


Forest Health and Adaptation in Alberta

Annual Report 2015

Alberta Government

2015 Annual Report
Forest Health and Adaptation Program
Alberta Agriculture and Forestry

Forest Health and Adaptation Vision

To lead Canada in science-based, proactive, adaptive and innovative management of forest health and productivity in a forest environment with a multitude of values and challenges posed by a changing climate.

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Main cover photo: Aspen serpentine leaf miner, *Phyllocnisris populiella*, feeding damage.

Minor cover photos (left to right): Forest tent caterpillar, *Malacosoma disstria*; large aspen tortrix, *Choristoneura conflictana*; aspen twoleaf tier, *Enargia decolour*.

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Acknowledgements

This report was compiled by Caroline Whitehouse and built upon the contributions of both field and headquarter staff participating in the Forest Health and Adaptation program of Alberta Agriculture and Forestry. In particular, forest health data and program information included in this report was primarily collected and reported by Forest Health Officers (Colton Briggs, Megan Evans, Devin Letourneau, Jennifer MacCormick, Fraser McKee, Pam Melnick, Andrea Sharpe) and Forest Health Technicians (Allison Brown, Caroline Charbonneau, Crystal Ionson, Marian Jones, Bart McAnally, Martin Robillard and Jarrett Totton). Aaron McGill (Senior Information Management Technologist) prepared the maps included in this report. Alberta Tree Improvement and Seed Centre staff also contributed to the information included in this report; namely Andy Benowicz, Lee Charleson, Arvind Cheniveerappan, Jodie Krakowski, Eleanor Morin, Donna Palamarek, John Quinn, Lindsay Robb and Deogratias Rweyongeza.

Gwen Edge (Graphic Designer, Environment and Parks) formatted, designed and published the report.

Alberta Agriculture and Forestry staff gratefully acknowledge support provided by the multiple individuals, agencies, municipalities and forest companies that helped with the successful completion of the 2015 Forest Health and Adaptation program.

Executive Summary

The 2015 Forest Health and Adaptation Annual Report summarizes forest health data collected during provincial aerial and ground surveys to assess the extent and severity of biotic and abiotic forest damage agents. This report also includes details regarding the management of insects and diseases that occurred on Alberta's forested Crown land. Summaries of forest genetics research; seed science, collection and storage; as well as policy development are included in this report. The Government of Alberta's Ministry of Agriculture and Forestry's (AAF) involvement with collaborative projects is also outlined and include those led by the Canadian Forest Service, Canadian Food Inspection Agency and projects focused on gene conservation.

Mountain pine beetle (MPB) continues to be the primary bark beetle causing tree mortality in Alberta. Overall MPB spring population forecast surveys suggested reduced success in 2015 compared to 2014, with populations in some parts of the province remaining stable. The majority of green to red ratio surveys carried out in early fall of 2014 and 2015 predicted low population growth. The number of red trees detected in 2015 decreased by one-third to 107,984 at 19,259 sites. Single tree cut-and-burn control operations removed 128,885 MPB-infested trees in 2014 and 89,044 in 2015, a decrease of 31 per cent. A project to measure and classify the cumulative mortality of stands infested by in northwest Alberta was initiated in 2015. This inventory will assist the province with the strategic rehabilitation of forests impacted by MPB.

Eastern larch and spruce beetle infestations were mapped to a limited extent in 2015. A total of 63 stands infested with eastern larch beetle of varying severity were recorded. The majority of disturbances were observed east of Rocky Mountain House and west of Drayton Valley in and around agricultural land. Spruce beetle activity was mapped in scattered patches over 1,400 hectares (ha). Given that spruce beetle is a rising concern in other jurisdictions, AAF is refining detection and monitoring techniques and preparing a manual to assist industry to manage spruce beetle.

An estimated 1.74 million ha of defoliators and abiotic damage agents were mapped. Aspen defoliators were responsible for 94% of the observed disturbance. Damage was largely attributed to forest tent caterpillar even though there was a 51 per cent decrease in the area defoliated in 2015 (1.6 million ha) compared to the previous year. Large aspen tortrix (54,444 ha) and Bruce spanworm (3,564 ha) infestations increased between 2014 and 2015 but were mapped to small extent in the province. The greatest decrease occurred in aspen twoleaf tier infestations, which dropped to 536 ha. Spruce budworm populations continue to decrease (51,750 ha) since the peak in 2012. The main abiotic damage agents mapped in 2015 were winter drying (redbelt) and aspen die-back attributed to drought and repeated defoliation.

In 2015, AAF-owned and cooperative seed orchards had moderate to heavy cone crops. The Alberta Tree Improvement and Seed Centre received 374 new seedlots representing 40 different species for registration and storage. Over 873 kg of tree, shrub, grass, and forb seed were withdrawn from the seed bank for reclamation and reforestation projects. A total of 21,720 seedlings were grown for various projects while 1,564 grafts were made in 2015. The seed centre provided over 25,000 seeds from 127 seed lots to fulfill external research needs. Whitebark and limber pine seed longevity research continued in 2015, as did trials to investigate better handling and propagation methods for beaked hazelnut.

AAF continued to conduct applied forest genetics research in 2015. Projects included collaborations with Tree Improvement Alberta, the Universities of Alberta and British Columbia, and the Canadian Forest Service. Amendments to Forest Genetic Resource Management and Conservation Standards were developed and a revised and updated document was completed in 2015.

Approximately 1,476 ha were surveyed for invasive plants and 11 per cent of that area was infested. Seventeen noxious and four prohibited noxious invasive plant species were recorded during surveys. Provincially 48 per cent of identified AAF-occupied sites were surveyed. Canada thistle, common tansy, tall buttercup and ox-eye daisy are the most common invasive plants noted during surveys. In 2015, 74 per cent of the infested area surveyed was controlled. Biological control was successfully employed to manage infestations of hound's tongue, scentless chamomile, and yellow toadflax. AAF continued to participate in cooperatives and educational events to prevent the introduction and establishment of invasive plants.

AAF participated in the annual province-wide surveillance to detect North American and Asian gypsy moths. One North American gypsy moth was captured in a trap south of Fort McMurray. In 2015, staff assisted with the Climate Change Impacts on the Productivity and Health of Aspen project led by the Canadian Forest Service. Other collaborative projects included the recovery of whitebark and limber pine, and forest gene conservation. As part of an ongoing commitment, staff assisted with forest condition surveys at approximately 40 pine sites for the Wood Buffalo Environmental Association's Terrestrial Environmental Effects Monitoring program.

Staff participated in and/or led events to increase awareness about forest health damage agents and the role of AAF in monitoring and managing the health of Alberta forests. These events included training courses, community outreach events, and activities performed by staff ranged from manning information booths to giving detailed public presentations about forest health.

Introduction

Alberta is a diverse province, covered by approximately 38 million hectares of forest that are home to a tremendous range of plants and animals. Natural disturbances caused by insect, wildfire and disease are crucial for maintaining the health and resiliency of Alberta's forests. These same disturbances can also lead to insect and disease outbreaks that result in forest loss that put recreational, aesthetic, habitat and resource-based values at risk. Forest health monitoring helps to determine the extent and intensity of insect disturbance and disease and informs management practices used to ensure Alberta's forests remain resilient and sustainable.

In Alberta, major forest disturbances are monitored annually. Forest health monitoring is the responsibility of Forest Health and Adaptation Section of the Government of Alberta's Ministry of Agriculture and Forestry (AAF). Surveys are conducted on forested Crown lands that are under AAF management (i.e. Green Area[1]) and delineated by Forest Area (Fig. 1). Damage agents are reported only if significant occurrences were observed during the year. Pest infestations in national parks and on private lands are not the mandate of AAF and are therefore not included in this report unless otherwise noted. This report includes a summary of major forest damage agents (excluding fire disturbance) surveyed in 2015.

The management of forest genetic resources for biodiversity, conservation and the maintenance of forest health and productivity is the mandate of Alberta Agriculture and Forestry. Annually, AAF engages in applied research at Alberta Tree Improvement and Seed Centre field sites, which drive policy development, forest genetic resource management practices and applied tree breeding to meet these responsibilities and program objectives.

This report contains:

1. Details regarding the monitoring and management of mountain pine beetle populations.
2. The spatial distribution of defoliation, population trends, and the extent and severity of damage caused by the spruce budworm and other conifer defoliators detected across the province.
3. The spatial distribution of disturbance caused by aspen defoliators.
4. Forest pathogen incidence and management.
5. The spatial distribution of abiotic forest damage agents.
6. Invasive plant program details, including ground survey results, and control programs carried out at selected sites in the Green Area.
7. Summary of programs specific to forest genetics, seed science and collections, plant propagation and policy.
8. AAFs involvement with collaborative projects which include those led by the Canadian Forest Service, Canadian Food Inspection Agency and projects focused on gene conservation.
9. Information regarding increased awareness and training in forest health topics.

The data reported in this document were collected for resource management purposes over the Green Area of Alberta. These surveys do not necessarily cover the entire forested land base. Every effort is made to ensure the accuracy and completeness of this report.

[1] Green Area is defined as forest lands not available for agricultural development other than grazing. In general, the Green Area is public land outside the parkland and prairie regions, or roughly in the northern half of the province and within a strip running along the Rocky Mountains and foothills.

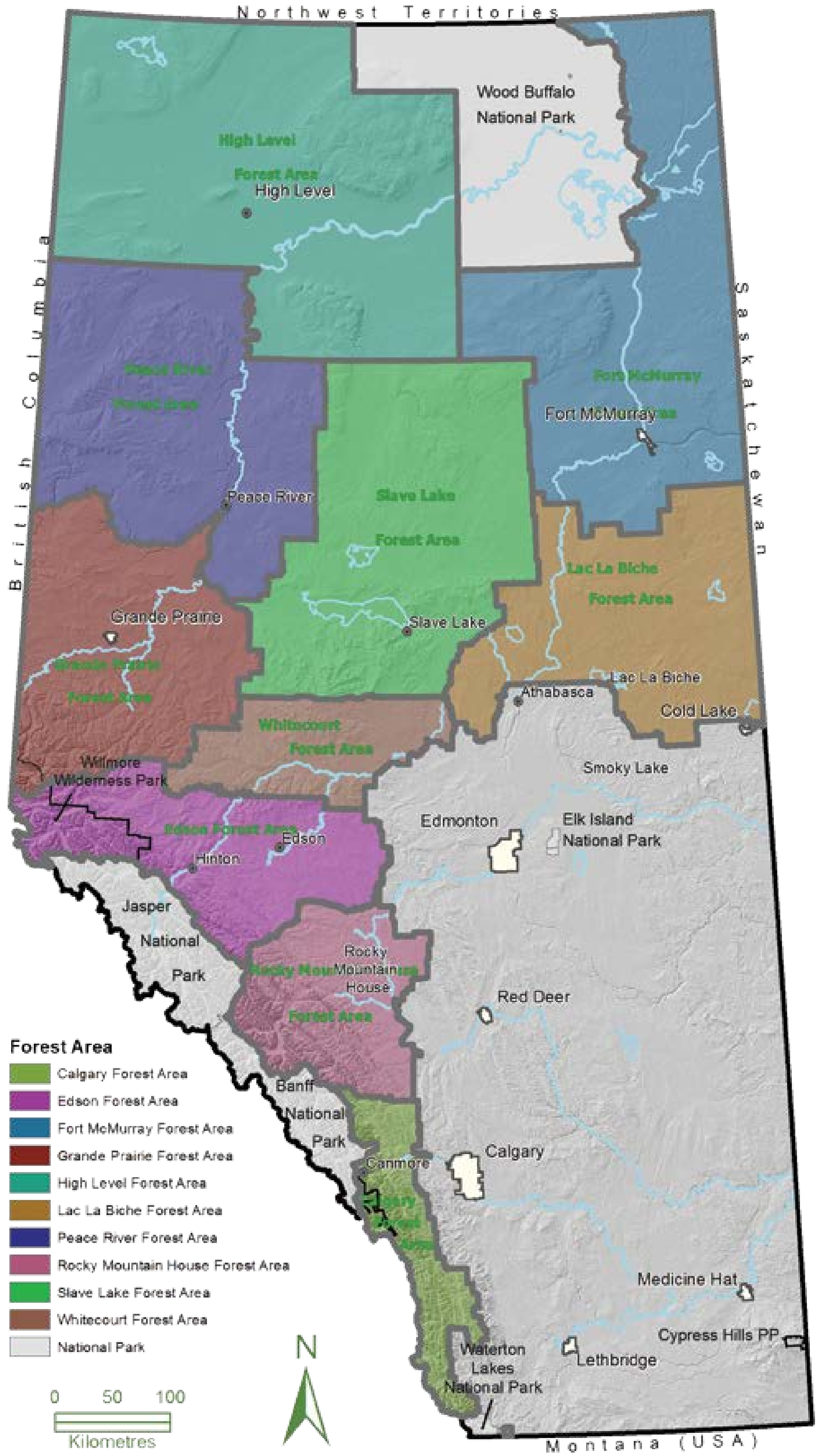


Figure 1. Forest area boundaries in Alberta, 2015.

Forest Health Damage Agents Conditions and Management Programs

Bark Beetle

Mountain pine beetle (*Dendroctonus ponderosae Hopkins*)

In previous reports, mountain pine beetle (MPB) activity was reported on the basis of a "beetle year" (i.e. August 15 of one year to August 14 of the following year). MPB activity will now be reported to the end of the control season, March 31; therefore this update includes information spanning August 15, 2014 to
March 31, 2016.

This report covers historical aspects of the current MPB outbreak and details of the following activities:

- detection and assessment of 2014 and 2015 MPB infestations;
- actions taken to manage these infestations in 2014 and 2015;
- ground surveys carried out to forecast 2015/16 MPB population trends.

The objectives, principles and actions of Alberta's MPB program are outlined in Alberta's management strategy.

Population forecast surveys

Population forecast surveys are conducted each spring to assess the relative overwintering success of MPB and provide a relative measure of potential adult productivity for the coming year. These surveys are based on r-values, which are calculated by summing all live MPB life-stages for each plot and dividing that value by the sum of all attack starts from the previous year.

Approximately 560 trees at 100 sites were surveyed in each year, 2014 and 2015 (Fig. 2). Overall population forecast surveys predicted a reduction in success in 2015 compared to the previous year though some populations remained stable. North of Peace River, results projected moderate to extremely high success in 2014 but decreased success in 2015. Predictions for populations north of Slave Lake, on the eastern edge of the infestation, were moderate in 2014 but low in 2015. The region along the eastern slopes of the Rocky Mountains that projected high success in 2014 contracted in size in 2015.

Detection and assessment of MPB infestations

Long-distance dispersal monitoring

Aggregation pheromones are used to monitor the presence of MPB along the eastern slopes of the Rocky Mountains and in eastern Alberta along the Saskatchewan border. A small number of dispersal baits are deployed in northern Alberta as well. Sites are ranked as MPB being absent (zero attacked trees), present (at least one tree with less than 40 attack

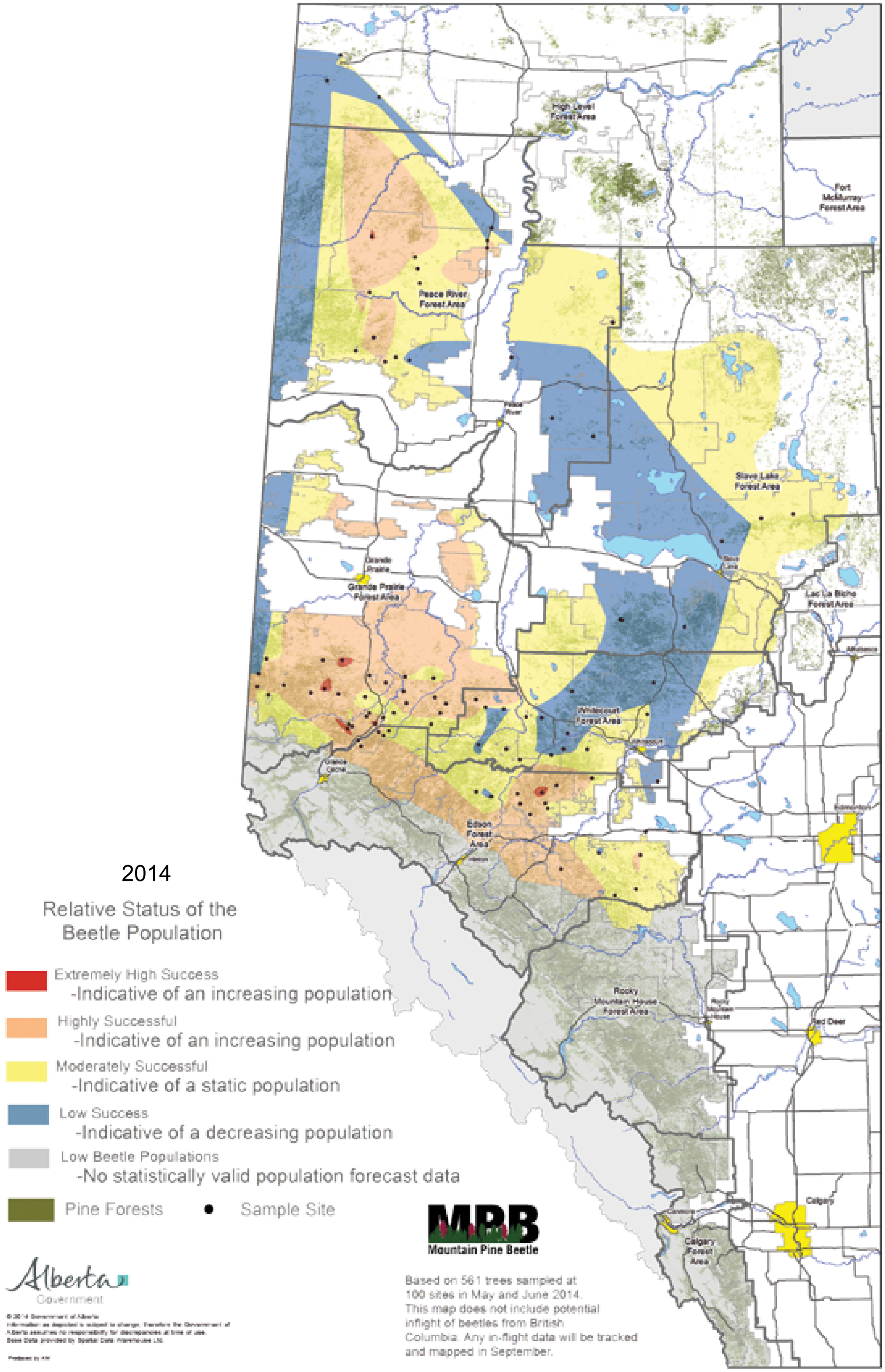


Figure 2. Relative overwintering success of mountain pine beetle across Alberta based on the results of R-value surveys carried out in the spring of 2014.

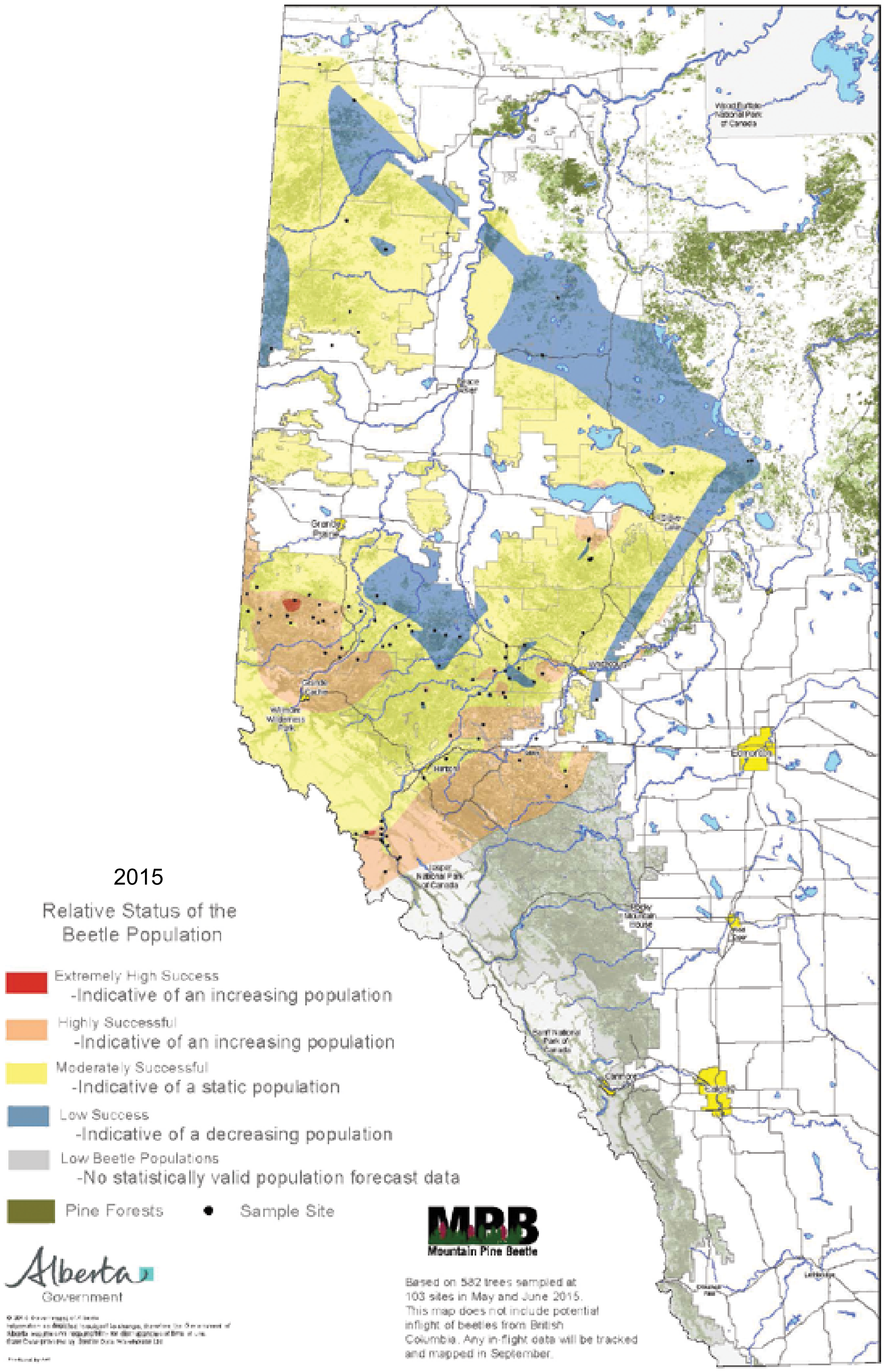


Figure 2a. Relative overwintering success of mountain pine beetle across Alberta based on the results of R-value surveys carried out in the spring of 2015.

starts), or mass-attacked (at least one tree with more than 40 attack starts).

In 2014 and 2015, 311 and 263 sites were monitored, respectively (Fig. 3, Table 1). There was no indication of a large inflight from British Columbia in 2014 and 2015 in area that AAF monitors. In the Calgary Forest Area (FA), MPB was absent from the majority of sites in 2014 but attack intensity increased in 2015. MPB continued to be present and mass-attack sites in the Edson FA at similar rates in 2014 and 2015. In the Rocky Mountain House FA MPB was absent from 81 per cent of sites monitored. MPB was largely absent (95%) sites in the Lac La Biche and Fort McMurray FAs in 2014 but detection increased in 2015; MPB was present at 23 per cent of sites and one tree at one site was mass-attacked.

Heli-GPS surveys

Aerial surveys are conducted annually in late summer and early fall to quantify the number of red-crowned pine symptomatic of MPB infestations. Generally, groups of three or more pine with red crowns are recorded using sketch mapping and heli-GPS.

Table 1. The number of mountain pine beetle dispersal bait sites monitored in 2014 and 2015; categorized by forest area and attack intensity.

Forest Area	2014	2015
Calgary		
Absent	17	9
Present	3	7
Mass-attack	2	4
Edson		
Absent	22	6
Present	27	19
Mass-attack	48	35
High Level		
Absent	1	1
Present	1	1
Mass-attack	2	0
Lac La Biche & Ft. McMurray		
Absent	74	55
Present	4	17
Mass-attack	0	1
Rocky Mountain House		
Absent	89	87
Present	16	17
Mass-attack	5	4
Total	**311**	**263**

Attack categories: Absent (zero trees attacked), present (at least one tree with <40 attacks) and mass-attack (at least one tree with ≥40 attacks).

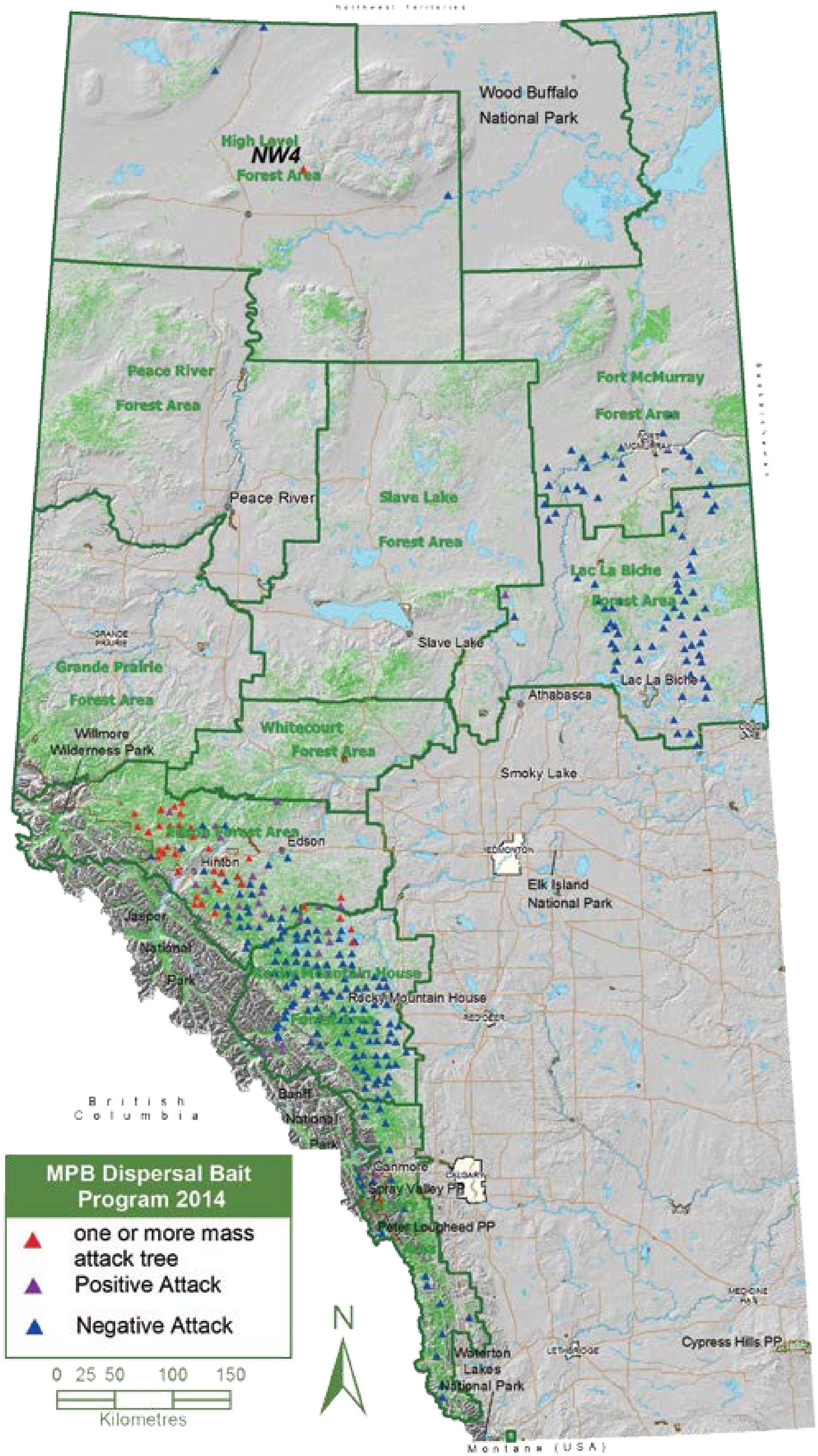


Figure 3. Results of the mountain pine beetle long-distance aerial dispersal baiting survey carried out from July to September in 2014.

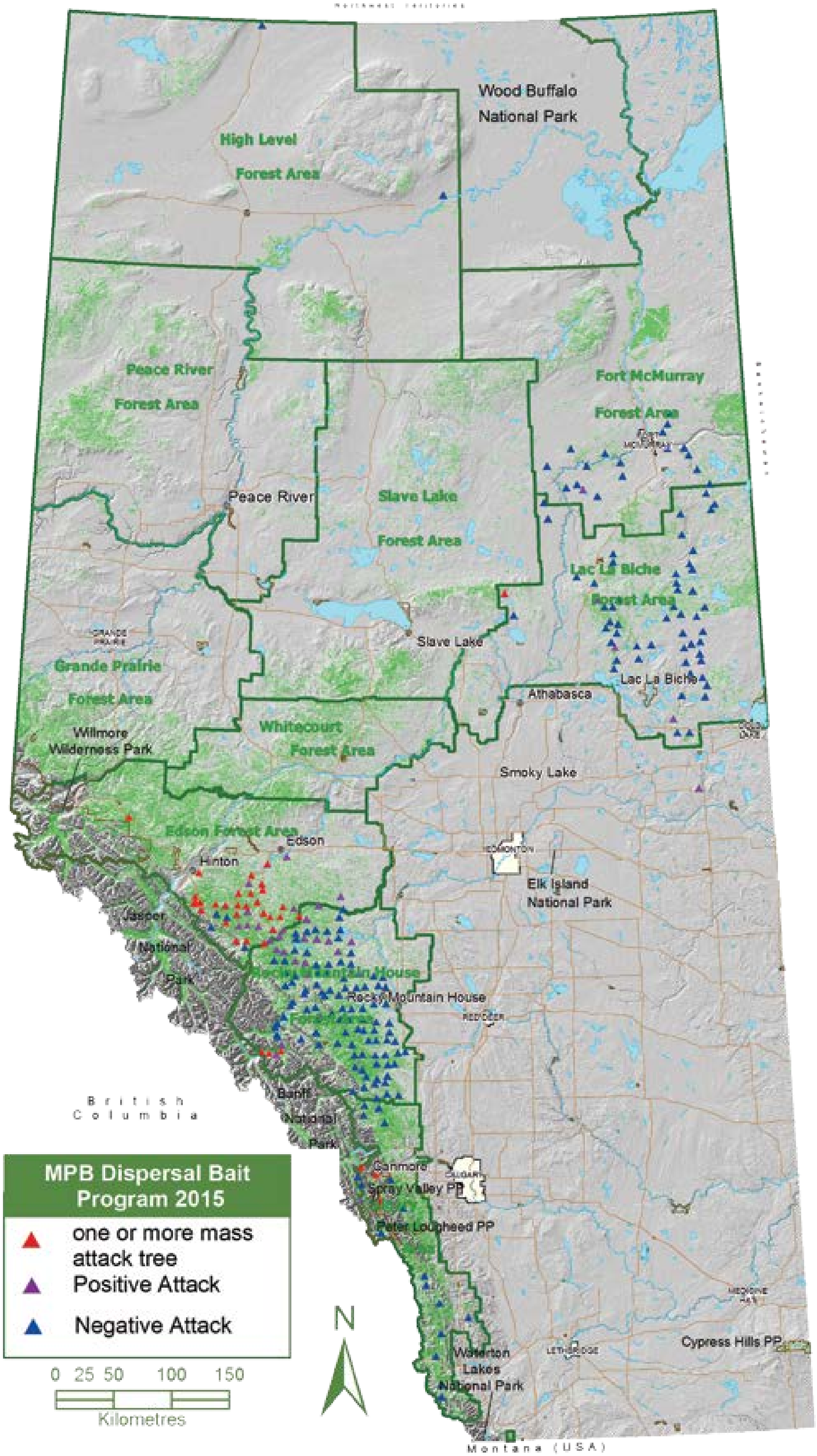


Figure 3a. Results of the mountain pine beetle long-distance aerial dispersal baiting survey carried out from July to September in 2015.

These surveys cover areas that have been determined as a priority for control and therefore the same area is not necessarily surveyed every year nor does survey coverage span the province. It should be noted that the region of the province prioritized for control activity in 2014 and 2015 were similar, therefore aerial surveys were conducted over comparable areas (Fig. 4).

Surveys conducted in August and September of 2014 detected 197,452 red trees at 29,091 sites (Fig. 5). The number of red trees detected in 2015 decreased by one-third to 107,984 at 19,259 sites and small isolated infestations continue to be detected in the Rocky Mountain House and Calgary FAs.

Green to red ratios

Green to red ratio surveys are conducted each fall to assess the relative success of MPB and potential for their spread the following summer. These surveys are based on a ratio of green attack (trees infested during the current year, retaining green crowns) to red attack (trees with red crowns, infested the previous year) trees in a given site. A value less than 1.0 suggests a decreasing population with low potential for spread; 1.1 – 3.0 indicates a stable population with moderate spread potential while a value greater than 3.0 suggests an increasing population with high potential for spread.

Surveys were carried out in early fall of 2014 and 2015 at 407 and 416 plots, respectively (Fig. 6). The majority of plots predicted low population growth in 2014 (73 per cent) and 2015 (67 per cent) while relatively few plots predicted high population expansion in the same years (6 per cent - 2014; 11 per cent - 2015).

Mountain pine beetle infested-tree treatment program

A spatial Decision Support System (DSS) is used to prioritize sites with MPB-infested trees for survey and control. The DSS categorizes sites recorded during heli-GPS surveys into five spread risk categories, varying from very low to extreme, based on MPB biology and stand characteristics. The goal is to survey and control trees at 80 per cent or more of the sites in the Leading-Edge and Active Holding zones ranked as moderate, high or extreme spread risk (Fig. 7). Management zone borders vary annually.

MPB infested trees were treated by:

- level 1 single-tree control by AAF;
- single tree control by municipalities under an AAF grant program.

Level 1 single-tree survey and control

Concentric ground surveys to assess trees for management are completed each year in late fall and early winter. The majority of these concentric surveys were conducted by external contractors though some of the work was performed in-house. The number of trees flagged for control decreased by 31 per cent between 2014 (128,885) and 2015 (89,044). Trees were removed from the landscape during single tree cut-and-burn control operations conducted in the winter. Between 2006 and 2015, AAF has controlled approximately 1.12 million MPB-infested pine trees.

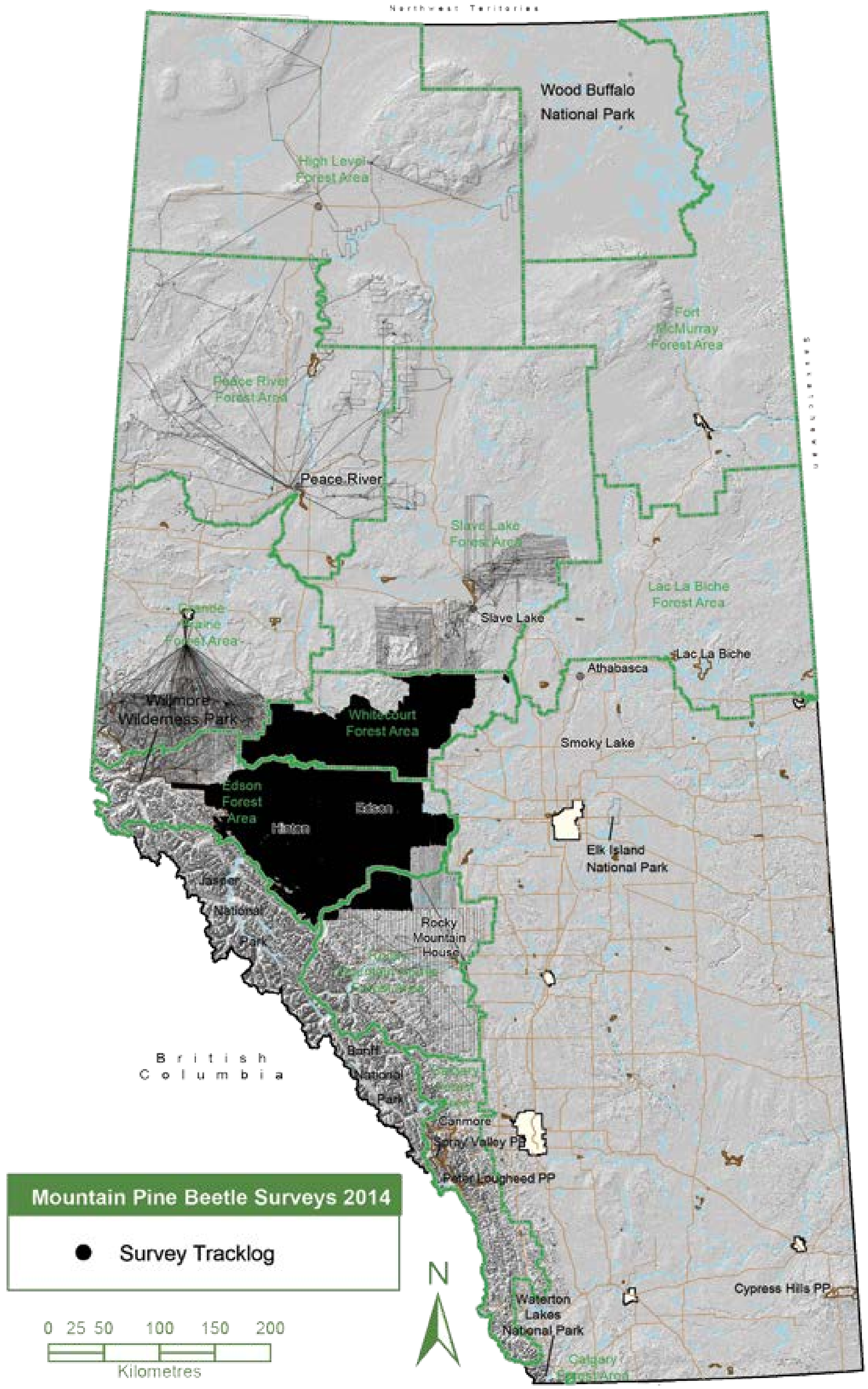


Figure 4. Mountain pine beetle heli-GPS track log for 2014 aerial surveys to located pines with red crowns suspected to be infested by mountain pine beetle.

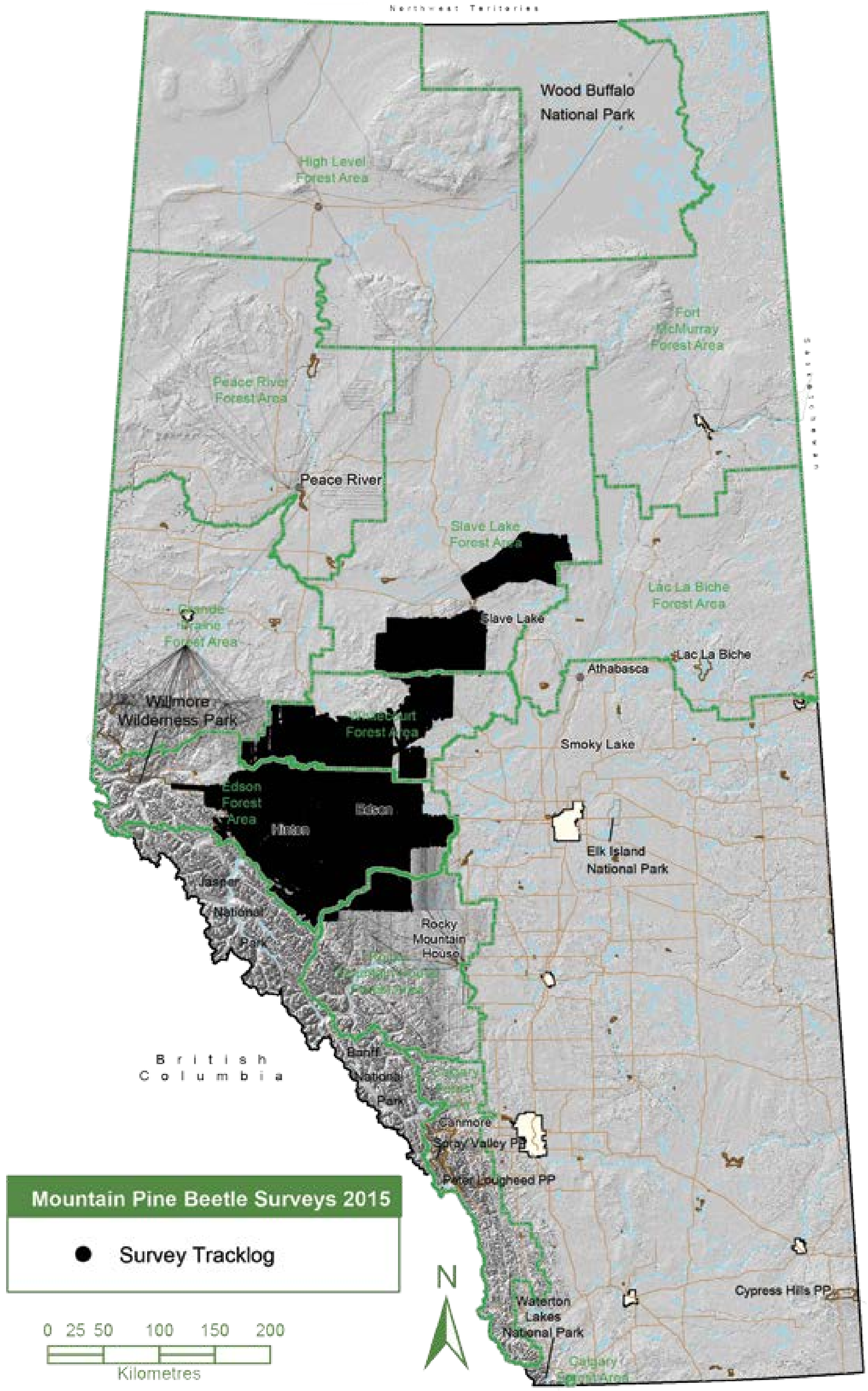


Figure 4a. Mountain pine beetle heli-GPS track log for 2015 aerial surveys to located pines with red crowns suspected to be infested by mountain pine beetle.

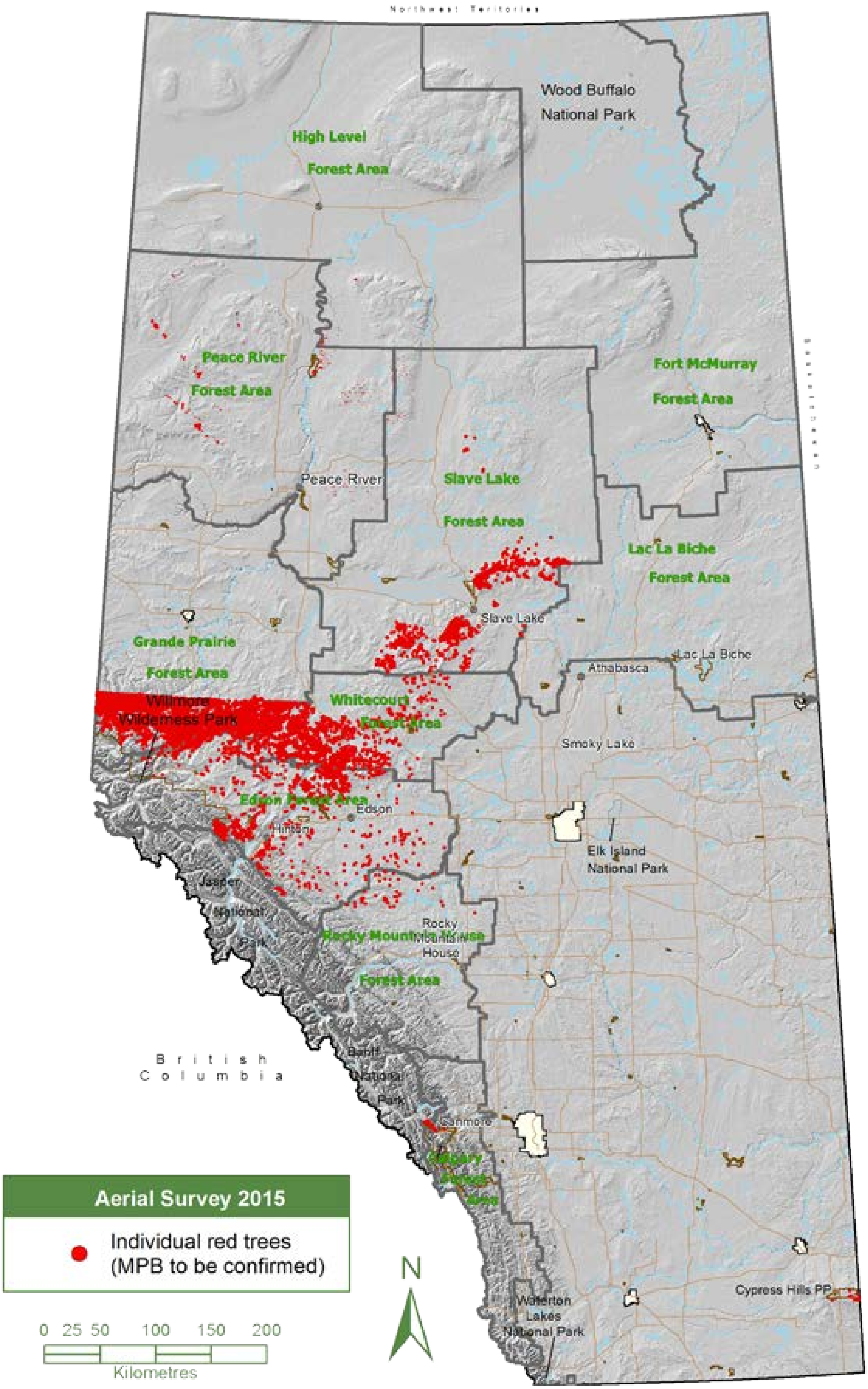


Figure 5. Locations of pines with red crowns suspected of being killed by mountain pine beetle detected during aerial surveys in August and September, 2014.

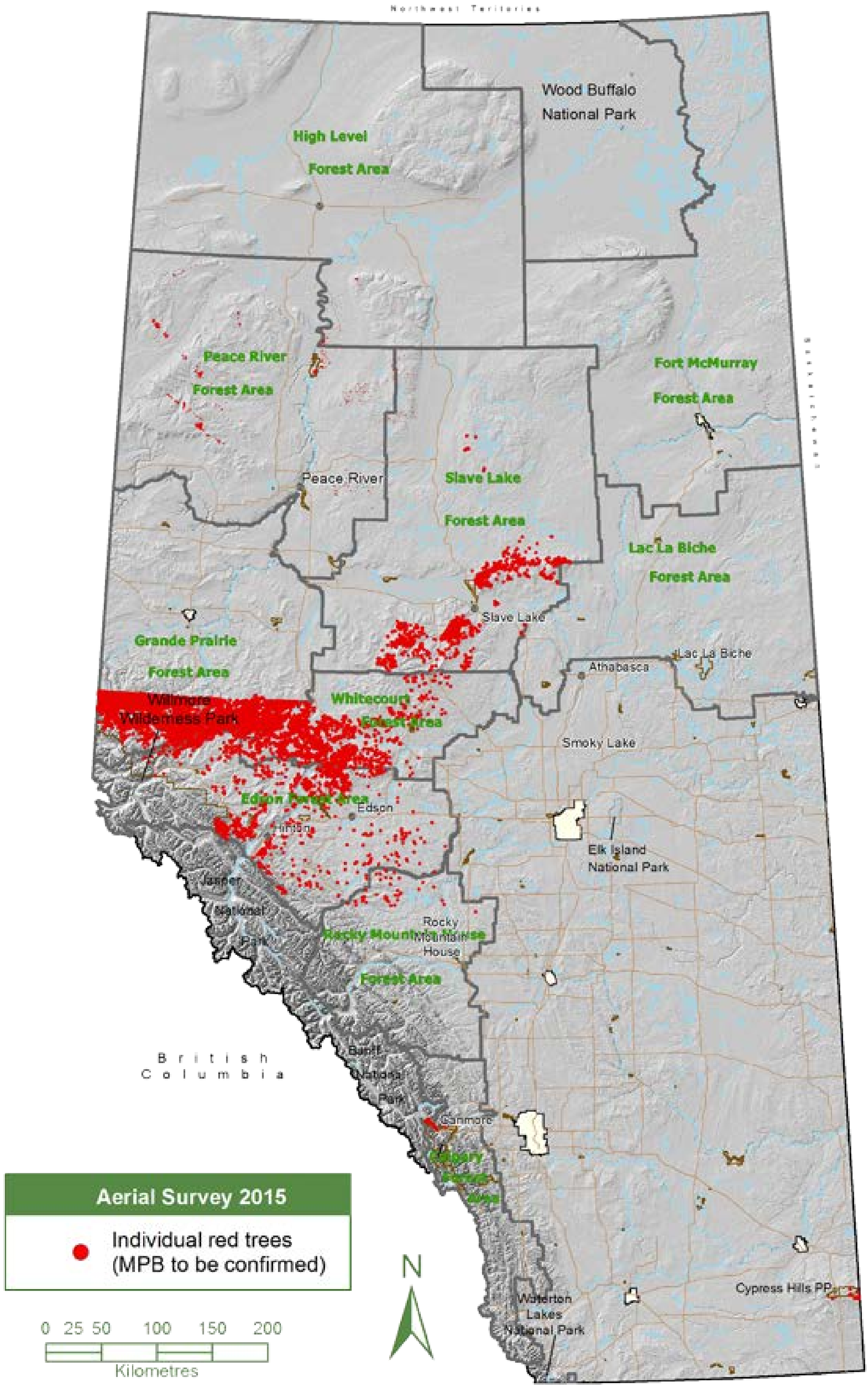


Figure 5a. Locations of pines with red crowns suspected of being killed by mountain pine beetle detected during aerial surveys in August and September, 2015.

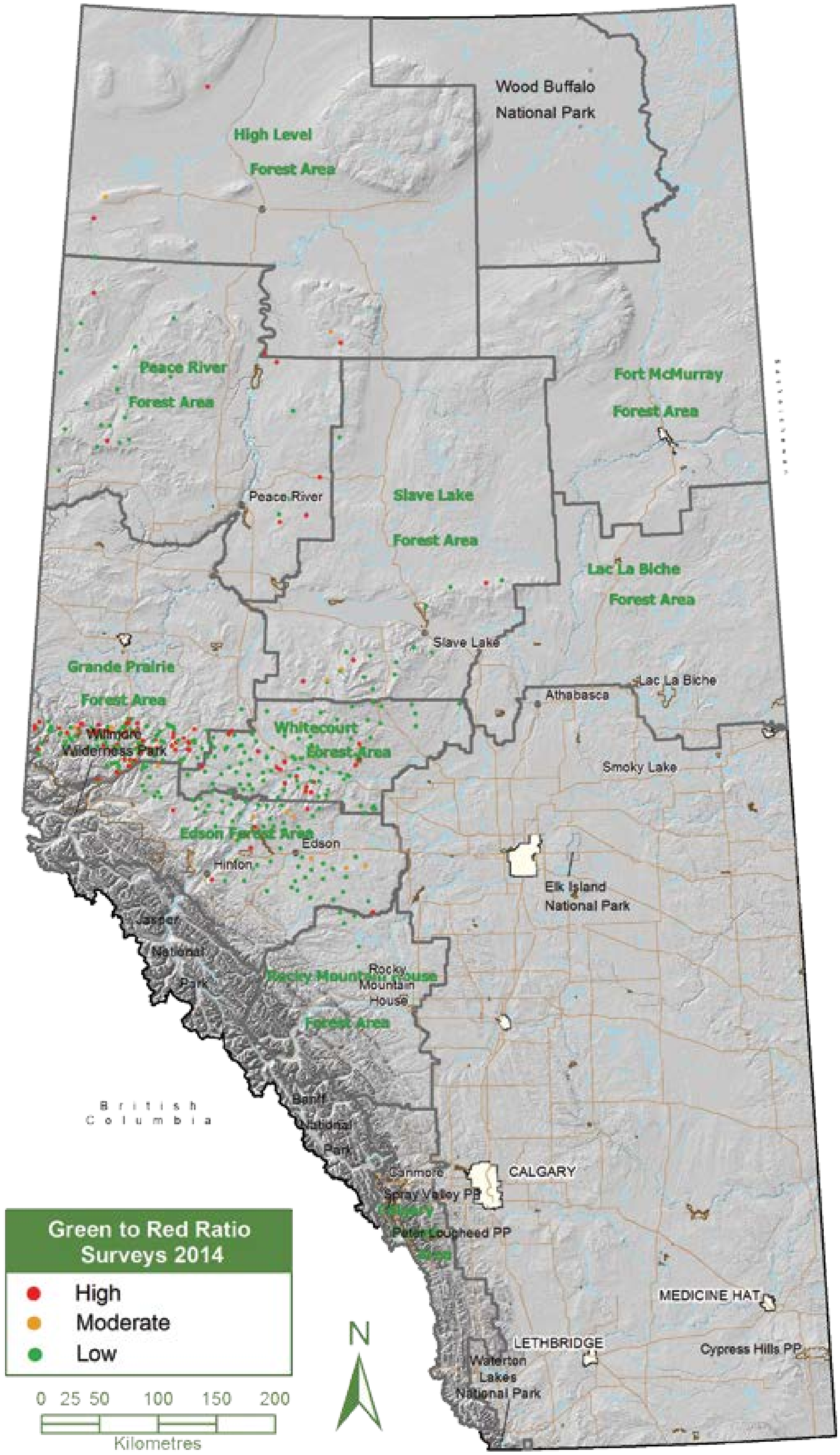


Figure 6. Green to red attack ratio surveys results from 2014.

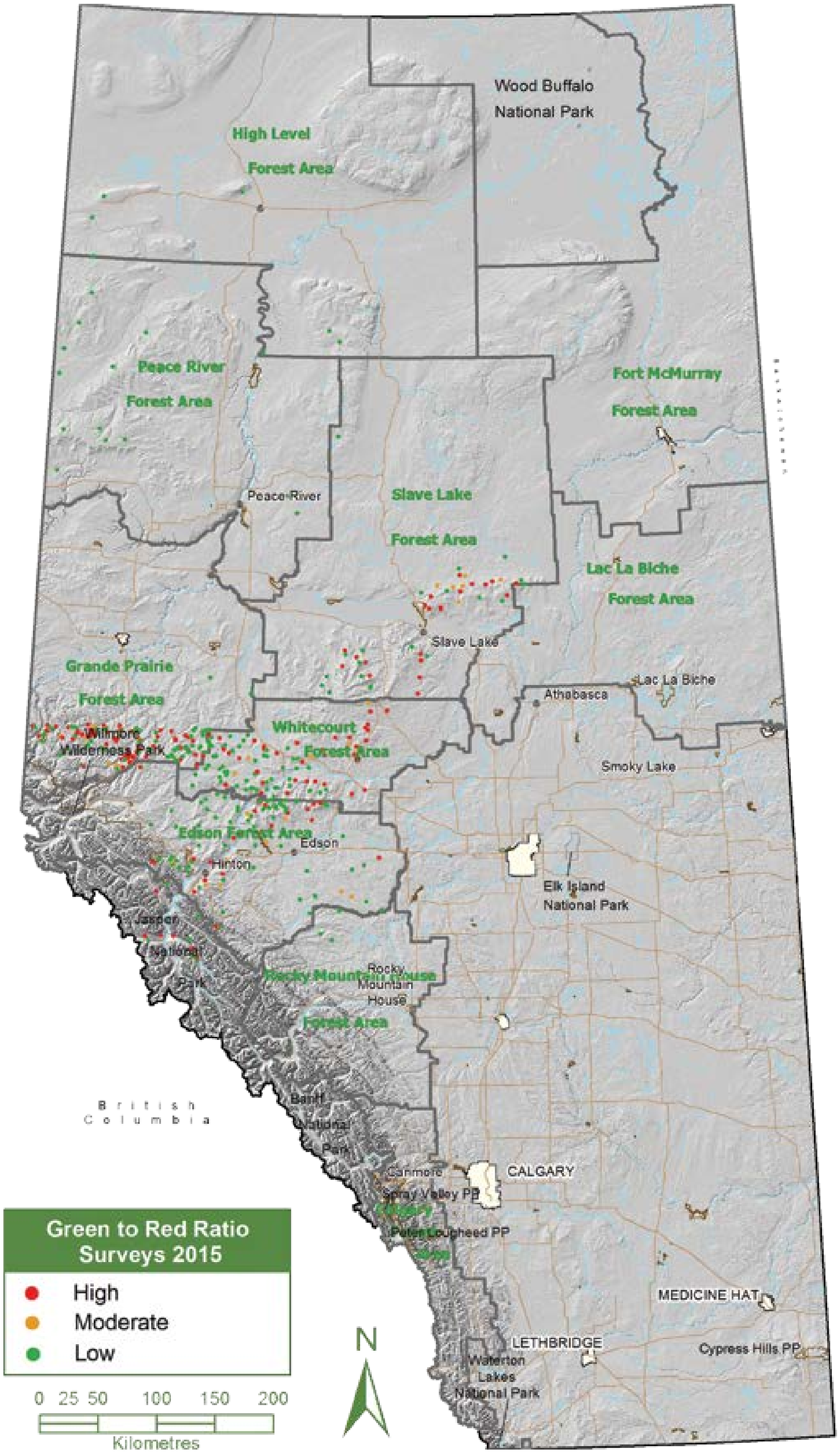


Figure 6a. Green to red attack ratio surveys results from 2015.

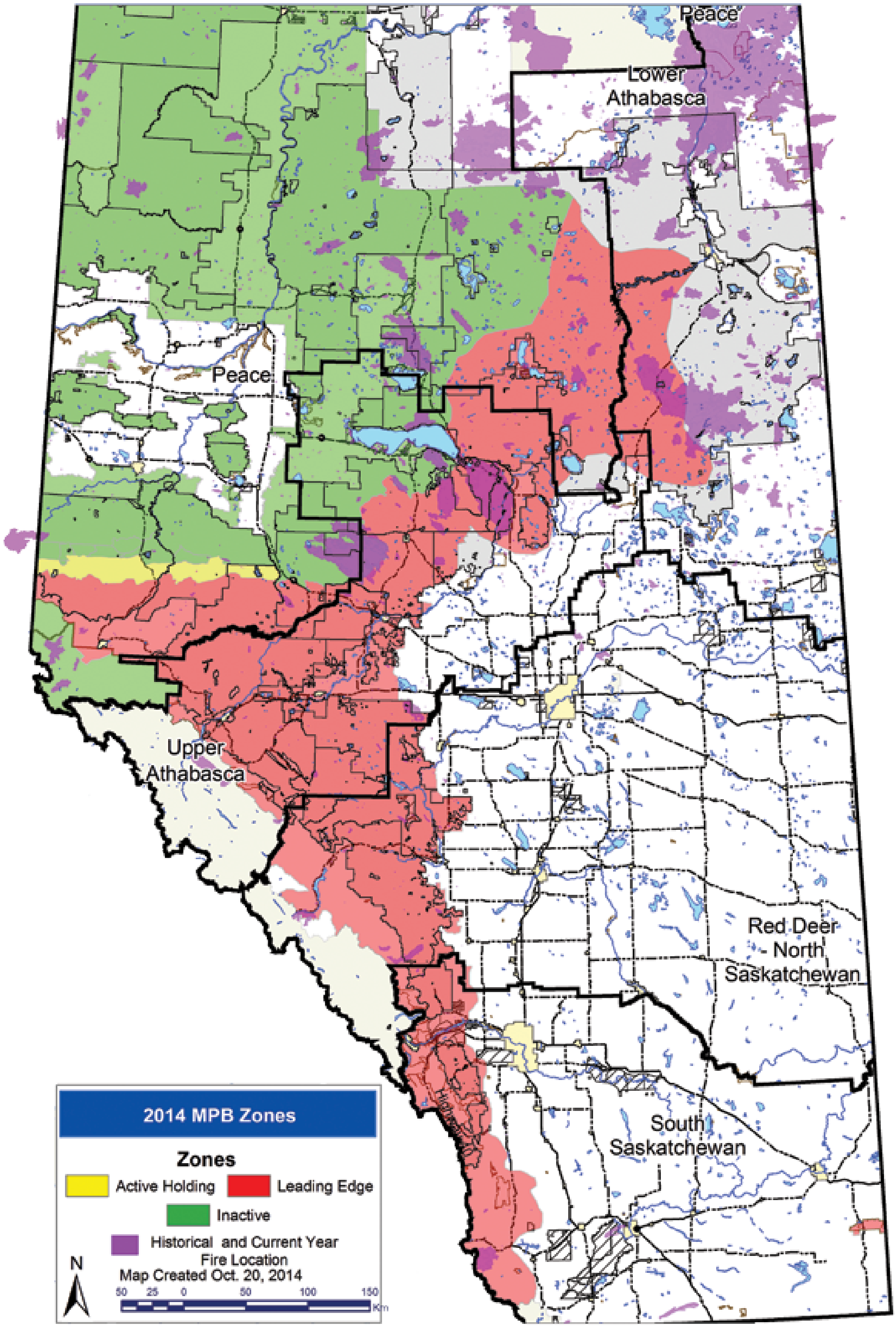


Figure 7. Mountain pine beetle management zones in Alberta in 2014.

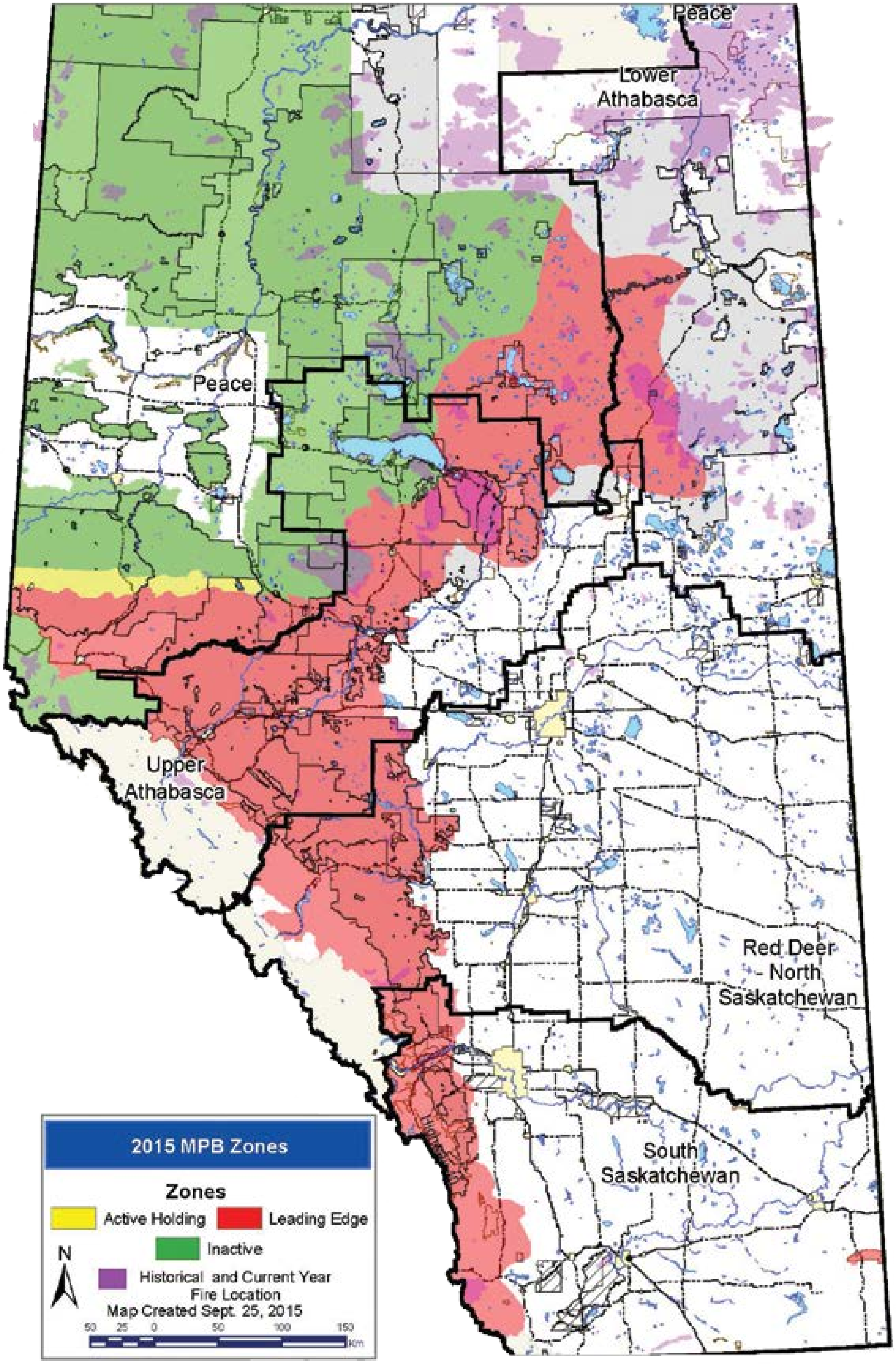


Figure 7a. Mountain pine beetle management zones in Alberta in 2015.

Mountain pine beetle municipal grant program

AAF administers a municipal grant program that provides funding support for municipalities in the Leading Edge zone to conduct MPB management activities. During 2014-2015 fiscal year, the Town of Whitecourt, Woodlands County, and Yellowhead County received grant funding. Funding to control 111 (2014) and 173 (2015) infested trees.

FRIAA aerial seed collection.

Mountain pine beetle reforestation seed inventory enhancement program

The MPB Reforestation Seed Inventory Enhancement Program was established in 2007 to ensure sufficient seed supply for areas identified at a high risk for infestation by MPB and that had an inadequate supply of seed. A portion of this program is administered by Forest Resource Improvement Association of Alberta (FRIAA) which is funded through the AAF MPB Program Grant Agreement (MPBGA). AAF also undertakes targeted collections through seed collection contracts.

The MPBGA was designed to fund wild seed collections (Stream 1 seed) through FRIAA and made provisions for proposals to expand non-capital pine seed orchards to further enhance the supply of genetically improved (Stream 2 seed) reforestation seed. Since 2007 this program has collected 5,046 kg of lodgepole pine seed, representing 131 seedlot collections from 23 seed zones.

AAF MPB Stream 1 operational reforestation collections started in 2008/2009. AAF staff select collection sites with low lodgepole pine seed supply, low probability for collection by industry, and high MPB attack risk. Seed collections for the identified areas are then contracted out. Contract ground and aerial collections have been made from 46 different seed zones and generated 3,135 kg of seed since the program began.

Cumulative mortality classification of MPB-attacked stands in northwest Alberta

Submitted by Brooks Horne, Senior Forester - Forest Rehabilitation, Alberta Agriculture and Forestry

Quantifying cumulative pine mortality due to MPB is required in order to accurately assess the impact of this insect on Alberta's forests. Without this inventory, the province has limited information with which to plan for the strategic rehabilitation of forests in order to maintain ecosystem functioning, assess provincial timber supply, prioritize seed collections for future pine reforestation, measure the impacts to wildlife habitat, and predict fire behaviour and assess risk. An inventory of the number of trees infested by MPB does exist in areas of the province where infestations are actively managed (i.e. the Leading Edge zone), the borders of which change annually depending on provincial priorities.

The goal of this project was to determine the cumulative mortality of pine killed by MPB for the northern portion of the province that has been not continuously surveyed. This was accomplished using high-resolution imagery to classify the percent cumulative mortality of pine stands in select townships. This data provided the foundation for a decision support system that will be used to determine rehabilitation priorities.

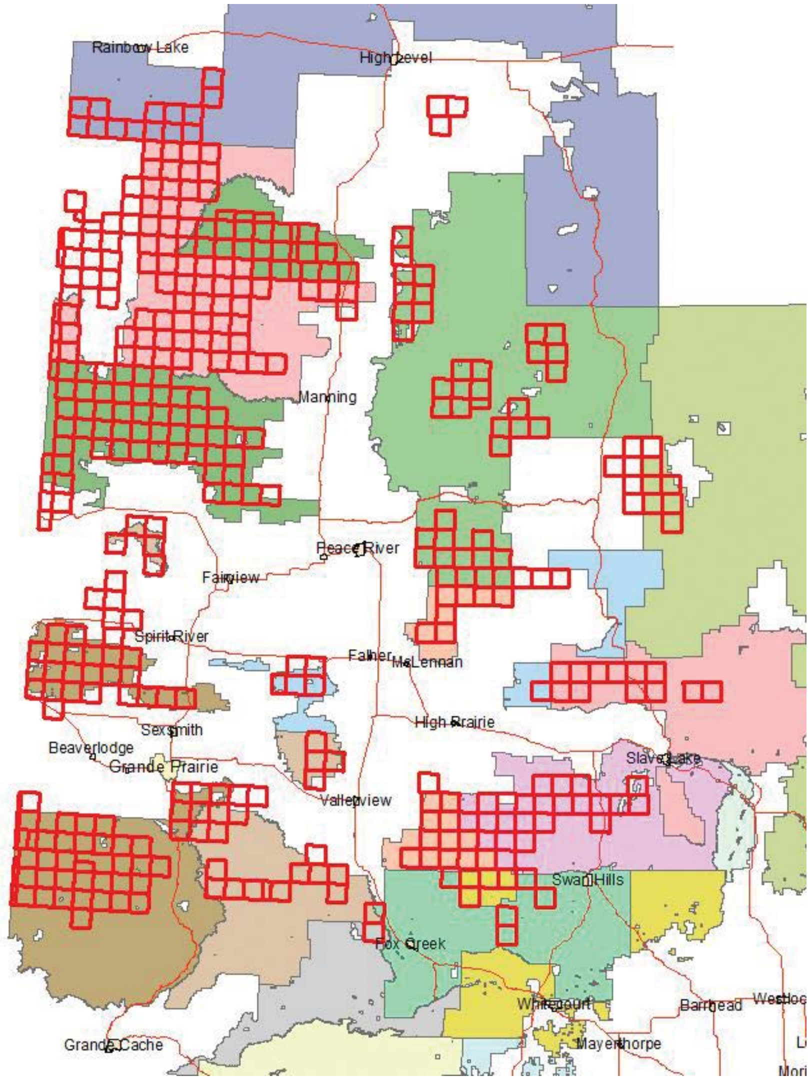


Figure 8. Cumulative mortality of pine due to mountain pine beetle project area.

It was first established that single tree red and grey cumulative mortality classification was possible on a large scale using remote sensing technology. The project area was defined according to historic and current MPB presence as well as percent pine; ultimately 412 townships were selected for classification (Fig. 8). High-resolution orthographic imagery (0.3 and 0.4 m) had been acquired in 2013 for 74 townships within the project area. Imagery for 278 townships was captured in August and September, 2014 and the remainder in September, 2015.

An analysis of the imagery was performed by a contractor and entailed classification of single pine trees as either red or grey (Fig. 9). The results of the analysis were returned in the form of classified polygons. Polygons in 214 townships were checked for quality to ensure that no more than 15 per cent of the trees were incorrectly classified. On average, data was well below the allowable error with an average of 4 per cent of the dead trees missed during analysis. Image quality did occasionally impact classification ability and therefore some townships were more accurately assessed than others.

The classified polygon data was used to calculate the percent of trees killed in each polygon. To calculate this, the area of mortality was compared to the area of overall merchantable (i.e. pine taller than 12 metres) canopy in each polygon. This was done by overlaying a 30m x 30m pixel grid over the project area. LiDAR was then used to discern the merchantable from non-merchantable canopy within the 0.09Ha pixel (Fig. 10). The mortality polygon numerator was divided by the merchantable canopy denominator to derive the percent impact to the pixel. Pixels above a certain threshold were grouped to create the disturbance unit polygons (Fig. 11) that can be ran through a decision support tool to determine which units should be prioritized for rehabilitation.

At this time, the mortality inventory data set cannot be used to explicitly measure the impact of MPB to merchantable basal area (BA). The proportion of overall dead canopy will be used as a surrogate to identify units potentially eligible for treatment. Based on a limited number of image observations, 25 per cent overall crown mortality will be used as the threshold to approximate the point at which the majority of merchantable BA in pine-leading stands is dead. This 25 per cent figure is an interim number that will be used until ongoing permanent sample plots in classified MPB-affected stands are assessed in 2016. The canopy mortality that equates to 50 per cent overall mortality to merchantable BA will then be established and utilized

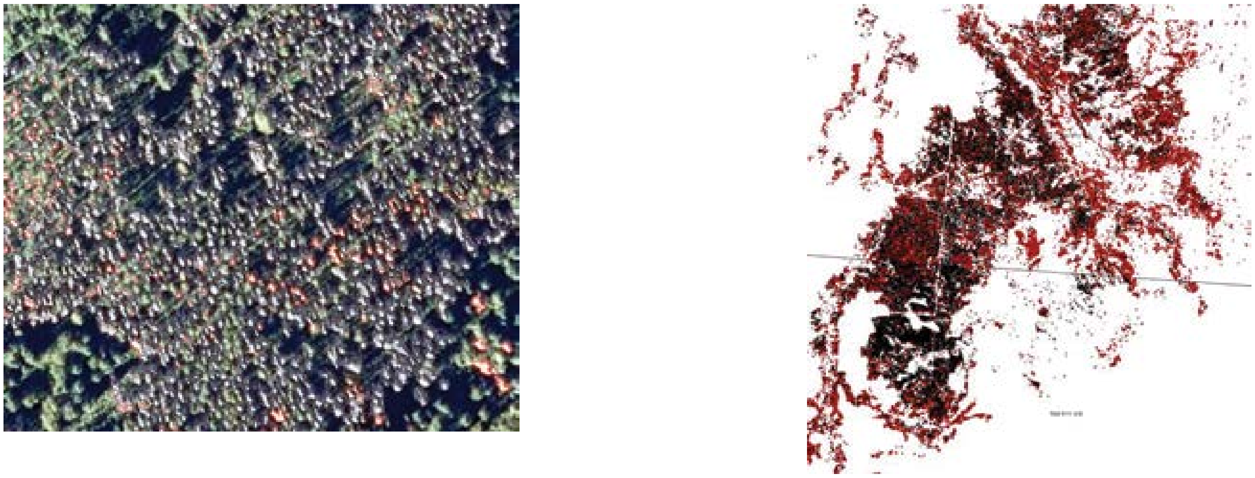


Figure 9. A) High-resolution orthographic imagery with single pine trees killed by mountain pine beetle and classified as red or grey; and B) classified red and grey trees.

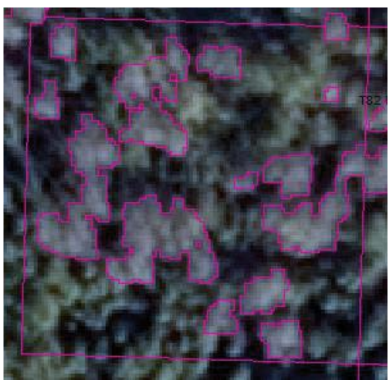
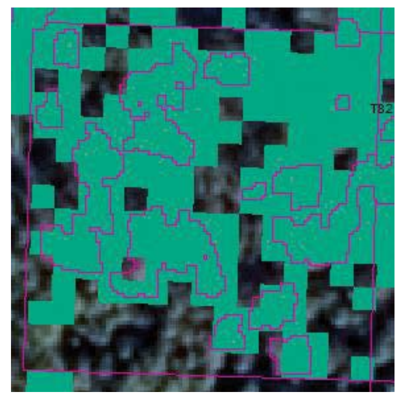


Figure 10. Pixel-based canopy mortality polygons.



10a. 30m by 30m merchantable canopy grid overlaid on canopy mortality polygons.

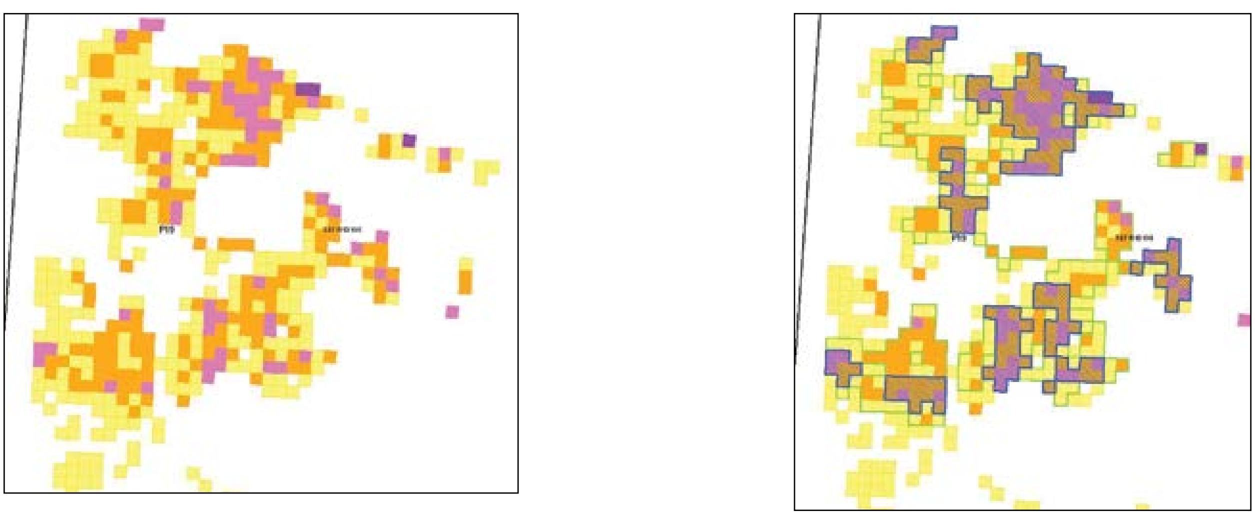


Figure 11. Mortality unit creation: canopy mortality polygons buffered by 0.5 hectare disturbance unit polygons.

in future prioritization efforts. Figure 12 displays the distribution of units above the 25 per cent threshold for canopy mortality. The spatial classification data is available from the province. Draft summary statistics for impacts to Alberta's pine will not be finalized until the relationship between canopy mortality to BA mortality relationship is established.

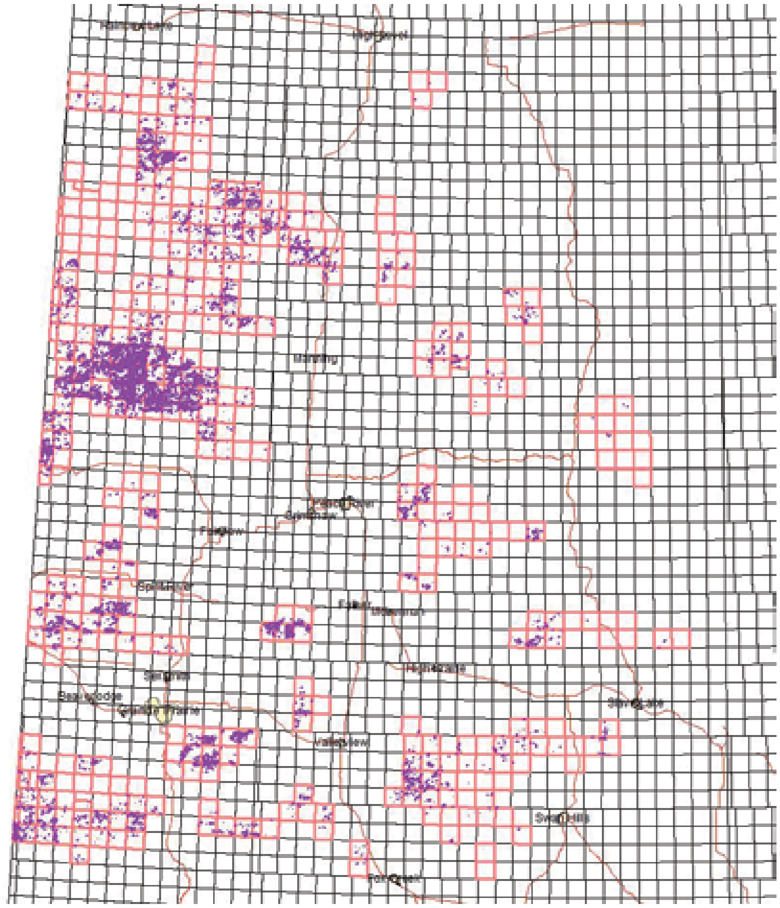


Figure 12. Distribution of mortality units in project area that exceed the 25 per cent canopy mortality threshold.

Eastern larch beetle (*Dendroctonus simplex*)

Eastern larch beetle infestations were identified and mapped in the Rocky Mountain House and Whitecourt FAs in 2015. A total of 63 infested stands spread over 918 ha of land were recorded in both FAs. The majority of disturbances were observed east of Rocky Mountain House and west of Drayton Valley in and around agricultural land. Cumulative stand damage rates varied: 400 ha with less than 20 per cent; 150 ha with 30 per cent; and 100 ha ranging between 40 per cent to 60 per cent.

Figure 13. Adult eastern larch beetle.

2015 was the first year eastern larch beetle was mapped in the Whitecourt FA. Infestations were mapped north of Fort Assiniboine in the Swan Hills, and in and around Whitecourt. Cumulative stand damage varied between 5 per cent to 70 per cent. It is expected that rates of infestation will continue to increase concurrently with aerial detection expertise.

Spruce beetle (*Dendroctonus rufipennis*)

Historically in Alberta spruce beetle population densities have been low and represented by small, scattered infestations. The most recent outbreak of spruce beetle occurred northwest of Manning, in the Peace River FA, between 1989 and 1995. During this period of time approximately 1,200 ha of white spruce experienced 25 per cent to 50 per cent mortality.

Currently the only noteworthy spruce beetle damage in Alberta is located northwest of Rocky Mountain House (Fig. 14). In 2015, 1,400 ha of scattered patches infested with spruce beetle were aerially mapped (720 ha with 10 per cent and less cumulative stand damage, 480 ha with 15 per cent to 20 per cent damage, and 200 ha with 25 per cent to 40 per cent damage). Very few patches increased in size and rate of infestation in 2015 compared to 2014. Due to the typical two-year lifecycle and the unknown dispersal range, an increase in the number of newly infested trees may occur in 2016 in this forest area.

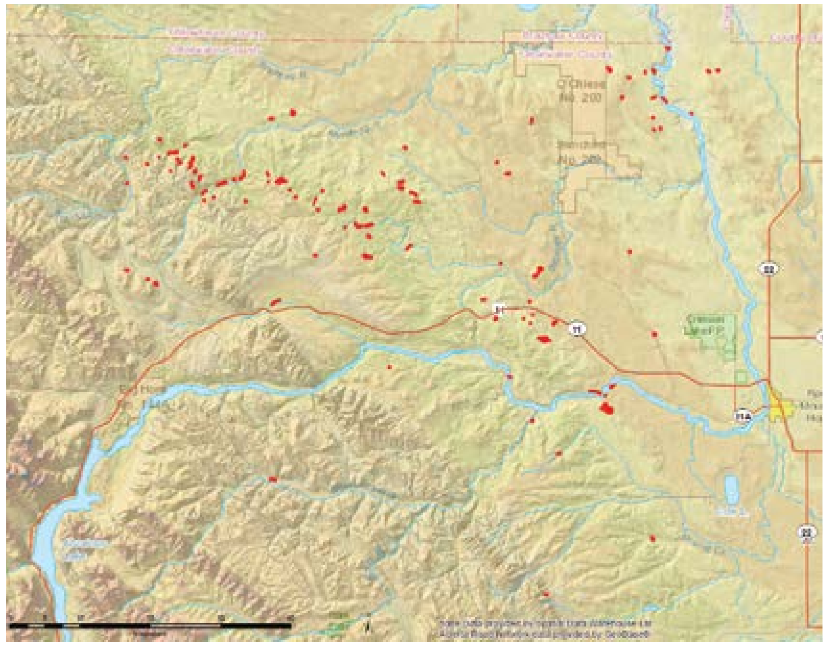


Figure 14. Spruce beetle infestations in the Rocky Mountain Forest Area mapped in 2015 using heli-GPS.

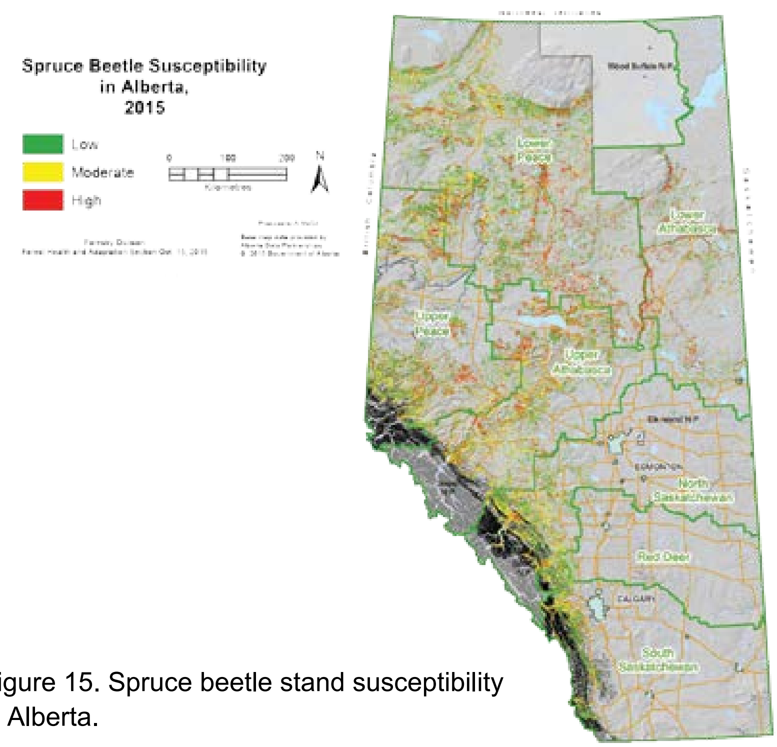


Figure 15. Spruce beetle stand susceptibility in Alberta.

Given that spruce beetle is a rising concern in other jurisdictions, AAF is preparing for potentially notable increases in the extent and severity of infestations occurring in Alberta. Current initiatives involve the refinement of detection and monitoring techniques, as well as understanding aspects of spruce beetle's biology that contribute to changes in population dynamics. A pre-existing stand susceptibility index (SSI) using provincial vegetation inventory was adapted to assist with monitoring. The spruce beetle SSI (Fig. 15) will be validated for use in Alberta in 2016. A guide is under development that will outline integrated pest management strategies for spruce beetle. Detection, ground survey, and pheromone-use procedures will also be incorporated into the guide.

Conifer Defoliators

Spruce budworm (*Choristoneura fumiferana*)

Spruce budworm is a native defoliator that has co-evolved with white spruce and balsam fir in Alberta. Over the last 50 years, spruce budworm infestations occurred mainly in river valleys of northern Alberta with rare infestations of spruce budworm and other closely-related *Choristoneura* species in southern Alberta.

Forest Health Officers annually conduct aerial surveys to detect and assess spruce budworm-defoliated stands in the Green Area. The goals of this program are to:

- build a historical record of these infestations, and
- assess the need to take management action if spruce budworm infestations compromise land management objectives.

Aerial surveys conducted in the summer of 2015 detected 51,751 ha of visible defoliation due to spruce budworm (Fig. 16, Table 2). Defoliation in the Peace River and High Level FAs spanned a net area of 4,121 ha, of which 94 per cent was moderately defoliated. The Fort McMurray and Lac La Biche FAs had the highest defoliation rates in the province, 46,223 ha of disturbance was mapped. The majority of spruce was moderately defoliated (93 per cent). A small amount of moderate defoliation was observed in the Slave Lake FA (1,407 ha). Provincially there was a 37 per cent decrease in the area disturbed by spruce budworm compared to 2014. The extent of spruce budworm defoliation peaked in 2010 and has remained relatively low since 2011, though small increases were observed in 2013 and 2014 (Fig. 17).

Table 2. The extent (hectares) of spruce budworm defoliation recorded by severity category mapped during overview aerial surveys carried out in Alberta in 2014 and 2015.

Category[1]	2014	2015	Percent change
Moderate	70,935	47,767	-33
Severe	0	2,983	>100
Total	**70,935**	**51,750**	**-27**

[1] Moderate: ≤70% of new foliage defoliated; severe: >70% of new foliage defoliated.

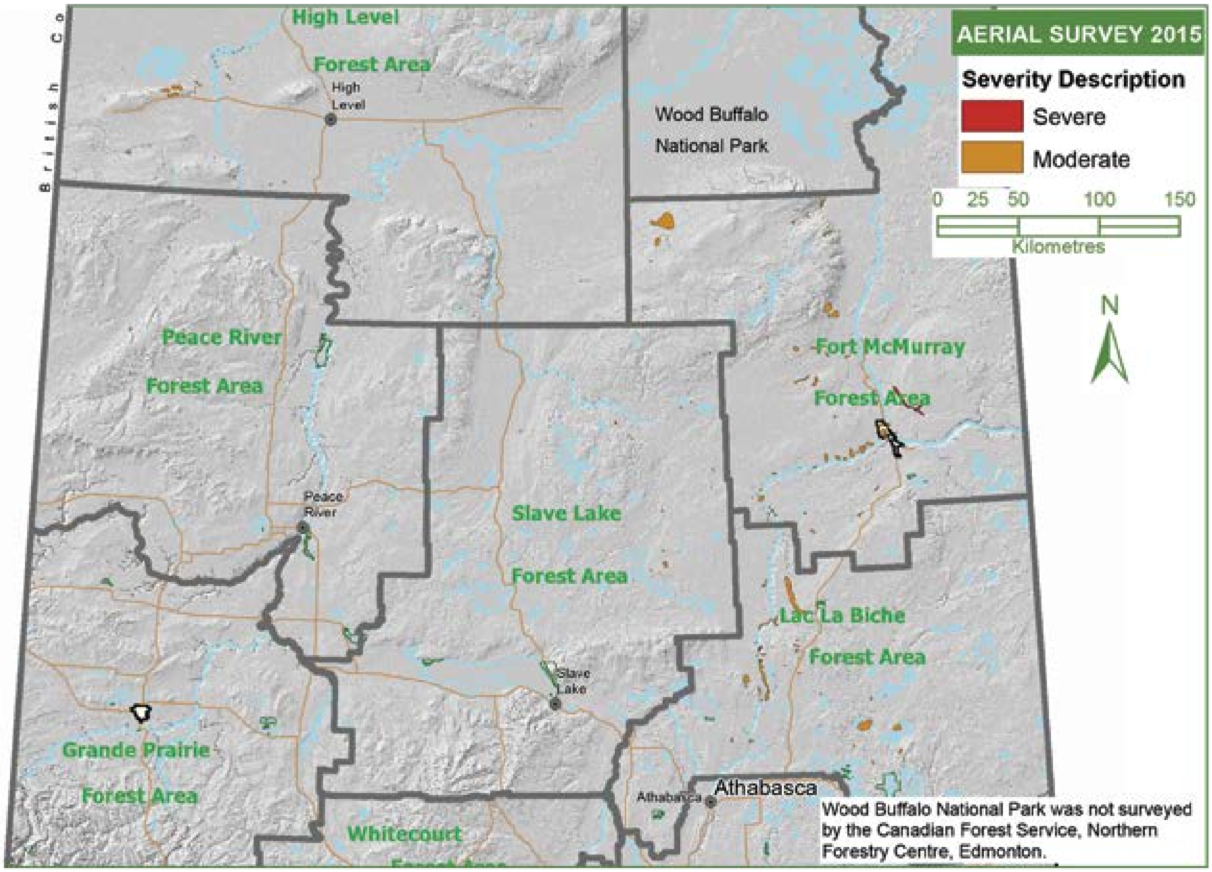


Figure 16. Spatial distribution of visible spruce budworm defoliation aerially surveyed in 2015 in Alberta.

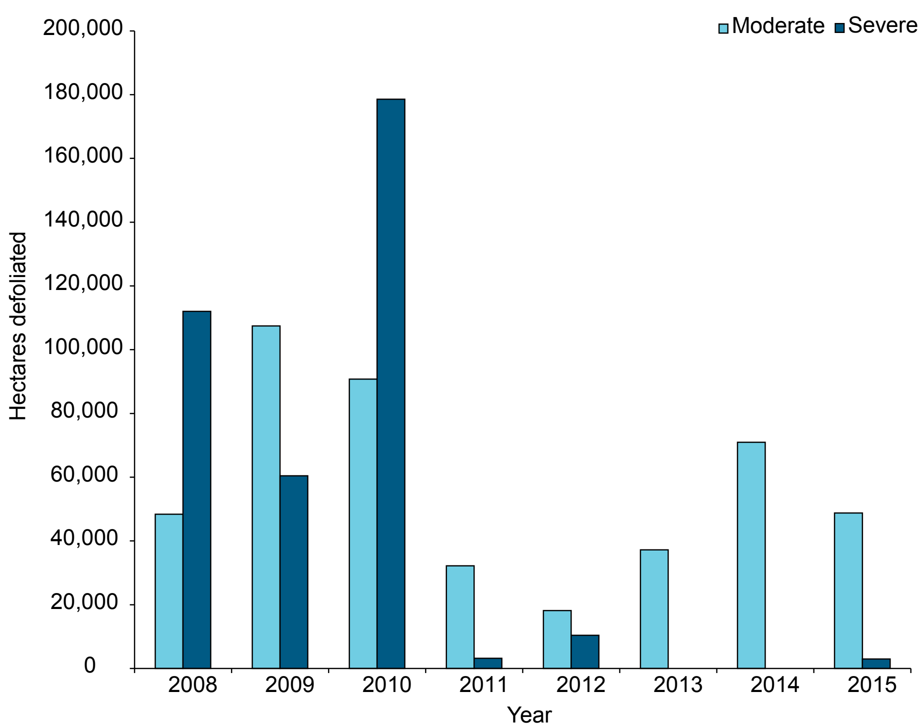


Figure 17. Hectares (in thousands) of spruce budworm defoliation observed during aerial surveys in Alberta 2008 – 2015.

Broadleaf Defoliators

Aspen defoliators

Annual aerial overview surveys are conducted to record the gross area affected by aspen defoliation in the Green Area. Severity is not recorded as these categories have limited accuracy since aerial surveys are done once a year and only capture a snapshot of the defoliation season. The Forest Health Aerial Survey Manual outlines the protocols followed when conducting aerial surveys.

The objective of this survey is to maintain an historical record of aspen defoliation over the Green Area. This data will enable practitioners to follow the long-term trends of aspen defoliation in relation to changes in biological and environmental factors. It can also reveal status change of innocuous agents into forest health damage agents. These surveys provide the information used to assess the impact of these damage agents and if there is a need to manage populations based on forest management objectives. Survey records are included in a national database on incidence and impacts of pests across Canada.

Total aspen defoliation across the province amounted to 1.65 million ha in 2015, a 54 per cent decrease from the previous year. Defoliation was largely attributed to forest tent caterpillar (*Malacosoma disstria*), aspen twoleaf tier (*Enargia decolour*), Bruce spanworm (*Operophtera bruceata*), and large aspen tortrix (*Choristoneura conflictana*) (Fig. 18, Table 3). Forest tent caterpillar (FTC) was the major pest; defoliating approximately 1.5 million ha (51 per cent decrease from 2014) and was largely responsible for high levels of defoliation in the Grande Prairie FA (Table 4). The outbreak in the Peace River and High Level FAs has begun to decline though small pockets remain disturbed. Defoliation by large aspen tortrix increased from 1,389 ha to 54,444 ha in 2015, and occurred primarily in Rocky Mountain House and Calgary FAs. Aspen twoleaf tier defoliation decreased from 295,089 ha to 536 ha between 2014 and 2015.

Table 3. The extent (hectares) of aspen defoliation recording during aerial overview surveys conducted in 2014 and 2015 in Alberta categorized by agent.

Pest	2014	2015	Percent change
Forest tent caterpillar	3,294,041	1,586,486	-51
Large aspen tortrix	1,389	54,444	>100
Bruce spanworm	0	3,564	>100
Aspen twoleaf tier	295,089	536	>100
Total*	**3,590,519**	**1,646,030**	**-54**

* Total area defoliated by agent may include defoliation falling outside of the current Green Area boundary. Area surveyed varies between years.

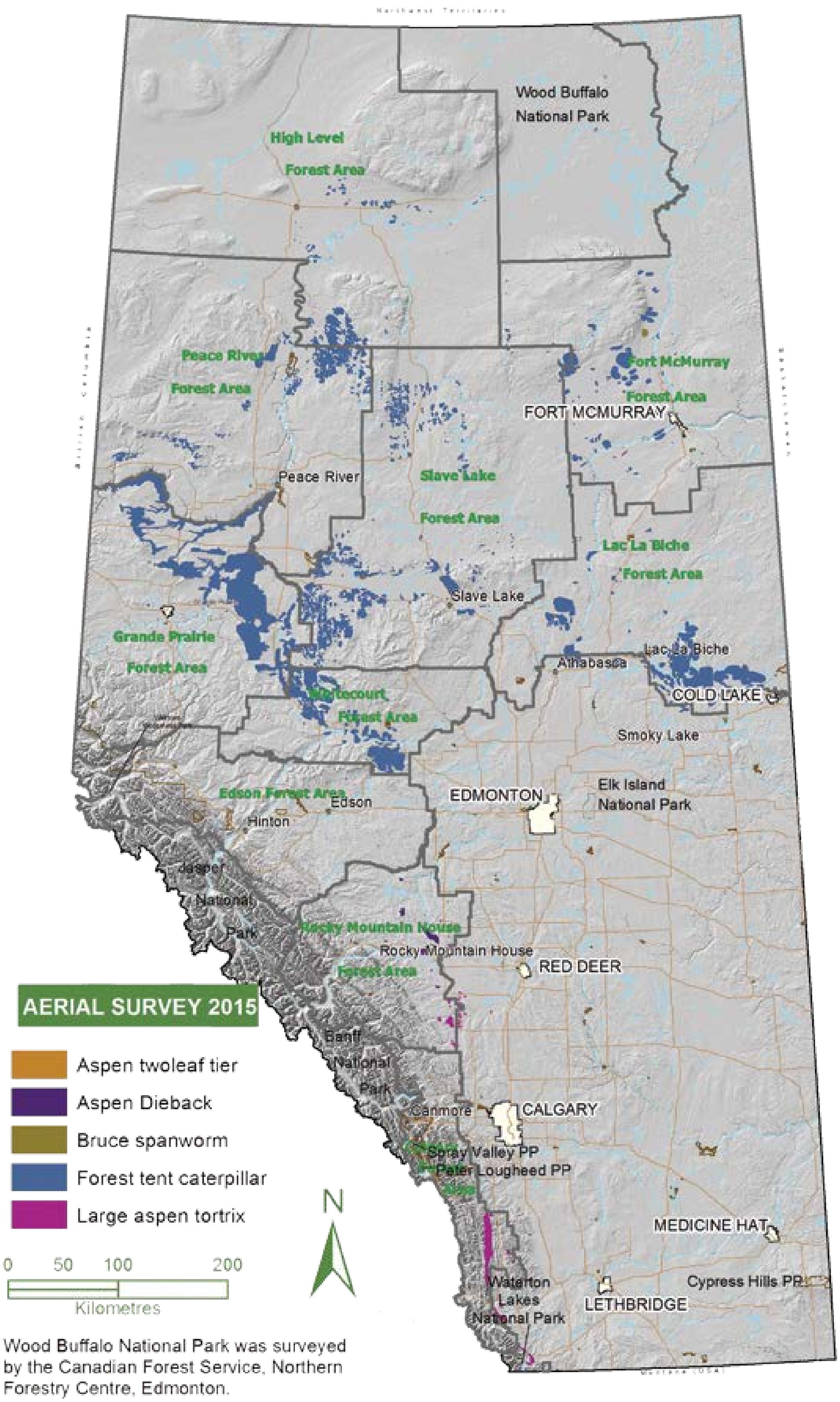


Figure 18. Spatial distribution of aerially visible, aspen defoliation detected during aerial surveys conducted in Alberta, 2015.

Table 4. Summary of 2015 aspen defoliation (in hectares) by forest area.

Forest Area	Total area defoliated (ha)*
Calgary	34,843
Edson	941
Fort McMurray	101,855
Grande Prairie	528,922
High Level	71,635
Lac La Biche	246,678
Peace River	135,566
Rocky Mountain House	9,095
Slave Lake	288,547
Whitecourt	189,383
Total	1,615,936

*Regional boundaries changed between 2014 and 2015, therefore a direct comparison of defoliated hectares by forest area is not possible.

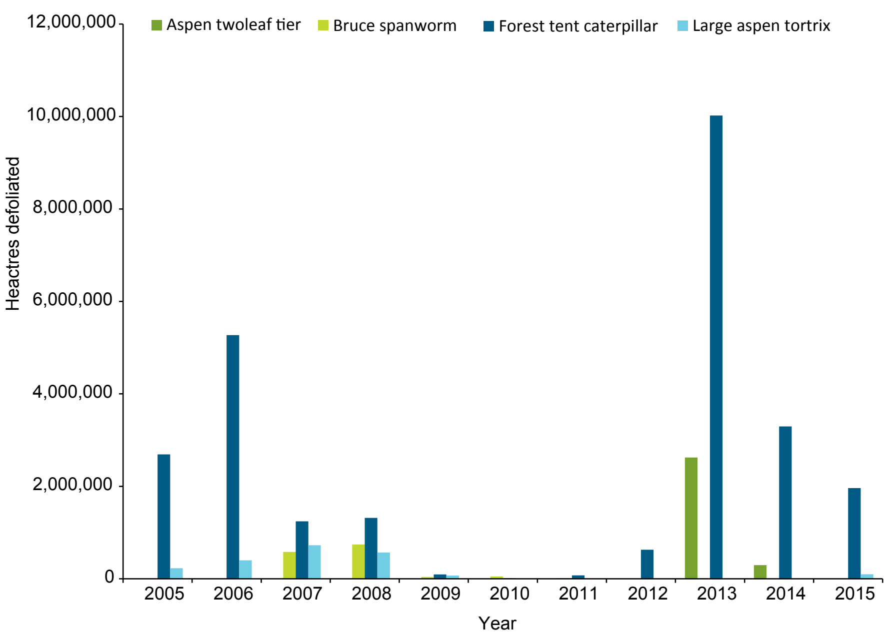


Figure 19. Extent (hectares) of aspen defoliators observed during aerial surveys performed between 2005 – 2015

Between 2005 and 2015, FTC was the most abundant aspen defoliator observed during aerial overview surveys (Fig. 19). While four main defoliators recorded during the last 10 years, FTC was responsible for 72 per cent of cumulative defoliation during this time period. FTC populations reached outbreak proportions in 2006 (5,271,489 ha). Though the outbreak was distributed throughout the province, the majority of defoliation occurred in the High Level FA. Populations again reached outbreak levels in 2013 (10,021,918 ha). As noted during the previous outbreak, FTC was distributed thoughout much of the province but the greatest amount of disturbed area occurred in the Peace River, Slave Lake and Grande Prairie FAs. Some regions of the province have experienced repeated years of defoliation by FTC and when combined with the effects of drought, aspen decline may be a concern. The health of aspen stands will continue to be monitored during aerial overview surveys and observations made on the ground.

Aspen twoleaf tier

Forest tent caterpillar

Large aspen tortrix

Bruce spanworm

Diseases of Conifers

Red-band needle blight (*Dothistroma septosporum*)

Red-band needle blight was observed at the Alberta Tree Improvement and Seed Centre (ATISC) in Smoky Lake and at a pine provenance trial located near Calling Lake in 2013. In 2014, infected pines were noted at another site located near Blue Ridge. A management program was implemented because of the severity of the infection and to reduce loss of genetic material at this high value pine clone bank.

Surveys are conducted annually in early May to monitor tree health and this data will be used to measure treatment efficacy once enough data has been collected. Since 2013, infected trees have been treated with Bordeaux mixture, a copper sulphate-based fungicide. Treatments are applied in May to reduce inoculum potential and again in late June or early July to protect fully erupted needles.

Pine needle cast (*Lophodermella concolor*)

Small pockets of pine needle cast were mapped in the Rocky Mountain House FA. Approximately 20 ha were observed and the stands appear to have been infected at least one year ago as the 2014 needles showed signs of infection.

Abiotic Damage Agents

Drought

Occurrences of abiotic damage agents are also mapped during aerial overview surveys. Table 5 shows the amount of visible damage caused by various abiotic agents in the Green Area based on overview aerial surveys conducted between 2012 and 2015. The total area affected by abiotic disturbances has generally increased in extent, and the upward trend may be due to increases in both detection efficacy and occurrence of these damage agents.

Conifers affected by winter desiccation (redbelt) were mapped in the Edson and Calgary FAs and were most prevalent in the south region of the Rockies. Almost 11,000 ha were mapped in the Castle Special Management Area and in Pole Haven. The affected area was more than double the amount mapped in 2014. The increase in redbelt can be attributed to unusually mild winters combined with typical Chinook winds, which provide the appropriate warming and cooling conditions for winter drying.

Aspen stands showing signs of dieback were mapped in the Grande Prairie and Lac La Biche FAs and may have been caused by drought and repeated defoliation though this remains to be determined. From the air, aspen dieback can be difficult to distinguish from defoliated aspen given the timing of aerial surveys and therefore the number of hectares mapped may be an underestimation.

Flooding was noted in many FAs of the province but the majority was mapped in the High Level FA. Hail was recorded in the Grande Prairie FA and primarily affected moderate-aged regenerating stands. Blowdown was mapped in the Edson FA.

Table 5. The extent (hectares) of abiotic damage mapped during aerial surveys conducted in Alberta between 2012 and 2015.

Abiotic Damage Agent (ha)				
Damage	**2015**	**2014**	**2013**	**2012**
Blowdown	1,204	2,693	1,679	1,106
Dieback	23,657	34,852	348	42,239
Flooding	5,457	1,233	970	301
Hail	1,419	0	0	648
Winter Desiccation (Redbelt)	15,341	4,174	0	819
Total	**45,659**	**42,952**	**2,997**	**45,113**

Other Observations

Balsam fir mortality and extensive willow damage was noted in many of the northern FAs. Though not always mapped, willow damage and balsam fir mortality were noted in the Grande Prairie, Peace River, High Level, Whitecourt, Lac La Biche and Fort McMurray FAs. Willow leafblotch miner was observed in locations where ground truthing occurred but may be just one of the agents causing the widespread damage. The direct cause of balsam fir mortality is unknown at this time but effort will be directed towards ground truthing in 2016. Subapline fir mortality and willow damage was observed in the Calgary FA during aerial surveys.

Alberta Tree Improvement and Seed Centre Programs

Seed production, collection and storage

The province owns partial or complete seed shares in six white spruce, two black spruce, one jack pine and two lodgepole pine seed orchards. The majority of the white and black spruce orchards had good cone production in 2015. The pine orchards, while young, continue to steadily increase their seed production. The AAF contract MPB Wild Pine Seed Collection program was suspended at the end of the 2014/15 fiscal year but not before over 3,090 kg of pine seed were amassed over the seven years that this program ran.

In 2015, AAF-owned and -cooperative seed orchards had moderate to heavy cone crops (Table 6). Two white spruce orchards exceeded previous production records and other orchards were slightly below.

Table 6. Volume of cones collected (hL) and seed produced (kg) in 2015 from Alberta Agriculture and Forestry-owned and cooperative seed orchards.

Orchard seed	Volume of Cones (hL)	Weight of Seed (kg)
AAF-owned CPP program seed orchard collections		
Region H (Sw)	21.5	27.2
Region L1 (Sb)	3.5	1.3
Region L3 (Sb)	6.6	2.7
Total	**31.6**	**31.2**
Cooperative CPP program seed orchard collections		
Region E (Sw)	52.3	74.9
Region G2 (Sw)	45.9	70.7
Region P1 (Pi)	10.9	5.7
Region J (Pl)	3.0	1.2
Region K1 (Pl)	15.3	5.8
Total	**127.4**	**158.3**
Wild seed		
FRIAA MPB Rehabilitation pine wild seed collections	-	180
Contract MPB wild pine seed collections (Pl, Px and Pj)	-	561

[1] AAF: Alberta Agriculture and Forestry; FRIAA: Forest Resource Improvement Association of Alberta; Pl: lodgepole pine; Px: hybrid lodgepole-jack pine; Pj: jack pine; Sw: white spruce; Sb: black spruce; – Region codes in this section refer to breeding zones for each species.

With the presence of a heavy cone crop, seed orchards were ranked by seed requirements and the top priority orchards were harvested. Cone collections were completed with tripod ladders and a motorized lift in conjunction with moderate topping in orchards. Spring conelet surveys showed little to no pest infestations, therefore no treatment was required to control cone feeding insects.

In 2015, 374 new seedlots representing 40 different species were received at ATISC for registration and storage. Reclamation species are in high demand for the oil and gas industry adding 158 collections made from 30 shrub, grass and forb species for a total of 101 kg of seed. Seed collection of tree species still exceeds that for shrubs, grasses and forbs with 216 new collections, adding 2,645 kilograms of tree seed to the provincial inventory.

Seed withdrawals over the course of the year saw more than 700 kg of tree seed shipped to nurseries to meet orders for over 91 million seedlings. A further 27 withdrawals, totalling 153 kg of seed for direct seeding were made. As well, 223 withdrawals of shrubs, grasses and forbs amounting to almost 20 kg of seed for the production of over 234 thousand seedlings.

Plant propagation

In 2015, staff at ATISC embraced a LEAN approach to ensure that the centre remains ahead of industry trends. LEAN emphasises continuous improvement by systematically achieving small and incremental changes to increase process efficacy. At ATISC this strategy is aimed at improving standardized plant propagation activities and processes and all employees are actively engaged in program improvement. Staff are progressively adopting biological pest and disease controls and continuously improving growing and propagation techniques.

Figure 20. Hot grafted whitebark pine seedlings.

A total of 21,720 seedlings were grown for various projects in 2015 (Table 7).

Grafting is a major activity for the plant propagation section; a total of 1,564 grafts were completed in 2015. Most of the grafted material was for Breeding Region A, part of a superior tree selection program, for which about 750 scions were collected from 44 selected trees. This is the first year of a two-year project. Grafting was also done for clonal archiving (clone banks) and infill for other breeding region seed orchards.

One exciting new grafting technique tested this year was whitebark and limber pine "hot grafting" (Fig. 20) which is grafting done during the growing season. Hot grafting under Alberta conditions is difficult; the growing period is narrow

Table 7. Summary of seedlings produced in 2015 at the Alberta Tree Improvement and Seed Centre broken down by project.

Project	Number of seedlings	Remarks
White spruce progeny trial, phase 2 Breeding Region E1.	17,520	176 families
Lodgepole and jack pine, University of Alberta, TRIA-NET[1]	1,200	For screening of western gall rust resistance
Seedlings – mix of species	3,000	For 2016 grafting rootstock

[1] Turning Risk Into Action for the Mountain Pine Beetle Epidemic research initiative funded by NSERC.

and seedlings start shutting down relatively early in preparation for winter. The results from 2015 were promising and the growing and grafting requirements of these two endangered species will continue to be studied.

Seed science and conservation, and research seed bank

The seed technology program housed at the ATISC manages long-term conservation seed collections including Alberta's two endangered tree species, whitebark and limber pine. This seed bank also provides the majority of research seed for provincial tree improvement programs and forest genetics. The lab endeavours to further Alberta's knowledge of seed science in order to advise practical methods for industry seed and cone handling and use. 2015 was the largest seed shipping year to-date. The seed centre provided over 25,000 seeds from 127 seedlots to fulfill research needs in support of academia and National Parks projects, including western gall rust and drought tolerance projects. The program also sent 58 of Alberta's limber and whitebark pine seed lots to British Columbia and the United States for white pine blister rust resistance screening tests. Lastly, the centre processed 160 hectolitres (hL) collected from this year's cone crop and completed the regular requests for seeding in-house genetics trials.

Whitebark and limber pine seed longevity research continued in 2015. Trials were nearly complete and are still supporting earlier estimates of a useable lifetime of 10-20 years in cold storage. Unfortunately, this is not a long time period compared to other pine species (lodgepole pine seed is viable for 125 or more years). This short life is not ideal for an endangered species but the information will assist with future decision making.

Beaked hazelnut, *Corylus cornuta*, trials were expanded in 2015 to investigate better methods for handling and propagating seeds. This information will be used by greenhouses that supply seedlings to the oil and gas industry for public land reclamation. Smaller tests in 2013 and 2014 provided proof that the seeds are not recalcitrant - they can be dried for cold storage. Results from those tests and the myriad of contradicting published papers for hazelnut over the past 40 years have pointed to issues of lack of maturity at collection. Current testing is aimed at developing new handling methods that would mature the nuts ex situ and provide efficient germination protocols for this species. Preliminary results are promising.

When Alberta's new Forest Genetic Resources Management & Conservation Standards (FGRMS) are released, the province will embrace a new type of seed moisture testing. AAF has helped other provincial governments and research facilities purchase equipment and understand the principles required for these measurements. The new method and standards it creates will ensure optimum storage conditions, not just for tree seeds and conifers but also the shrub and herbaceous seeds that are now being stored for reclamation and restoration use. This change in seed practice, as well as others, instigated the rewrite of Alberta's Seed Testing Standards, which are tied to FGRMS. The updates and new additions are based on recommendations from best practice, the International Seed Testing Association's International Rules for Seed Testing and the United Nations Food and Agriculture Organization's Genebank Standards for Plant Genetic Resources. The changes to these standards will ensure modern practices are utilized and uniformity in testing and handling of Alberta seed.

Forest genetics research and development

AAF conducts applied forest genetics research to support government and government-industry cooperative tree breeding programs. This research is implemented through a series of field trials, analyzing and interpreting existing data records, and collaborating with research teams at academic and research institutions in and outside Alberta. Results from this work provide knowledge transfer and further the science of forest genetic research and are published as internal reports, public reports accessible through government or external websites and scholarly articles. The following is a review of the highlights for the 2015 and 2016 work in forest genetics research.

Climate Change and Emissions Management Corporation project

In collaboration with Tree Improvement Alberta and the University of Alberta the government implemented the

Tree Species Adaptation Risk Management project in 2015. This three-year project aimed to integrate climate change adaptation into tree improvement and seed transfer guidelines was funded by the Climate Change and Emissions Management Corporation (CCEMC).

Briefly, the project:

- analyzed white spruce and lodgepole pine data to explore opportunities for seed transfer among breeding programs;
- assessed the vulnerability and risk that climate change poses to Alberta tree breeding programs;
- modeled current and future climates for Alberta and individual tree breeding programs;
- explored techniques for cost-efficient vegetative propagation of aspen; and,
- investigated other orchard-related activities relevant to climate change adaptation.

The reports are available at the [Tree Species Adaptation Risk Management Project] on the CCEMC website.

Dothistroma needle blight

Following the discovery of dothistroma needle blight disease in lodgepole pine genetic field trials, clonal banks and seed orchards, AAF, in collaboration with the University of British Columbia and Canadian Forest Service, have undertaken initiatives to track the source of the disease through genomics. Preliminary results point to the possibility of both internal (Alberta) and external (British Columbia) sources of infection. When completed, this project will facilitate control or prevention measures; it may also open a new avenue of inquiry.

Climate change adaptation trials

AAF will establish at least four provenance-progeny trials for each lodgepole pine and white spruce. This expanded testing for climate change adaptation is designed to extend field testing to dry and high elevation regions of Alberta to allow identification of drought and frost tolerant populations. At the moment the project is identifying appropriate families and provenances to test. Planting is scheduled for spring 2017. Results will add to our knowledge of the role that climate plays in the genetic differentiation between the two species in Alberta and the extent of seed transfer among seed zones and breeding regions that the government can permit through provincial rules and guidelines.

Realized genetic gain trials

The Forest Management Branch (FMB-Biometrics and ATISC) will work with forest companies and Tree Improvement Alberta to implement realized genetic gain trials. The purpose of these trials is to determine how much of the expected genetic gain predicted by height growth in structured field trials is potentially realized as area-based volume increases in operational forest stands within the Alberta forest management system. Trial design is being finalized and planting is scheduled for 2017.

Western Gall Rust genomics

The western gall rust genomics project co-funded by Alberta Innovates Bio Solutions and FMB is looking for lodgepole pine DNA markers linked with resistance to the disease. The project is led by Dr. Janice Cooke at the University of Alberta (Biological Sciences) in collaboration with Dr. Rong-Cai Yang (Agricultural, Food and Nutritional Sciences/AAF), Dr. Todd Ramsfield (Canadian Forest Service), and Deogratias Rweyongeza and Andy Benowicz (FMB, AAF). The project involves data from seedling inoculations, genotyping and data from western gall rust infections in government and industry field trials. It is still in the initial stages of implementation; no results available at the moment.

Publications

Gray, L. K., Hamann, A., John, S., Rweyongeza, D., Barnhardt, L. and Thomas, B. R. 2016. Climate change risk management in tree improvement programs: selection and movement of genotypes. Tree Genetics & Genomes 12:23. DOI 10.1007/s11295-016-0983-1.

Forest Genetics Policy Development

AAF develops updates and administers the Forest Genetic Resource Management and Conservation Standards (FGRMS). These standards are the rules for managing genetic resources on public land with the aim of working with disposition holders to ensure adaptable, diverse and healthy forests and other woody plant communities that are productive for years to come. The standards were last amended in 2009.

Working with a broad range of stakeholders, amendments to FGRMS were developed and a revised and updated document was completed in 2015. This round of revisions to FGRMS is designed to provide clearer and expanded set of guidelines for managing genetic resources when using native trees and shrubs in reforestation and reclamation. A consultation period took place in the fall of 2015 and information sessions were held at two locations and comments were received. By the end of the year, AAF staff were working through the comments and evaluating whether further amendments to FGRMS are needed.

Invasive Plant Program

This program covers invasive plant species detection, survey and control on Crown land in the Green Area. Relatively large areas with either noxious or prohibited noxious invasive plants growing on Crown land are the main focus of this program. Early detection and rapid response (EDRR[1]) are integral for prompt mitigation of new or low-level invasive plant infestations found either on high value sites or on vacant Crown land.

The overall objectives of this program are to:

1. Fulfil obligations of any 'weed notices' issued by municipalities.
2. Early detection and rapid response to invasive plants in relatively clean and un-infested portions of vacant public land and priority areas[2] identified through regional land use framework initiatives.
3. Control isolated, small infestations[3] of high risk-plants on vacant public land.
4. Coordinate with willing occupants and/or agencies to cooperatively survey and control invasive plants within designated areas. Participate with internal and external stakeholders (e.g. education and outreach, data sharing).
5. Survey and control of invasive plants on AAF-occupied sites (e.g. towers, camps, bases).
6. Any of the above mentioned activities where results are achievable and measurable (e.g. low risk of re-infestation).

Invasive plant detection and distribution surveys

Approximately 1,476 ha were surveyed and 11 per cent of that area was found to be infested. The number of ha surveyed is likely underestimated due to regional differences in survey procedures. In total, 17 noxious and four prohibited noxious invasive plant species were recorded during surveys. Provincially 48 per cent of identified AAF-occupied sites were surveyed. The survey sites included AAF and Environment and Parks (EP) facilities such as cabins, campgrounds, wildfire bases and staging areas, and wildfire lookout sites. Surveys were also conducted on vacant Crown land and targeted random camp sites, abandoned forestry roads and quad trails. Table 8 contains a list of invasive plant species that were observed during ground surveys carried out at selected sites in the Green Area in 2015.

Invasive plant control

Management of invasive plants in the Green Area occurs annually. As resources are limited, infestations are prioritized according to provincial and AAF program objectives. Control of invasive plants is conducted by qualified in-house staff, contractors and through cooperative groups. In 2015, 74 per cent of the infested survey area was controlled. Four of the five FAs that conducted management activities controlled 100 per cent of all prohibited noxious infestations detected in 2015. Control efforts on these sites include hand-pulling, mowing and treatment with herbicide.

In the Rocky Mountain House FA, AAF and EP facilities were treated for invasive plants in the Blackstone, Hummingbird, Onion Lake Trail, Cut Off and Eagle campgrounds, staging areas, and cabins. Fly-in weed control was completed in the Blackstone Gap and in an outfitter camp along George Creek. The main camp west of Blackstone Basin was again heavily infested with

1 EDRR efforts will be directed towards small manageable infestations with a reasonable chance of eradication.
2 High priority plants are defined as an infestation of invasive plant species that are a high priority for containment. This category may include infestations that were previously considered EDRR but have become ineradicable.
3 Any point, line or polygon patch of invasive plants is considered an infestation.

Table 8. Invasive plant species observed during ground surveys carried out over selected sites in the Green Area in 2015.

Common Name	Scientific Name	Occurrence[1]
Blueweed	*Echium vulgare*	1
Bull thistle	*Cirsium vulgare*	1, 4
Lesser burdock	*Arctium minus*	1
Canada thistle	*Cirsium arvense*	1, 2, 3, 4, 5, 6, 7
Common mullein	*Verbascum thapsus*	1
Common tansy	*Tanacetum vulgare*	1, 2, 3, 4, 6, 7
Creeping bellflower	*Campanula rapunculoides*	4
Dalmatian toadflax	*Linaria dalmatica*	1
Downy brome	*Bromus tectorum*	1
Field bindweed	*Convolvulus arvensis*	1
Hound's tongue	*Cynoglossum officinale*	1
Marsh thistle[2]	*Cirsium palustre*	4
Meadow hawkweed[2]	*Hieracium caespitosum*	4, 5
Orange hawkweed[2]	*Hieracium aurantiacum*	1, 4, 7
Ox-eye daisy	*Leucanthemum vulgare*	1, 3, 5, 6, 7
Perennial sow thistle	*Sonchus arvensis*	1, 4, 5, 6
Scentless chamomile	*Tripleurospermum perforatum*	1, 4, 6, 7
Spotted knapweed[2]	*Centaurea maculosa*	1
Tall buttercup	*Rananculus acris*	1, 2, 3, 4, 5, 6, 7
Tall hawkweed[3]	*Hieracium piloselloides*	1, 2, 6
White cockle	*Silene latifolia Poiret ssp.*	4, 5, 6
Wild caraway[3]	*Carum carvi*	1, 5
Yellowdevil hawkweed[3]	*Hieracium glomeratum*	1
Yellow toadflax	*Linaria vulgaris*	1, 2, 5, 6

[1] Forest Area: 1. Calgary, 2. Edson, 3. Lac La Biche, 4. Grande Prairie, 5. Rocky Mountain House, 6. Slave Lake, 7. Whitecourt. These are the regions that did surveys in 2015. Note that surveys do not cover the entire expanse of the Forest Area and species not included on this list may be present in the area.

[2] Prohibited noxious weeds

[3] Species of concern

Ox-eye daisy

Common tansy

tall buttercup. A horse camp on the trail to Job Lake treated for tall buttercup in 2014 showed improvement in 2015.

In 2015, the Calgary FA contracted survey and control activity on lands in the Municipality of the Crowsnest Pass and the Municipal District (M.D.) of Pincher Creek. A contract agreement was drafted between AAF and the M.D. of Ranchland. Agricultural fieldman staff conducted invasive plant surveys, while Ranchland Weed Management LTD was contracted by the M.D. to conduct control work. The Castle Crown Wilderness Coalition (CCWC) to employ two full-time staff members to control invasive plants through hand pulling in the Castle area. In total, 326 garbage bags of invasive plants were removed from the area.

In an effort to prevent the establishment of new invasive plant species in the Calgary FA, nine species have been flagged for early detection and rapid response efforts. These species are either not yet present in this jurisdiction but infestations are known to occur nearby; are currently present at low densities; or, are highly invasive and damaging. Of these species, four were detected and controlled in 2015. These infestations of common tansy, field bindweed, scentless chamomile and spotted knapweed will be monitored in future years and any new growth controlled.

Invasive plant cooperatives

The cooperative program between AAF and Sundre Forest Products was maintained in the Williams Creek area in 2015. Tall buttercup and wild caraway are the main invasive plant species targeted through this cooperative program. There has been a significant decrease in the number of plants due in part to three consecutive years of herbicide application.

Biological control of invasive plants

The overall goal of biological control (biocontrol) is to reduce the size and density of invasive plant infestations for which conventional methods are not feasible (e.g. due to size of infestation, difficult access, ecosite characteristics). Biocontrol employs an integrated pest management approach to control a target species, in this case a weed, by taking advantage of its natural enemies in order to control the invasive species.

Hound's tongue, *Cynoglossum officinale*, has one approved biocontrol agent in Alberta: a stem-mining weevil, *Mogulones cruciger*. This is a very successful agent that can decimate a hound's tongue population. This agent was released in 2008 and 2009 in the south end of the Porcupine Hills. Monitoring in subsequent years found *M. cruciger* still present and the plant population greatly reduced. Four more releases of this agent were made in 2014; two in the Castle Special Management Area and two in the Porcupine Hills. Surveys conducted in 2015 confirmed that weevils are still present at these sites. Another release was made in the central region of the Porcupine Hills in 2015.

Scentless chamomile, *Tripleurospermum perforatum*, has two agents available for release in Alberta: a gall-forming midge, *Rhopalomyia tripleurosperm*, and a seedhead-eating weevil, *Omphalapion hookeri*. Both agents were deployed in 2013 at a site near Wandering River in the Lac La Biche FA. Monitoring in 2014 revealed that none of the galled plants which contained *R. tripleurosperm* had survived and this was likely due to the hot dry August in 2013. However, *O. hookeri* had dispersed throughout the chamomile patch and establishment was confirmed by their continued presence in 2015.These weevils were released at a site west of Whitecourt and an abundance of weevils were observed at the site during 2015 monitoring.

The stem-mining weevil, *Mecinus janthinus*, is used to control yellow toadflax, *Linaria vulgaris*. Attempts have been made to establish populations in southern Alberta but warm winter temperatures associated with chinooks have played havoc with the insect's ability to survive over winter. Small populations have become established in central Alberta. In an attempt to mass rear these insects, yellow toadflax plants were collected from the Castle Special Management Area near

Spotted knapweed

the Crowsnest Pass and insects collected from established sites spent the summer on plants in a rearing tent in Sundre. Female *M. janthinus* oviposit into the stems of toadflax and the larvae feed in the stems and then emerge as adults the next growing season. Stems infested with weevils were held in cold storage over winter but did not yield enough live adults for release in 2015. Another attempt was made to mass-rear *M. janthinus* in larger diameter toadflax stems in the summer of 2015.

Mecinus janthinus adults for release in 2015 were obtained from an external source. One release was made at a site in the Castle Special Management Area that should hold a snowpack throughout the winter and allow the insects to overwinter and establish a population. The second release of *M. janthinus* was made just north of Athabasca.

Rhinusa pilosa, a yellow toadflax stem-galling weevil, was approved for field release in 2014 and Agriculture and Agri-Food Canada is investigating habitat preferences in Alberta. Insects were offered to AAF for release in a more northerly location in 2015. These weevils were released in the spring just north of Athabasca. The site was checked later in the summer and more than 25 galls were found within one metre of the release stake. About 162 galls containing the yellow toadflax root-galling weevil, *Rhinusa linariae*, were received from British Columbia where this agent is established. The weevil has significantly reduced yellow toadflax in locations where it has been released. These insects will be reared in a field tent along with their host plant in 2016.

Education and increased awareness

Education and increased awareness is essential to prevent the introduction and establishment of invasive plants and AAF undertake a variety of activities to accomplish this goal.

The Northern Alberta Invasive Weeds Cooperative workshop was held in Slave Lake on June 4, 2015. Over 50 participants attended the workshop and represented industry, contractors, various levels of government and other users. Guest speakers presented a variety of topics which included biological control, the Alberta Weed Spotter application, invasive yellow hawkweed, and the prevention and control of weeds in forest operations.

AAF is an active participant on the Southwest Alberta Regional Working Group, which also includes several municipalities, Alberta Environment and Parks, Parks Canada, the Alberta Association of Agricultural Fieldmen and the Agricultural Services board. The working group hosts a workshop to assist land managers with invasive plant control, reclamation and monitoring, EDRR, as well as prevention. The workshop was held on April 23, 2015 in Pincher Creek and a total of 72 people attended.

The Yellowhead Invasive Plant Initiative involves AAF, Yellowhead County and Hinton Wood Products. This group meets annually to discuss plans to eradicate Hawkweed species and other invasive plants of concern. Priority areas are delineated and outreach programs are discussed.

A meeting was held with Alberta Energy Regulator staff in Red Deer, September, 2015. The purpose of the meeting was to offer assistance in identification of invasive plants, as well as issues around management of invasive plants. The benefits of communication with AAF staff regarding management and cooperative control by disposition holders in the Green Area was also discussed.

Other educational efforts were directed towards provincial government staff, Junior Forest Rangers and grade school students, and local recreation and special interest clubs.

Collaborative Programs

North American (*Lymantria dispar dispar*) and Asian gypsy moth (*L. dispar asiatica*) Detection Surveys

AAF cooperates in annual province-wide surveillance for both sub-species of gypsy moth. The survey is led by the Canadian Food Inspection Agency (CFIA) and conducted in cooperation with other provincial agencies. In 2015, 74 pheromone-baited traps were deployed throughout the Green Area by AAF staff. One North American gypsy moth was captured in a trap approximately 75 km south west of Fort McMurray and CFIA further confirmed the identity using DNA analysis. This location is 40 km south of the 2014 positive trap at Gregoire Lake Provincial Park.

As both sub-species of gypsy moth are invasive, the presence of one is a source of concern but there is no indication of damage attributed to either agent in Alberta. However due to huge economic impacts in other parts of North America, CFIA performs two years of intensive delimitation surveys (i.e. intensive grid sampling) around positive trap catch sites. The intensive grid survey conducted around Gregoire Lake Provincial Park in 2015 did not capture any further moths and the survey will be repeated in 2016.

Monitoring of climate impacts on the productivity and health of aspen

The purpose of the Climate Impacts on the Productivity and Health of Aspen (CIPHA) study is to detect interactions among climate, forest insects and diseases, and trembling aspen. This collaboration between the Canadian Forest Service (CFS), various provincial governments and industry in Canada established a network of monitoring nodes in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario and the Northwest Territories in 2000. Each node consists of three aspen stands; each stand contains two monitoring plots. Tree health assessments are conducted annually, while tree mensuration occurs every fifth year. More information concerning the CIPHA program, as well as links to related research and scientific publications related to this project can be found here.

In 2015, AAF staff monitored plots in seven of the nine nodes Fig. 21). Trees were assessed for percent defoliation, dieback, and foliage compliment, as well as signs and symptoms of pests.

Figure 21. Network of climate change impacts on the productivity and health of aspen nodes in Alberta.

Provincial 2015 CIPHA results

Submitted by Michael Michaelian, Forest Health Technician, Natural Resources Canada, Canadian Forest Service

Defoliation at the Alberta CIPHA sites decreased slightly in 2015 to an average of 9 per cent from 11 per cent in 2014. The Dunvegan site had the highest defoliation in 2015; 30 per cent of the aspen crown foliage was defoliated and although this was substantially less than the 85 per cent defoliation this site experienced in 2012 and 2013, 2015 marked the fourth consecutive year of defoliation. The remaining CIPHA sites, on average, showed a slight reduction or stabilization in defoliation. Most of the defoliation across the province was caused by the forest tent caterpillar which first appeared at CIPHA sites in 2011.

The incidence of the two most common decay fungi encountered at the CIPHA sites, *Phellinus tremulae* and *Peniophora polygonia*, has remained relatively stable over the last 16 years. *Phellinus*, which is twice as common in the parkland than in the boreal ecozone, has shown a slow but steady increase since the beginning of the CIPHA program in 2000. By 2015, almost 19 per cent of live aspen trees in the parkland were infected with *Phellinus*. The steady increase was largely expected since incidence of *Phellinus* is related to tree age. *Peniophora*, which is four times more common in the boreal than parkland ecozone, decreased slightly in both the boreal and parkland forests. In 2015, approximately 12 per cent of live aspen trees in the boreal and 3 per cent of those in the parkland were infected with *Peniophora*. The other fungal pathogens common to the CIPHA sites include the canker fungi *Cytospora chrysosperma* and *Entoleuca mammata* (commonly known as hypoxylon canker). Unlike *Phellinus* and *Peniophora*, these two fungi often cause tree death. Combined, these two fungi caused cankers on approximately 5 per cent of all live trees but were present on approximately 30 per cent of trees that had died since last year.

Photographs of the four most common borers are provided in Figure 22. The overall incidence of wood borers has increased marginally for the last four years. The combined incidence of the poplar borer (*Saperda calcarata*), bronze poplar borer (*Agrilus liragus*), ambrosia beetle (*Trypodendron retusum*), and the flatheaded borer (*Dicerca* spp.) rose to 47 per cent of all live parkland trees from 42 per cent last year. In the boreal there was a slight decrease in wood borer incidence to 21 per cent from 23 per cent last year. Although these numbers seem high, aspen can often survive borer attack, especially from *Saperda*, while the damage caused by borers remains visible for many years. Surviving trees with signs of old borer activity are included in these incidence figures and this may, in part, be the reason why the most commonly recorded borer was *Saperda*.

Moisture is crucial to aspen growth and the lack of moisture is a strong determinant of tree mortality. After the relatively moist conditions in 2014, the 2015 moisture levels, as measured by the Climate Moisture Index (CMI = precipitation – potential evapotranspiration, as cm water/year), dropped significantly to the third lowest levels recorded since the start of the CIPHA program in 2000 and were significantly lower than the 30 year average of 1961-1990 (Fig. 23). The drop in moisture was larger in the parkland than in

Figure 22. Common aspen wood borers noted during Climate Change Impacts on Productivity and Health of Aspen health assessments. Clockwise from top left: *Agrilus liragus*, *Dicerca* spp., *Trypodendron retusum* and *Saperda calcarata*.

the boreal. Water balance at the parkland sites dropped from an average of 5 cm in 2014 to -13 cm in 2015 while moisture at the boreal sites dropped from 13 cm to 4 cm. Although these drops were significant, the severe drought of 2002, as a comparison, resulted in moisture balances of -24 and 3 cm for the parkland and boreal sites respectively.

The severity of the 2002 drought was unprecedented for at least the last 50 years and aspen mortality across many CIPHA sites began to rise a number of years following the drought. During the peak, biomass losses due to mortality were actually greater than the gains due to growth, which led to a net loss of biomass from aspen stands across western Canada. The slow return to “normal” rates of mortality implies that the effect of future drought is likely to persist long after the drought event itself.

Most of the CIPHA sites across the prairies follow this pattern of a decrease in mortality following a peak in the mid to late 2000s. However, regional defoliation and persistent dry conditions in many parts of Alberta since 2010 have led to higher than normal mortality rates at some sites. The annual rate of tree mortality at the Alberta CIPHA parkland sites doubled from 5 per cent in 2014 to 10 per cent in 2015. This increase, in large part, was due to the dramatic increase of mortality (29 per cent) at a single site, the Dunvegan site. Dunvegan has experienced not only high levels of defoliation over the last four years but also low moisture levels over the last two years. Conversely, mortality at the CIPHA boreal sites dropped slightly from 6 per cent in 2014 to 4 per cent in 2015. As a comparison, based on our analysis of sites across the CIPHA network, healthy sites without drought and without defoliation usually experience an annual mortality rate of about 2 per cent.

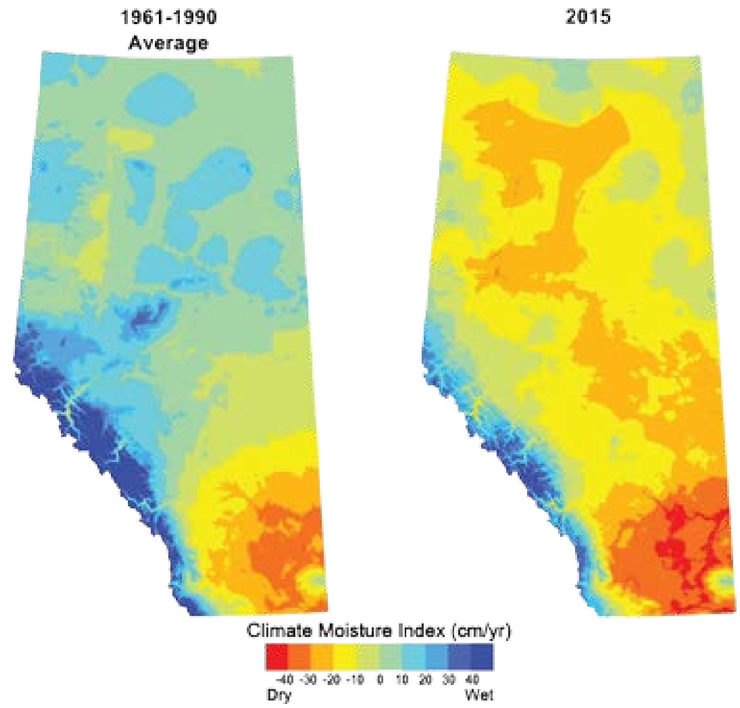


Figure 23. Comparison of the 2015 climate moisture index with the average 1961 to 1990 climate moisture index.

The 2015 CIPHA assessments reveal that three sites will be of special interest in the next few years. The Notikewin site experienced a relatively strong drought for the last four years and mortality more than doubled this year to 10 per cent. We can expect a relatively high level of mortality at this site over the next few years. The second site of interest, Dunvegan, in 2015 experienced one of highest levels of mortality, 28 per cent, ever recorded at a CIPHA site. The lingering effects of previous defoliation and low moisture levels will mean that this site is likely to experience continued high mortality next year. The third site of interest is Red Earth which had a mortality rate of 6 per cent in 2015. Although defoliation dropped this year, moisture was the lowest recorded at this site since the CIPHA program began in 2000. This is another site that may experience high mortality in 2016.

Although there are many biotic and abiotic factors and interactions of factors affecting aspen forest health, the 2015 CIPHA results demonstrate the importance of both defoliation and drought on tree mortality. These two factors, more than any others, account for the majority of aspen mortality. Mortality due to defoliation tends to be localized to specific areas of defoliator infestations while mortality due to drought is much more widespread, reflecting the scales of the underlying processes. Defoliation and drought not only affect mortality, they also affect growth. 2016 is a major re-measurement year for the CIPHA program. Forest mensuration will be conducted at each CIPHA site this coming summer. These data will help not only to determine the effects of defoliation and drought on growth but also the net biomass and carbon balance of trembling aspen stands across Alberta and the rest of the CIPHA study area.

Gene conservation

Whitebark and limber pine

Both whitebark (*Pinus albicaulis*) and limber pine (*Pinus flexilis*) are listed as endangered species in Alberta under the *Wildlife Act*. Whitebark pine is also listed as federally endangered under the *Species at Risk Act* and limber pine has been recommended for endangered status by Committee on the Status of Endangered Wildlife in Canada.

Four causes of decline have been identified:

- the alien invasive fungus causing white pine blister rust kills trees and seedlings;
- MPB infestations in cone-bearing trees;
- changes in wildfire regimes kill trees and reduce habitat suitability for regeneration; and
- climate change related reductions in suitable habitat, increased competition and mortality caused by shade tolerant species, insects and pathogens.

Recovery plans for both species were completed in 2014 and can be found on this website. Urgent action items within these plans were identified and have been implemented by the provincial recovery team. Building on the foundation of previous years, collaboration has been essential to success. AAF staff have supported provincial and federal government agencies in Alberta, Canada and the United States, as well as faculty and students from The Kings University and the University of British Columbia in numerous projects.

Range-wide predictive and detailed mapping has been completed for both species and consolidates existing field data and habitat information. This data will be used to effectively allocate resources for recovery and management activities, and for the identification of projects that may affect these species at risk. Field survey data will be consolidated and submitted for inclusion in the provincial endangered species reporting and tracking database. The data will also be given to the Whitebark Pine Ecosystem Foundation to support range-wide mapping. The locations of high value rust-resistant trees will be shared with the provincial wildfire program to enable their protection during fire management and suppression activities.

Parks Canada and AAF staff have been trained to identify and collect seed from valuable rust resistant trees, as well as to document tree and stand status. Seed has been collected from 84 limber pines putatively resistant to white pine blister rust and will be tested for disease resistance by the United States Department of Agriculture (USDA). Scions

Forest tent caterpillar

Whitebark pine

taken from whitebark pine trees in southwestern Alberta have also been sent to the USDA for disease resistance testing.

Other efforts have been directed towards increasing public awareness of these endangered species and recovery actions through the development and revision of extension tools. Alberta has been able to share its successes with other agencies across the species' range by liaising with the Whitebark Pine Ecosystem Foundation of Canada, the Crown Managers Partnership, and other organizations. Finally, the recovery team is drafting a framework to standardize the provincial approach in order to avoid, minimize, mitigate, compensate, or offset impacts to whitebark and limber pine ecosystems from proposed development.

Forest gene conservation

In 2009 Alberta published the *Gene Conservation Plan for Native Trees* of Alberta addressing conservation status and priorities for 28 native trees in their natural habitat, or in situ. This document highlights genetic diversity as a foundation of biodiversity, containing the basic ingredients for adaptation and evolution as the environment changes over time. Revisions are underway to reflect changes and updates and a revised edition is expected in 2016 or 2017. To complement that plan, a strategy for conserving provincial genetic resources ex situ, or outside of their native habitat, has been drafted and is planned for release at the same time. Ex situ conservation consists of seed banking, clone archives, cryopreserving tissues, arboreta, research trials, and seed orchards.

Alberta also plays a key role nationally and internationally in supporting forest gene conservation. We are participants in the Canadian program for conservation of forest genetic resources (CONFORGEN), which collates data and produces national reports that are included in the State of the World's Forest Genetic Resources reports for international agencies. CONFORGEN also reports to the Canadian Council of Forest Ministers to guide national policy, indicator development, and status reporting on sustainable forest management.

Limber pine

Terrestrial Environmental Effects Monitoring program of Wood Buffalo Environmental Association.

As part of an ongoing commitment, AAF staff assisted with forest condition surveys at approximately 40 pine sites for the Wood Buffalo Environmental Association's (WBEA) Terrestrial Environmental Effects Monitoring (TEEM) program. This is a multi-stakeholder, not-for-profit organization that conducts air quality and terrestrial monitoring, largely in the Regional Municipality of Wood Buffalo. The TEEM program measures the effects of oil sands emissions on natural ecosystems. Forest health monitoring is used to quantify the relationship between air emissions and the occurrence of forest damage agents.

In July, AAF and WBEA staff conducted assessments of TEEM sites. The surveys consist of tree condition assessments of cone production, crown condition (i.e. needle condition and retention), woody tissue damage, as well as insects and diseases in jack pine.

Increased Awareness and Training

Forest Health and Adaptation newsletter

In 2015, the Forest Health and Adaptation program published three issues of the Bugs and Diseases newsletter. These three publications included a wide range of forest health topics. Visit this website to access the most recent and archived issues of the newsletter.

Forest Health 100

This course is held every second year and is designed for forest industry professionals responsible for managing forests through the development, review, and implementation of forest and land management plans. It is also applicable to municipal government staff, natural resource professionals, or other individuals interested in the identification of forest health damage agents and their management.

The three-day course consisted of a combination of classroom lectures, presentations, and field tours. The purpose of the course was to show participants how to recognize and understand forest health issues as well as the best practices available to deal with them. A record 31 participants completed the course in 2015.

Forest health damage agent identification training

AAF staff provided a one-day training session for Foothills Growth and Yield association crews. This session was focused on the identification of damage agents typically encountered in young stands. Staff also led a NAIT forestry field tour to introduce students to insect pests and diseases commonly found in the forests of the Foothills.

Aerial survey training

An aerial survey training course for AAF staff was held in Slave Lake in 2015. The course objective was to educate new staff and to ensure consistency in survey methods and damage agent calls. The two-day course consisted of classroom instruction the first day and a second day of practical instruction while flying in the boreal forest.

Collaboration, community and industry outreach

Owners of private land frequently contact AAF staff regarding the health of trees on their property. Staff assist the home owner to identify the damage agent(s) contributing to the decline in tree health and often visit the property to diagnose the issue.

AAF staff participate in community outreach events sponsored by AAF, Alberta Environment and Parks, as well as those organized by special interest groups and schools. Activities performed by staff range from manning information booths to giving detailed public presentations. The presence of AAF staff at these events helps to increase awareness about forest health damage agents and the role of AAF in monitoring and managing the health of Alberta forests.