Canada staff inspected all military cargo arriving from Germany. Inspections failed to detect any gypsy moth life stages.

In **Manitoba**, 335 traps were placed throughout the province, most south of the Trans-Canada Highway 1, and the remainder in Riding Mountain National Park and the beach areas of Lake Manitoba and Lake Winnipeg. Male moths were trapped at Prawda east of Winnipeg on Trans-Canada Highway 1 and in east Winnipeg at the CN Transcona rail yards. No moths were captured in Birds Hill Provincial Park or in Shilo, southeast of Brandon, where moths were captured in 1992. Inspections of military cargo in Manitoba failed to detect any gypsy moth life stages.

DUTCH ELM DISEASE
Ophiostoma ulmi (Buis.) Nannf.

In **Alberta**, surveys to detect the incidence of Dutch elm disease (DED) were conducted by the municipalities of Medicine Hat, Red Deer, Calgary, and Edmonton. Surveys were also conducted by Alberta Agriculture under the Dutch Elm Disease Initiative. This initiative consists of three programs: monitoring DED, the smaller European elm bark beetle (*Scolytus multistriatus* [Marsh.]), and the native elm bark beetle (*Hylurgopinus rufipes* [Eichh.]); maintaining an inventory of American elm (*Ulmus americana* L.) in the province; and monitoring ports of entry into the province and confiscating elm firewood. Both elm bark beetles species are important vectors of DED. Elm bark beetle monitoring was conducted at 30 locations in Alberta from Cold Lake to the Crowsnest Pass. Most monitoring sites were at points of entry into the province. Traps were baited with the smaller European elm bark beetle pheromone and trap logs. There were no reports of the disease or beetle vectors in the province.

In **Saskatchewan**, three new locations were recorded as having DED-infected elms: the town of Langenburg, just outside of MacNutt, and in the Qu'Appelle River valley southeast of Crooked Lake in the Cowessess Indian Reserve (Fig. 11). At Langenburg three trees were infected in the town and one infected tree was found just outside of town. Near Round Lake about 100 trees were infected. The provincial Dutch Elm Disease Program staff, the Saskatchewan Dutch Elm

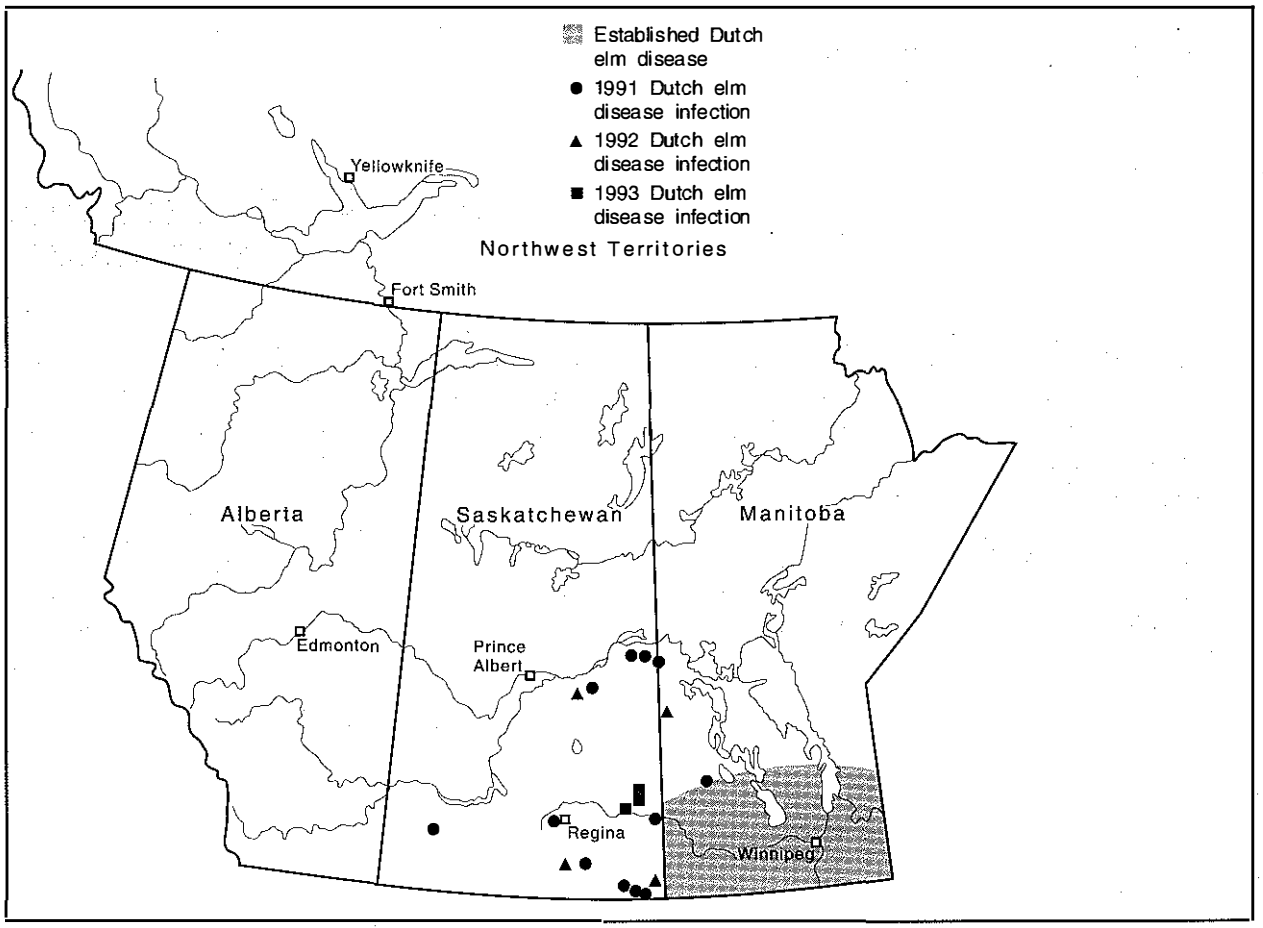

Figure 11. Distribution of Dutch elm disease in the prairie provinces in 1993, and infections identified in Manitoba and Saskatchewan in 1991, 1992, and 1993.

Disease Committee, and the public detected these new infections. In 1993, intensive ground surveys were conducted in areas known to be infested such as the Souris River valley south of Estevan, the Qu'Appelle River valley between Crooked Lake and Round Lake, and in the Wascana Creek area. Samples were taken from 237 suspect trees and sent to the laboratory for identification. Only 11 samples were identified as being positively infected by DED. No aerial surveys were conducted in 1993.

Staff of the provincial Dutch Elm Disease Program distributed about 80 traps baited with smaller European elm bark beetle pheromone to 34 communities for deployment. In traps placed in and around Estevan a few *H. rufipes* were captured but no *S. multistriatus* were trapped. In Regina and in Sherwood Forest, just west of Regina, traps were set at 52 locations and visited periodically during the course of the summer and early fall. From these traps, 233 native elm bark beetles were captured. No elm bark beetles were captured in any other communities. Limited control operations for DED were carried out in the province, which involved the removal of DED-infected trees. Twenty trees were removed in the Sherwood Forest Country Club west of Regina and 10 trees were removed in the community of Carrot River.

In **Manitoba**, the current range of DED extends through the southern portion of the province in riparian forests and in communities north to Swan River (Fig. 11). In Winnipeg, DED incidence remains at 2.4%. In 1993, 10 000 diseased and hazardous elm trees were marked by surveyors for removal in Manitoba: approximately 4000 in Winnipeg, 175 in Brandon, and the remainder in 42 rural communities.

Thirty-two communities participated in the 1993 cost-shared DED program with Manitoba Natural Resources. An additional ten communities

that did not participate in the program were surveyed for DED by Manitoba Natural Resources. The cost-shared program helped with sanitation pruning, basal spraying with insecticide to reduce vector beetle populations, and replacement plantings.

PESTS AND DAMAGE CONDITIONS IN YOUNG STANDS

Young coniferous stands were surveyed for insects, diseases, and other damage agents in **Alberta,** in the Bow-Crow and Grande Prairie forests; in **Saskatchewan,** in the Meadow Lake and Prince Albert regions; and in **Manitoba,** in the Saskatchewan River Section (Fig. 12).

Young coniferous stands surveyed in 1993 were healthy. Within the surveyed stands in Alberta, Saskatchewan, and Manitoba 95.8, 98.6, and 97.3% of the trees were healthy, respectively; 1.7, 0.8, and 1.9% of the trees were declining; and 2.5, 0.6, and 0.8% of the trees were dead. The values for healthy, declining, and dead trees are comparable to the values reported for stands surveyed in 1992 (Cerezke and Brandt 1993).

In the Bow-Crow Forest, animal browse was evident on 12 and 7% of the lodgepole pine and alpine fir (*Abies lasiocarpa* [Hook.] Nutt.) trees surveyed, respectively. No other pest or pest symptom caused significant levels of damage.

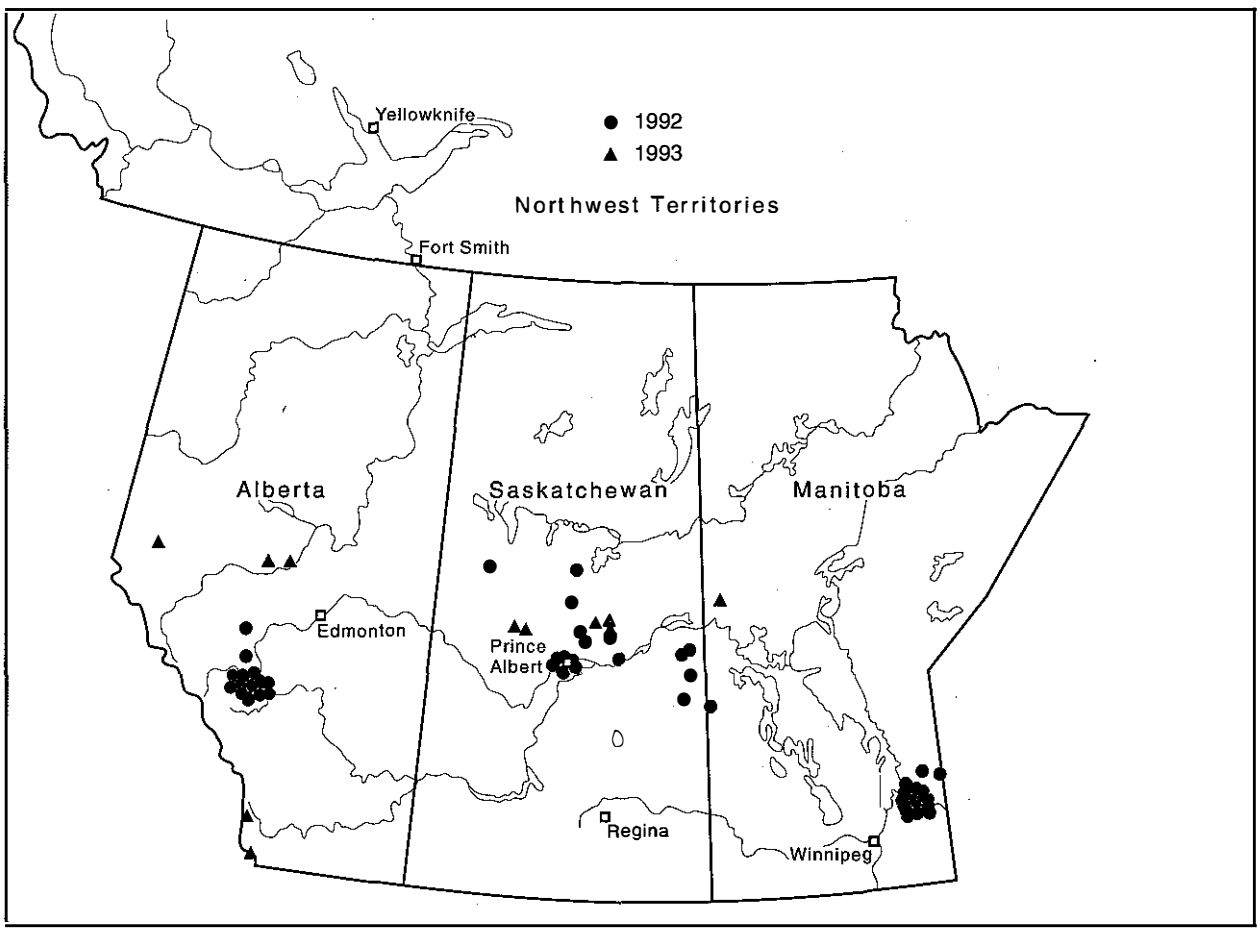

Figure 12. Locations of young stands surveyed for pest incidence in Alberta, Saskatchewan, and Manitoba in 1992 and 1993.

In the Grande Prairie Forest, the most prevalent pests or other damage agents observed on lodgepole pine trees surveyed were a pine needle rust (*Coleosporium asterum* [Diet.] Syd.) (20.8%), western gall rust (*Endocronartium harknessii* [J.P. Moore] Y. Hiratsuka) (11.3%), J-root deformation (1.9%), and lodgepole terminal weevil (*Pissodes terminalis* Hopping) (1.9%). Animal browse damaged 3.3% of the white spruce trees and 7.1% of the alpine fir trees surveyed. Ragged sprucegall adelgid (*Pineus similis* [Gill.]) was found on 13.3% of the white spruce trees surveyed.

In the Prince Albert Region, the jack pine (*Pinus banksiana* Lamb.) trees surveyed were affected by lodgepole terminal weevil (18.6%), animal browse (13.9%), northern pitch twig moth (*Petrova albicapitana* [Bsk.] (0.4%), and Armillaria root rot (*Armillaria* sp.) (0.4%). Spruce gall adelgid (*Adelges lariciatus* [Patch]) was found on 4.5% of the white spruce trees surveyed.

In the Meadow Lake Region, 17.6% of the jack pine trees surveyed were attacked by lodgepole terminal weevil. The surveyed white spruce trees were affected by spruce gall midge (*Mayetiola piceae* [Felt]) (5.3%), white pine weevil (*Pissodes strobi* [Peck]) (5.3%), and Armillaria root (2.9%).

In the Saskatchewan River Section, animal browse was evident on 6.1% of the black spruce trees surveyed. Venturia leaf and shoot blight (*Venturia macularis* (Fr.) E. Müller & Arx) was found on 2.5% of the trembling aspen (*Populus tremuloides* Michx.) trees surveyed.

After completing two years of surveys in young coniferous stands, data accumulated indicate that stands are generally healthy. Most young stands contain relatively few pests. Some stands contain pest populations at levels where pests are causing losses and mortality. In the 1992 and 1993 surveys, the most prevalent pests of young trees include browsing animals, root collar weevils, terminal weevils, Armillaria root rot, western gall rust, and needle casts and rusts. While not a pest, improper planting (J-root deformation) also appears as a common problem influencing the health of young coniferous plantations.

SURVEYS OF ASPEN STAND CONDITIONS

Surveys of trembling aspen stands were initiated in 1992 in the prairie provinces to monitor the incidence, distribution, and relative abundance of insect and disease pests. Other damage agents, defects, and tree mortality were also assessed. This survey utilized the forest inventory permanent sample plot (PSP) sites previously established by the provinces. In 1993, 12 PSP sites in **Alberta**, 10 PSP sites in **Saskatchewan**, and 10 PSP sites in **Manitoba** (Fig. 13) were assessed. All aspen that had been previously tagged, numbered, and measured was included in the survey. Aboveground tree components were examined for insect and disease injury on all living trees. On recently dead or dying trees the root collar area was examined for insect- and fungus-caused injury to determine the cause of decline (Table 6).

Results of the 1993 survey indicate that pest incidence was not significantly different than 1992 (Cerezke and Brandt 1993). Aspen defoliators, such as forest tent caterpillar, large aspen tortrix, and some leaf beetles, and the decay fungi, *Phellinus tremulae* (Bond.) Bond. & Boriss and *Peniophora polygonia* (Pers.:Fr.) Boud. were the most prevalent pests. In Alberta, of the trees that were assessed, 0.8% were dying, 5.0% were dead ≤2 years, and 12.9% were dead >2 years. There were similar values for Saskatchewan: 2.0% were dying, 3.7% were dead ≤2 years, and 31.2% were dead >2 years. In Manitoba, 2.3 and 16.1% of the trees assessed were dying or dead >1 year, respectively.

NURSERY PEST SURVEY

In 1989, Alberta Forestry, Lands and Wildlife, now called Alberta Land and Forest Services, requested that FIDS staff conduct an annual pest survey of the Pine Ridge Forest Nursery and its

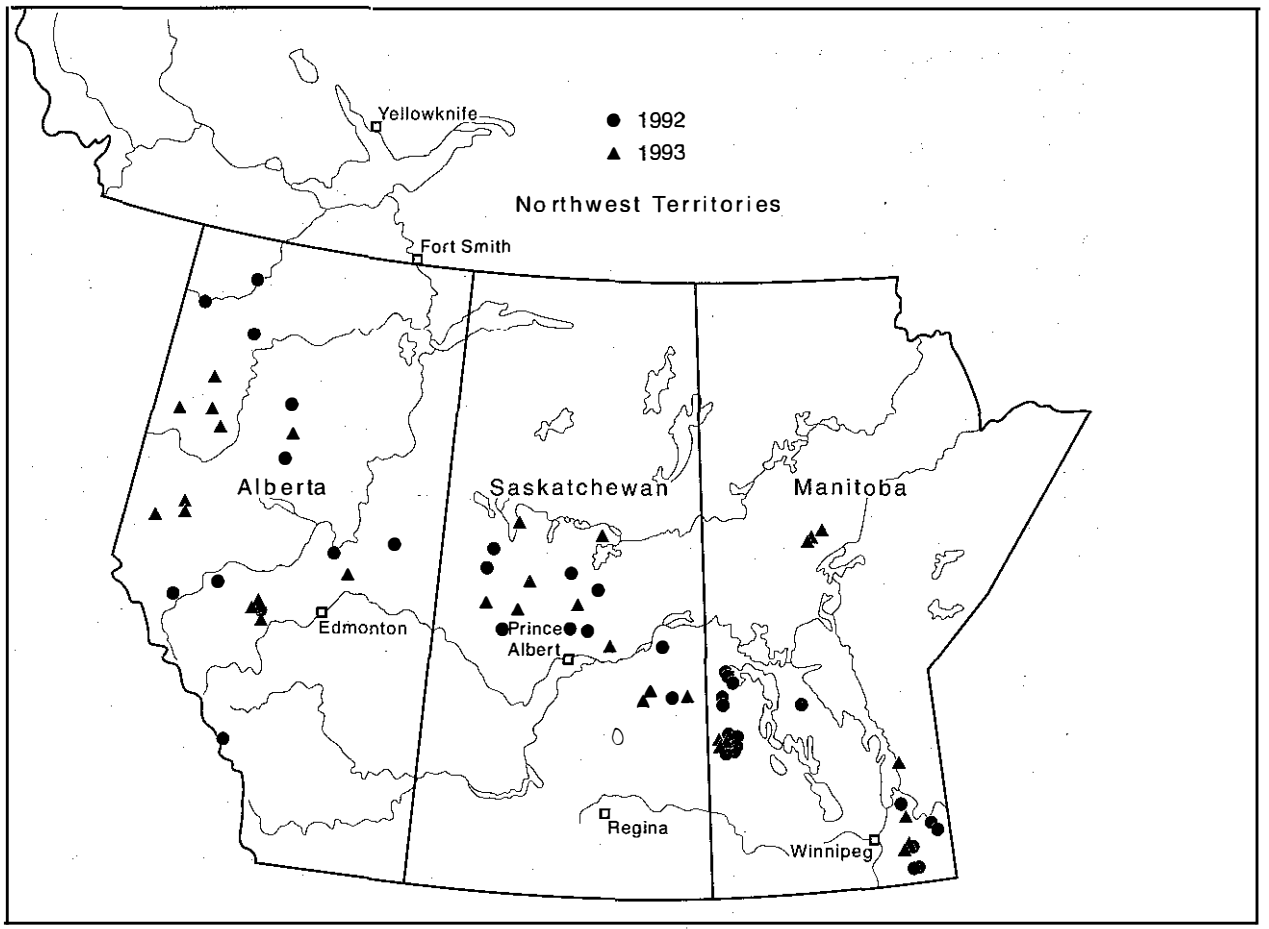

Figure 13. Locations of permanent sample plots used for surveying trembling aspen forests in Alberta, Saskatchewan, and Manitoba in 1992 and 1993.

associated genetic plantations and seed orchards near Smoky Lake, **Alberta**. The 1993 survey was conducted on 24–25 June. Nursery stock inspected included bare-root, 2–0, and 3–0 white spruce seedlings and container-grown white spruce and lodgepole pine. Genetic plantations, seed orchards, shelterbelt trees, and other trees in the nursery were also inspected for pests.

In the seedling beds, the most prevalent pest found was a woolly aphid, *Mindarus obliquus* Cholodkovsky. This aphid is a close relative of balsam twig aphid (*M. abietinus* Koch), which can be a serious pest of fir and spruce. In many seedling beds, groups of seedlings contained high populations of aphids. The aphids were sucking on flushing shoots causing wilting and, in some cases, shoot mortality. Populations of this pest were high enough to warrant insecticidal applications, which were carried out by nursery staff. In the same beds where *M. obliquus* was found, many dead seedlings and seedlings with dead tops were found. Close examination failed to reveal the cause of this mortality. No pathogenic fungi were isolated from dead tissue from the sampled seedlings.

Other pests found in and around the seedling beds included a damping-off disease, probably *Fusarium* species, *Lygus* sp., and adult strawberry root weevils (*Otiorhynchus ovatus* [L.]). All of these pests were found at very low or endemic populations and were not causing serious injury to seedlings. It is worth noting the detection of adult strawberry root weevils in the areas near seedling beds. In the past, some seedlings showed evidence of root crown girdling, which had been attributed to strawberry root weevil, although no adults or larvae had been observed (Cerezke and Brandt 1993). The 1993 survey detected adult weevils but no damage was found. Strawberry root weevil is

Table 6. Incidence (by percentage of trees affected) of important insects and diseases, and condition of trembling aspen surveyed on permanent sample plots in Alberta, Saskatchewan, and Manitoba in 1993

	Alberta	Saskatchewan	Manitoba
Number of sites sampled	12	10	10
Total trees sampled	665	1161	2277
Damage agent or tree condition	Affected trees (% of total)		
Aspen defoliators[a] *Choristoneura conflictana* (Wlk.) *Malacosoma disstria* Hbn.	29.5	33.4	5.4
Poplar borer *Saperda calcarata* Say	0.3	5.9	0.1
Armillaria root rot[b] *Armillaria* sp.	2.0	1.7	0
Hypoxylon canker *Hypoxylon mammatum* (Wahl.) J.H. Miller	1.5	0.4	0.1
False tinder conk *Phellinus tremulae* (Bond.) Bond. & Boriss.	12.0	4.4	1.1
Poplar Peniophora *Peniophora polygonia* (Pers.:Fr.) Boud.	4.8	3.5	0
Top dieback[c]	1.7	6.0	0.8
Dying and dead trees	18.7	36.9	18.4
Other[d]	15.3	11.9	12.7

[a] Defoliation classes varied widely from light to severe; defoliation was due mostly to large aspen tortrix (*C. conflictana*).

[b] Values are for trees that died from this disease only. Incidence of this disease may have been higher because sampling was nondestructive.

[c] Top dieback = partial mortality of shoots and branches in the upper crown.

[d] Other factors include frost cracks, mechanical injury, and partial girdling by hares or other animals, and major defects such as forked stems, severe lean, broken top, and twisted stem.

suspected of causing insignificant damage and losses at the Pine Ridge Forest Nursery.

In the genetic tree plantations and seed orchards, all pests observed were found at endemic populations causing little damage. Cytospora canker (*Cytospora chrysosperma* [Pers.] Fr.), Venturia leaf and shoot blight, a gall midge (*Cecidomyia* sp.), aspen leaf beetle (*Chrysomela crotchi* Brown), and a leaf-rolling sawfly were observed on aspen. Conifer–aspen rust (*Melampsora medusae* Thuem.) was found on larch (*Larix* spp.). Armillaria root rot, a woolly aphid (*M. obliquus*), and a bark weevil (*Pissodes schwarzi* Hopkins) were observed on white spruce. A *Dioryctria* sp., northern pitch twig moth, and porcupine (*Erethizon dorsatum* L.) damage were noted on jack pine. Other abiotic damage symptoms noted in the nursery plantations were winter injury on jack pine and frost injury to green ash (*Fraxinus pennsylvanica* var. *subintegerrima* [Vahl] Fern.).

The Acid Rain National Early Warning System (ARNEWS) was established in 1984 to detect symptoms of acid rain injury to forests. Twelve permanent sample plots were established in the Northwest Region at that time. Eight of these still remain: four in **Alberta**, one in **Saskatchewan**, and three in **Manitoba**. Two additional plots were established in 1986 with one each in Alberta and Saskatchewan. In 1990, a new plot was established in Manitoba to replace a plot that was burned in a forest fire in 1989. In 1991, three new plots were established: one in Alberta, and two in the Northwest Territories. In 1993, three more plots were established in each of the three model forests created in Alberta, Saskatchewan, and Manitoba. The 17 ARNEWS plots now in the Northwest Region are part of a permanent, nationwide network of plots where changes in soil, minor vegetation, tree condition, tree growth, and insect and disease incidence are assessed (Fig. 14). Further information on ARNEWS is provided in Magasi (1988), D'Eon and Power (1989), Hall and Addison (1991), Hall (1991), and Hall and Pendrell (1992).

In 1993, 15 ARNEWS plots were visited twice, once in May or June and once in August. The two additional plots in the Northwest Territories were visited only once in August. No symptoms associated with acid rain were observed on trees at any of the 17 sites. A number of pests were observed at various plots. Some of these pests were occurring at population levels where damage was evident. Pest populations did not appear to be related to anthropogenic effects.

At sites in **Alberta**, insects and diseases that caused injury included Armillaria root rot

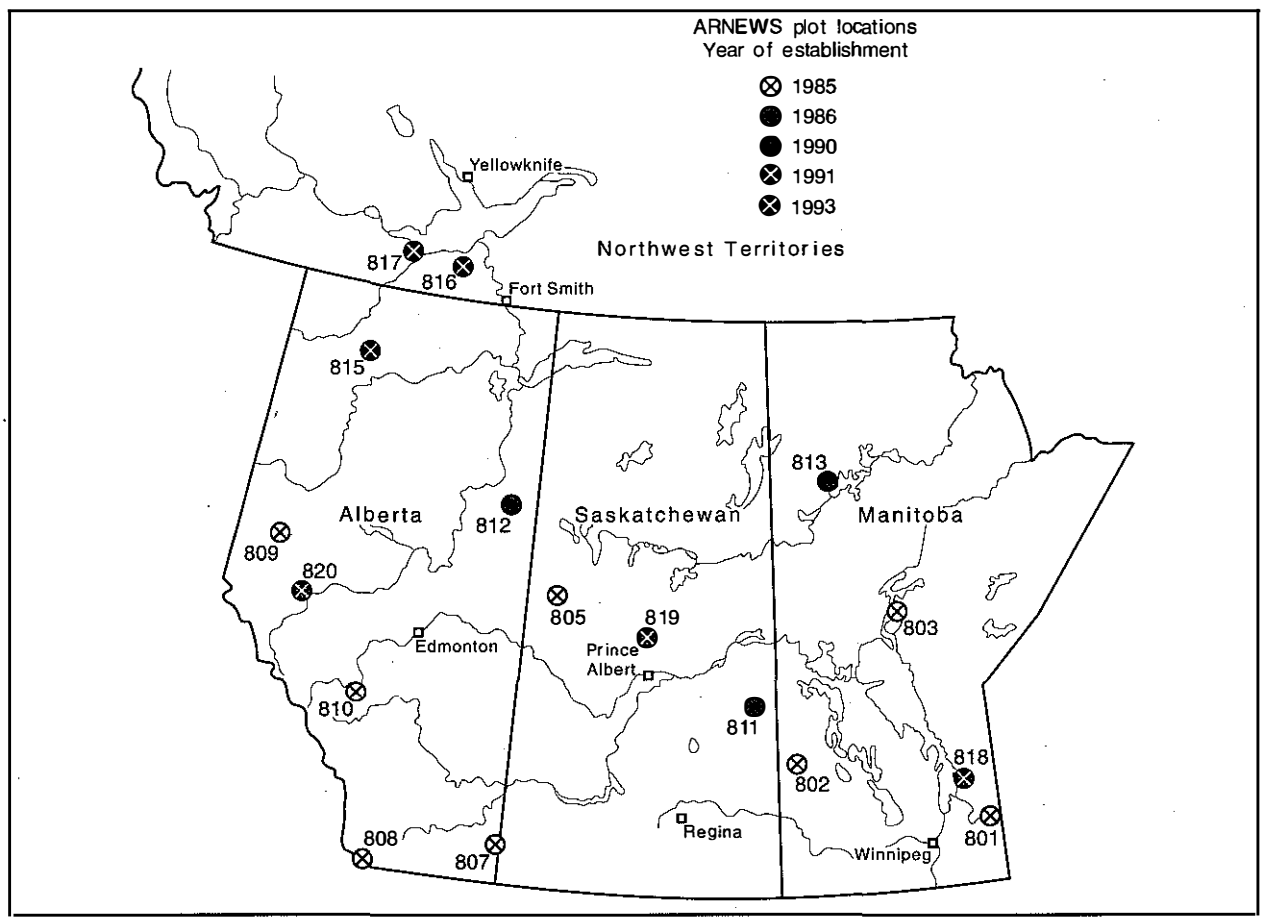

Figure 14. Locations of Acid Rain National Early Warning System plots used for detecting symptoms of acid rain injury to forests in the Northwest Region.

(*Armillaria* sp.), Atropellis canker (*Atropellis piniphila* [Weir] Lohman & Cash), false tinder conk, large aspen tortrix, large-spored spruce–Labrador tea rust (*Chrysomyxa ledicola* Lagh.), Elytroderma needle cast (*Elytroderma deformans* [Weir] Darker), ragged sprucegall adelgid, spruce gall midge, and yellow witches' broom (*Chrysomyxa arctostaphyli* Diet.).

In **Saskatchewan**, pests observed on trees in ARNEWS plots were Armillaria root rot (*Armillaria* sp.), false tinder conk, lodgepole pine dwarfmistletoe (*Arceuthobium americanum* Nutt. ex Engelm.), large aspen tortrix, pale spruce gall adelgid (*Adelges strobilobius* [Kltb.]), poplar borer, spruce budworm, and western gall rust.

Pests found on trees in **Manitoba** ARNEWS plots included false tinder conk, introduced false balsam gall midge (*Dasineura balsamicola* [Lint.]), large aspen tortrix, poplar Peniophora, spruce budworm, and western gall rust. Squirrel (*Tamiasciurus* sp.) damage was also evident.

In the **Northwest Territories**, only false tinder conk and spruce gall midge were observed on trees in the ARNEWS plots.

NOTEWORTHY INSECTS, DISEASES, AND OTHER DAMAGE AGENTS

Insect, disease, or damage agent	Host	Location	Remarks
American aspen beetle *Gonioctena americana* (Schaeff.)	Aspen	Alberta	Observed defoliating aspen in the southern foothills.
Aphids *Pterocomma bicolor* (Oestlund) *Chaitophorus populifolii neglectus* (Hottes & Frison)	Aspen	Alberta	High populations of these aphids caused severe damage in many areas of Calgary.
Armillaria root rot *Armillaria ostoyae* (Romag.) Herink	Pine species	Alberta Saskatchewan	Infection centers found throughout most of the region.
Ash borer *Podosesia syringae* (Harr.)	Ash	Saskatchewan	Injury noted on ornamentals in Saskatoon.
Aspen leaf beetle *Chrysomela crotchi* Brown	Aspen	Saskatchewan Manitoba	Found defoliating aspen regeneration in northeastern Saskatchewan. Also found in Spruce Woods Provincial Forest in Manitoba.
Aspen mortality	Aspen	Alberta Saskatchewan	Mortality resulting from drought and past insect defoliation observed throughout Athabasca and Lac La Biche forests in Alberta and throughout north-central Saskatchewan.
Aspen serpentine leafminer *Phyllocnistis populiella* (Cham.)	Aspen	NWT	Observed low population densities near Fort Liard.

Insect, disease, or damage agent	Host	Location	Remarks
Atropellis canker *Atropellis piniphila* (Weir) Lohman & Cash	Pine	Alberta	Commonly found on lodgepole pine near Rocky Mountain House.
Balsam fir mortality	Balsam fir	Alberta	Observed in Slave Lake, Athabasca, Lac La Biche, Whitecourt, and Grande Prairie forests.
Bark beetles *Pityophthorus* sp.	Jack pine	Saskatchewan	Found attacking jack pine regeneration that had been girdled by hares.
Birch leafminers *Fenusa pusilla* (Lep.) *Profenusa thomsoni* (Konow) *Heterarthrus nemoratus* (Fall.)	Birch	Alberta Manitoba	Leaf mining occurred throughout north-central Alberta and most urban areas. Also prevalent in Manitoba.
Birch skeletonizer *Bucculatrix canadensisella* Cham.	White birch	Alberta	Moderate-to-severe injury noted in the Fox Creek and Whitecourt area. Light injury noted near Swan Hills.
Climatic damage	Lodgepole pine Alpine larch	Alberta	Sunscald damage noted on lodgepole pine near Grande Cache. Alpine larch cones damaged by late frosts between Coleman and Canmore.
Conifer–aspen rust *Melampsora medusae* Thuem.	Aspen	Alberta	Trees south of Longview were moderately to severely infected with this disease.
Cytospora canker *Leucostoma kunzei* var. *piceae* (Fr.) Munk	Blue spruce White spruce	Manitoba	Damage observed on spruce shelterbelts.
Diplodia tip blight *Sphaeropsis sapinea* (Fr.) Dyko & Sutton	Red pine	Manitoba	Prevalent in southeast Manitoba. Caused cankers on the stems.
Dothiorella wilt *Dothiorella ulmi* Verrall & May	American elm	Alberta	Crown wilt and defoliation occurred on one tree in Edmonton.
Eastern larch beetle *Dendroctonus simplex* Lec.	Tamarack	Saskatchewan	Found attacking tamarack trees that had been defoliated by spruce budworm near Red Earth. Scattered patches over 10 km^2.

Insect, disease, or damage agent	Host	Location	Remarks
European fruit lecanium *Parthenolecanium corni* (Bouché)	Green ash Elm	Alberta	Severe outbreak in some parts of Edmonton, especially near the university.
Gall-forming mites and midges *Aceria dispar* (Nal.) *Cecidomyia* sp.	Aspen	Alberta	Found causing damage to regenerating aspen near Peace River.
Hemlock looper *Lambdina f. fiscellaria* (Gn.)	Conifers	Saskatchewan	Moths captured in spruce budworm pheromone traps in the Big River area.
Ink spot of aspen *Ciborinia whetzelii* (Seaver) Seaver	Aspen	Alberta	Patches of aspen severely defoliated in the Bow-Crow Forest near Highwood River.
Larch sawfly *Pristiphora erichsonii* (Htg.)	Tamarack	Alberta NWT	Defoliation ranged from light to moderate in tamarack stands along the Slave River in northern Alberta and the NWT.
Large-spored spruce–Labrador tea rust *Chrysomyxa ledicola* Lagh.	Spruce	Alberta Saskatchewan	Observed in northeastern Alberta near Fort McMurray and southwest of Rocky Mountain House. Also found north of Hudson Bay, Saskatchewan.
Linospora leaf blight *Linospora tetraspora* G.E. Thompson	Aspen	Manitoba	Found throughout the southern range of balsam poplar in Manitoba.
Linden looper *Erannis tiliaria tiliaria* (Harr.)	Hardwoods	Alberta	Light, light-to-moderate, and moderate defoliation on hazelnut and other hardwoods south of Grande Prairie.
Lodgepole pine beetle *Dendroctonus murrayanae* Hopk.	Lodgepole pine	Alberta	Several infested trees found in Jasper National Park.
Lodgepole pine dwarf mistletoe *Arceuthobium americanum* Nutt. ex Engelm.	Pine	Alberta Saskatchewan Manitoba	Important cause of degradation and mortality in commercial pine stands in the Northwest Region.
Lodgepole terminal weevil *Pissodes terminalis* Hopping	Jack pine Lodgepole pine	Alberta Saskatchewan	Jack pine regeneration (about 2 m tall) infested in central Saskatchewan. Common on lodgepole pine (2–7 m tall) near Hinton, Alberta, and on jack pine near The Pas, Manitoba.

Insect, disease, or damage agent	Host	Location	Remarks
Marssonina leaf spot *Marssonina tremuloides* Kleb.	Aspen	Alberta	Severe infestation at Belly River campground in Waterton Lakes National Park.
Northern pitch twig moth *Petrova albicapitana* (Bsk.)	Pine	Alberta	High population observed attacking pine regeneration in Whitecourt Forest and in Rocky-Clearwater Forest.
Pine engraver *Ips pini* (Say)	Tamarack Jack pine	Saskatchewan	Found attacking tamarack weakened by spruce budworm defoliation and on weakened jack pine near Prince Albert.
Pine needle casts *Lophodermella concolor* (Dearn.) Darker *Davisomycella ampla* (Davis) Darker *Elytroderma deformans* (Weir) Darker	Lodgepole pine	Alberta	Needle casts observed in the Rocky Mountain national parks and in Edson, Rocky-Clearwater, and Bow-Crow forests.
Poplar-and-willow borer *Cryptorhynchus lapathi* (L.)	Poplar	Alberta	Found for the first time in St. Albert, near Redwater, and Edmonton.
Ragged sprucegall adelgid	Spruce	Alberta	In Banff and Jasper national parks near Saskatchewan River Crossing.
Salt damage	Jack pine	NWT	Several patches of dead or dying jack pine regeneration were found along Highway 5 east of Hay River killed by accidental deposits of road salt.
Septoria leaf spot *Mycosphaerella populicola* G.E. Thompson	Aspen	Alberta	Moderate infestation observed in Waterton Lakes National Park.
Snow mold *Herpotrichia* sp.	Alpine fir Spruce	Alberta	Common at high elevations in Waterton Lakes National Park.
Snowshoe hare *Lepus americanus* Erxleben	Jack pine White spruce	Saskatchewan	Severe tree mortality noted in jack pine and white spruce regeneration southeast of Hudson Bay in the Porcupine Hills.
Spruce cone axis midge *Kaltenbachiola rachiphaga* (Tripp)	White spruce	Alberta	Found feeding in spruce cones collected for seed from Lac La Biche and Peace River forests.

Insect, disease, or damage agent	Host	Location	Remarks
Spruce cone maggot *Strobilomyia neanthracina* Michelsen	White spruce	Alberta	Found feeding in spruce cones collected for seed from Lac La Biche and Peace River forests.
Spruce cone rust *Chrysomyxa pirolata* (Körn.) Winter	White spruce	Alberta	Severely infested cones noted in William A. Switzer Provincial Park.
Spruce gall adelgids *Adelges cooleyi* (Gill.) *A. lariciatus* (Patch) *A. strobilobius* (Kltb.)	Spruce	Alberta Saskatchewan	All three adelgids commonly observed throughout northern and western Alberta and northwestern Saskatchewan.
Spruce seed chalcid *Megastigmus atedius* Wlk.	White spruce	Alberta	Found feeding in white spruce cones collected for seed from Lac La Biche and Peace River forests.
Spruce seed moth *Cydia strobilella* L.	White spruce	Alberta	Found feeding in white spruce cones collected near Jasper National Park.
Spruce spider mite *Oligonychus ununguis* (Jac.)	Spruce	Alberta	Severe damage occurred in Edmonton and in rural shelterbelts throughout the Northwest Region.
Stalactiform blister rust *Cronartium coleosporioides* Arth.	Lodgepole pine	Alberta	High incidence of this disease in Banff and Jasper national parks.
Striped ambrosia beetle *Trypodendron lineatum* (Oliv.)	Aspen	Saskatchewan	Found as a secondary pest attacking dead or dying aspen succumbing to drought in eastern Saskatchewan.
Sulphur dioxide damage (SO_2)	Aspen	Alberta	Light damage attributed to SO_2 noted on aspen west of High Level near Zama Lake.
Venturia leaf and shoot blight *Venturia macularis* (Fr.) E. Müller and Arx.	Aspen	Alberta	Infestations of this blight were observed in aspen regeneration in southern Alberta in the foothills and near Peace River.
Warren rootcollar weevil *Hylobius warreni* Wood	Jack pine Lodgepole pine	Alberta Manitoba	Mortality caused by *H. warreni* noted generally throughout the Northwest Region. Severe damage noted near The Pas in northern Manitoba.

Insect, disease, or damage agent	Host	Location	Remarks
Western gall rust *Endocronartium harknessii* (J.P. Moore) Y. Hiratsuka	Pine	Alberta Saskatchewan Manitoba	Common on pines throughout the Northwest Region.
Wetwood or slime flux	Elm	Manitoba	Numerous reports of this symptom (caused by a bacterium) received from landowners in Manitoba.
White pine weevil *Pissodes strobi* (Peck)	Spruce	Alberta Saskatchewan Manitoba	Commonly found on roadside trees and plantations throughout the north-central region of Alberta and Saskatchewan, and Manitoba.
Willow leaf miner *Micrurapteryx salicifoliella* (Cham.)	Willow	Alberta	Severe damage observed from Alberta/NWT border to just north of High Level.

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APPENDIX 1
INSECTS, PHEROMONE-RELATED INFORMATION, LURES AND TRAP TYPES

Douglas-fir beetle
- Chemical component(s): frontalin, (±)-(1-methyl-2-cyclohexen-1-ol), ethanol
- Lure type: Douglas-fir Beetle Funnel Lures
- Trap: Lindgren Funnel Trap
- Pheromone source: Phero Tech Inc., Delta, British Columbia

Gypsy moth
- Chemical component(s): (+)cis-7, 8-epoxy-2-methyloctadecane (Disparlure^{R})
- Lure type: laminate strip
- Trap: Delta Sticky Trap
- Pheromone source: Trécé Inc., Salinas, California (purchased and distributed by Agriculture Canada)

Jack pine budworm
- Chemical component(s): 85% of [95/5 E/Z-11-tetradecenyl acetate] and 15% of [95/5 E/Z-11-tetradecenol]
- Lure type: PVC rods or rubber septa
- Trap: Pherocon IC, Unitrap, Multipher JPBW Trap
- Pheromone source: Research Productivity Council, Fredericton, New Brunswick

Mountain pine beetle
- Chemical component(s): trans-verbenol, exo-brevicomin
- Lure type: Mountain Pine Beetle Tree Bait
- Trap: not applicable
- Pheromone source: Phero Tech Inc., Delta, British Columbia

Smaller European elm bark beetle
- Chemical component(s): α-cubebene, 4-methyl-3-heptanol, and α-multistriatin
- Lure type: capsule
- Trap: Dewill Elm Bark Beetle Trap
- Pheromone source: Great Lakes IPM, Vestaburg, Michigan

Spruce budworm
- Chemical component(s): 95% E-11-tetradecenal, 5% Z-11-tetradecenal
- Lure type: Biolure
- Trap: Multipher SBW Trap
- Pheromone source: Dr. C.J. Sanders, Natural Resources Canada, Sault Ste. Marie, Ontario

Spruce beetle
- Chemical component(s): frontalin, α-pinene
- Lure type: Spruce Beetle Tree Bait, Spruce Beetle Funnel Lure
- Trap: not applicable, Lindgren Funnel Trap
- Pheromone source: Phero Tech Inc., Delta, British Columbia

APPENDIX 2
SUMMARY OF SPRUCE BUDWORM PHEROMONE TRAP SURVEY RESULTS IN ALBERTA IN 1993

Forest	Site	Location[a]				Number of moths			
		Sec.	Twp.	Rge.	Mer.	Trap 1	Trap 2	Trap 3	Average
Athabasca	1	2	95	15	W4	78	203	135	139
	2	7	94	10	W4	51	78	64	64
	3	17	82	12	W4	N/A[b]	N/A	N/A	178
	4	29	86	15	W4	N/A	N/A	N/A	533
	5	12	86	13	W4	N/A	N/A	N/A	51
	6	26	88	6	W4	N/A	N/A	N/A	142
	7	22	121	9	W4	229	285	280	265
	8	12	108	10	W4	N/A	N/A	N/A	N/A
	9	28	91	13	W4	N/A	N/A	N/A	N/A
Bow-Crow	1	34	9	5	W5	1	2	2	2
	2	11	11	5	W5	7	7	9	8
	3	21	13	5	W5	1	1	2	1
	4	30	22	10	W5	6	5	6	6
	5	5	22	10	W5	3	4	5	4
	6	32	6	5	W5	5	2	1	3
	7	18	24	7	W5	1	2	1	1
Edson	1	7	57	13	W6	N/A	N/A	N/A	1
	2	9	51	11	W6	N/A	N/A	N/A	1
	3	26	51	12	W6	N/A	N/A	N/A	2
	4	31	55	13	W6	N/A	N/A	N/A	1
	5	24	54	13	W6	N/A	N/A	N/A	2
	6	3	56	12	W6	N/A	N/A	N/A	3
	7	27	56	11	W6	N/A	N/A	N/A	0
	8	23	55	13	W6	N/A	N/A	N/A	1
	9	23	48	25	W5	N/A	N/A	N/A	1
	10	20	46	18	W5	N/A	N/A	N/A	5
	11	9	45	21	W5	N/A	N/A	N/A	0
Footner Lake	1	2	111	7	W5	N/A	N/A	N/A	N/A
	2	28	101	10	W5	16	20	34	23
	3	6	99	8	W5	43	30	13	29
	4	21	118	4	W6	N/A	N/A	N/A	N/A
	5	1	112	20	W5	N/A	N/A	N/A	N/A
	6	30	103	19	W5	183	N/A	N/A	183
	7	5	118	8	W6	N/A	N/A	N/A	N/A
	8	33	107	6	W6	678	1120	928	909
	9	28	116	22	W5	419	356	452	409
	10	16	111	6	W6	2350	1827	2235	2137
	11	21	110	22	W5	328	351	401	360
	12	26	110	3	W6	252	187	225	221
	13	10	117	22	W5	54	23	78	52
	14	19	112	20	W5	220	149	232	200
	15	15	107	9	W6	N/A	836	448	642
	16	6	108	9	W6	N/A	N/A	2200	2200
	17	N/A	116	3	W6	1201	1125	1056	1127

Appendix 2 concluded.

Forest	Site	Location[a]				Number of moths			
		Sec.	Twp.	Rge.	Mer.	Trap 1	Trap 2	Trap 3	Average
Grande Prairie	1	13	80	26	W5	116	99	105	107
	2	2	80	1	W6	110	N/A[b]	N/A	110
	3	10	74	24	W5	78	82	62	74
	4	24	72	24	W5	N/A	N/A	N/A	N/A
	5	26	59	14	W6	2	0	6	3
	6	33	58	12	W6	9	2	1	4
	7	17	62	12	W6	3	1	3	2
	8	23	61	6	W6	5	2	0	2
	9	8	61	3	W6	2	5	8	5
Lac La Biche	1	9	74	22	W4	192	223	N/A	208
	2	36	70	20	W4	57	35	27	40
	3	16	78	15	W4	180	184	165	176
	4	19	77	17	W4	170	207	46	141
Peace River	1	23	90	20	W5	175	340	138	218
	2	33	93	16	W5	270	553	621	481
	3	16	93	19	W5	184	145	157	162
	4	3	94	25	W5	216	363	546	375
	5	20	96	22	W5	350	354	367	357
	6	9	99	22	W5	640	1431	581	884
	7	14	94	20	W5	384	293	360	346
	8	36	98	23	W5	N/A	1921	1170	1546
Rocky-Clearwater	1	25	44	12	W5	10	20	42	24
	2	13	43	7	W5	N/A	N/A	N/A	N/A
	3	13	35	9	W5	6	11	13	10
	4	21	40	15	W5	0	1	0	0
	5	18	43	6	W5	22	41	N/A	32
Slave Lake	1	20	73	3	W5	123	70	80	91
	2	32	69	25	W4	118	104	126	116
	3	24	73	8	W5	73	89	67	76
	4	3	69	9	W5	152	122	N/A	137
	5	8	83	13	W5	143	355	184	227
	6	17	73	15	W5	109	172	N/A	141
	7	36	90	12	W5	732	913	539	728
	8	27	91	3	W5	150	109	N/A	130
	9	14	86	21	W4	182	421	249	284
	10	19	86	20	W4	495	144	571	403
Whitecourt	1	30	52	11	W5	11	13	25	16
	2	12	62	19	W5	N/A	N/A	N/A	48
	3	33	63	10	W5	16	N/A	13	15

Note: Pheromone trap surveys were conducted by Alberta Land and Forest Services.

[a] Location described as section, township, range, and meridian.

[b] Not available.

APPENDIX 3
SPRUCE BUDWORM SECOND INSTAR LARVAE DENSITIES AND 1994 DEFOLIATION FORECASTS FOR ALBERTA

Forest	Site	Location[a]			Avg. no. of L_2 counts/10 m^2 of foliage[b]	Predicted defoliation in 1994[c]
		Twp.	Rge.	Mer.		
Footner Lake	1	111	23	W5	655	Severe
	2	110	23	W5	6	Light
	3	110	23	W5	329	Moderate
	4	109	23	W5	0	Nil
	5	109	24	W5	796	Severe
	6	110	24	W5	1066	Severe
	7	110	24	W5	14	Light
	8	111	23	W5	353	Moderate
	9	111	24	W5	252	Moderate
	10	111	1	W6	69	Light
	11	112	24	W5	56	Light
	12	110	1	W6	70	Light
	13	109	1	W6	830	Severe
	14	110	1	W6	1399	Severe
	15	109	1	W6	20	Light
	16	110	1	W6	141	Light
	17	112	1	W6	120	Light
	18	111	1	W6	356	Moderate
	19	112	2	W6	606	Severe
	20	110	2	W6	1010	Severe
	21	111	2	W6	446	Moderate
	22	110	2	W6	380	Moderate
	23	110	2	W6	66	Light
	25	110	3	W6	201	Moderate
	26	109	3	W6	889	Severe
	27	109	2	W6	93	Light
	28	108	3	W6	272	Moderate
	29	109	3	W6	221	Moderate
	30	109	3	W6	351	Moderate
	31	110	4	W6	1536	Severe
	32	110	5	W6	227	Moderate
	33	111	5	W6	551	Severe
	34	111	5	W6	134	Light
	35	111	6	W6	297	Moderate
	36	112	10	W6	71	Light

Appendix 3 concluded.

Forest	Site	Location[a] Twp.	Rge.	Mer.	Avg. no. of L_2 counts/10 m^2 of foliage[b]	Predicted defoliation in 1994[c]
Athabasca	1	84	17	W4	305	Moderate
	2	84	17	W4	155	Light
	3	84	17	W4	224	Moderate
	4	84	17	W4	37	Light
	5	86	18	W4	380	Moderate
	6	84	17	W4	29	Light
	7	86	18	W4	7	Light
	8	85	18	W4	27	Light
	9	85	17	W4	55	Light
	10	82	12	W4	9	Light

Note: L_2 surveys were conducted by Alberta Land and Forest Services.
Site 24 was not surveyed.

[a] Location described as township, range, and meridian.

[b] Values for L_2 counts are an average of 4 trees (1 branch/tree) per site.

[c] Predicted defoliation is based on second instar larval densities per 10 m^2. Light = ≤188 larvae/10 m^2, moderate = 189–540 larvae/10 m^2, and severe = ≥541 larvae/10 m^2 (Juneau 1989).

APPENDIX 4
SUMMARY OF 1993 SPRUCE BUDWORM PHEROMONE TRAP SURVEY RESULTS IN SASKATCHEWAN

Region	UTM location[a]			Number of moths			
	Zone	E	N	Trap 1	Trap 2	Trap 3	Average
Hudson Bay	13	60	581	98	N/A[b]	109	104
	13	61	580	N/A	N/A	182	182
	13	61	580	52	112	79	81
	13	63	581	N/A	349	220	285
	13	63	585	N/A	683	N/A	683
	13	61	588	609	520	486	538
	13	64	581	1372	1289	1403	1355
	13	64	585	634	489	643	589
	13	64	591	865	846	977	896
	13	65	584	923	1070	914	969
	13	66	579	83	94	91	89
	13	66	580	1339	1293	949	1194
	13	66	584	1062	1186	943	1064
	13	66	581	1053	873	916	947
	13	67	581	113	172	156	147
	13	67	581	117	N/A	283	200
	13	67	587	183	N/A	163	173
	13	68	581	107	83	179	123
	13	68	581	103	129	138	123
	13	68	582	94	N/A	72	83
	13	69	580	87	79	73	80
	13	69	591	23	17	14	18
	13	69	591	79	109	96	95
	13	69	593	43	46	42	44
	13	70	579	18	33	37	29
	14	31	578	56	49	68	58
	14	31	579	78	113	34	75
	14	31	581	N/A	21	N/A	21
	14	31	584	63	22	51	45
	14	31	585	77	127	66	90
Meadow Lake	12	57	605	28	24	41	31
	12	59	605	40	96	46	61
	12	65	598	11	33	6	17
	12	65	605	188	149	131	156
	12	66	604	119	183	183	162
	12	66	605	208	155	163	175
	12	67	594	35	49	76	53
	12	67	595	75	44	46	55
	12	67	597	112	N/A	71	92
	12	67	609	N/A	N/A	N/A	N/A
	12	67	610	103	138	143	128
	12	68	595	70	N/A	N/A	70
	12	69	595	N/A	109	111	110
	13	30	592	150	161	139	150
	13	31	604	N/A	1574	N/A	1574
	13	31	605	76	72	78	75

Appendix 4 continued.

Region	UTM location[a]			Number of moths			
	Zone	E	N	Trap 1	Trap 2	Trap 3	Average
Meadow Lake	13	31	605	105	251	194	183
	13	32	598	N/A[b]	140	81	111
	13	32	600	N/A	N/A	391	391
	13	32	600	178	N/A	N/A	178
	13	32	601	410	330	N/A	370
	13	32	601	N/A	N/A	N/A	N/A
	13	32	601	750	750	N/A	750
	13	32	601	450	580	725	585
	13	32	608	144	253	238	212
	13	33	597	60	82	79	74
	13	33	599	220	500	750	490
	13	33	600	720	1200	525	815
	13	33	600	161	91	139	130
	13	33	601	264	N/A	344	304
	13	33	601	357	297	396	350
	13	34	599	186	260	213	220
	13	34	599	123	127	N/A	125
	13	34	599	165	N/A	71	118
	13	34	599	162	165	169	165
	13	34	599	123	N/A	311	217
Prince Albert	13	34	600	497	90	225	271
	13	34	600	N/A	N/A	N/A	N/A
	13	34	600	N/A	N/A	N/A	N/A
	13	34	600	112	N/A	273	193
	13	34	601	1051	N/A	1043	1047
	13	34	601	1160	1300	N/A	1230
	13	34	601	N/A	1050	N/A	1050
	13	34	602	N/A	N/A	N/A	N/A
	13	34	602	313	109	235	219
	13	34	603	2130	1160	1220	1503
	13	34	605	1570	2134	N/A	1852
	13	35	598	N/A	N/A	N/A	N/A
	13	35	599	N/A	742	N/A	742
	13	35	600	N/A	N/A	N/A	N/A
	13	35	602	400	290	375	355
	13	35	603	283	131	221	212
	13	35	603	2244	1198	2211	1884
	13	35	603	62	497	565	375
	13	35	604	N/A	N/A	622	622
	13	35	604	418	300	345	354
	13	35	604	198	286	269	251
	13	35	605	N/A	N/A	1260	1260
	13	35	605	N/A	N/A	N/A	N/A
	13	36	598	3100	1760	1970	2277
	13	36	599	N/A	N/A	N/A	N/A
	13	36	599	1440	1050	1160	1217

Appendix 4 concluded.

Region	UTM location[a]			Number of moths			
	Zone	E	N	Trap 1	Trap 2	Trap 3	Average
Prince Albert	13	36	600	331	687	372	463
	13	36	605	N/A[b]	N/A	N/A	N/A
	13	37	598	475	1881	445	934
	13	37	598	2762	1410	3118	2430
	13	37	598	892	1084	1228	1068
	13	37	598	N/A	1200	1400	1300
	13	37	598	226	239	375	280
	13	37	599	1440	770	870	1027
	13	37	599	1149	N/A	2400	1775
	13	37	599	N/A	2030	2030	2030
	13	37	599	1115	792	651	853
	13	37	601	N/A	N/A	N/A	N/A
	13	37	604	800	N/A	N/A	800
	13	37	606	390	N/A	N/A	390
	13	38	604	140	560	220	307
	13	39	605	742	594	594	643
	13	39	606	180	N/A	60	120
	13	40	605	330	N/A	N/A	330
	13	41	606	N/A	N/A	N/A	N/A
	13	43	594	103	77	66	82
	13	43	596	109	86	109	101
	13	43	601	1606	N/A	N/A	1606
	13	44	594	66	49	54	56
	13	44	594	N/A	N/A	N/A	N/A
	13	44	602	254	168	145	189
	13	44	603	206	N/A	N/A	206
	13	45	598	N/A	N/A	N/A	N/A
	13	45	599	90	132	117	113
	13	45	611	N/A	N/A	N/A	N/A
	13	46	599	N/A	399	379	389
	13	47	597	141	N/A	N/A	141
	13	48	595	185	303	N/A	244
	13	49	597	166	226	N/A	196
	13	49	598	200	323	202	242
	13	50	600	190	145	124	153
	13	50	602	N/A	N/A	N/A	N/A
	13	51	606	N/A	314	457	386
	13	53	595	N/A	433	N/A	433
	13	55	595	N/A	254	310	282
Prince Albert National Park	N/A	N/A	N/A	130	208	116	151
	N/A	N/A	N/A	126	112	N/A	119
	N/A	N/A	N/A	110	62	90	87
	N/A	N/A	N/A	117	117	N/A	117
	N/A	N/A	N/A	61	N/A	50	56

Note: Pheromone trap surveys were conducted by Saskatchewan Environment and Resource Management.

[a] UTM (Universal Transverse Mercator Grid =100 km^2 map sheet area) location described as zone, easting, and northing.

[b] Not available.

APPENDIX 5
SPRUCE BUDWORM SECOND INSTAR LARVAE DENSITIES AND 1994 DEFOLIATION FORECASTS FOR SASKATCHEWAN

Region	UTM location[a]			Avg. no. of L_2 larvae/10 m^2 of foliage	Predicted defoliation in 1994[b]
	Zone	E	N		
Hudson Bay	13	60	581	19	Light
	13	61	580	3	Light
	13	61	588	5	Light
	13	62	585	7	Light
	13	64	585	25	Light
	13	65	584	65	Light
	13	66	581	74	Light
	13	67	581	28	Light
	13	67	587	15	Light
	13	70	579	7	Light
Meadow Lake	13	31	604	12	Light
	13	32	600	92	Light
	13	32	601	17	Light
	13	33	599	75	Light
	13	33	600	26	Light
	13	33	601	58	Light
	13	33	602	9	Light
	13	33	604	77	Light
	13	33	605	458	Moderate
	13	33	606	30	Light
	13	34	599	23	Light
Prince Albert	13	34	600	8	Light
	13	34	601	133	Light
	13	34	602	100	Light
	13	34	603	24	Light
	13	34	604	8	Light
	13	34	605	172	Light
	13	34	606	159	Light
	13	35	598	32	Light
	13	35	599	42	Light
	13	35	600	459	Moderate
	13	35	601	73	Light
	13	35	603	65	Light
	13	35	604	11	Light
	13	35	605	17	Light
	13	35	606	103	Light
	13	36	599	23	Light
	13	36	600	27	Light
	13	36	603	343	Moderate
	13	36	604	130	Light
	13	36	605	194	Moderate

Appendix 5 concluded.

Region	UTM location[a] Zone	E	N	Avg. no. of L_2 larvae/10 m^2 of foliage	Predicted defoliation in 1994[b]
Prince Albert	13	36	606	40	Light
	13	37	598	43	Light
	13	37	599	113	Light
	13	37	600	35	Light
	13	37	604	8	Light
	13	37	605	42	Light
	13	37	606	15	Light
	13	39	605	96	Light
	13	39	606	0	Nil
	13	40	605	0	Nil
	13	43	601	20	Light
	13	43	594	15	Light

Note: L_2 surveys were conducted by Saskatchewan Environment and Resource Management.

[a] UTM (Universal Transverse Mercator Grid =100 km^2 map sheet area) location described as zone, easting, and northing.

[b] Predicted defoliation is based on second instar larval densities per 10 m^2. Light = ≤188 larvae/10 m^2, moderate = 189–540 larvae/10 m^2, and severe = ≥541 larvae/10 m^2 (Juneau 1989). Forecasts are an average for each 100 km^2 map sheet area (i.e., UTM cell); some stands within each cell may be more or less defoliated than predicted.

APPENDIX 6
SUMMARY OF JACK PINE BUDWORM PHEROMONE TRAP SURVEY RESULTS IN ALBERTA AND SASKATCHEWAN IN 1993

Province	UTM location[a]			Number of moths			
	Zone	E	N	Trap 1	Trap 2	Trap 3	Average
Alberta	12	415	5992	0	5	12	6
	12	336	6003	6	0	3	3
	12	316	5918	3	2	5	3
Saskatchewan	13	561	5934	0	5	1	2
	13	561	5934	5	2	9	5
	13	561	5934	3	7	8	6
	13	535	5905	1	0	0	1
	13	535	5905	0	0	0	0
	13	535	5905	0	0	0	0
	13	436	5897	3	N/A[b]	0	1
	13	436	5897	2	2	2	2
	13	436	5897	0	1	3	1

[a] UTM (Universal Transverse Mercator Grid =100 km^2 map sheet area) location described as zone, easting, and northing.
[b] Not available.

APPENDIX 7
SUMMARY OF JACK PINE BUDWORM EGG-MASS SURVEY RESULTS IN MANITOBA IN 1993

Section	Location	Location[a] Sec.	Twp.	Rge.	Mer.	No. egg masses/ plot	1993 avg. defoliation (%)	1994 predicted defoliation
Aspen Parkland	Shilo[b]	18	10	16	W	0	5	Nil
	Shilo[b]	18	10	16	W	0	5	Nil
Pineland	Richer	11	7	10	E	0	5	Nil
	Marchland	15	6	10	E	0	5	Nil
	Richer	30	7	10	E	0	5	Nil
	Richer	36	7	9	E	0	5	Nil
	Richer	30	7	11	E	1	5	Light
	Bedford	3	5	9	E	0	5	Nil
	Bedford	22	5	9	E	0	5	Nil
	Badger	28	3	11	E	0	5	Nil
	Badger	7	3	12	E	0	5	Nil
	Woodridge[b]	11	4	10	E	0	5	Nil
	Woodridge[b]	11	4	10	E	0	5	Nil
	Vassar[b]	36	1	12	E	0	5	Nil
	Lonesand[b]	15	3	9	E	0	5	Nil
	Woodridge[b]	12	4	10	E	0	5	Nil
	Sandiland[b]	32	4	10	E	0	5	Nil
	Kerry[b]	21	5	10	E	0	5	Nil
	Richer[b]	5	8	10	E	0	5	Nil
	Hadashville[b]	6	8	12	E	0	5	Nil
	Menisino[b]	30	1	11	E	0	5	Nil
	Lonesand[b]	9	3	9	E	0	5	Nil
	Sandilands[b]	8	4	9	E	0	5	Nil
	Bedford[b]	2	5	9	E	0	5	Nil
	Sandilands[b]	34	4	10	E	0	5	Nil
	Bedford[b]	8	5	10	E	0	5	Nil
	Bedford[b]	13	5	9	E	0	5	Nil
	Marchland[b]	19	5	10	E	0	5	Nil
	Marchland[b]	5	6	10	E	0	5	Nil
	Richer[b]	26	7	10	E	0	5	Nil
	Belair[b]	15	17	8	E	0	5	Nil
	Belair[b]	15	17	8	E	0	5	Nil
Highrock	Kississing[b]	14	67	27	W	0	5	Nil
	Kississing[b]	14	67	27	W	0	5	Nil
	Reed Lake[b]	32	64	21	W	0	5	Nil
	Reed Lake[b]	32	64	21	W	0	5	Nil
Interlake	St. Martin[b]	4	34	10	W	0	5	Nil
	St. Martin[b]	4	34	10	W	0	5	Nil
	Devils Lake	1	40	11	W	0	8	Nil
	Devils Lake	7	40	10	W	0	5	Nil
	Devils Lake	32	40	10	W	0	6	Nil
	Devils Lake	18	39	10	W	0	5	Nil

Appendix 7 concluded.

Section	Location	Location[a] Sec.	Twp.	Rge.	Mer.	No. egg masses/ plot	1993 avg. defoliation (%)	1994 predicted defoliation
Interlake	Devils Lake	7	39	10	W	0	5	Nil
	Devils Lake	36	37	11	W	0	5	Nil
	Twin Creeks	5	41	10	W	0	5	Nil
	Twin Creeks	7	42	10	W	0	6	Nil
	Twin Creeks	28	44	11	W	0	5	Nil
	Twin Creeks	34	43	11	W	0	5	Nil
Lake Winnipeg	Easy Cat Lake	2	19	15	E	0	5	Nil
	Euclid Lake Rd.	28	19	15	E	0	5	Nil
	Shoe Lake	35	19	15	E	0	5	Nil
	Black River	35	19	15	E	0	5	Nil
	Nopiming[b]	15	22	16	E	0	5	Nil
	Nopiming[b]	15	22	16	E	0	5	Nil
	Whiteshell[b]	15	13	14	E	0	5	Nil
	Whiteshell[b]	15	13	14	E	0	5	Nil
	Manigotagan[b]	30	24	12	E	0	5	Nil
	Manigotagan[b]	30	24	12	E	0	5	Nil
Mountain	Porcupine Mountain[b]	20	43	26	W	0	5	Nil
	Porcupine Mountain[b]	20	43	26	W	0	5	Nil
Nelson River	Wabowden[b]	24	67	9	W	0	5	Nil
	Wabowden[b]	24	67	9	W	0	5	Nil
	Thompson[b]	3	72	7	W	0	5	Nil
	Thompson[b]	3	72	7	W	0	5	Nil
Saskatchewan River	Westray	26	51	27	W	0	6	Nil
	Root Lake	9	59	26	W	0	5	Nil
	Westray	21	52	27	W	0	5	Nil
	Root Lake	8	59	26	W	0	5	Nil
	Moose Lake Rd.	34	55	23	W	0	5	Nil
	Wanless	28	60	26	W	0	5	Nil
	Moose Lake[b]	13	56	24	W	0	5	Nil
	Moose Lake[b]	13	56	24	W	0	5	Nil
	Grand Rapids[b]	32	50	13	W	0	5	Nil
	Grand Rapids[b]	32	50	13	W	0	5	Nil

Note: Surveys were conducted by Manitoba Natural Resources.

[a] Location described as section, township, range, and east or west of the principal meridian.

[b] Three jack pine budworm pheromone traps/location were set up in addition to the egg-mass survey.