Forest insect and disease conditions in west-central Canada in 1995 and predictions for 1996

J.P. Brandt, K.R. Knowles, R.M. Larson, H. Ono, and B.L. Walter

Northwest Region • Information Report NOR-X-347

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ABSTRACT

Forest insect and disease conditions in Alberta, Saskatchewan, Manitoba, and the Northwest Territories are summarized for 1995. Ground and aerial surveys included mapping pest infestations, trapping pests using pheromone-baited traps, conducting field pest collections and identifications, measuring damage intensity, and updating of pest distributions and their hosts throughout the study area. Infestations of and defoliation by spruce budworm, forest tent caterpillar, large aspen tortrix, aspen leafroller, mountain pine beetle, spruce beetle, Douglas-fir beetle, lodgepole pine dwarf mistletoe, satin moth, gypsy moth, and Dutch elm disease are discussed and compared to 1994 levels, as are other pests specifically affecting forest nurseries. An update of surveys for acid rain symptoms in permanently established Acid Rain National Early Warning System plots is also reported. Other noteworthy insects, diseases, and tree damage agents are discussed in tabular form. Forecasts of spruce budworm, jack pine budworm, and forest tent caterpillar populations are reported for 1996.

RÉSUMÉ

Ce rapport rend compte des conditions relatives au insectes et aux maladies des arbres en Alberta, en Saskatchewan, au Manitoba et dans les Territoires du Nord-Ouest en 1995. Les données ont été obtenues par des relevés effectués à la fois au sol et à l'aide d'aéronefs et comprenant cartographie des zones attaquées, capture d'insectes à l'aide de pièges à phéromone, récolte d'organismes sur le terrain pour leur identification, mesure des dommages et mise à jour des données sur la distribution des insectes et maladies et leurs hôtes dans toute la zone d'étude. Les auteurs examinent les données sur les infestations et la défoliation par la tordeuse des bourgeons de l'épinette, la livrée des forêts, la tordeuse du tremble, l'enrouleuse du tremble, le dendroctone du pin ponderosa, le dendroctone de l'épinette, le dendroctone du douglas, le faux-gui du pin tordu, le papillon satiné, la spongieuse et la maladie hollandaise de l'orme, sans oublier d'autres organismes qui affectent plus spécifiquement les pépinières forestières, et en comparant avec la situation en 1994. Ils font le point sur les observations des symptômes des pluies acides dans les placettes permanentes du Dispositif national d'alerte rapide pour les pluies acides. Ils présentent des renseignements sur d'autres insectes, maladies et agents importants sous forme de tableau. Enfin, ils fournissent des prévisions sur les populations de la tordeuse des bourgeons de l'épinette, de la tordeuse du pin gris et de la livrée des forêts pour 1996.

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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.

INTRODUCTION

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

Forest insect and disease surveys include aerial surveys to map pest infestations and damage intensity, ground surveys of permanent and temporary sample plots to assess forest health, and examinations of pests or damage symptoms in the laboratory. These activities involve collecting and identifying pests, measuring and assessing damage intensity, and updating pest distributions and hosts.

This report summarizes forest insect and disease conditions and other tree-damaging agents within the Northwest Region in 1995. The report also describes pest control projects throughout the region. Collections of insect and disease specimens

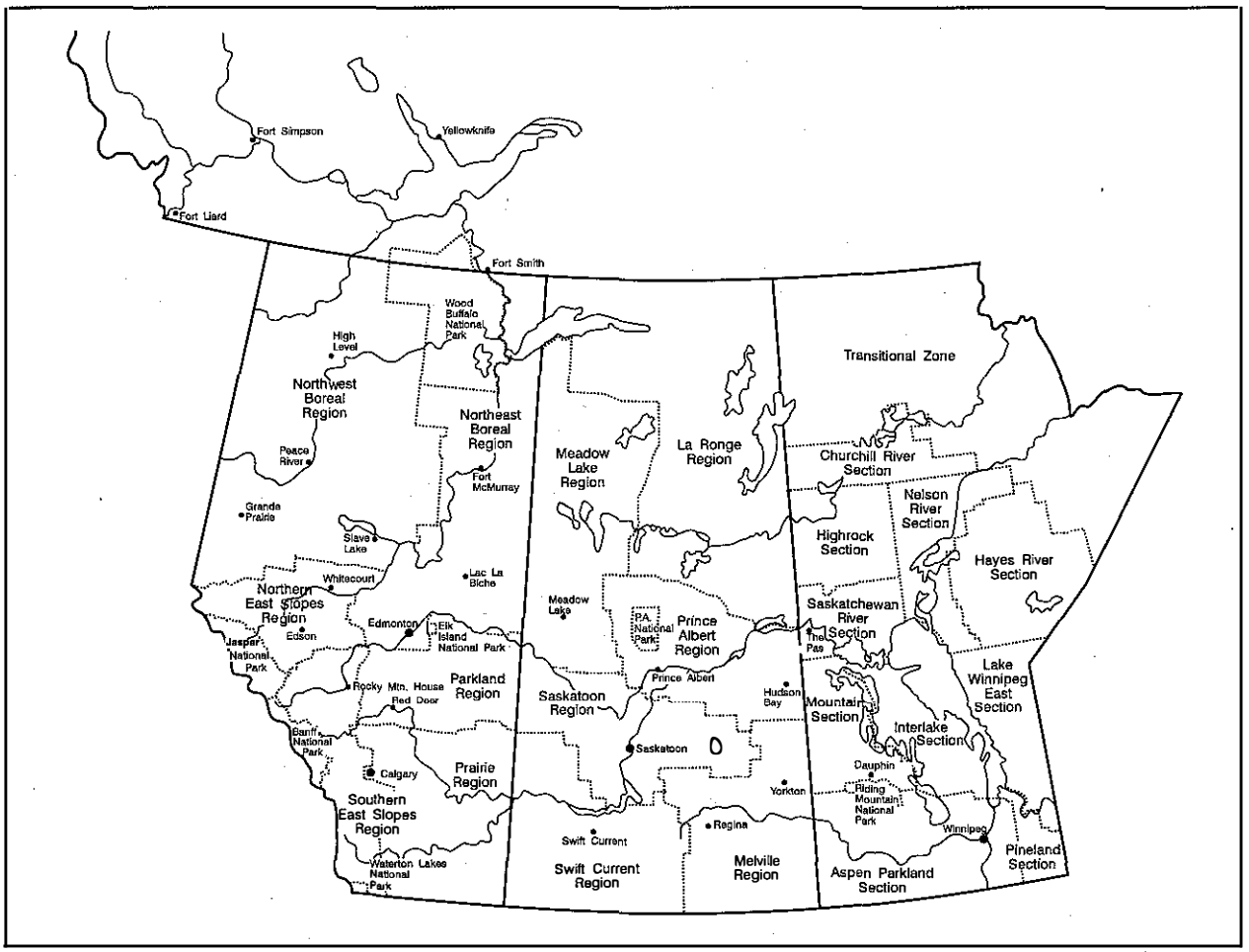

Figure 1. Boundaries of administrative districts of the three prairie provinces and the Northwest Territories.

made during the surveys are maintained at the Northern Forestry Centre in an insect reference collection and a disease reference collection (mycological herbarium). Mapped pest infestations are archived in a geographic information system (GIS). Records of new pests, new pest hosts, and changes in pest distribution are added annually to a national electronic data base known as FIDSINFOBASE (the Forest Insect and Disease Survey Information System). Reference collections and FIDSINFOBASE 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 surveys of tree nurseries are also reported. Other noteworthy tree-damaging agents are summarized in tabular form.

This report is based on forest insect and disease surveys and collections made from May to October, 1995, by staff of the provincial and territorial forestry agencies and by the following FIDS ranger staff: Roger Brett, Mike Grandmaison, Howard Gates, Colin Myrholm, and Daryl Williams. At the Northern Forestry Centre, other contributors to this report were Dr. David Langor, entomologist; Dr. Ken Mallett, pathologist; Dr. Jan Volney, entomologist and Project Leader for Forest Insect and Disease Management Systems and Surveys; and Andu Yohannes, entomology technician.

SPRUCE BUDWORM *Choristoneura fumiferana* (Clem.)

The locations of spruce budworm infestations and the intensity of defoliation observed in the Northwest Region in 1995 remained similar to observations made over the last two years (Brandt 1994, 1995). In Alberta, Saskatchewan, and Manitoba, infestations increased by 17, 89, and 15%, respectively, from the area of defoliation observed in 1994 (Table 1). In the Northwest Territories, infestations decreased 90% from 1994. Overall, infestations in the Northwest Region covered an area estimated at 395 065 ha, compared to 644 826 ha in 1994; this was a decrease of about 39%. The area of defoliation by defoliation class[1] was 111 977 ha of moderate defoliation, 98 910 ha of moderate-to-severe defoliation, and 184 178 ha of severe defoliation.

In **Alberta**, small infestations were observed along the Red Deer River in Red Deer and along the North Saskatchewan River in Edmonton. The outbreak in the Alberta portion of Wood Buffalo National Park decreased substantially in size—from 46 975 ha in 1994 to 695 ha of moderate defoliation in 1995.

Infestations in the administrative regions were monitored during aerial and ground surveys

Table 1. Area of spruce budworm defoliation in the Northwest Region, as determined from aerial and ground surveys in 1994 and 1995[a]

Location	Area of defoliation (ha) 1994	1995	Change (%)
Alberta	173 680	203 741	17
Saskatchewan	52 339	98 910	89
Manitoba	48 537	55 592	15
Northwest Territories	370 270	36 822	–90
Total	644 826	395 065	–39

[a] Estimates include all areas with visible defoliation (i.e., ≥ 35% defoliation).

[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.

staffed by Alberta Land and Forest Service and FIDS personnel. Spruce budworm infestations (Fig. 2) continued in the Northwest Boreal Region (formerly the Peace River Region and the Grande Prairie and Slave Lake forests) and in the Northeast Boreal Region (formerly the Athabasca and Lac La Biche forests). The total area of defoliation in these two regions was 203 741 ha, of which 83% (168 479 ha) was rated as severe and 17% (35 262 ha) was rated as moderate.

Spruce budworm infestations in the Northwest Boreal Region increased in area from 1994, while the severity of defoliation remained about the same. The area of defoliation in the region mapped during aerial surveys of infested white spruce (*Picea glauca* [Moench] Voss) forests was 173 266 ha. All areas of defoliation noted in 1994 were still present in 1995. They included areas near Hawk Hills (2487 ha); the main infestation along the Chinchaga River, including areas on the Zama ridge between the Chinchaga River and the Rainbow Lake townsite, and several areas northwest of Paddle Prairie (95 685 ha); along the Amber River about 35 km north of Zama Lake (8294 ha); along the Zama River (12 340 ha); along the Moody Creek (8198 ha); along the Meander River near the Meander River townsite (8957 ha); along the Steen and Hay rivers near the hamlet of Steen River (5961 ha); along the Little Rapids Creek just east of its confluence with the Hay River (1262 ha); along the Yates River (1921 ha); north of Mount Watt (2178 ha); and between Bushe River and Highway 58, north of Child Lake Indian Reserve (612 ha).

New infestations were observed along the South Shekilie River (3398 ha); in the Cameron Hills west of the hamlets of Steen River and Indian Cabins (4806 ha); along the James Creek (3639 ha); along the Dizzy Creek (2383 ha); west of Zama Lake along the Hay River (6094 ha); south of Mount Watt near Highway 58 (846 ha); east of the Rainbow Lake townsite (1917 ha); east of John D'Or Prairie Indian Reserve (2253 ha); and along the Peace River near Dunvegan (35 ha).

Aerial applications of the bacterial insecticide, *Bacillus thuringiensis* var. *kurstaki* (*Btk*; Foray 48B formulation), were applied operationally to 110 923 ha of white spruce forests in the Northwest Boreal Region to protect spruce foliage and suppress budworm populations (Table 2). To test the efficacy of these insecticides, an additional 665 ha were treated with Foray 76B and 1033 ha were treated with DiPel 48AF.

In the Northeast Boreal Region, the area and severity of defoliation increased slightly over that reported in 1994. The areas of moderate and severe defoliation were 17 621 and 12 854 ha, respectively. The area of moderate defoliation included the 695 ha of defoliation in Wood Buffalo National Park. Infested stands near the Athabasca and House rivers occurred in most of the same areas recorded in 1994. New infestations were observed along the Deadman and Loon creeks and areas adjacent to the Athabasca River, and along the Algar River.

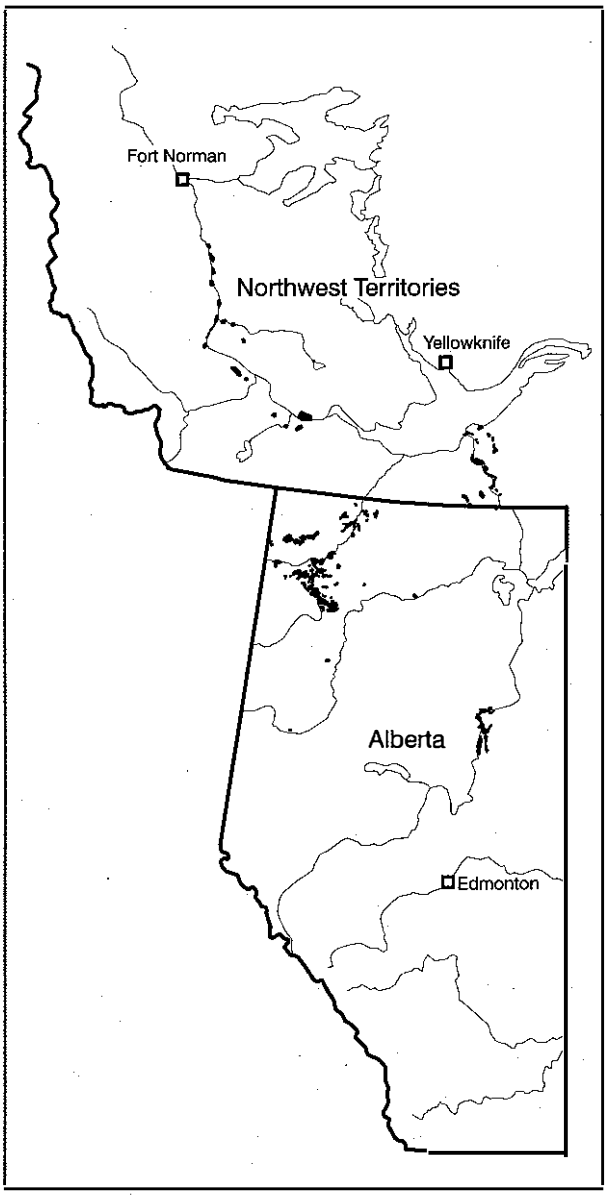

Figure 2. Areas of spruce budworm defoliation in Alberta and the Northwest Territories in 1995.

Table 2. Operational and experimental spruce budworm control programs in Alberta, Saskatchewan, and Manitoba in 1995 using aerial applications of *Bacillus thuringiensis* var. *kurstaki* (*Btk*) and Mimic® insecticides

Location	Area treated (ha)	Host tree species	*Bt* product	Application rate (BIU)[a] and volume/ha
Alberta				
Northwest Boreal Region	73 524[b]	White spruce	Foray 48B[c]	25.4 BIU; 2.0 L
	37 399[d]	White spruce	Foray 48B	25.4 BIU; 2.0 L
	665[b, e]	White spruce	Foray 76B[c]	25.0 BIU; 1.25 L
	1 033[b, e]	White spruce	DiPel 48AF[c]	25.4 BIU; 2.0 L
Saskatchewan				
Prince Albert Region	6 750[b]	White spruce	DiPel 48AF[c]	30.0 BIU; 2.4 L
	360[b, e]	White spruce	DiPel 48AF[c]	30.0 BIU; 2.4 L
La Ronge Region	1 782[b]	White spruce	DiPel 48AF[c]	30.0 BIU; 2.4 L
Manitoba				
Lake Winnipeg East	11 633[b]	White spruce–balsam fir	DiPel 48AF	30.4 BIU; 2.4 L
	450[d]	White spruce–balsam fir	DiPel 48AF	30.4 BIU; 2.4 L
	150[d, e]	White spruce–balsam fir	Foray 76B[c]	30.0 BIU; 2.4 L
	50[d, e]	White spruce–balsam fir	DiPel 48AF	30.0 BIU; 2.4 L
	50[d, e]	White spruce–balsam fir	DiPel ABG 6387	30.0 BIU; 2.4 L
	200[b, e]	White spruce–balsam fir	Mimic 240 LV	70.0 AI[f]; 2.0 L
	1 260[d, e]	White spruce–balsam fir	Mimic 240 LV	70.0 AI; 2.0 L
Mountain	3 140[b]	White spruce–balsam fir	DiPel 48AF	30.4 BIU; 2.4 L

[a] BIU = Billion International Units.
[b] Area received two spray applications.
[c] Water-based formulation.
[d] Area received one spray application.
[e] Experimental application.
[f] Active ingredient.

Alberta Land and Forest Service deployed 158 pheromone-baited traps[2] at 79 locations throughout the four forest regions in the province to monitor spruce budworm population levels (Fig. 3). Moth counts ≥500 moths/trap were observed at 10 locations in the Northwest Boreal Region in areas north and west of High Level, east of Paddle Prairie, and near Hawk Hills[3]. In the Northeast Boreal Region, high moth captures were observed at two locations near the Athabasca River southwest of Fort McMurray and at one location along the Slave River near Hay Camp. Second instar (L_2) surveys were conducted at 230 sites in the Northwest Boreal Region (Fig. 4) and at 23 sites in the Northeast Boreal Region (Fig. 5), based on 1995 defoliation and pheromone trap results. In the Northwest Boreal Region, 46% of the sites are expected to have at least moderate defoliation in 1996; at the remainder of the sites, only light defoliation is expected[4]. Sites where at least moderate defoliation is expected

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

[3] A summary of spruce budworm pheromone trap survey results in Alberta in 1995 is listed in Appendix 2.

[4] A summary of spruce budworm second instar densities in 1995 and defoliation forecasts for Alberta in 1996 are provided in Appendix 3.

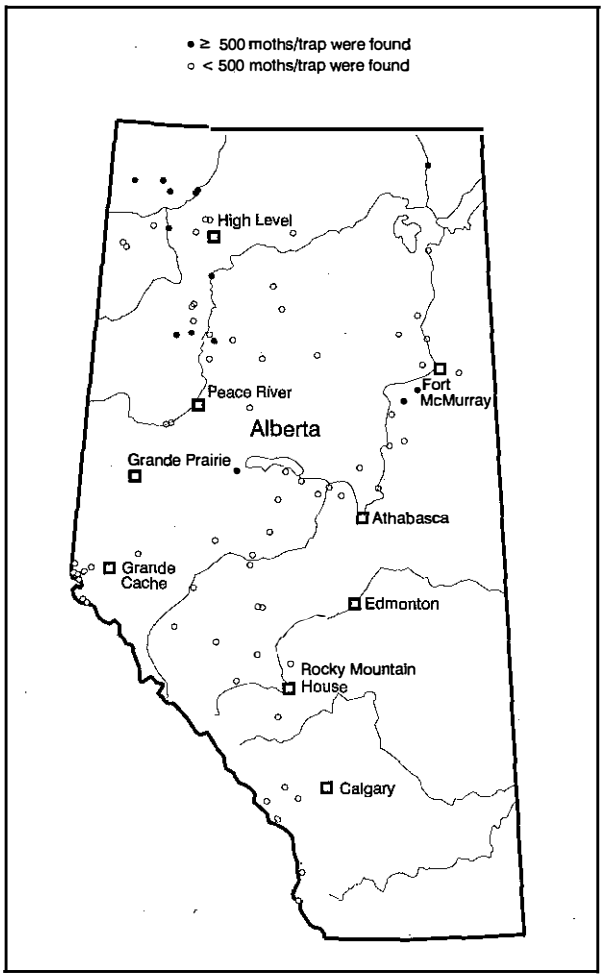

Figure 3. Spruce budworm pheromone trap locations in Alberta in 1995.

were located in the infestations near Hawk Hills; the main infestation along the Chinchaga River; in the Cameron Hills; east of John D'Or Prairie Indian Reserve; along the James and Dizzy creeks; and along the Amber, Zama, Meander, Steen, Hay, Yates, and South Shekilie rivers. Ninety-one percent of the sites sampled in the Northeast Boreal Region along the Athabasca River are expected to have at least moderate defoliation in 1996.

In **Saskatchewan**, the total area of defoliated white spruce–balsam fir (*Abies balsamea* [L.]) forests mapped by Saskatchewan Environment and Resource Management and FIDS was 98 910 ha, compared to the 52 339 ha reported in 1994. Spruce budworm infestations in Saskatchewan are shown in Figure 6. Infestations persisted north of Big River near Doré and Smoothstone lakes; near Red Earth; southwest of Hudson Bay; near Tibiska Lake in Prince Albert National Park; and areas surrounding Lac la Ronge and Wapawekka, Besnard, Morin, and Pinehouse lakes. Administrative regions within the province changed in 1995 and are shown in Figure 1. The Prince Albert Region now includes most of the former Hudson Bay Region. The remaining area of the former Hudson Bay Region is now part of a larger La Ronge Region. These changes should be considered when comparing results of the current year to previous years. New infestations were observed at many locations throughout the province.

Spruce budworm infestations in the Prince Albert Region covered 65 079 ha. All defoliation was rated as moderate-to-severe. North of Big River, defoliation occurred in five areas: east of Delaronde Lake (1502 ha); south and east of Smoothstone Lake (4489 ha); between Doré and Smoothstone lakes (6850 ha); and near Sled Lake (553 ha). The infestation in Prince Albert National Park increased in size in 1995 and included areas outside the park. The area of defoliation in the park near Tibiska and Crean lakes covered 6000 ha, while the defoliation outside of the park south of Leadley Lake and east of Montreal Lake covered 1478 ha.

The two major infestations near Red Earth and Hudson Bay increased in size in 1995. Near Red Earth, the infestation covered 4564 ha and included several areas along the Carrot River east of Red Earth, south of Highway 55, and east of the Connell Creek townsite. The Hudson Bay infestation consisted of one large area covering 36 449 ha to the south and west of the townsite. Several new infestations were detected in 1995. One infestation (2386 ha) consisted of several patches: along the Sipanok Channel, the Saskatchewan River east of Tobin Lake, the Torch River, and northwest of Potato Lake. The second new infestation (808 ha) occurred in several areas southwest of Prince Albert in and adjacent to the Nisbet Provincial Forest.

In the La Ronge Region, infestations covered 33 085 ha. The infestations near Lac la Ronge increased from 14 690 ha in 1994 to 26 678 ha. In Figure 6, the infestation near Lac la Ronge is delineated by a line along its north boundary. The reason for this is not biological, but rather, indicates the northern limit of inventoried forest zone in the province. The Lac la Ronge infestations included large areas of spruce forest between Lac la Ronge, Pinehouse Lake, and north of the Churchill River (19 862 ha), and between Wapawekka Lake and Lac la Ronge (6816 ha). New infestations covering 6407 ha were observed between Cumberland and

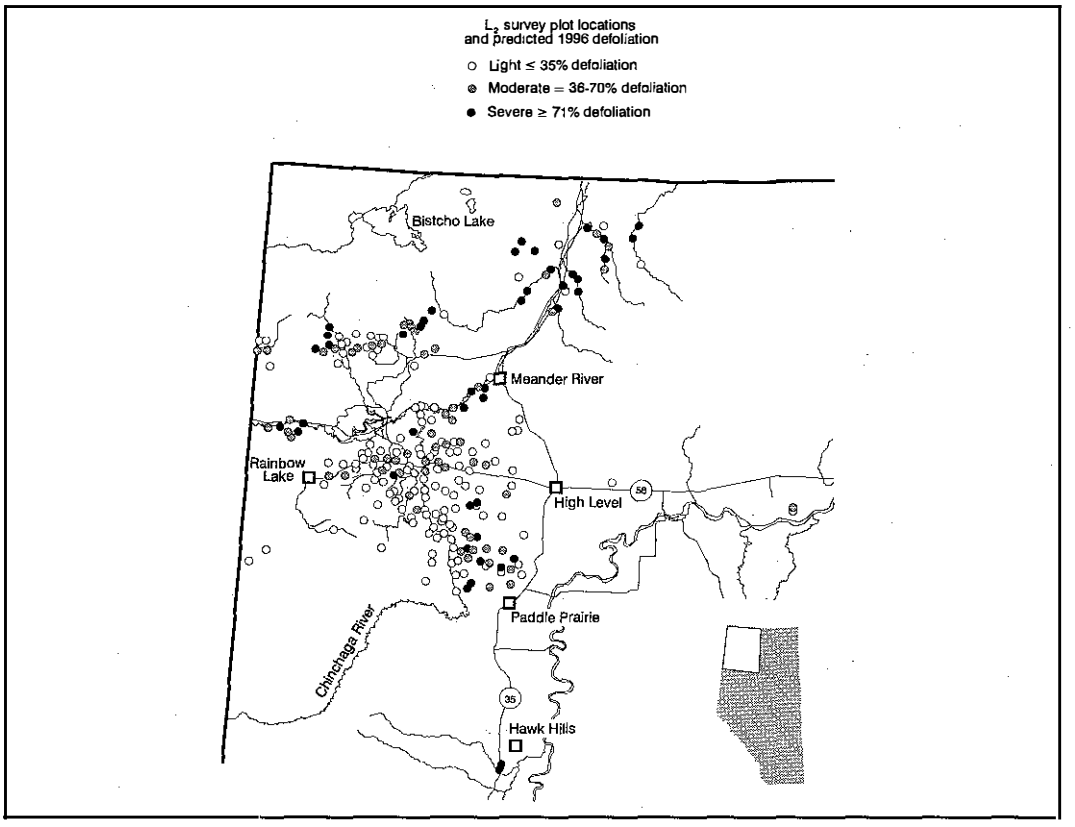

Figure 4. Survey locations of spruce budworm second instar in Northwest Boreal Region of Alberta in 1995 and predicted defoliation in 1996.

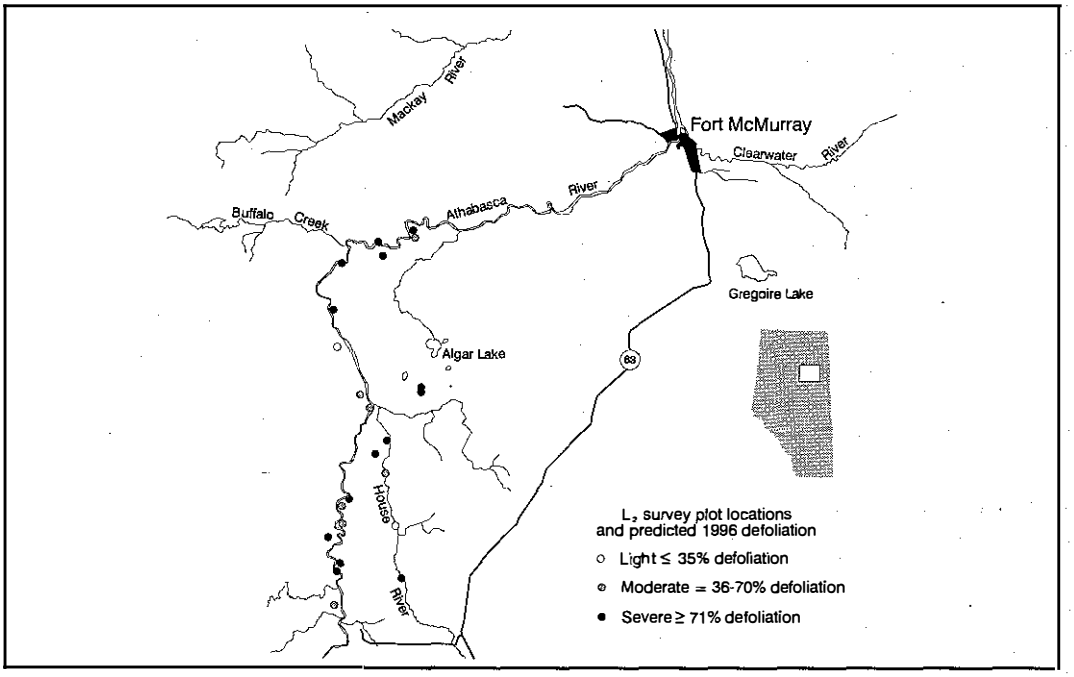

Figure 5. Survey locations of spruce budworm second instar in the Northeast Boreal Region of Alberta in 1995 and predicted defoliation in 1996.

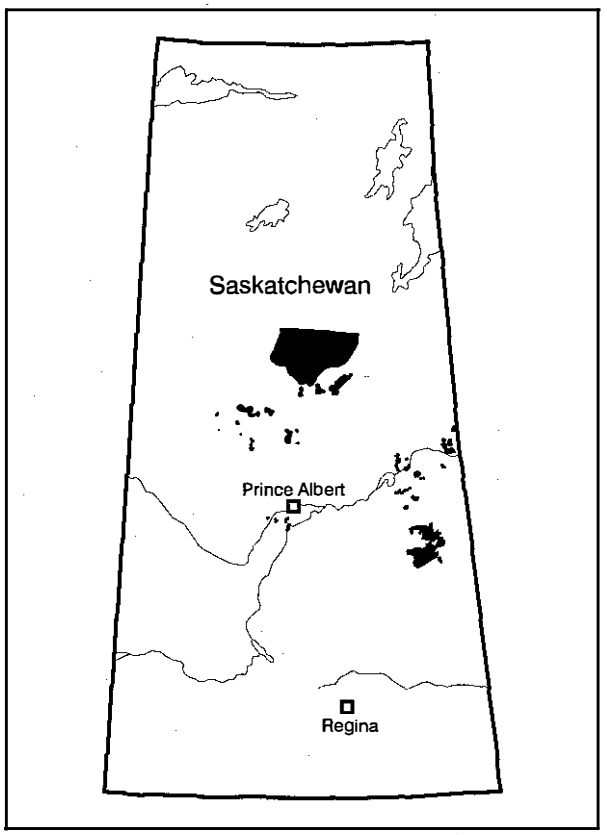

Figure 6. Areas of spruce budworm defoliation in Saskatchewan in 1995.

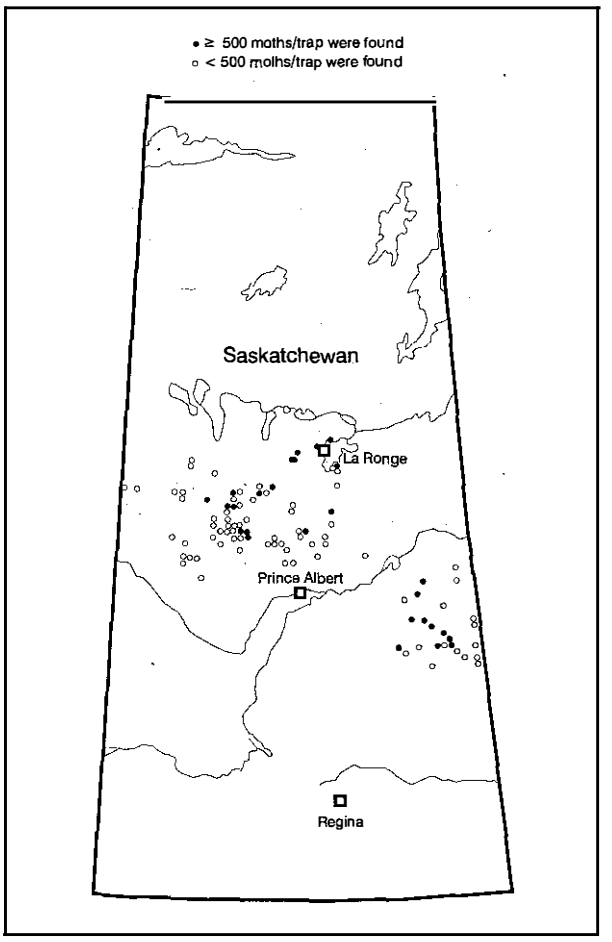

Figure 7. Spruce budworm pheromone trap locations in Saskatchewan in 1995.

Namew lakes. A previous spruce budworm outbreak occurred in this area near Namew Lake along the Saskatchewan–Manitoba border between 1951 and 1970.

In the Meadow Lake Region, two small infestations totaling 746 ha were noted southeast of the town of Green Lake and along the Beaver River north of Green Lake.

Aerial applications of *Btk* (DiPel 48AF) were applied by Saskatchewan Environment and Resource Management at a rate of 30 BIU/ha (Billion International Units) over 8892 ha of spruce-budworm-infested stands to suppress spruce budworm populations and reduce the risk of timber losses (Table 2). There were two main spray blocks: one near Wapawekka Lake south of Lac la Ronge (1782 ha), and the other between Doré and Smoothstone lakes (6750 ha). Another small area (360 ha) between Green and Cowan lakes was also sprayed to determine the effects of spraying on nontarget Lepidoptera. Each spray area received two applications. Additional strategies used to manage spruce budworm included salvage cutting of severely damaged sawlog timber and containment (i.e., using adjacent nonhost stands and bog areas) to reduce the rate of spread of spruce budworm.

Saskatchewan Environment and Resource Management deployed 396 pheromone-baited traps at 132 sites (Fig. 7). Moth counts ≥500 moths/trap were observed at one location in the Meadow Lake Region, 17 locations in the Prince Albert Region, and six locations in the La Ronge Region[5]. The pheromone trapping survey was used to estimate moth populations and identify areas

[5] A summary of spruce budworm pheromone trap survey results in Saskatchewan in 1995 is provided in Appendix 4.

where further survey work should be conducted to forecast budworm populations in 1996. Second instar (L_2) surveys were conducted in the Meadow Lake, Prince Albert, and La Ronge regions (Fig. 8)[6]. Mostly moderate and severe defoliation is expected west and south of Hudson Bay in the Prince Albert Region. In other areas of the Prince Albert Region, moderate and severe defoliation is expected near Smoothstone, Delaronde, and Montreal lakes; near the Beaver River north of Green Lake; and southwest of Prince Albert. Light defoliation is expected elsewhere in the region. In the La Ronge Region, mostly moderate and severe defoliation is expected in 1996 near Lac la Ronge, Besnard Lake, Cumberland House, and Namew Lake. These forecasts are based on a larval density per 10 m^2 of foliage averaged from sampled stands in each 100-km^2 map sheet area (UTM 10 x 10 km map sheet). A total of 142 stands were surveyed covering 91 different map sheets.

Spruce budworm infestations in **Manitoba** (Fig. 9) surveyed by Manitoba Natural Resources occurred in five forest sections: Aspen Parkland, Interlake, Lake Winnipeg East, Mountain, and Pineland. A total of 55 592 ha of white spruce and spruce–balsam fir forests were infested (Table 1), of which 40 125 ha were classed as moderate, and 15 467 ha were classed as severe. Infestations were found in the same general areas as those reported in 1994. In the Aspen Parkland Section, a spruce budworm infestation, which had been present for several years, continued in the Spruce Woods Provincial Forest. An aerial survey was not conducted over this infestation.

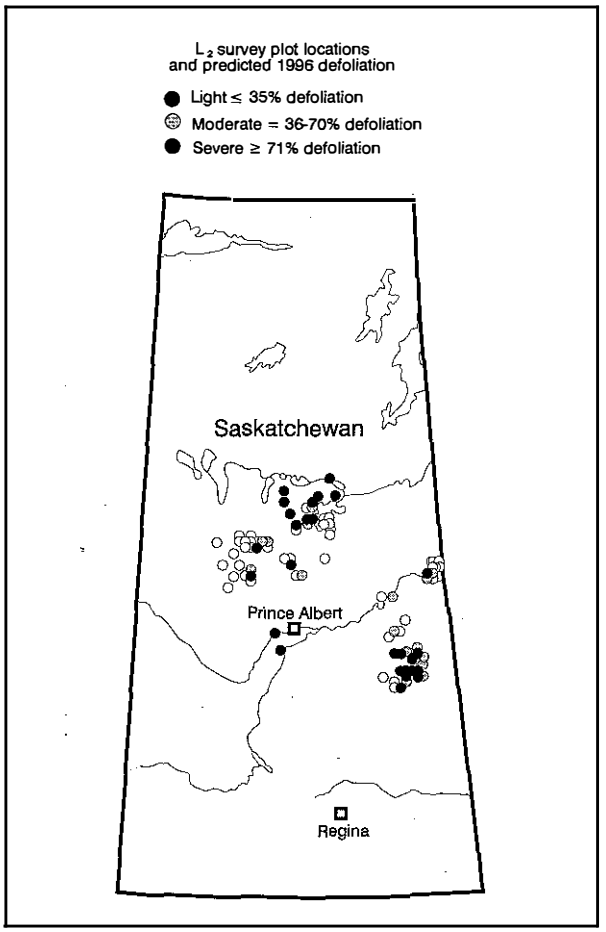

Figure 8. Survey locations of spruce budworm second instar in Saskatchewan in 1995 and predicted defoliation in 1996.

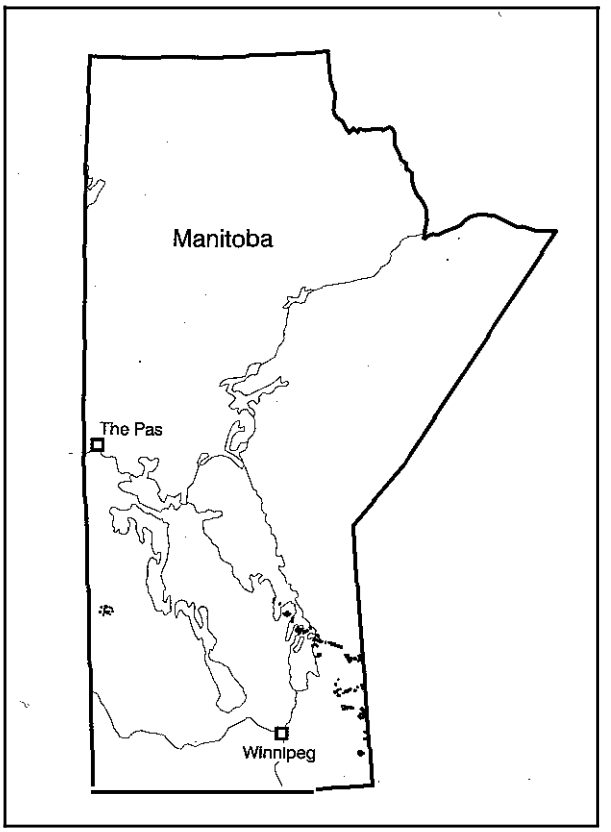

Figure 9. Areas of spruce budworm defoliation in Manitoba in 1995.

[6] A summary of spruce budworm second instar densities in 1995 and defoliation forecasts for Saskatchewan in 1996 are provided in Appendix 5.

In the Interlake Section, spruce budworm infestations covered 11 562 ha, of which 9419 ha were rated as moderate and 2143 ha were rated as severe. Infestations in Management Unit 40 continued on Moose (271 ha) and Deer (1119 ha) islands; near Ebb and Flow and Moose lakes (4378 ha); and south of Washow Bay in Grindstone Provincial Recreation Park (5254 ha). In Management Unit 41, 540 ha were defoliated near Lake St. George and Jackhead Lake.

As in the Interlake Section, many of the outbreaks in the Lake Winnipeg East Section occurred in the same areas as reported in 1994. Moderate spruce budworm defoliation occurred on 28 249 ha and severe defoliation occurred on 8733 ha. In Management Unit 30, infestations persisted near Dorothy and Nutimik lakes (3233 ha); near Big Whiteshell, Little Whiteshell, Crowduck, and Lone Island lakes (6456 ha); west and south of West Hawk Lake (677 ha); and near Falcon Lake (1395 ha). Infestations in Management Unit 31 continued near the Hollow Water and Manigotagan villages (4516 ha); east of Manigotagan (231 ha); near Wanipigow Lake (3696 ha); in the Long and Quesnel lakes area (4289 ha); in the Garner and Gem lakes area (2404 ha); near the Sandy, Black, and O'Hanly rivers (827 ha); east of the Winnipeg River near the Maskwa River (1660 ha); north and east of Lac du Bonnet (4651 ha); and in the Oiseau and Bernic lakes area (2237 ha). In Management Unit 35, infestations also continued on the east side of Lake Winnipeg across from Deer Island (442 ha) and in the area of Loon Straits (268 ha).

In the Mountain Section, budworm defoliation covered 1816 ha and occurred in the same area as reported in 1994—near Davey, Cutbank, Little Island, Snake, Noses, and Drugstore lakes. There were 1764 ha of moderate defoliation and 52 ha of severe defoliation in this area.

Spruce budworm outbreaks in the Pineland Section occurred in three areas. Two of these occurred in Management Unit 23 on the south side of Lac du Bonnet and on several islands in the lake (575 ha) and east of the Pinawa Channel (131 ha). The third area was in Management Unit 20 south of East Braintree (4526 ha). Of the 5232 ha of defoliation in the Pineland Section, 693 ha were rated as moderate and 4539 ha were rated as severe.

For the first time since 1990, an operational spray program was conducted by Manitoba Natural Resources. *Bacillus thuringiensis* var. *kurstaki* (DiPel 48AF) was applied at a rate of 30 BIU/ha once over 450 ha and twice over 14 773 ha. The treated areas included those near Falcon, Dorothy, Garner, and Beresford lakes, Maskwa and Sandy rivers, Loon Straits, and Duck Mountain. Manitoba Natural Resources, the Canadian Forest Service, and Rohm and Haas Canada Inc. also continued an experimental trial using Mimic® 240 LV (formerly known as RH-5992® Mimic [tebufeno-zide], Rohm and Haas Canada Inc.) over 1260 ha near Garner Lake in Management Unit 31; 1995 was the second year of the trial. The trial involved one application of the insecticide at a rate of 70 g active ingredient per hectare. Spray trials were also conducted by the Canadian Forest Service in cooperation with Manitoba Natural Resources using various *Btk* products and Mimic® (Table 2). Salvage harvesting in severely damaged forests also continued as a management strategy in many areas.

In Manitoba, 120 pheromone-baited traps were deployed at 40 sites (Fig. 10) by both Manitoba Natural Resources and FIDS. Moth counts

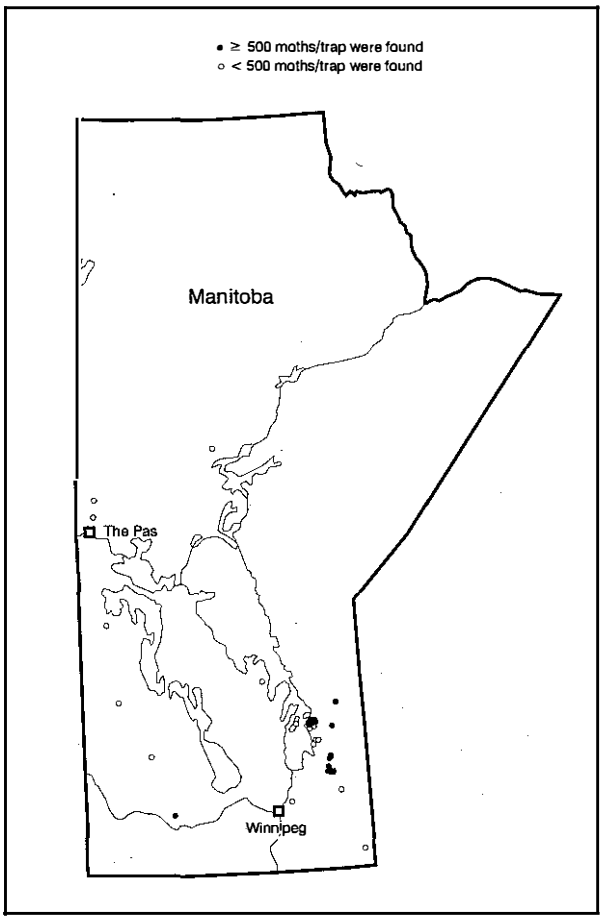

Figure 10. Spruce budworm pheromone trap locations in Manitoba in 1995.

≥500 moths/trap were observed at 16 of these sites[7]: one in the Aspen Parkland Section and 15 in the Lake Winnipeg East Section. There were 134 sites selected for spruce budworm egg-mass surveys to forecast spruce budworm defoliation in 1996. Egg-mass surveys were conducted by Manitoba Natural Resources and FIDS[8]. In the Lake Winnipeg East and Pineland sections, mostly light defoliation is expected in 1996, except in some stands in the infestations near the Maskwa River and north and east of Lac du Bonnet, where defoliation rated from moderate to severe is expected (Fig. 11). Moderate-to-severe defoliation is expected in 1996 in the Spruce Woods Provincial Forest. In the Interlake and Mountain

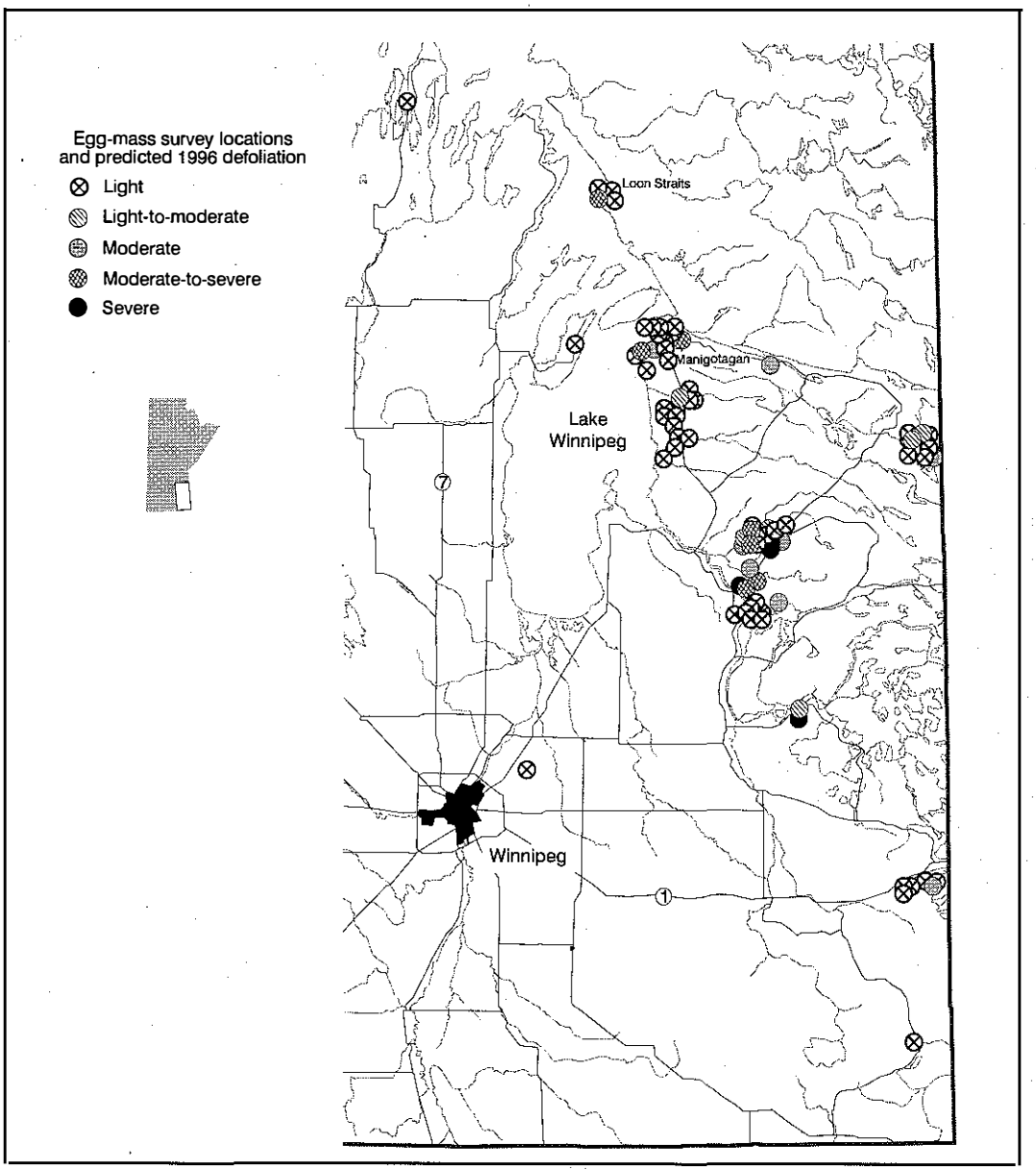

Figure 11. Survey locations of spruce budworm egg masses in southeastern Manitoba in 1995 and predicted defoliation in 1996.

[7] A summary of spruce budworm pheromone trap survey results in Manitoba in 1995 is provided in Appendix 6.

[8] A summary of spruce budworm egg-mass densities in 1995 and defoliation forecasts for Manitoba for 1996 are provided in Appendix 7.

sections, mostly light defoliation is expected in 1996, except in two areas near Davey Lake. Forecasts for the Mountain Section are shown in Figure 12. The only other region in the province where at least moderate defoliation is predicted for 1996 is in the Saskatchewan River Section near Namew Lake (Fig. 13). This area is east of the infestation noted in Saskatchewan.

In the **Northwest Territories**, aerial surveys to map infestations of spruce budworm were conducted jointly by Northwest Territories Renewable Resources and FIDS. Populations of spruce budworm dropped significantly in 1995. While the insect was still widespread throughout white spruce forests, the area of defoliation was much less—36 822 ha in 1995 compared to 370 270 ha in 1994 (Table 1). All mapped defoliation was rated from moderate to severe.

Sporadic infestations were present along the Slave River from Great Slave Lake to the Alberta–Northwest Territories border, including small areas within Wood Buffalo National Park; along the Taltson River east of the Slave River; along the Martin River and on the slopes of the Martin Hills; along the Mackenzie River from its confluence with the Redknife River north to its confluence with the Dahadinni River; along the Willowlake River, and along the North Nahanni River near its confluence with the Mackenzie River. One new area of defoliation was observed along the upper Kotaneelee River near the Yukon–Northwest Territories border. Another area, along the Hay River just north of the Alberta–Northwest Territories border, was observed but was not mapped.

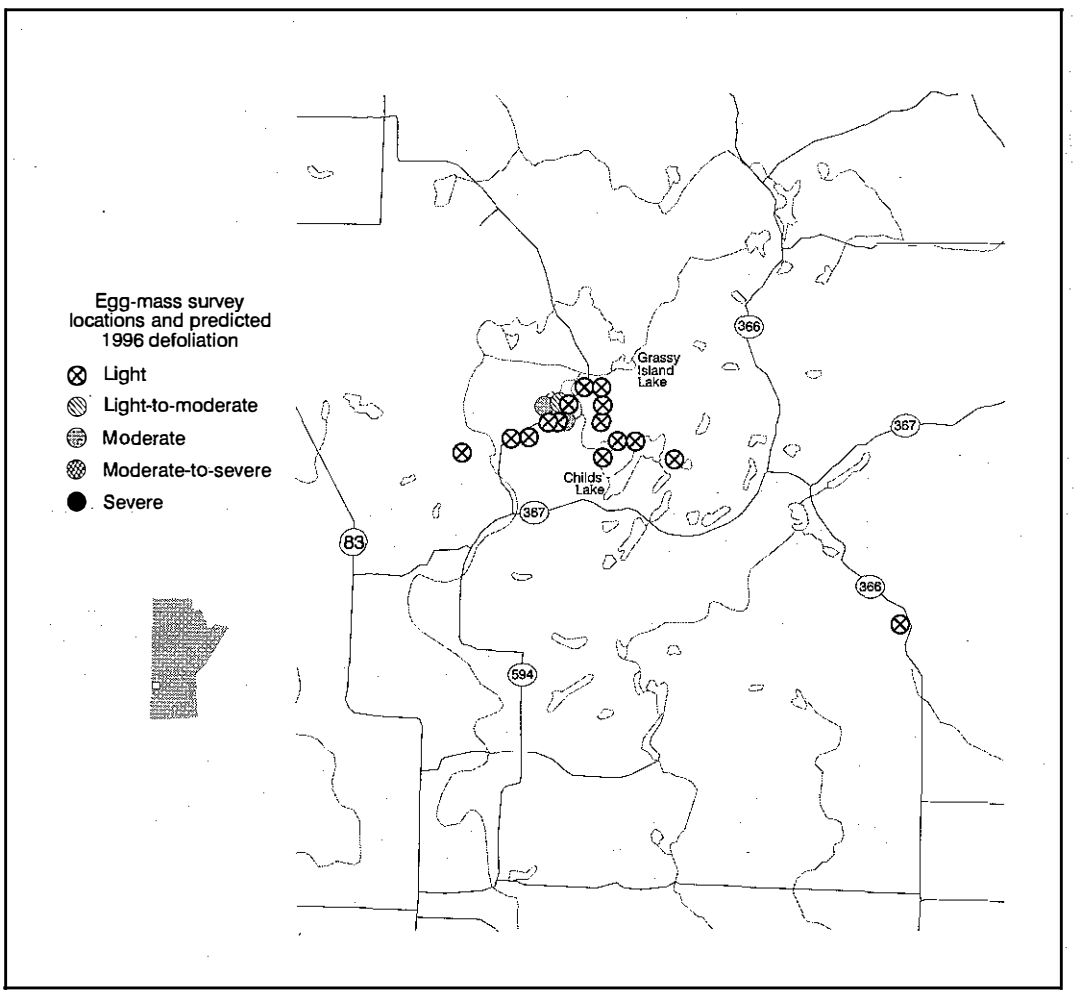

Figure 12. Survey locations of spruce budworm egg masses in the Mountain Section of Manitoba in 1995 and predicted defoliation in 1996.

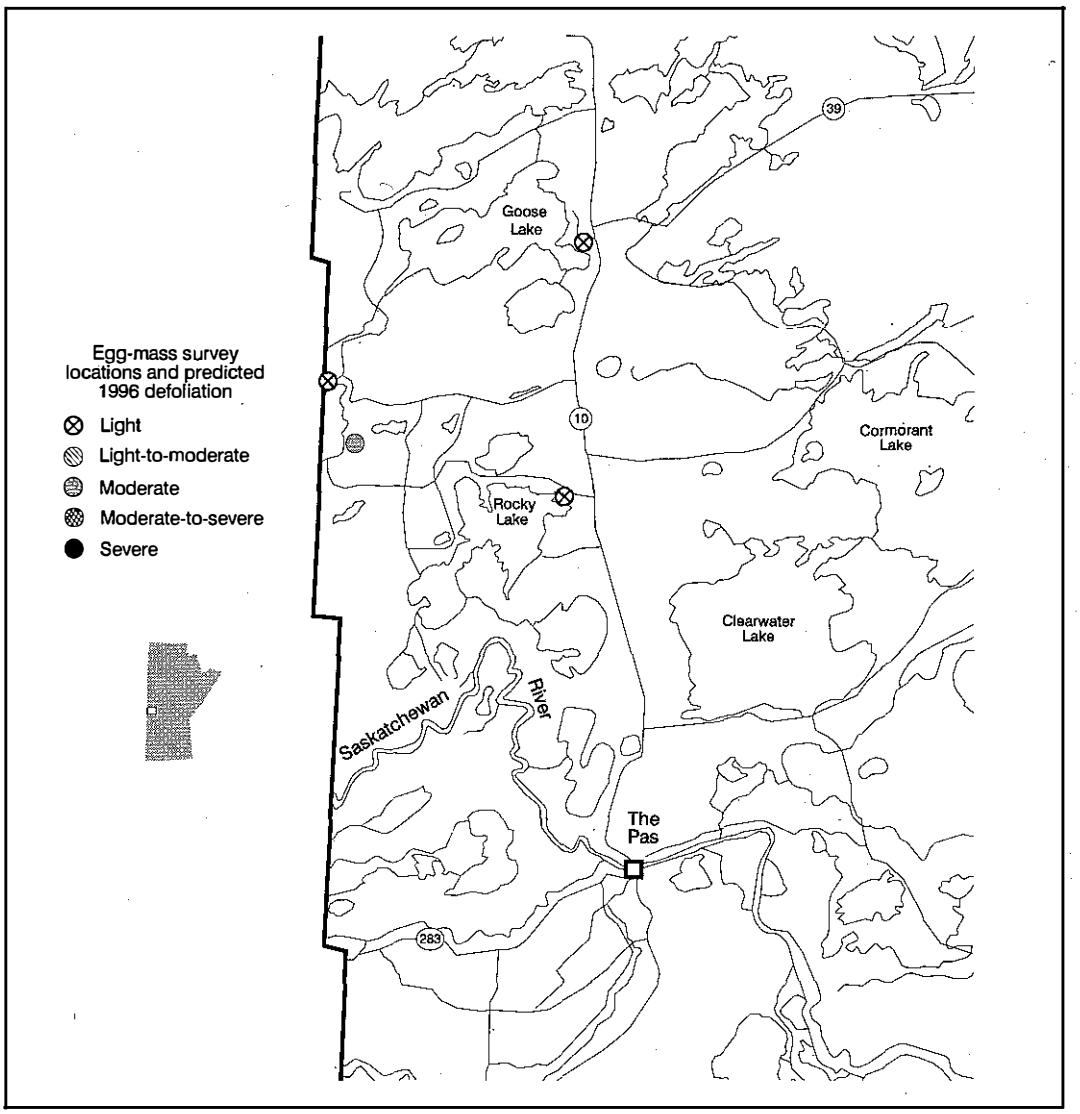

Figure 13. Survey locations of spruce budworm egg masses in the Saskatchewan River Section in 1995 and predicted defoliation in 1996.

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. Efforts have concentrated on pheromone traps for male moths and egg-mass surveys (Fig. 14). Based on the pheromone and egg-mass surveys, populations of jack pine budworm are anticipated to remain low in 1996 across the Northwest Region and little or no defoliation is expected[9].

[9] A summary of jack pine budworm pheromone trap survey results in Alberta and Saskatchewan in 1995 is provided in Appendix 8. Jack pine budworm egg-mass densities in 1995 and defoliation forecasts for Manitoba for 1996 are provided in Appendix 9.

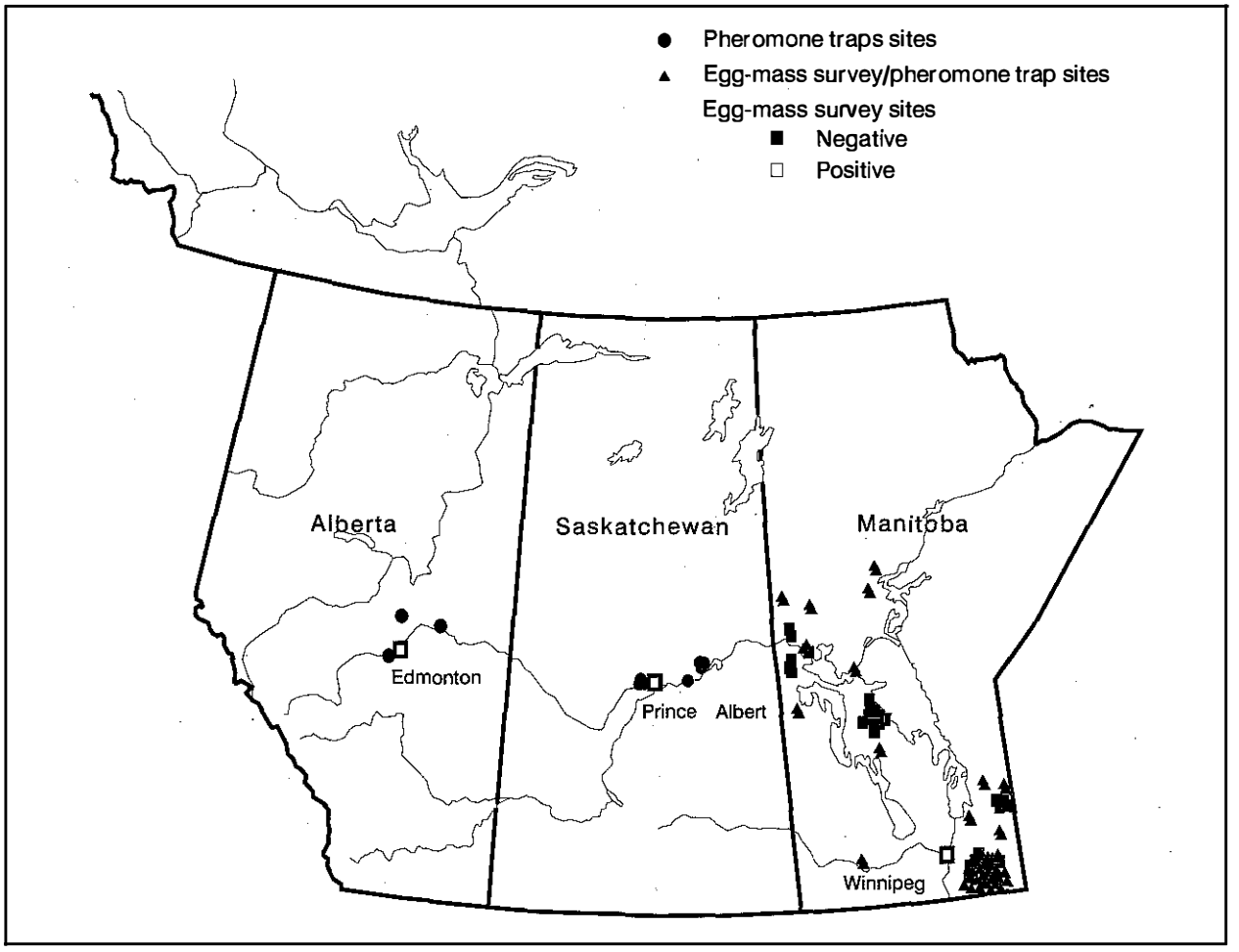

Figure 14. Jack pine budworm pheromone trap locations and egg-mass survey sites in the Northwest Region in 1995.

FOREST TENT CATERPILLAR *Malacosoma disstria* Hbn.

In the Northwest Region, forest tent caterpillar defoliated 364 470 ha of trembling aspen (*Populus tremuloides* Michx.) forests in 1995, compared to 231 077 ha in 1994. In Alberta, the area of defoliated aspen increased 13%, up to 222 017 ha in 1995 from 196 547 ha in 1994 (Table 3). The area of forest tent caterpillar defoliation in Saskatchewan totaled 109 831 ha, equivalent to a 375% increase over the area reported in 1994. In Manitoba, almost no forest tent caterpillar defoliation occurred. For the first time in 1995, a large outbreak of forest tent caterpillar was observed in the Northwest Territories. Areas of aspen defoliated by forest tent caterpillar and other aspen defoliators in Alberta and the Northwest Territories, Saskatchewan, and Manitoba are shown in Figures 15–17.

In **Alberta**, the number of areas where forest tent caterpillar defoliation occurred increased substantially. Areas in the Northwest Boreal Region north of Guy (2326 ha); south of the Little Smoky River along Highway 43 (2112 ha); near Jean Côté (3069 ha); in the Peace River valley around the Peace River townsite (33 183 ha); and west of Peace River to Fairview (11 142 ha) were all defoliated in 1995, as they were in 1994. The same was true for areas in the Northeast Boreal and Parkland regions: south, north, and east of Cooking Lake (15 490 ha), and the southern portion of Elk Island National Park (36 486 ha).

New areas of defoliation were detected south of Bonnyville near Moose (895 ha) and Muriel (5391 ha)

Table 3. Area of forest tent caterpillar, large aspen tortrix, and aspen leafroller defoliation in the Northwest Region, as determined from aerial and ground surveys in 1994 and 1995

Location and pest	Areas of defoliation (ha) 1994	1995	Change (%)
Alberta			
Forest tent caterpillar	196 547	222 017	13
Large aspen tortrix	6 968	67 075	863
Aspen leafroller	72 616	66 917	–8
Total	276 131	356 009	29
Saskatchewan			
Forest tent caterpillar	23 134	109 831	375
Large aspen tortrix	221 442	9 947	–96
Aspen leafroller	0	1 806	–[a]
Total	244576	121 584	-50
Manitoba			
Forest tent caterpillar	11 396	163	–99
Large aspen tortrix	0	0	0
Aspen leafroller	0	0	0
Total	11 396	163	–99
Northwest Territories			
Forest tent caterpillar	0	32 459	–
Large aspen tortrix	0	0	0
Aspen leafroller	0	0	0
Total	0	32 459	–
Total	532 103	510 215	–4

[a] Not applicable.

lakes in the Northeast Boreal Region. New areas of defoliation in the Northwest Boreal Region occurred southwest of Grande Prairie (8719 ha); west of the village of Bad Heart (2862 ha); along the Peace River near its confluence with the Ksituan River (3821 ha); north and west of the Peace River townsite up onto the Whitemud Hills (58 186 ha); southeast of Peace River to Nampa (8983 ha); along Highway 35 north of Dixonville (2872 ha) and northwest of the village of Hawk Hills (15 196 ha); along the Peace River northeast of the Hawk Hills townsite (1979 ha); near the Twin Lakes (784 ha); west of Wadlin Lake (8295 ha); and along Highway 58 just east of the Chinchaga River (226 ha).

In the Northeast Boreal Region, there was 15 490 ha of moderate-to-severe defoliation and 6286 ha of severe defoliation. In the Northwest Boreal Region, there was 17 553 ha of moderate defoliation and 146 202 ha of severe defoliation. In the Parkland Region, moderate-to-severe defoliation occurred over 36 486 ha.

Forest tent caterpillars overwinter as neonate larvae within egg-masses, which are laid as bands on aspen twigs. The number of egg bands on individual aspen trees provides estimates of defoliation in the subsequent year. Egg-band surveys were completed at 45 sites throughout Alberta where infestations occurred in 1995. In the Northeast Boreal and Parkland regions, the results of these surveys indicated that mostly moderate and severe defoliation is expected in 1996 south of Cooking and Hasting lakes. South of Elk Island National Park, just east of Islet Lake, moderate defoliation is expected. Mostly light defoliation is expected near Lindbrook, north of Cooking Lake, and in Elk Island

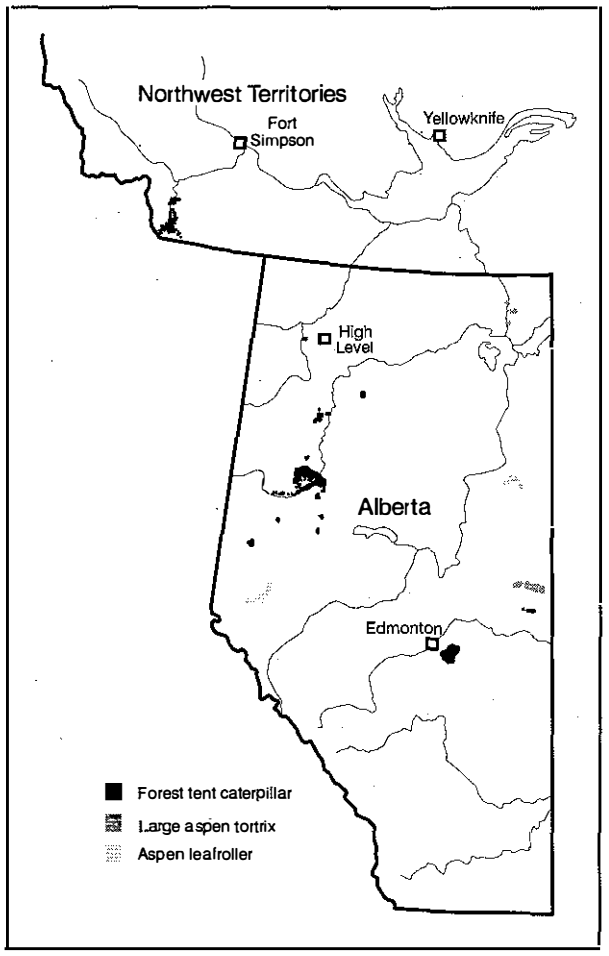

Figure 15. Areas of forest tent caterpillar, large aspen tortrix, and aspen leafroller defoliation in Alberta and the Northwest Territories in 1995.

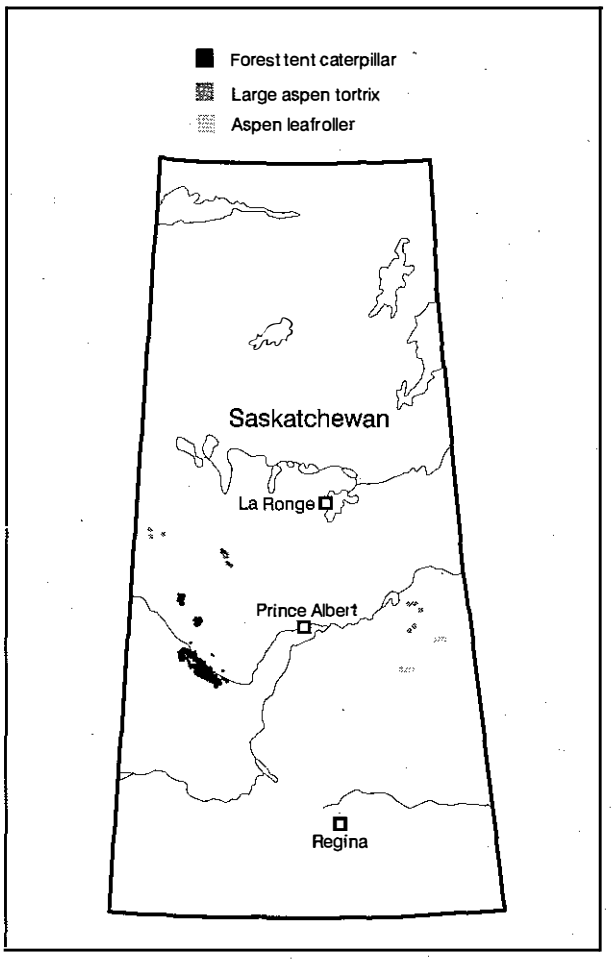

Figure 16. Areas of forest tent caterpillar, large aspen tortrix, and aspen leafroller defoliation in Saskatchewan in 1995.

National Park. South of Bonnyville, moderate and severe defoliation is expected in 1996 near Muriel Lake, while light defoliation is expected in areas adjacent to Moose Lake.

In the Northwest Boreal Region, the results of egg-band surveys indicated that forest tent caterpillar defoliation is expected to continue throughout the Peace River–Grimshaw–Nampa areas. The defoliation in these areas will vary widely from light to severe as it did in 1995. North and west of Fairview, light defoliation is expected. Between Fairview and the Peace River, severe defoliation is expected. The infestations near Dixonville, northwest of the village of Hawk Hills, and near the Twin Lakes are expected to persist in 1996. West of High Level near the Chinchaga River, light defoliation is expected in 1996.

In **Saskatchewan**, the forest tent caterpillar infestation near Battleford in the Saskatoon Region increased in area in 1995, covering 91 049 ha. By defoliation class, 4782 ha were lightly defoliated, 47 714 ha were moderately defoliated, 8604 ha were moderately-to-severely defoliated, and 29 949 ha were severely defoliated. The infestation in the Battleford area now extends from Sweet Grass Indian Reserve northwest of Battleford to just west of Struan, including areas east of Winniford Lake, Mosquito and Red Pheasant Indian reserves, and the Eagle Hills Escarpment. Two areas were also noted east of North Battleford along Highway 40, and one area along the North Saskatchewan River near Sonningdale. In the Meadow Lake Region, additional areas of forest tent caterpillar defoliation were observed south of Glaslyn along Highway 4 (10 371 ha, rated severe) and between Brightsand and Turtle lakes (8411 ha, rated moderate).

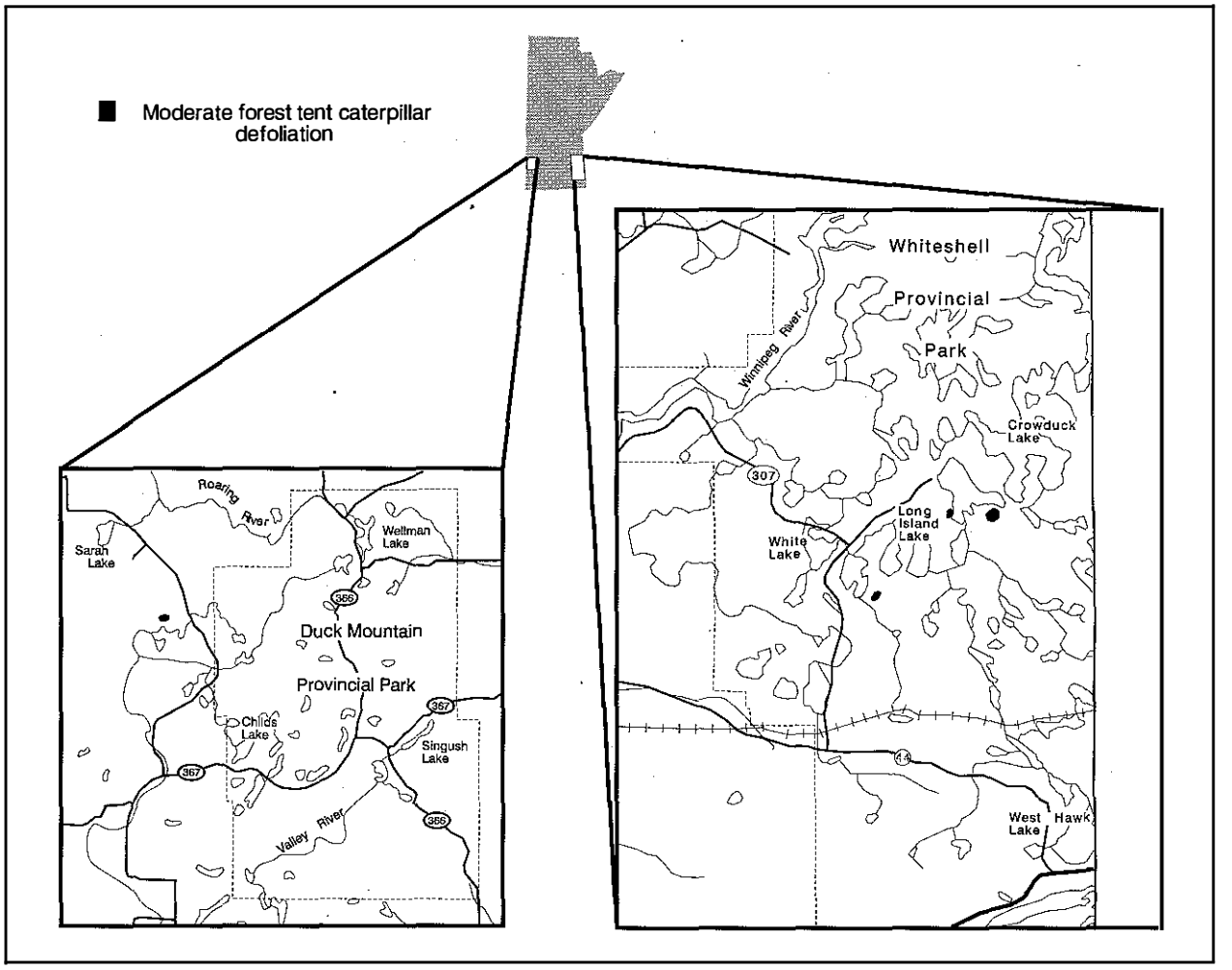

Figure 17. Areas of forest tent caterpillar defoliation in Manitoba in 1995.

Egg-band surveys were completed at 23 sites throughout western Saskatchewan near areas infested in 1995. In the Saskatoon Region, the infestation in the Battleford area from Sweet Grass Indian Reserve northwest of Battleford to just west of Struan, will continue in 1996, with mostly severe defoliation expected. The infestation south of Glaslyn in the Meadow Lake Region will also continue in 1996; defoliation is expected to be mostly severe. No forest tent caterpillar defoliation is expected in the area between Brightsand and Turtle lakes.

In **Manitoba**, only 163 ha of moderate defoliation was mapped in the province: 32 ha in the Duck Mountain Provincial Forest in the Mountain Section, and 131 ha in Whiteshell Provincial Park in the Lake Winnipeg East Section. Based on egg-band surveys conducted in the fall of 1995, forest tent caterpillar populations are expected to remain low in 1996.

A large outbreak of forest tent caterpillar was detected for the first time in the **Northwest Territories**. Several areas of defoliation were observed along the Liard River from south of Fort Liard to north of the Flett Rapids, along the Petitot River near its confluence with the Liard River, and southwest of Lake Bovie. Of the 32 459 ha of forest tent caterpillar defoliation in the Fort Liard area, there was 3294 ha of light defoliation, 6499 ha of light-to-moderate defoliation, 4836 ha of moderate defoliation, and 17 830 ha of moderate-to-severe defoliation. Egg-band surveys were completed at five sites near Fort Liard. Severe defoliation is expected in 1996 near the Fort Liard townsite and along Highway 7 near the Flett Rapids. Light defoliation is expected north of Fort Liard near the Rabbit Creek and the Muskeg River. South of Fort Liard, at the British Columbia–Northwest Territories border, no defoliation is expected.

OTHER ASPEN DEFOLIATORS
Large aspen tortrix, *Choristoneura conflictana* (Wlk.)
Aspen leafroller, *Pseudexentera oregonana* (Wlsm.)

Two other insects caused significant aspen defoliation in the Northwest Region: large aspen tortrix and aspen leafroller. Large aspen tortrix defoliation covered 67 075 ha in Alberta, an increase of 863% from that observed in 1994 (Table 3). In Saskatchewan, large aspen tortrix defoliation occurred on only 9947 ha in 1995, a decrease of 96% from the previous year. The area of aspen leafroller defoliation in Alberta dropped to 66 917 ha in 1995, while in Saskatchewan there were 1806 ha of aspen leafroller defoliation. No large aspen tortrix or aspen leafroller defoliation was observed in Manitoba or in the Northwest Territories.

In **Alberta,** large aspen tortrix caused defoliation in Wood Buffalo National Park (6968 ha); east of the Slave River (7841 ha); in small isolated patches west of Edmonton (341 ha) and near Sundre (152 ha); south of Wolf Lake (12 658 ha); and between Tucker, Marie, and Cold lakes (39 115 ha). There were 8365 ha of light-to-moderate defoliation, 42 401 ha of moderate defoliation, 14 247 ha of moderate-to-severe defoliation, and 2062 ha of severe defoliation.

Aspen leafroller caused patchy defoliation in many of the same locations in Alberta noted in 1994 along river valleys and adjacent aspen forests, but the defoliation was less severe in 1995. Exceptions were two large areas with light-to-moderate defoliation: along the Smoky River northeast of Grande Cache in the Northwest Boreal (24 730 ha) and Northern East Slopes (22 248 ha) regions; and near Gregoire Lake (19 939 ha) in the Northeast Boreal Region.

In **Saskatchewan,** populations of large aspen tortrix continued to decline from the peak in 1993. Only 9947 ha of defoliation occurred in 1995, compared to the 440 755 and 221 442 ha that occurred in 1993 and 1994, respectively. Large aspen tortrix defoliation was observed in five small patches (3071 ha) in the Prince Albert Region along the north slopes of the Pasquia Hills and north and northeast of Smoky Burn. Other tortrix infestations were observed east of Green Lake (6581 ha) and in two small patches north of Meadow Lake Provincial Park (295 ha) in the Meadow Lake Region.

Aspen leafroller defoliation was observed in several small patches north and northwest of Hudson Bay (698 ha) and in or near Greenwater Lake Provincial Park (1108 ha) in the Prince Albert Region.

MOUNTAIN PINE BEETLE
Dendroctonus ponderosae Hopk.

Mountain pine beetle infestations remained low in **Alberta** in 1995. Beetles were detected at several locations by means of pheromone-baited trap trees. Aerial and ground surveys were concentrated in areas in Alberta where dispersing beetles might invade from British Columbia or the United States, and included the foothills region southwest of Calgary to the Canada–U.S. border, Willmore Wilderness Provincial Park, and Jasper, Banff, and Waterton Lakes national parks (Fig. 18).

No mountain pine beetle-killed lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) trees were observed during an aerial survey conducted in August in the Southern East Slopes Region. The flight included surveys of the Oldman, Castle, West Castle, Crowsnest, and Carbondale river valleys, and the Allison, Lynx, Racehorse, and Dutch creek valleys. Pheromone baits were deployed on trap trees at 29 sites throughout the region (Fig. 18): 23 in the former Bow-Crow Forest, and six in the former Rocky-Clearwater Forest. Mountain pine beetle attacks occurred on baited trap trees at sites near Tent Mountain, Allison Creek, McGillivray Creek, Racehorse Creek, and north of Coleman. No successful attacks occurred at any of these sites. At the remaining 24 sites, no trap trees were attacked.

In the Northern East Slopes Region, no mountain pine beetle-killed trees were observed during

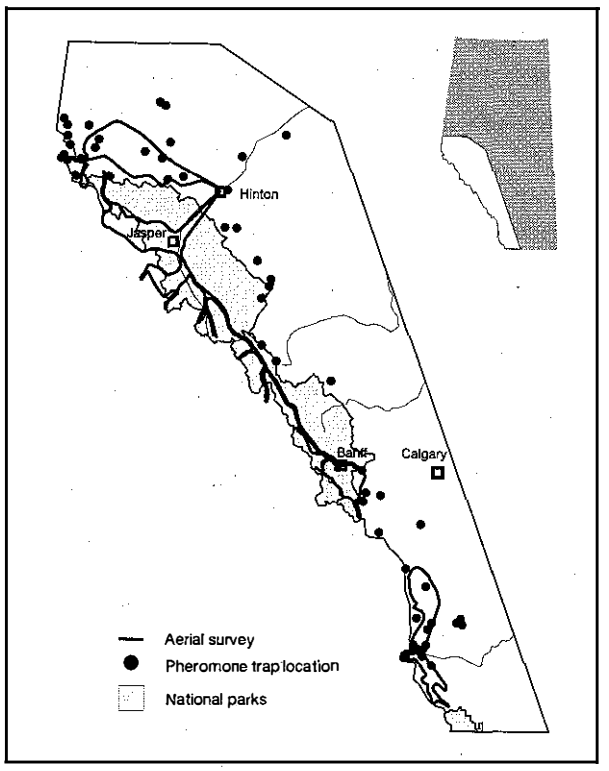

Figure 18. Areas aerially surveyed in Alberta for mountain pine beetle and locations where pheromone baits were placed on lodgepole pine trees in 1995.

aerial surveys of the Jackpine, Muddywater, South Sulphur, and Wildhay river valleys, and the Pauline, Hardscrabble, Rock, and Sheep creek valleys in Willmore Wilderness Provincial Park. Pheromone baits were placed on trap trees at 26 locations, mainly along the region's boundary with Jasper National Park and in Willmore Wilderness Provincial Park. Unsuccessful mountain pine beetle attacks occurred near Côté Creek, Fetherstonhaugh Creek, Beaverdam Pass, and the confluence of Jackpine River and Spider Creek. Lodgepole pine beetle (*D. murrayanae* Hopk.) was found attacking two baited trap trees near Ptarmigan Lake.

Parks Canada provided an aircraft and assisted in aerial surveys over Banff and Jasper national parks. Areas surveyed aerially in Jasper National Park included the Smoky, Miette, Snaring, Athabasca, Whirlpool, Middle Whirlpool, Chaba, Astoria, and Sunwapta river valleys. Areas aerially surveyed in Banff National Park included areas near the Kicking Horse Pass, the North Saskatchewan, Alexandra, Howse, Spray, Mistaya, and Bow river valleys, and the Healy, Brewster, Redearth, Pharaoh, and Bryant creek valleys. No recently killed trees were observed in either Banff or Jasper national parks.

SPRUCE BEETLE
Dendroctonus rufipennis (Kby.)

Spruce beetle infestations in the Northwest Boreal Region in Alberta were mapped for the first time in several years. Several patches of scattered spruce-beetle-killed white spruce trees were mapped in an area bounded by Nina Lake to the east, Keg River to the north, 30 km west of the sixth meridian to the west, and the Hotchkiss River to the south (Fig. 19). Two other isolated patches were observed: one was southwest of Bison Lake east of the Peace River, and the second patch was on the Halverson Ridge southeast of the Chinchaga River. The total area of these patches of scattered dead spruce was 23 771 ha. This area does not include the area of the infestation reported in 1994 in Wood Buffalo National Park (13 655 ha), which is also shown in Figure 19.

Alberta Land and Forest Service continued its detection survey for spruce beetle using Lindgren funnel traps baited with pheromones. Traps were set up at eight locations in the Northwest Boreal Region and at two locations in the Southern East Slopes Region. High numbers of beetles were captured in three traps. The Province continues to use three strategies to control the spruce beetle outbreak: deployment of pheromone-baited trap trees, felled trap trees, and salvage logging. During the winter of 1994–95 about 98 ha or 14 781 m^3 of white spruce were salvage-logged near Hawk Hills. More salvage cutting has been approved for the winter of 1995–96, amounting to 15 000 m^3 of spruce on about 300 ha in an area northwest of Hotchkiss and south of the Naylor Hills.

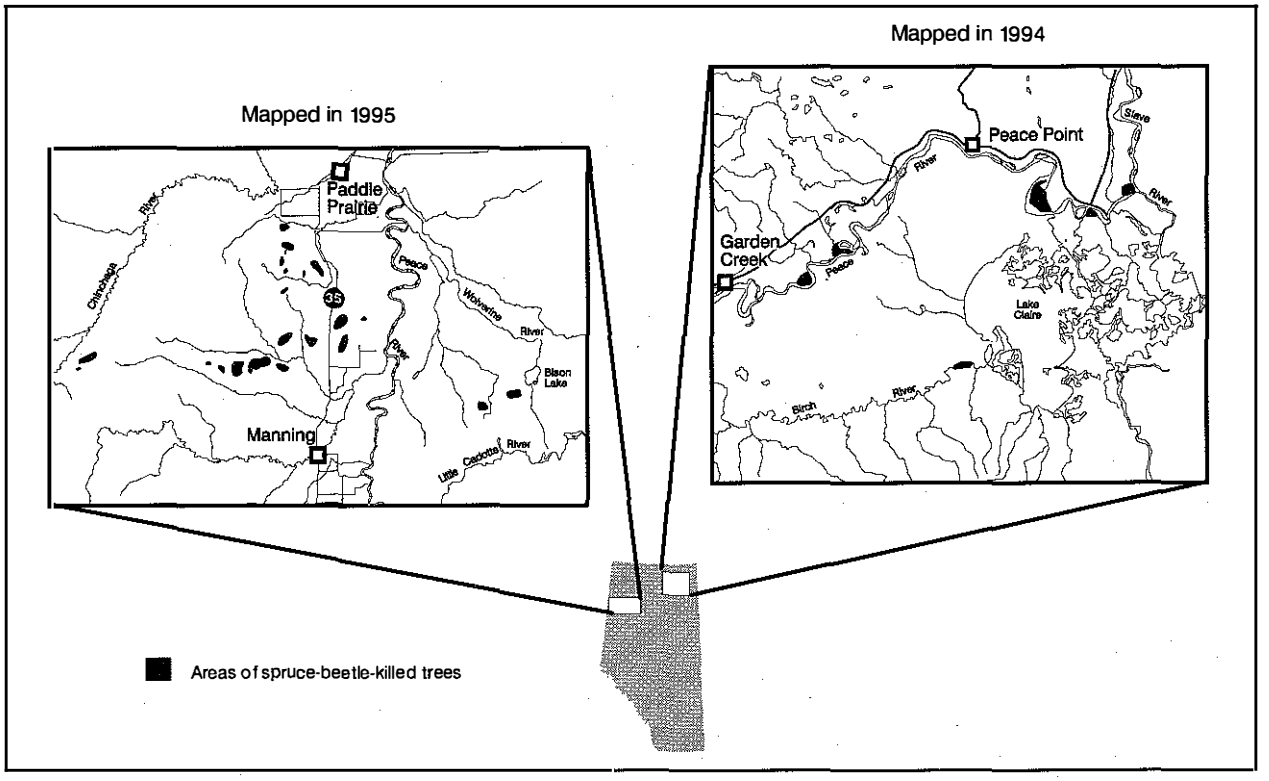

Figure 19. Areas of spruce-beetle-killed white spruce trees mapped during aerial surveys of northern Alberta in 1994 and 1995.

DOUGLAS-FIR BEETLE
Dendroctonus pseudotsugae Hopk.

The infestation of Douglas-fir beetle in **Alberta,** which was initially reported in 1991 in Jasper National Park, continued to expand in 1995. While the number of infested areas remained unchanged, the number of dead trees has increased since 1994. Beetle-killed Douglas-fir trees (*Pseudotsuga menziesii* [Mirb.] Franco) occur at about 63 areas scattered in the Athabasca River valley north and south of the Jasper townsite. Most areas had less than 50 attacked trees that had been killed since the infestation began.

LODGEPOLE PINE DWARF MISTLETOE
Arceuthobium americanum Nutt. ex Engelm.

In 1995, surveys were conducted in Alberta and Saskatchewan to map severe infestations of lodgepole pine dwarf mistletoe. These surveys were a continuation of those initiated in 1994 (Brandt 1995). Areas not previously mapped in **Alberta** (Fig. 20) included areas along the North Saskatchewan River near the Amelia, Bruderheim, Sniatyn, Smoky Lake, and Lindbergh townsites; near North Buck Lake northeast of Boyle; northwest of Algar Lake near Fort McMurray; and north of Lake Athabasca. All infestations occurred in jack pine (*Pinus banksiana* Lamb.) forests. The total area of previously unmapped infestations in Alberta was 63 888 ha, bringing the total area of jack pine forest infested by dwarf mistletoe to 176 013 ha (Table 4). The area of lodgepole pine forests infested in Alberta was 54 528 ha; one area (199 ha) was mapped late in 1994 near the Livingstone River and was not included in the 54 329 ha reported in 1994.

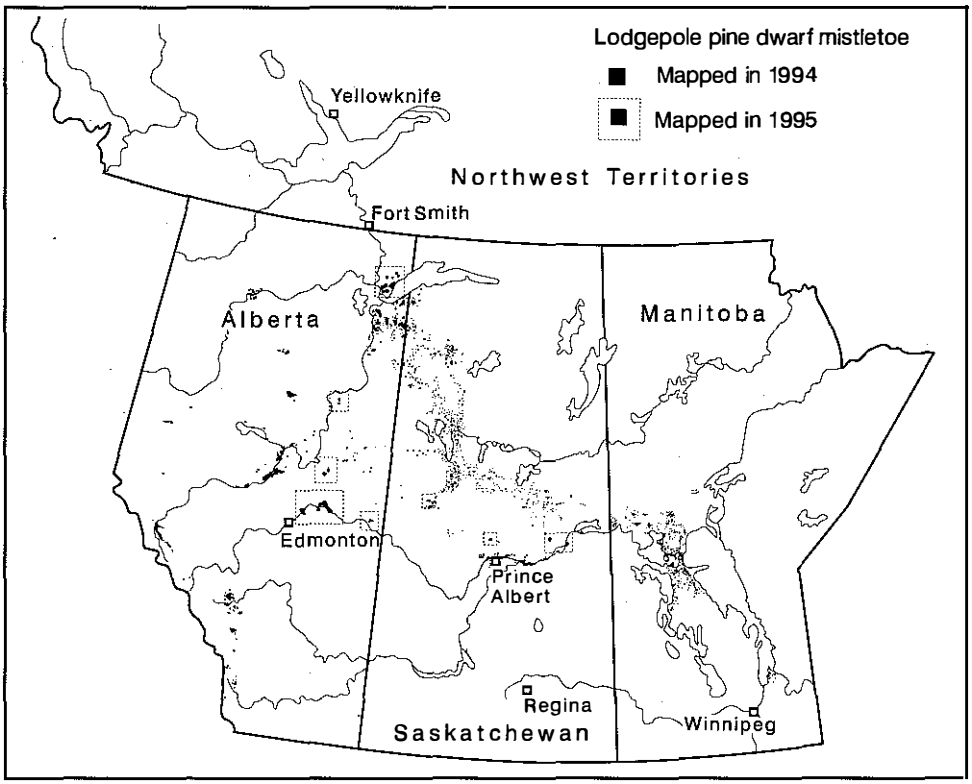

Figure 20. Areas of pine forests severely infected by lodgepole pine dwarf mistletoe mapped in 1994 and 1995.

Table 4. Area of severe infection by lodgepole pine dwarf mistletoe mapped during aerial and ground surveys in 1994 and 1995 in the Northwest Region

Location	Mapped areas of severe infection (ha) 1994	1995	Total
Alberta			
Jack pine	112 125	63 888	176013
Lodgepole pine	54 329	199	54 528
Saskatchewan			
Jack pine	123 982	12 723	136 705
Lodgepole pine	–[a]	0	–
Manitoba			
Jack pine	12 000	0	12 000
Northwest Territories			
Jack pine	0	0	0
Total	302 436	76810	379 246

[a] Only small areas (<200 ha) exist in Cypress Hills Provincial Park.

In **Saskatchewan**, an additional 12 723 ha of dwarf-mistletoe-infested jack pine forests were mapped in late 1994 and in 1995. The new areas were located along the Saskatchewan River northeast of Squaw Rapids; southeast of Canoe Lake; northwest of the Torch River townsite; near Durocher Lake; north of Matheson Lake in Meadow Lake Provincial Park; and south of Hunters Lake in Prince Albert National Park. The total area of jack pine forests severely infected by dwarf mistletoe was 136 705 ha, which included the 123 982 ha reported in 1994 (Brandt 1995).

GYPSY MOTH
Lymantria dispar (L.)

Agriculture and Agri-Food Canada, in cooperation with other federal, provincial, and municipal agencies, continued its gypsy moth pheromone-trapping program in 1995. The intent of the program is to detect the introduction of gypsy moth into the prairie provinces, an area of Canada where the moth is not established. In **Alberta**, 503 traps were placed in Banff, Jasper, and Waterton Lakes national parks; in Calgary, Edmonton, Grande Prairie, Lethbridge, Lloydminster, Peace River, and Red Deer; and in provincial parks and recreation areas. No male gypsy moths were captured.

In **Saskatchewan**, Agriculture and Agri-Food Canada placed 121 traps throughout the province, including more-northerly locations such as Narrow Hills, Greenwater Lake, and Meadow Lake provincial parks, Candle Lake Provincial Recreation Site, and Prince Albert National Park. Two male gypsy moths were captured: one in Saskatoon, and one in White City east of Regina. In **Manitoba**, 223 traps were deployed, mostly south of the Trans-Canada Highway 1, and the remainder in more-northerly recreation areas such as Riding Mountain National Park, and Duck Mountain, Clearwater Lake, and Asessippi provincial parks. No moths were captured at any of the trap sites.

SATIN MOTH
Leucoma salicis (L.)

A localized outbreak of satin moth, which was detected in Edmonton in 1994, continued in 1995. Three sites with defoliation were observed in St. Albert and several sites were found farther north and east in Edmonton than observed in 1994, including one site on the south side of the North Saskatchewan River in the Strathcona Science Park. In total, defoliated trees were found at over 100 sites. The most-common tree species defoliated were hybrid poplars (*Populus* spp.). The City of Edmonton initiated a control program to limit the spread of the insect in the city by using the insecticide Ambush®. The City also tested the efficacy of *Btk* and attempted to identify and rear some of the natural parasitoids of satin moth. Monitoring efforts to track the spread of male moths were initiated using traps baited with virgin female moths. Male moths were collected from traps located throughout south, east, and north Edmonton, in St. Albert, and in Sherwood Park.

DUTCH ELM DISEASE
Ophiostoma ulmi (Buis.) Nannf.

Surveys to detect the incidence of Dutch elm disease (DED) in **Alberta** were continued in 1995 by Alberta Agriculture, through the Dutch Elm Disease Initiative, and the municipalities of Brooks, Medicine Hat, Lethbridge, Red Deer, St. Albert, Strathcona County No. 20, Calgary, and Edmonton. The Dutch Elm Disease Initiative consisted of seven aspects: 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; monitoring ports of entry into the province and confiscating elm firewood; educating the public; developing a DED action response plan in the event of a DED introduction; upgrading highway signs alerting travelers about DED; and encouraging and developing interprovincial cooperation.

Elm bark beetle monitoring was conducted at 60 locations in Alberta from Cold Lake to the Crowsnest Pass at points of entry into the province and along major traffic routes to the province's large urban centers. At each of the monitoring sites, traps were set up and baited with a pheromone to attract the smaller European elm bark beetle and American elm trap logs were cut to attract the native elm bark beetle. The smaller European elm bark beetle was intercepted in traps in Calgary for the second consecutive year, and in Edmonton (3 beetles in 3 traps) for the first time. The DED pathogen was not cultured from any of the captured bark beetle specimens.

In **Saskatchewan**, the distribution of DED was similar to its occurrence in 1994 (Brandt 1995). Figure 21 shows the areas where DED is now established. The main areas of infestation included the Carrot, Saskatchewan, Red Deer, Souris and Qu'Appelle river valleys, and the Wascana and Brokenshell creek valleys.

Fifty-seven traps baited with smaller European elm bark beetle pheromone were distributed by staff of the provincial Dutch Elm Disease Program for deployment to many municipalities, including Carrot River, Estevan, Hudson Bay, Moose Jaw, Prince Albert, Saskatoon, Swift Current, Weyburn, and the Wascana Centre Authority in Regina. Results of the trapping program were not available at the time of printing. Between June 1994 and April 1995, 1959 American elm trees were removed from 18 different locations as part of control operations for DED. Between June 1995 and April 1996, an

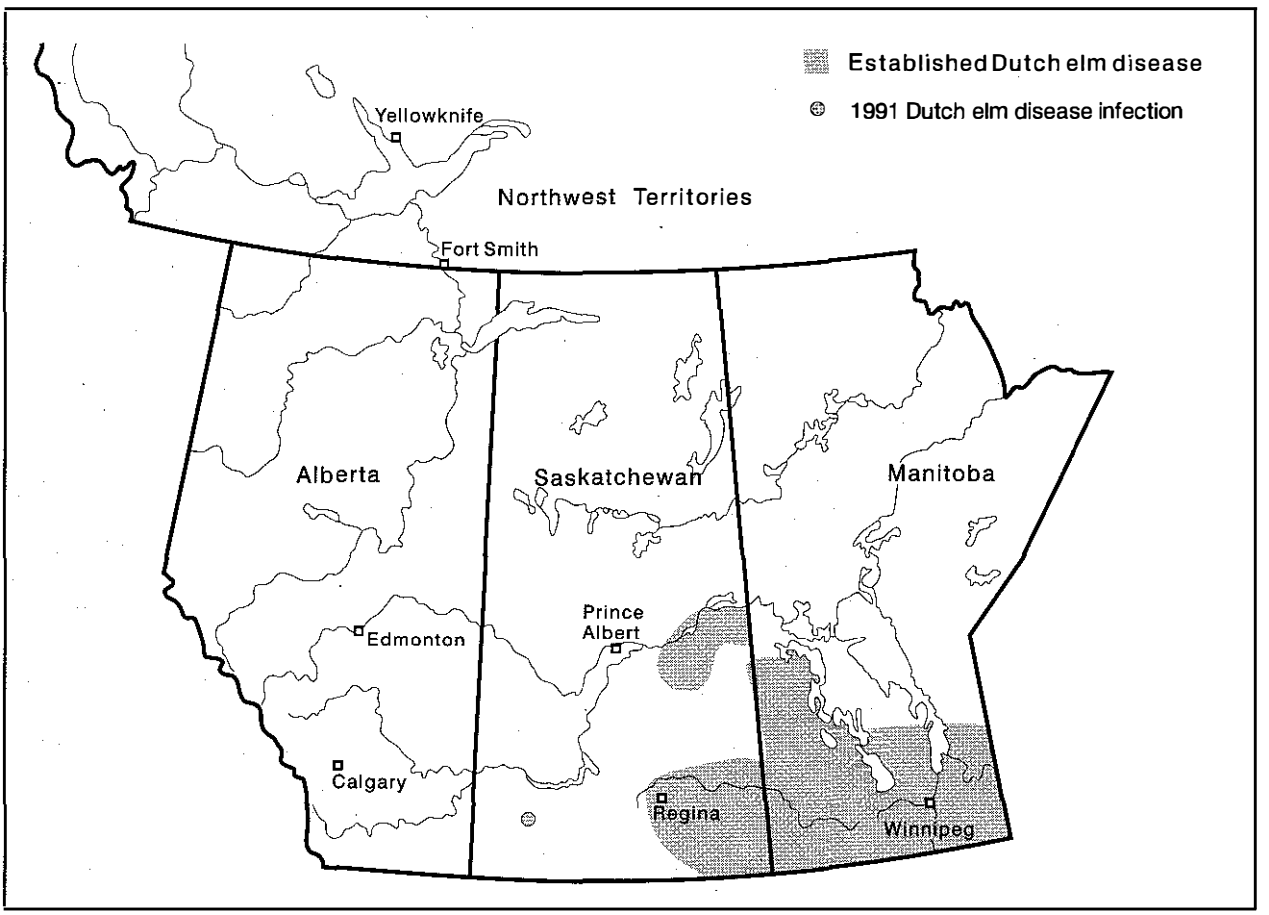

Figure 21. Distribution of Dutch elm disease in the prairie provinces in 1995.

additional 6327 trees were scheduled for removal throughout the range where DED occurred in 1995.

The range of DED in **Manitoba** extended northward to the Red Deer River in the western portion of the province in 1995. Riparian forests with a high incidence of DED included those adjacent to the Red, Assiniboine, Boyne, and Souris rivers. Urban centers with a high incidence of the disease included Brandon, Dauphin, Morden, Portage la Prairie, Selkirk, Steinbach, Winkler, and Winnipeg. Both bark beetle vectors occur in Manitoba, but only the native elm bark beetle plays a major role in the spread of the disease. The smaller European elm bark beetle has been trapped in Winnipeg in small numbers each year since 1979. Two specimens were captured in rural Manitoba near Emerson in 1989, but none has been captured since.

A total of 33 communities and seven buffer-zone municipalities around selected communities, including Winnipeg, participated in the cost-shared DED program with the Province of Manitoba. The cost-shared program helped with sanitation pruning, basal spraying with insecticide to reduce vector beetle populations, and replacement plantings. Provincial responsibilities involved surveys and tree removal, except in Winnipeg, where both of these activities were the municipality's responsibility, and Brandon, where the municipality was responsible for tree removal. The objective of the DED program is to manage the disease so that the annual mortality of high-value urban trees is less than 3% of the total number of urban elm trees.

Between April 1994 and April 1995, provincial sanitation crews removed 8194 elm trees considered to be diseased or hazardous (i.e., dead or dying trees suitable as elm bark beetle brood material). In Winnipeg and Brandon, an additional 3593 trees were removed during the same period. In 1995, provincial surveys marked 8119 trees in the province, of which 6658 were American elm and the remainder were Siberian elm (*U. pumila* L.). The provincial survey included a new area in Portage la Prairie and excluded Winnipeg. The provincial total for marked trees consisted of 375 diseased trees and 7744 trees considered to be hazards. In Winnipeg, 8461 trees were marked for removal: 2843 diseased American elm trees, 2392 trees considered to be hazards, and 3226 Siberian elm trees killed by recent flooding.

NURSERY PEST SURVEYS

Pest surveys were conducted in June at the Pine Ridge Forest Nursery in **Alberta**, and the Big River and Prince Albert forest nurseries in **Saskatchewan**. Nursery stock was inspected in seeded beds and transplant beds and in greenhouses. Genetic plantations, seed orchards, shelterbelt trees, and other trees in the nurseries were also inspected.

At the Pine Ridge Forest Nursery, only three pests of any significance were found in the seedling beds: woolly aphid (*Mindarus obliquus* Cholodkovsky) on white spruce, tarnished plant bug (*Lygus lineolaris* [Palisot de Beauvois]) on white spruce, and fusarium root rot (*Fusarium* spp.) on white spruce. Only fusarium root rot caused significant damage, with mortality in the range of 1–5%.

In the genetic tree plantations and seed orchards at the Pine Ridge nursery, no pests caused any substantial damage. The most notable pests and their hosts included Armillaria root rot (*Armillaria* sp.) and yellowheaded spruce sawfly (*Pikonema alaskensis* [Roh.]) on white spruce; black larch aphid (*Cinara laricifex* [Fitch]) and spruce gall adelgid (*Adelges lariciatus* [Patch]) on tamarack (*Larix laricina* [Du Roi] K. Koch); Venturia leaf and shoot blight (*Venturia macularis* [Fr.:Fr.] E. Müller & Arx) on trembling aspen; lodgepole terminal weevil (*Pissodes terminalis* Hopping) on lodgepole, jack, and Scots pine (*Pinus sylvestris* L.); white pine weevil (*P. strobi* [Peck]) on white spruce; and birch leafminer (*Fenusa pusilla* [Lep.]) on white birch (*Betula papyrifera* Marsh).

At Big River Forest Nursery, few pests were found in the seedling beds. Two pests caused significant damage: craneflies (*Nephrotoma* spp.) and tarnished plant bug (*Lygus lineolaris* [Palisot de Beauvois]). About 5–10% of white spruce seedlings in two seedling beds were girdled and killed by cranefly larvae. One seedling bed was treated with an insecticide for high populations of tarnished plant bug. Other pest species and their hosts included a bug (*Geocoris bullatus* [Say]) on spruce and pine; aster leafhopper (*Macrosteles quadrilineatus* [Fbs.]) on spruce; and uglynest caterpillar

(*Archips cerasivorana* [Fitch]) on prickly rose (*Rosa acicularis* Lindl.) in the shelterbelts. Another widespread problem, which was not attributed to any pest, was terminal bud failure; about 10–15% of the white spruce seedlings in several seedling beds were affected.

In the genetic plantations and seed orchards, there was little change in the incidence of pests and severity of damage from that observed in 1994 (Brandt 1995). White pine weevil was the most prevalent and damaging pest, killing terminals of white and Norway spruce (*Picea abies* [L.] Karst.). Spruce gall adelgid and pale spruce gall adelgid (*A. laricis* Vallot) were common on white spruce. Branches on several Scots pine trees were infected with western gall rust (*Endocronartium harknessii* [J.P. Moore] Y. Hiratsuka).

At the Prince Albert Forest Nursery, craneflies (*Nephrotoma* spp.) caused losses at about the same levels as those observed at the other Saskatchewan nursery. Larvae of the common June beetle (*Phyllophaga anxia* [Lec.]) damaged white spruce seedlings in several seedling beds. Tarnished plant bug was observed at low population levels throughout the nursery. In the deciduous seedling and cutting beds, gray willow leaf beetle (*Tricholochmaea decora* [Say]), willow redgall sawfly (*Pontania proxima* [Lep.]), green rose chafer (*Dichelonyx backii* [Kby.]), and poplar–willow leaf weevil (*Lepyrus nordenskioldi canadensis* Csy.) were all found causing minor damage.

ACID RAIN NATIONAL EARLY WARNING SYSTEM

The Acid Rain National Early Warning System (ARNEWS) was established in 1984 to detect symptoms of acid rain injury to forests. Seventeen ARNEWS plots have been maintained in the Northwest Region as 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. 22). There are 151 plots across Canada. Further information on ARNEWS methods and results is provided in Magasi (1988), D'Eon and Power (1989), Hall (1991, 1993, 1995), Hall and Addison (1991), Hall and Pendrell (1992), and D'Eon et al. (1994).

In 1995, all 17 ARNEWS plots were visited twice, once in May or June and once in August or September. No symptoms associated with acid rain were observed on trees at any of the sites. A number of pests were observed at various plots. Some of these pests occurred at population levels where damage was evident. Pest incidence has not changed significantly over the years since the 17 plots were established. As frequently occurs with many pests in natural environments, populations have fluctuated widely.

There are seven plots in **Alberta** in: Cypress Hills Provincial Park; Waterton Lakes National Park; an area southwest of Rocky Mountain House; William A. Switzer Provincial Park (part of the Foothills Model Forest); an area south of Grande Prairie; Gregoire Lake Provincial Park; and an area north of High Level. There were 425 living trees on the plots in 1995, of which 216 were lodgepole pine, 15 were black spruce (*P. mariana* [Mill.] BSP), 124 were white spruce, 25 were balsam fir, 40 were trembling aspen, two were balsam poplar (*Populus balsamifera* L.), and three were white birch.

Eighty-eight percent of the living lodgepole pine trees were rated as healthy, and 12% were rated as declining, while 25% of the total number of living and dead trees were dead. The most prevalent pests on lodgepole pine were Atropellis canker (*Atropellis piniphila* [Weir] Lohman & Cash), western gall rust, and the pine needle cast, *Elytroderma deformans* [Weir] Darker. White spruce trees were in healthy condition, with 98% of the living trees rated as healthy, 2% of the living trees rated as declining, and 2% of the total number of living and dead trees rated as dead. Large-spored spruce–Labrador tea rust (*Chrysomyxa ledicola* Lagh.) and yellow witches' broom (*C. arctostaphyli* Diet.) were the only pests on spruce that occurred with any frequency. Neither of these pests caused significant damage. No pests were observed on balsam fir; consequently, all trees were healthy. Ninety percent of living trembling aspen were rated as healthy, 10% of the living trees were rated as declining; 7% of the total number of living and dead trees were rated as dead. The only pest that occurred on living trembling aspen was poplar Peniophora (*Peniophora polygonia* [Pers.:Fr.] Boud.). Armillaria root rot was observed on one dead aspen.

In **Saskatchewan** there are three plots in: an area south of Hudson Bay, Prince Albert National Park (part of the Prince Albert Model Forest), and

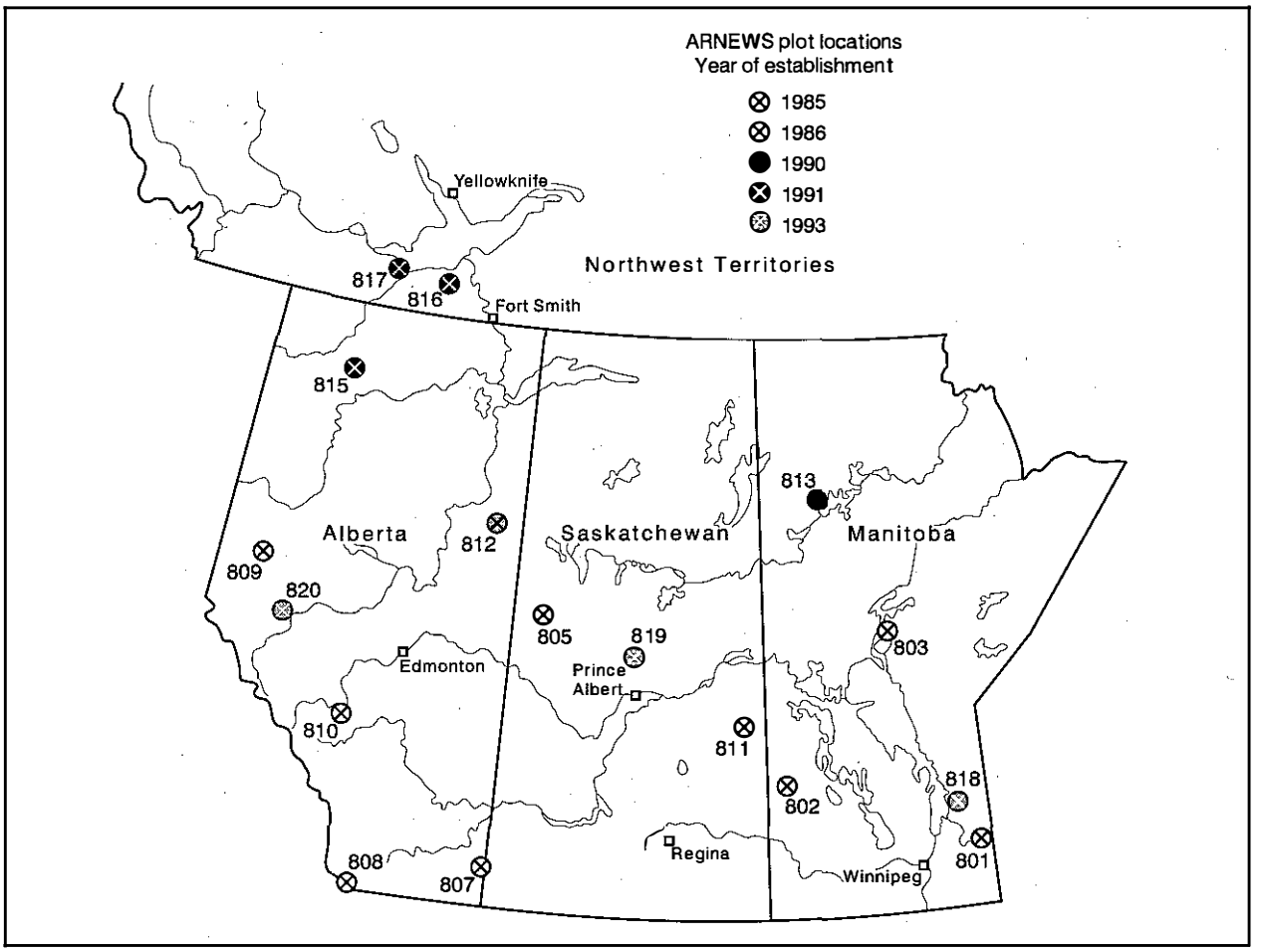

Figure 22. Locations of Acid Rain National Early Warning System plots used for detecting symptoms of acid rain injury to forests in the Northwest Region.

Meadow Lake Provincial Park. There were 152 living trees on the three plots, of which 42 were jack pine, one was black spruce, 75 were white spruce, 33 were trembling aspen, and one was balsam poplar. Cumulative mortality for all tree species since the plots were established was 11% of total number of living and dead trees. For the jack pine trees on the plots, 98% of the living trees were healthy, 2% of the living trees were declining, and 14% of the total number of living and dead trees were dead. Jack pine pests included northern pitch twig moth (*Petrova albicapitana* [Bsk.]) and western gall rust. For white spruce trees on the plots, the percentages for healthy, declining, and dead trees were 24, 76, and 5%, respectively. Spruce budworm was the only pest found on white spruce. The insect caused 50–70% defoliation on 57 trees in one plot (near Hudson Bay), dramatically reducing tree health and, consequently, the high percentage of trees in the declining class. Trembling aspen trees were generally healthy, with 82, 15, and 18% of the trees rated as healthy, declining, or dead, respectively. On the living aspen, false tinder conk (*Phellinus tremulae* [Bond.] Bond. & Boriss.) was the only pest of consequence. A few of the dead aspen showed evidence of Armillaria root rot (*Armillaria* sp.); this organism was the most likely cause of mortality.

In **Manitoba** there are five ARNEWS plots in: Whiteshell Provincial Park, Duck Mountain Provincial Park, an area south of Jenpeg, an area north of Leaf Rapids, and an area near Manigotagan in the Manitoba Model Forest. There were 259 living trees on the five plots in 1995, of which 162 were jack pine, 62 were trembling aspen, 21 were black spruce, eight were white spruce, and six were balsam fir.

Ninety-nine percent of the living jack pine trees were rated as healthy and 1% were rated as declining;

2% of the total number of living and dead trees were dead. The most prevalent pests on jack pine were a shoot-boring insect (*Rhyacionia* sp.) and western gall rust. The shoot-boring insect was common on about 25% of the jack pine trees but did not affect tree health seriously. Eighty-seven percent of living trembling aspen were rated as healthy, 5% of the living trees were rated as declining; 37% of the total number of living and dead trees were rated as dead. Most dead trees occurred on the plot near Manigotagan, which is located on a poor site. Two pests were found on living trembling aspen: poplar Peniophora and false tinder conk. Neither of these pests was seriously reducing tree vigor. No pests were observed on black and white spruce trees; consequently, all trees were healthy. Three percent of the total number of living and dead black spruce trees rated as dead. Balsam fir trees were in relatively poor condition because of spruce budworm defoliation; 17% of the living trees were rated as healthy, and 83% of the living trees were rated as declining. There were no dead balsam fir trees. Another insect that was common on balsam fir but caused little damage was the introduced false balsam gall midge (*Dasineura balsamicola* [Lint.]).

There are two ARNEWS plots in the **Northwest Territories**, one in an area south of Pine Point and the other near Kakisa Lake. They contained 46 living white spruce, 44 living trembling aspen, and four living balsam poplar in 1995. Both white spruce and trembling aspen were generally healthy. The percentages for healthy, declining, and dead trees for spruce were 98, 2, and 0%, respectively, while for aspen they were 89, 11, and 4%, respectively. Several pests were observed on the two plots, but none caused significant damage to the trees. Pests that were observed included spruce spider mite (*Oligonychus ununguis* [Jac.]) on white spruce; and false tinder conk, black gall, aspen leafroller, and alder leaf beetle (*Chrysomela m. mainensis* Bechst.) on trembling aspen.

OTHER NOTEWORTHY INSECTS, DISEASES, AND OTHER DAMAGE AGENTS

Insect, disease, or damage agent	Host	Location	Remarks
Armillaria root rot *Armillaria ostoyae* (Romag.) Herink	Pine species	Alberta Saskatchewan Manitoba NWT	Infection centers found throughout most of the region.
Aspen mortality	Trembling aspen	Alberta Saskatchewan	Mortality resulting from drought and past insect defoliation was still common in 1995 throughout the southern portions of the Northeast Boreal Region in Alberta and the southern portions of the Meadow Lake Region in Saskatchewan.
Aspen serpentine leafminer *Phyllocnistis populiella* (Cham.)	Trembling aspen	NWT	Observed in Wood Buffalo National Park and north of Fort Liard.
Atropellis canker *Atropellis piniphila* (Weir) Lohman & Cash	Lodgepole pine	Alberta	Commonly found on lodgepole pine near Rocky Mountain House, south of Hinton near Robb, and between Blairmore and Livingstone Falls.

Insect, disease, or damage agent	Host	Location	Remarks
Chameleon caterpillar *Anomogyna elimata* (Guenée)	Jack pine	Alberta	Low populations feeding on jack pine east of the Peace River near Deadwood.
Cottonwood leaf beetle *Chrysomela scripta* F.	Trembling aspen	Alberta NWT	Low populations found near Trout River and in Wood Buffalo National Park.
Diplodia tip blight *Sphaeropsis sapinea* (Fr.) Dyko & Sutton	Jack pine Red pine	Manitoba	Prevalent in southeast Manitoba. Caused cankers on the stems.
Eastern blackheaded budworm *Acleris variana* (Fern.)	White spruce	Saskatchewan Manitoba	Low populations found on white spruce in Prince Albert National Park and the Porcupine Hills in Saskatchewan, and throughout Manitoba.
European fruit lecanium *Parthenolecanium corni* (Bouché)	Green ash Elm	Alberta	Severe outbreak in some parts of Edmonton, especially near the University of Alberta campus and in the downtown core.
Gray willow leaf beetle *Tricholochmaea decora* (Hbn.)	Willow Trembling aspen	Manitoba	Found feeding on both tree species in eastern Manitoba.
Hail damage	Balsam fir White spruce Trembling aspen	Alberta	About 400 ha of forest were severely damaged in a 1994 storm northeast of Grande Cache east of the Smoky River.
Larch sawfly *Pristiphora erichsonii* (Htg.)	Tamarack	NWT	Defoliation observed in Wood Buffalo National Park and an area bounded by the north park boundary, east of the Hay River, west of the Taltson River, and Great Slave Lake.
Large-spored spruce–Labrador tea rust *Chrysomyxa ledicola* Lagh.	White spruce	Alberta	Moderate-to-high population levels observed in the foothills near Hinton and in Jasper National Park.
Lodgepole terminal weevil *Pissodes terminalis* Hopping	Jack pine Lodgepole pine	Alberta Saskatchewan Manitoba NWT	Common throughout the region on jack and lodgepole pine regeneration.

Insect, disease, or damage agent	Host	Location	Remarks
Meria needle cast of larch *Meria laricis* Vuill.	Alpine larch	Alberta	Severe damage to trees near Leman Lake and the headwaters of the Spray River.
Northern pitch twig moth *Petrova albicapitana* (Bsk.)	Pine	Alberta Saskatchewan	Common throughout Alberta and Saskatchewan.
Pine needle casts *Elytroderma deformans* (Weir) Darker *Lophodermella concolor* (Dearn.) Darker *L. arcuata* (Darker) Darker	Lodgepole pine Limber pine	Alberta	*Elytroderma deformans* was common near Hinton. *Lophodermella concolor* was observed in the Rocky Mountain national parks and in the Northern East Slopes Region, but at much-reduced levels over those seen in the last several years. Moderate damage caused by *L. arcuata* was observed on limber pine (*Pinus flexilis* James) in the Porcupine Hills.
Prairie tent caterpillar *Malacosoma californicum lutescens* (N. & D.)	Cherry	Saskatchewan Manitoba	Observed near North Battleford in Saskatchewan and in many locations east of Winnipeg in Manitoba.
Rhabdocline needle cast of Douglas-fir *Rhabdocline pseudotsugae* Syd.	Douglas-fir	Alberta	Low populations observed on trees in the Porcupine Hills.
Spearmarked black moth *Rheumaptera hastata* (L.)	White birch	NWT	Moderate defoliation observed near Fort Liard and near the Blackstone River.
Spruce budmoth *Zeiraphera canadensis* Mut. & Free.	White spruce	Manitoba	Moderate-to-high populations observed in the eastern area of the province.
Spruce cone rust *Chrysomyxa pirolata* Wint.	White spruce	Alberta	Common near Robb in the foothills, in Kananaskis Provincial Park, and in Jasper National Park along the Athabasca and Miette rivers.
Spruce gall adelgids *Adelges lariciatus* (Patch) *A. strobilobius* (Kltb.)	Spruce	Alberta Saskatchewan Manitoba NWT	Both adelgids common throughout the region.

Insect, disease, or damage agent	Host	Location	Remarks
Uglynest caterpillar *Archips cerasivorana* (Fitch)	Cherry	Manitoba	Common through eastern Manitoba.
Venturia leaf and shoot blight *Venturia macularis* (Fr.) E. Müller & Arx (anam. *Pollaccia radiosa* [Lib.] Bald & Cif.)	Trembling aspen	Alberta	Infestations were observed near Pierre Greys Lakes east of Grande Cache, in William A. Switzer Provincial Park, and in the Bow River valley in Banff National Park.
Warren rootcollar weevil *Hylobius warreni* Wood	Jack pine Lodgepole pine	Alberta Saskatchewan Manitoba	Mortality caused by *H. warreni* noted generally throughout the region.
Western gall rust *Endocronartium harknessii* (J.P. Moore) Y. Hiratsuka	Pine	Alberta Saskatchewan Manitoba NWT	Common on pines throughout the region. High incidence of this disease observed between Blairmore and Livingstone Falls, in Cypress Hills Provincial Park, and in Jasper National Park in Alberta; and in Duck Mountain Provincial Forest in Manitoba.
White pine weevil *Pissodes strobi* (Peck)	Spruce	Alberta Saskatchewan Manitoba NWT	Commonly found on roadside and plantation regeneration throughout the region.
Willow leafminer *Micrurapteryx salicifoliella* (Cham.)	Willow	Alberta NWT	Severe damage observed in northern Alberta, including Wood Buffalo National Park, and in the NWT. Defoliation in the latter area has occurred for several consecutive years.
Willow redgall sawfly *Pontania proxima* (Lep.)	Willow	Alberta	High population levels observed in Edmonton.
Yellowheaded spruce sawfly *Pikonema alaskensis* (Roh.)	Spruce	Alberta Saskatchewan Manitoba	High populations observed throughout the prairie provinces.
Yellow witches' broom of spruce *Chrysomyxa arctostaphyli* Diet.	Spruce	Alberta	High incidence of this disease observed in Banff National Park north of Banff townsite in the Bow River valley.

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

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 and Agri-Food 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
- heromone source: Dr. C.J. Sanders, Natural Resources Canada, Sault Ste. Marie, Ontario

Spruce beetle
- Chemical component(s): frontalin, α-pinene, 1-methycyclo-hex-2-enol
- 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 1995

Region	Site	Location[a]				Number of moths		
		Sec.	Twp.	Rge.	Mer.	Trap 1	Trap 2	Average
Northwest Boreal	1	2	80	1	W6	130	130	130
	2	13	80	26	W5	300	300	300
	3	23	90	20	W5	238	221	230
	4	33	93	16	W5	622	337	480
	5	16	93	19	W5	320	733	527
	6	3	94	25	W5	779	815	797
	7	20	96	22	W5	632	233	433
	8	9	99	22	W5	285	325	305
	9	14	94	20	W5	335	564	450
	10	36	98	23	W5	414	258	336
	11	25	94	23	W5	6602	5053	5828
	12	2	111	7	W5	65	67	66
	13	22	102	10	W5	93	83	88
	14	6	99	8	W5	148	N/A[b]	148
	15	30	103	19	W5	971	704	838
	16	28	116	22	W5	717	409	563
	17	11	117	22	W5	654	403	529
	18	19	112	20	W5	471	250	361
	19	23	112	20	W5	37	61	49
	20	21	110	22	W5	66	188	127
	21	31	110	2	W6	1717	2356	2037
	22	2	111	5	W6	106	343	225
	23	26	116	3	W6	1692	N/A	1692
	24	15	118	4	W6	754	1738	1246
	25	6	108	9	W6	348	257	303
	26	15	107	9	W6	309	346	328
	27	5	118	8	W6	1502	1529	1516
	28	3	69	9	W5	77	N/A	77
	29	24	73	8	W5	59	80	70
	30	17	73	15	W5	42	12	27
	31	8	83	13	W5	68	78	73
	32	36	90	12	W5	361	480	421
	33	27	91	3	W5	N/A	N/A	N/A
	34	3	71	1	W5	221	N/A	221
	35	2	70	3	W5	61	N/A	61
	36	5	72	5	W5	15	N/A	15
Northeast Boreal	1	9	74	22	W4	257	239	248
	2	36	70	20	W4	97	90	94
	3	16	78	15	W4	N/A	324	324
	4	19	77	17	W4	194	129	162
	5	14	82	17	W4	164	683	424
	6	32	69	25	W4	74	92	83
	7	2	95	15	W4	102	118	110
	8	3	98	12	W4	129	102	116
	9	26	88	6	W4	135	202	169

Appendix 2 concluded

Region	Site	Location[a]				Number of moths		
		Sec.	Twp.	Rge.	Mer.	Trap 1	Trap 2	Average
Northeast Boreal	10	24	84	15	W4	858	630	744
	11	12	86	13	W4	1185	922	1054
	12	7	90	11	W4	0	211	106
	13	12	94	11	W4	106	82	94
	14	12	108	10	W4	185	150	168
	15	22	121	9	W4	N/A[b]	725	725
Northeast Slopes	1	20	46	18	W5	3	0	2
	2	23	48	25	W5	1	0	1
	3	27	56	11	W6	6	0	3
	4	7	57	13	W6	2	2	2
	5	30	55	13	W6	5	6	6
	6	23	55	13	W6	8	8	8
	7	24	54	13	W6	N/A	10	10
	8	3	56	12	W6	5	6	6
	9	9	51	11	W6	3	3	3
	10	26	51	12	W6	2	2	2
	11	14	59	4	W6	0	0	0
	12	34	54	22	W5	2	0	1
	13	12	62	19	W5	22	30	26
	14	11	52	12	W5	27	27	27
	15	3	52	11	W5	24	24	24
	16	11	60	13	W5	0	0	0
	17	29	58	13	W5	0	0	0
	18	33	63	10	W5	18	66	42
Southeast Slopes	1	30	22	5	W5	0	0	0
	2	13	19	9	W5	0	0	0
	3	5	22	10	W5	0	0	0
	4	18	24	7	W5	0	0	0
	5	11	11	5	W5	35	25	30
	6	32	6	5	W5	0	0	0
	7	21	40	15	W5	3	3	3
	8	13	35	9	W5	12	12	12
	9	13	43	7	W5	16	15	16
	10	25	44	12	W5	25	29	27

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

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

[b] Not available.

APPENDIX 3
SPRUCE BUDWORM SECOND INSTAR DENSITIES IN 1995 AND 1996 DEFOLIATION FORECASTS FOR ALBERTA

Region	Site	Location[a]				Avg. no. of L_2 counts/10 m^2 of foliage[b]	Predicted defoliation in 1996[c]
		Sec.	Twp.	Rge.	Mer.		
Northwest Boreal	1	24	94	23	W5	1500	Severe
	2	30	94	22	W5	1257	Severe
	3	24	104	22	W5	278	Moderate
	4	14	104	23	W5	243	Moderate
	5	22	104	24	W5	884	Severe
	6	16	104	24	W5	721	Severe
	7	1	104	1	W6	29	Light
	8	20	104	2	W6	23	Light
	9	4	105	12	W6	0	Nil
	10	28	105	11	W6	13	Light
	11	22	105	2	W6	32	Light
	12	23	105	1	W6	66	Light
	13	1	105	1	W6	63	Light
	14	5	105	24	W5	140	Light
	16	25	105	1	W6	96	Light
	17	33	105	24	W5	396	Moderate
	18	21	105	23	W5	181	Light
	19	31	105	23	W5	645	Severe
	20	27	105	23	W5	320	Moderate
	21	20	105	22	W5	1127	Severe
	22	8	105	22	W5	173	Light
	23	14	105	22	W5	337	Moderate
	24	4	105	21	W5	132	Light
	25	19	105	21	W5	119	Light
	26	1	106	22	W5	702	Severe
	28	17	106	22	W5	456	Moderate
	29	21	106	23	W5	192	Moderate
	30	15	106	24	W5	305	Moderate
	31	18	106	24	W5	330	Moderate
	32	20	106	24	W5	608	Severe
	33	14	106	1	W6	6	Light
	34	34	106	1	W6	67	Light
	36	2	107	2	W6	118	Light
	37	3	106	2	W6	79	Light
	39	11	106	5	W6	5	Light
	40	6	107	7	W6	0	Nil
	41	26	107	6	W6	13	Light
	42	28	107	3	W6	135	Light
	44	9	107	2	W6	39	Light
	45	6	108	1	W6	106	Light
	46	15	107	2	W6	130	Light
	47	31	107	1	W6	116	Light
	48	8	107	1	W6	17	Light
	49	28	107	1	W6	77	Light

Appendix 3 continued

Region	Site	Location[a] Sec.	Twp.	Rge.	Mer.	Avg. no. of L_2 counts/10 m^2 of foliage[b]	Predicted defoliation in 1996[c]
Northwest Boreal	50	22	107	1	W6	109	Light
	51	16	107	24	W5	313	Moderate
	52	2	107	24	W5	435	Moderate
	53	7	107	23	W5	808	Severe
	56	15	107	21	W5	95	Light
	57	9	108	22	W5	56	Light
	58	16	108	23	W5	10	Light
	59	23	108	1	W6	9	Light
	60	19	108	1	W6	112	Light
	61	14	108	2	W6	135	Light
	62	19	108	2	W6	18	Light
	63	18	108	2	W6	29	Light
	64	4	108	3	W6	71	Light
	65	15	108	3	W6	276	Moderate
	66	14	108	4	W6	32	Light
	67	3	109	4	W6	148	Light
	69	28	108	5	W6	23	Light
	70	21	109	8	W6	21	Light
	71	23	109	6	W6	33	Light
	72	31	109	5	W6	129	Light
	73	34	109	5	W6	64	Light
	74	7	109	4	W6	19	Light
	75	17	109	4	W6	110	Light
	76	3	109	4	W6	0	Nil
	77	7	109	3	W6	380	Moderate
	78	21	109	3	W6	82	Light
	79	24	109	3	W6	42	Light
	80	7	109	2	W6	110	Light
	81	34	109	2	W6	8	Light
	82	19	109	1	W6	170	Light
	83	32	109	24	W5	4	Light
	84	15	109	1	W6	41	Light
	85	34	108	24	W5	742	Severe
	86	36	108	24	W5	169	Light
	87	12	109	24	W5	944	Severe
	88	30	109	23	W5	24	Light
	89	2	110	22	W5	96	Light
	90	22	109	22	W5	210	Moderate
	91	16	110	16	W5	143	Light
	92	8	109	6	W5	193	Moderate
	93	5	109	6	W5	116	Light
	94	36	110	22	W5	10	Light
	95	18	111	22	W5	9	Light
	96	10	111	23	W5	217	Moderate
	97	28	110	24	W5	77	Light
	98	11	110	1	W6	29	Light
	99	31	110	1	W6	282	Moderate
	100	26	110	2	W6	28	Light
	101	24	110	3	W6	295	Moderate
	102	12	110	3	W6	43	Light
	104	20	110	3	W6	95	Light

Appendix 3 continued

Region	Site	Location[a] Sec.	Twp.	Rge.	Mer.	Avg. no. of L_2 counts/10 m^2 of foliage[b]	Predicted defoliation in 1996[c]
Northwest Boreal	105	31	110	3	W6	135	Light
	106	25	110	4	W6	0	Nil
	107	16	110	4	W6	339	Moderate
	108	17	110	4	W6	595	Severe
	109	26	110	5	W6	99	Light
	110	15	110	5	W6	516	Moderate
	111	17	110	5	W6	71	Light
	112	30	110	5	W6	58	Light
	113	10	111	6	W6	11	Light
	114	31	110	6	W6	70	Light
	115	19	110	6	W6	82	Light
	116	9	110	7	W6	209	Moderate
	117	27	110	8	W6	51	Light
	118	27	110	8	W6	117	Light
	119	2	110	8	W6	278	Moderate
	120	33	111	10	W6	367	Moderate
	121	16	111	6	W6	18	Light
	122	14	111	6	W6	95	Light
	123	36	111	6	W6	89	Light
	124	8	111	5	W6	234	Moderate
	125	21	111	5	W6	46	Light
	126	12	111	5	W6	204	Moderate
	127	5	111	4	W6	462	Moderate
	128	17	111	4	W6	149	Light
	129	24	111	4	W6	190	Moderate
	130	12	111	3	W6	196	Moderate
	131	23	111	3	W6	89	Light
	132	34	111	3	W6	30	Light
	133	4	112	2	W6	267	Moderate
	134	28	111	2	W6	133	Light
	135	17	111	2	W6	116	Light
	136	2	111	2	W6	236	Moderate
	137	29	111	1	W6	48	Light
	138	34	111	1	W6	122	Light
	139	35	110	1	W6	130	Light
	140	12	111	24	W5	294	Moderate
	141	25	111	24	W5	168	Light
	142	10	112	23	W5	9	Light
	143	9	112	1	W6	154	Light
	144	6	112	1	W6	223	Moderate
	145	14	112	1	W6	236	Moderate
	147	11	112	2	W6	132	Light
	148	29	112	2	W6	399	Moderate
	151	31	112	3	W6	610	Severe
	152	16	112	4	W6	31	Light
	154	14	112	10	W6	1209	Severe
	155	36	112	10	W6	1057	Severe
	156	8	112	10	W6	347	Moderate
	157	32	112	10	W6	478	Moderate
	158	24	112	11	W6	1096	Severe
	159	17	112	11	W6	416	Moderate

Appendix 3 continued

Region	Site	Location[a] Sec.	Twp.	Rge.	Mer.	Avg. no. of L_2 counts/10 m^2 of foliage[b]	Predicted defoliation in 1996[c]
Northwest Boreal	160	10	113	3	W6	34	Light
	161	28	113	3	W6	7	Light
	162	5	114	3	W6	12	Light
	163	10	114	3	W6	46	Light
	164	17	113	2	W6	63	Light
	165	36	113	2	W6	398	Moderate
	166	5	114	2	W6	15	Light
	167	16	113	1	W6	322	Moderate
	168	8	114	1	W6	354	Moderate
	169	11	114	1	W6	863	Severe
	170	5	113	21	W5	119	Light
	171	1	113	22	W5	186	Light
	173	29	113	21	W5	4	Light
	175	32	114	23	W5	847	Severe
	176	2	115	24	W5	751	Severe
	177	17	115	23	W5	303	Moderate
	178	16	115	23	W5	568	Severe
	179	1	116	23	W5	163	Light
	180	30	115	11	W6	126	Light
	181	25	116	12	W6	259	Moderate
	182	28	116	12	W6	517	Moderate
	183	11	117	12	W6	10	Light
	184	9	117	12	W6	50	Light
	186	36	116	9	W6	538	Moderate
	187	12	116	8	W6	88	Light
	188	3	117	9	W6	1129	Severe
	189	17	117	8	W6	653	Severe
	191	10	117	8	W6	391	Moderate
	192	31	117	8	W6	756	Severe
	193	8	118	8	W6	585	Severe
	194	35	117	8	W6	87	Light
	195	13	117	8	W6	57	Light
	196	30	116	7	W6	119	Light
	197	17	117	7	W6	141	Light
	198	34	116	7	W6	258	Moderate
	199	12	117	7	W6	236	Moderate
	200	35	117	7	W6	123	Light
	201	9	117	6	W6	63	Light
	202	14	117	6	W6	220	Moderate
	203	35	116	6	W6	50	Light
	204	20	117	5	W6	315	Moderate
	205	32	117	5	W6	67	Light
	206	34	117	6	W6	75	Light
	207	25	117	6	W6	64	Light
	208	12	117	6	W6	74	Light
	210	18	116	3	W6	21	Light
	211	3	117	3	W6	226	Moderate
	212	18	117	3	W6	420	Moderate
	213	8	118	4	W6	638	Severe
	214	13	118	4	W6	540	Moderate
	216	21	118	4	W6	485	Moderate

Appendix 3 continued

Region	Site	Location[a] Sec.	Twp.	Rge.	Mer.	Avg. no. of L_2 counts/10 m^2 of foliage[b]	Predicted defoliation in 1996[c]
Northwest Boreal	217	23	118	4	W6	467	Moderate
	218	29	118	3	W6	983	Severe
	219	35	118	4	W6	354	Moderate
	220	4	119	3	W6	700	Severe
	221	24	119	3	W6	546	Severe
	222	10	119	2	W6	142	Light
	223	32	119	19	W5	300	Moderate
	224	10	120	19	W5	588	Severe
	225	15	120	21	W5	734	Severe
	226	35	120	21	W5	1114	Severe
	227	26	121	20	W5	308	Moderate
	228	29	121	21	W5	75	Light
	229	12	122	20	W5	1758	Severe
	230	36	120	19	W5	95	Light
	231	14	121	19	W5	1415	Severe
	232	3	121	18	W5	704	Severe
	233	28	121	18	W5	1380	Severe
	234	32	121	18	W5	1247	Severe
	236	5	123	21	W5	893	Severe
	237	27	123	21	W5	2654	Severe
	238	8	123	20	W5	1263	Severe
	239	7	122	16	W5	434	Moderate
	240	31	122	16	W5	695	Severe
	241	21	123	16	W5	239	Moderate
	242	24	122	15	W5	60	Light
	243	10	124	15	W5	1539	Severe
	244	25	124	15	W5	3617	Severe
	245	6	124	16	W5	1766	Severe
	246	11	124	17	W5	209	Moderate
	247	30	124	16	W5	57	Light
	248	29	124	17	W5	711	Severe
	249	23	123	19	W5	92	Light
	250	34	125	19	W5	443	Moderate
Northeast Boreal	1	20	87	15	W4	608	Severe
	2	17	87	15	W4	427	Moderate
	3	3	87	16	W4	664	Severe
	4	9	87	16	W4	1391	Severe
	5	28	86	17	W4	992	Severe
	6	29	85	17	W4	1202	Severe
	7	28	84	17	W4	156	Light
	8	25	83	17	W4	358	Moderate
	9	18	83	16	W4	242	Moderate
	10	18	82	16	W4	749	Severe
	11	29	82	16	W4	1234	Severe
	12	32	83	15	W4	1694	Severe
	13	32	83	15	W4	1194	Severe
	14	16	81	17	W4	604	Severe
	15	8	81	17	W4	288	Moderate
	16	29	80	17	W4	517	Moderate
	17	24	80	18	W4	1010	Severe

Appendix 3 concluded

Region	Site	Location[a] Sec.	Twp.	Rge.	Mer.	Avg. no. of L_2 counts/10 m^2 of foliage[b]	Predicted defoliation in 1996[c]
Northeast Boreal	18	30	79	17	W4	658	Severe
	19	32	79	17	W4	678	Severe
	20	36	78	18	W4	408	Moderate
	21	28	80	16	W4	161	Light
	22	22	79	16	W4	788	Severe
	23	32	81	16	W4	284	Moderate

Note: L_2 surveys were conducted by Alberta Land and Forest Service.

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

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

[c] Predicted defoliation is based on second instar 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).

Juneau, A. 1989. A review of aerial spraying technology for spruce budworm control in private woodlots in eastern Quebec. For. Can., Quebec Reg., Laurentian For. Cent., Sainte-Foy, Quebec.

APPENDIX 4
SUMMARY OF SPRUCE BUDWORM PHEROMONE TRAP SURVEY RESULTS IN SASKATCHEWAN IN 1995

Region	UTM location[a]			Number of moths			
	Zone	E	N	Trap 1	Trap 2	Trap 3	Average
Meadow Lake	12	57	605	11	13	N/A[b]	12
	12	59	605	N/A	20	40	30
	12	65	598	107	N/A	N/A	107
	12	65	605	67	N/A	58	63
	12	66	604	36	50	80	55
	12	66	605	131	162	115	136
	12	67	594	24	44	N/A	34
	12	67	595	N/A	34	24	29
	12	67	597	83	65	47	65
	12	67	609	N/A	256	575	416
	12	67	610	324	327	118	256
	12	68	595	57	54	25	45
	12	69	595	75	28	120	74
	13	30	592	82	N/A	48	65
	13	31	604	1800	2600	2450	2283
	13	31	605	173	170	185	176
	13	31	605	311	571	258	380
	13	32	600	43	117	145	102
	13	32	600	46	N/A	49	48
	13	32	601	76	76	145	99
	13	32	601	118	N/A	173	146
	13	32	601	N/A	174	N/A	174
	13	32	608	199	198	256	218
	13	33	597	60	42	47	50
	13	33	599	N/A	82	83	82
	13	34	599	20	N/A	N/A	20
	13	34	599	88	79	78	82
	13	34	599	N/A	120	163	142
	13	34	599	65	213	203	160
	13	34	600	109	N/A	N/A	109
	13	34	600	71	162	127	120
	13	34	601	79	78	150	102
	13	34	601	205	144	213	187
	13	34	601	N/A	145	77	111
Prince Albert	13	32	598	73	57	53	61
	13	34	602	124	97	81	101
	13	34	603	N/A	625	1375	1000
	13	35	598	264	355	173	264
	13	35	599	380	245	566	397
	13	35	600	52	115	97	88
	13	35	600	143	76	162	127
	13	35	603	688	532	672	631
	13	35	603	590	N/A	238	414
	13	35	604	410	580	370	453
	13	35	604	435	N/A	145	290
	13	35	604	N/A	N/A	440	440

Appendix 4 continued

Region	UTM location[a]			Number of moths			
	Zone	E	N	Trap 1	Trap 2	Trap 3	Average
Prince Albert	13	35	605	380	685	450	505
	13	36	596	138	79	90	102
	13	36	598	448	N/A[b]	N/A	448
	13	36	599	150	220	N/A	185
	13	36	599	173	149	284	202
	13	36	599	415	722	830	656
	13	36	600	154	204	117	158
	13	36	600	N/A	146	213	180
	13	36	603	190	265	300	252
	13	36	603	N/A	291	113	202
	13	36	605	373	304	303	327
	12	36	605	210	245	N/A	228
	13	36	605	142	132	197	157
	13	37	598	233	182	85	167
	13	37	598	90	N/A	921	506
	13	37	598	468	660	276	468
	13	37	598	N/A	134	149	142
	13	37	598	101	56	117	91
	13	37	599	759	500	747	669
	13	37	599	224	135	306	222
	13	37	599	290	295	370	318
	13	37	599	390	186	121	232
	13	37	601	105	200	112	139
	13	38	604	172	330	280	261
	13	39	605	1080	1232	870	1061
	13	39	606	263	415	390	356
	13	40	605	325	N/A	293	309
	13	41	606	820	N/A	800	810
	13	43	594	146	93	88	109
	13	43	596	N/A	97	133	115
	13	44	594	N/A	N/A	146	146
	13	44	602	586	430	269	428
	13	44	603	300	125	N/A	213
	13	45	598	205	155	173	178
	13	45	599	468	175	795	479
	13	46	599	775	303	428	502
	13	47	597	86	N/A	136	111
	13	48	595	226	122	235	194
	13	49	597	130	120	N/A	125
	13	49	598	145	205	138	163
	13	50	600	N/A	N/A	N/A	N/A
	13	50	602	1475	1415	450	1113
	13	55	595	137	110	N/A	124
	13	60	581	346	N/A	N/A	346
	13	61	580	151	130	80	120
	13	61	588	322	N/A	285	304
	13	62	585	2407	N/A	1615	2011
	13	63	581	N/A	N/A	455	455
	13	63	589	3097	780	1110	1662
	13	64	585	1000	1725	N/A	1363
	13	64	591	1260	320	1600	1060
	13	65	578	160	120	N/A	140

Appendix 4 concluded

Region	UTM location[a]			Number of moths			
	Zone	E	N	Trap 1	Trap 2	Trap 3	Average
Prince Albert	13	65	584	N/A[b]	4200	2750	3475
	13	66	581	2250	1400	2200	1950
	13	67	581	476	293	340	370
	13	67	581	261	400	296	319
	13	67	583	1450	1400	1230	1360
	13	67	587	152	160	59	124
	13	68	581	115	180	70	122
	13	68	581	84	65	80	76
	13	68	582	154	N/A	N/A	154
	13	69	580	46	44	39	43
	13	69	591	74	85	238	132
	13	69	591	115	82	100	99
	13	69	593	159	156	130	148
	13	70	579	9	30	0	13
	14	31	578	5	19	19	14
	14	31	579	19	14	18	17
	14	31	581	10	7	12	10
	14	31	584	100	90	N/A	95
	14	31	585	176	201	191	189
La Ronge	13	44	610	N/A	580	N/A	580
	13	44	610	2550	N/A	1742	2146
	13	45	611	864	850	900	871
	13	48	612	578	680	715	658
	13	50	609	N/A	398	N/A	398
	13	50	613	2200	1250	N/A	1725
	13	51	606	380	600	120	367
	13	51	608	400	366	245	337
	13	51	608	500	N/A	380	440
	13	51	609	600	963	950	838
	13	42	597	21	47	29	32
Prince Albert National Park	13	41	598	N/A	53	40	47
	13	41	597	87	33	108	76
	13	40	597	48	51	60	53
	13	39	596	N/A	N/A	N/A	N/A

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

[a] UTM (Universal Transverse Mercator Grid) location described as zone, easting, and northing.

[b] Not available.

APPENDIX 5
SPRUCE BUDWORM SECOND-INSTAR DENSITIES IN 1995 AND 1996 DEFOLIATION FORECASTS FOR SASKATCHEWAN

Region	UTM location[a]			Avg. no. of L_2 larvae/10 m^2 of foliage	Predicted defoliation in 1996[b]
	Zone	E	N		
Meadow Lake	13	31	604	660	Severe
	13	31	605	164	Light
	13	32	601	27	Light
	13	33	597	20	Light
	13	34	599	15	Light
Prince Albert	13	34	603	181	Light
	13	35	601	72	Light
	13	35	605	28	Light
	13	35	606	19	Light
	13	36	599	22	Light
	13	36	604	109	Light
	13	36	605	57	Light
	13	37	598	183	Light
	13	37	599	544	Severe
	13	37	600	212	Moderate
	13	37	604	49	Light
	13	37	605	26	Light
	13	37	606	51	Light
	13	38	604	638	Severe
	13	38	605	30	Light
	13	39	605	344	Moderate
	13	40	604	118	Light
	13	40	605	192	Moderate
	13	41	589	2240	Severe
	13	42	586	2871	Severe
	13	43	601	714	Severe
	13	43	602	101	Light
	13	44	601	1142	Severe
	13	44	602	184	Light
	13	45	599	16	Light
	13	45	607	92	Light
	13	46	599	509	Moderate
	13	60	581	142	Light
	13	60	595	39	Light
	13	61	588	14	Light
	13	62	579	33	Light
	13	62	580	45	Light
	13	62	585	2552	Severe
	13	62	589	213	Moderate
	13	62	595	435	Moderate

Appendix 5 continued

Region	UTM location[a] Zone	E	N	Avg. no. of L_2 larvae/10 m^2 of foliage	Predicted defoliation in 1996[b]
Prince Albert	13	63	579	2032	Severe
	13	63	581	923	Severe
	13	63	582	590	Severe
	13	63	585	1566	Severe
	13	63	589	58	Light
	13	64	580	257	Moderate
	13	64	581	1042	Severe
	13	64	582	968	Severe
	13	64	585	347	Moderate
	13	64	591	91	Light
	13	65	582	718	Severe
	13	65	584	2523	Severe
	13	65	585	105	Light
	13	66	581	1429	Severe
	13	66	582	1254	Severe
	13	66	584	83	Light
	13	66	585	5062	Severe
	13	66	586	326	Moderate
	13	67	581	344	Moderate
	13	67	583	450	Moderate
	13	67	584	455	Moderate
La Ronge	13	43	612	1355	Severe
	13	43	614	2452	Severe
	13	44	610	2535	Severe
	13	45	608	807	Severe
	13	47	608	257	Moderate
	13	47	609	874	Severe
	13	47	611	116	Light
	13	48	609	558	Severe
	13	48	611	239	Moderate
	13	48	612	1553	Severe
	13	49	613	642	Severe
	13	50	602	67	Light
	13	50	608	65	Light
	13	50	609	107	Light
	13	51	606	41	Light
	13	51	607	136	Light
	13	51	608	136	Light
	13	51	609	144	Light
	13	51	616	1090	Severe
	13	52	613	833	Severe
	13	68	598	499	Moderate
	13	68	599	831	Severe
	13	69	598	80	Light
	13	69	599	349	Moderate
	13	69	600	24	Light
	13	69	601	76	Light

Appendix 5 concluded

Region	UTM location[a]			Avg. no. of L_2 larvae/10 m^2 of foliage	Predicted defoliation in 1996[b]
	Zone	E	N		
La Ronge	14	30	600	59	Light
	14	30	601	21	Light
	14	31	600	19	Light
	14	31	601	119	Light

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

[a] UTM (Universal Transverse Mercator Grid) location described as zone, easting, and northing.

[b] Predicted defoliation is based on second instar 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 10 × 10 km cell); some stands within each cell could be more or less defoliated than predicted, based on the average.

Juneau, A. 1989. A review of aerial spraying technology for spruce budworm control in private woodlots in eastern Quebec. For. Can., Quebec Reg., Laurentian For. Cent., Sainte-Foy, Quebec.

APPENDIX 6
SUMMARY OF SPRUCE BUDWORM PHEROMONE TRAP SURVEY RESULTS IN MANITOBA IN 1995

Section	Location[a]				Number of moths			
	Sec.	Twp.	Rge.	Mer.	Trap 1	Trap 2	Trap 3	Average
Aspen Parkland	17	12	5	E1	9	169	150	109
	30	10	15	W1	1627	1785	N/A[b]	1706
Highrock	7	63	26	W1	187	287	N/A	237
Interlake	10	25	6	E1	237	169	135	180
	21	32	1	E1	75	146	69	97
Lake Winnipeg East	4	17	11	E1	509	692	1363	855
	5	17	12	E1	146	165	194	168
	36	16	11	E1	343	191	168	234
	2	17	11	E1	1195	765	852	937
	34	17	11	E1	1217	917	1020	1051
	32	16	12	E1	610	512	730	617
	18	22	10	E1	N/A	195	98	147
	29	21	9	E1	249	229	274	251
	14	22	9	E1	N/A	N/A	180	180
	28	24	9	E1	201	229	322	251
	33	24	8	E1	67	60	164	97
	14	24	8	E1	110	148	161	140
	1	25	8	E1	819	328	870	672
	5	25	9	E1	316	361	276	318
	8	25	9	E1	480	690	690	620
	11	19	11	E1	925	1053	1212	1063
	13	19	11	E1	718	1275	416	803
	24	19	11	E1	1169	1417	1070	1219
	33	13	13	E1	305	370	302	326
	21	24	12	E1	680	593	N/A	637
	14	25	9	E1	510	630	720	620
	22	25	9	E1	1930	1020	1740	1563
	25	25	8	E1	130	150	N/A	140
	26	25	8	E1	390	N/A	N/A	390
	30	25	9	E1	310	500	460	423
	25	25	8	E1	990	900	690	860
	19	25	9	E1	390	840	230	487
	27	25	9	E1	1380	1350	1030	1253
	3	25	8	E1	N/A	N/A	913	913
Mountain	17	42	25	W1	156	146	140	147
	14	29	24	W1	33	73	83	63
	14	20	19	W1	86	18	36	47
Nelson River	36	71	7	W1	115	75	76	89
Pineland	1	4	16	E1	260	203	186	216
Saskatchewan River	14	60	27	W1	219	374	373	322

Note: Pheromone trap surveys were conducted by Manitoba Natural Resources and the Canadian Forest Service.

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

[b] Not available.

APPENDIX 7
SPRUCE BUDWORM EGG-MASS DENSITIES IN 1995 AND 1996 DEFOLIATION FORECASTS FOR MANITOBA

Section	Location[a]				Avg. no. of egg masses/10 m^2 of foliage[b]	Predicted defoliation in 1996[c]
	Sec.	Twp.	Rge.	Mer.		
Aspen Parkland	17	12	5	E1	0	Light
	30	10	15	W1	194	Moderate-to-severe
Highrock	7	63	26	W1	0	Light
Interlake	10	25	6	E1	22	Light
	21	32	1	E1	0	Light
Lake Winnipeg East	33	13	13	E1	287	Severe
	21	24	12	E1	95	Moderate
	12	17	11	E1	18	Light
	18	17	12	E1	30	Light
	35	17	11	E1	127	Moderate-to-severe
	6	18	12	E1	113	Moderate-to-severe
	13	18	11	E1	69	Moderate
	14	17	12	E1	108	Moderate
	11	19	11	E1	97	Moderate
	11	19	11	E1	154	Moderate-to-severe
	12	19	11	E1	26	Light
	13	19	11	E1	64	Moderate
	24	19	11	E1	183	Moderate-to-severe
	21	19	12	E1	44	Light-to-moderate
	22	19	12	E1	0	Light
	25	19	12	E1	0	Light
	9	19	12	E1	1070	Severe
	16	19	12	E1	0	Light
	4	19	12	E1	599	Severe
	11	19	12	E1	61	Moderate
	9	19	12	E1	1221	Severe
	27	22	9	E1	0	Light
	3	22	9	E1	0	Light
	5	23	9	E1	0	Light
	3	23	9	E1	0	Light
	8	23	9	E1	0	Light
	23	23	9	E1	0	Light
	23	23	9	E1	0	Light
	23	23	9	E1	19	Light
	23	23	9	E1	0	Light
	23	23	9	E1	19	Light
	26	8	16	E1	7	Light

Appendix 7 continued

Section	Location[a] Sec.	Twp.	Rge.	Mer.	Avg. no. of egg masses/10 m^2 of foliage[b]	Predicted defoliation in 1996[c]
Lake Winnipeg East	27	8	16	E1	0	Light
	27	8	16	E1	0	Light
	27	8	16	E1	0	Light
	22	8	16	E1	0	Light
	32	8	17	E1	0	Light
	33	8	17	E1	65	Moderate
	33	8	17	E1	6	Light
	4	14	13	E1	59	Light-to-moderate
	4	14	13	E1	49	Light-to-moderate
	4	14	13	E1	48	Light-to-moderate
	18	22	17	E1	36	Light-to-moderate
	18	22	17	E1	29	Light
	11	19	11	E1	52	Light-to-moderate
	13	19	11	E1	24	Light
	24	19	11	E1	18	Light
	4	17	11	E1	13	Light
	5	17	12	E1	29	Light
	36	16	11	E1	14	Light
	2	17	11	E1	29	Light
	34	17	11	E1	373	Severe
	32	16	12	E1	7	Light
	18	22	10	E1	0	Light
	29	21	9	E1	10	Light
	14	22	9	E1	0	Light
	28	24	9	E1	13	Light
	33	24	8	E1	0	Light
	14	24	8	E1	14	Light
	1	25	8	E1	47	Moderate
	5	25	9	E1	0	Light
	8	25	9	E1	16	Light
	14	25	9	E1	141	Moderate-to-severe
	22	25	9	E1	0	Light
	25	25	8	E1	0	Light
	26	25	8	E1	0	Light
	30	25	9	E1	24	Light
	25	25	8	E1	0	Light
	19	25	9	E1	0	Light
	27	25	9	E1	0	Light
	3	25	8	E1	132	Moderate-to-severe
	23	23	9	E1	32	Light-to-moderate
	23	23	9	E1	0	Light
	24	23	9	E1	0	Light
	25	23	9	E1	7	Light
	10	23	9	E1	0	Light
	32	21	17	E1	8	Light
	29	21	17	E1	63	Moderate

Appendix 7 continued

Section	Location[a] Sec.	Twp.	Rge.	Mer.	Avg. no. of egg masses/10 m^2 of foliage[b]	Predicted defoliation in 1996[c]
Lake Winnipeg East	32	21	17	E1	8	Light
	29	21	17	E1	8	Light
	29	21	17	E1	19	Light
	35	21	16	E1	0	Light
	35	21	16	E1	8	Light
	35	21	16	E1	16	Light
	27	21	16	E1	0	Light
	27	21	16	E1	0	Light
	11	22	16	E1	47	Light-to-moderate
	11	22	16	E1	9	Light
	15	22	16	E1	0	Light
	29	29	7	E1	129	Moderate-to-severe
	29	29	7	E1	27	Light
	29	29	7	E1	17	Light
	29	29	7	E1	0	Light
	29	29	7	E1	0	Light
	27	29	7	E1	0	Light
	27	29	7	E1	0	Light
	27	29	7	E1	22	Light
	23	29	7	E1	0	Light
Mountain	17	42	25	W1	0	Light
	14	29	24	W1	0	Light
	14	20	19	W1	0	Light
	5	31	27	W1	0	Light
	10	31	27	W1	0	Light
	15	31	27	W1	57	Light-to-moderate
	11	31	27	W1	74	Moderate
	11	31	27	W1	7	Light
	14	31	27	W1	0	Light
	15	31	27	W1	34	Light-to-moderate
	15	31	27	W1	67	Moderate
	18	31	26	W1	8	Light
	24	31	27	W1	0	Light
	19	31	26	W1	9	Light
	4	31	26	W1	0	Light
	5	31	26	W1	18	Light
	4	31	27	W1	0	Light
	7	31	26	W1	0	Light
	5	31	26	W1	0	Light
	36	30	27	W1	0	Light
	4	31	27	W1	0	Light
	34	30	26	W1	0	Light
	34	30	26	W1	0	Light
	34	30	26	W1	0	Light
	34	30	28	W1	0	Light
	34	30	28	W1	0	Light

Appendix 7 concluded

Section	Location[a] Sec.	Twp.	Rge.	Mer.	Avg. no. of egg masses/10 m^2 of foliage[b]	Predicted defoliation in 1996[c]
Nelson River	36	71	7	W1	0	Light
Pineland	1	4	16	E1	0	Light
Saskatchewan River	14	60	27	W1	5	Light
	19	61	29	W1	0	Light
	33	60	29	W1	110	Moderate

Note: Egg-mass surveys were conducted by Manitoba Natural Resources and the Canadian Forest Service.

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

[b] Values for egg-mass counts are an average of five trees per location.

[c] 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 1996 apply only to the immediate area where trees were sampled.

Dorais, L.; Kettela, E.G., compilers. 1982. A review of entomological survey and assessment techniques used in regional spruce budworm, *Choristoneura fumiferana* (Clem.), surveys and in the assessment of operational spray programs. East. Spruce Budworm Counc., Comm. Standardization Surv. Assess. Techniques, Fredericton, New Brunswick, and Minist. l'Ener. Ress., Quebec, Quebec.

Morris, R.F. 1954. A sequential sampling technique for spruce budworm egg surveys. Can. J. Zool. 32:302–313.

APPENDIX 8
SUMMARY OF JACK PINE BUDWORM PHEROMONE TRAP SURVEY RESULTS IN ALBERTA AND SASKATCHEWAN IN 1995

Province	UTM location[a]			Number of moths			
	Zone	E	N	Trap 1	Trap 2	Trap 3	Average
Alberta	12	415	5992	8	18	12	13
	12	336	6003	0	3	7	3
	12	316	5918	6	1	4	4
Saskatchewan	13	561	5934	1	0	–[b]	1
	13	561	5934	1	0	–	1
	13	561	5934	0	0	–	0
	13	535	5905	1	2	2	2
	13	436	5897	12	11	10	11
	13	436	5897	6	12	2	7
	13	436	5897	9	1	9	6

[a] UTM (Universal Transverse Mercator Grid) location described as zone, easting, and northing.

[b] Only two traps were placed at this location in Saskatchewan.

APPENDIX 9
JACK PINE BUDWORM EGG-MASS DENSITIES IN 1995 AND 1996 DEFOLIATION FORECASTS FOR MANITOBA

Section	Location	Location[a] Sec.	Twp.	Rge.	Mer.	No. egg masses/ plot	1995 avg. defoliation (%)	1996 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	0	5	Nil
	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
	Sandilands[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 9 concluded

Section	Location	Location[a] Sec.	Twp.	Rge.	Mer.	No. egg masses/ plot	1995 avg. defoliation (%)	1996 predicted defoliation
Interlake	Devils Lake	7	39	11	W	0	5	Nil
	Devils Lake	36	39	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 East	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
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
	Rocky Lake	8	59	27	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.