Alberta Biodiversity
Monitoring Institute

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Monitoring Activity Report: Lower Athabasca Planning Region 2012 Season

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EXECUTIVE SUMMARY

The Alberta Biodiversity Monitoring Institute (ABMI) reports on the status of biodiversity, habitat, and human footprint across the province using scientifically credible indicators of environmental health. The ABMI monitors a network of 1656 terrestrial and wetland sites evenly spaced across the province, and also develops remote sensing products that provide data on land cover and land use throughout the province.

This report summarizes the ABMI's activities in the Lower Athabasca Planning Region (LAPR) for the 2012 operational year (April 2012-March 2013). The report includes: an overview of the ABMI's provincial program including the annual cycle of field operations; a summary of data collected by the ABMI; an outline of field methodologies; a summary of monitoring activities for both the province and the LAPR in 2012; and highlights of the species and remote sensing data collected. Finally, the report provides an overview of work accomplished thus far in 2013, and the ABMI's plans for future work in the LAPR in 2014 and beyond.

The ABMI is working to increase field activities across Alberta, with the goal to monitor the entire province once every five years. The ABMI's field activities continue to grow, with field activities increasing by more than 20% from 2011 to 2012. In 2012, the ABMI monitored 171 terrestrial sites and 147 wetland sites province wide. Most monitoring sites for 2012 were located in the Lower Athabasca, Lower Peace and South Saskatchewan Planning Regions. The ABMI also conducted winter tracking at 128 sites throughout the province.

The LAPR represents 14 % of the province of Alberta and was a focal point of ABMI field activity in 2012, with 38% of field activity located in the region. In 2012, 61 different spring and summer terrestrial sites, 52 wetland sites, and 62 winter tracking sites were located in the LAPR with crews operating out of Fort Chipewyan, Fort McMurray, Conklin and Fort Smith. The majority of the LAPR lies within the Boreal Plains Ecozone (BPE) which covers 58% of Alberta. In 2012, 50% of ABMI's monitoring activity occurred in the BPE, significantly contributing to the interpretation of data collected in the LAPR.

A summary of the species data collected in 2012 shows that the ABMI recorded more than 700 species of birds, plants, mosses, and soil mites at the terrestrial monitoring sites in the LAPR, and almost 500 species of plants, aquatic invertebrates and vertebrates at the LAPR wetland sites. These observations contribute to a comprehensive assessment of the current status of biodiversity in the region, to which future biodiversity can be compared. On average, field crews detected 27 bird species at terrestrial sites and 37 vascular plant species at wetland sites in the LAPR. 494 vascular plant species have been found at terrestrial sites in the LAPR by the ABMI, 326 of those in 2012; this added more than 50 new terrestrial site species in 2012. Similarly, in wetlands the ABMI has found 405 vascular plant species, 282 in 2012, increasing the number of species found in the region by nearly 70 compared to 2011. Repeated monitoring using consistent protocols will enable comparisons of this year's results with future

trends in the distribution and abundance of plants and other species in the LAPR relative to other regions of Alberta.

In 2013, the ABMI monitored 192 terrestrial sites and 174 wetland sites across the province. In the LAPR, 34 terrestrial sites and 26 wetland sites were monitored, decreasing core field activity in the area as Rotation 1 nears completion; results are currently being compiled and reviewed. The ABMI is planning for 84 winter mammal transects in the LAPR from December 2013-March 2014.

The ABMI supported the Ecological Monitoring Committee for the Lower Athabasca in piloting two new field projects in in the LAPR focusing on rare species. The first project is focused on monitoring owls, amphibians, and the Yellow Rail - species that are not currently being monitored under the ABMI's core protocols - using automated recorders. The second project is exploring an adaptive sampling approach to locate areas in the LAPR with rare plant populations using predictive habitat models. The rare animal pilot had 29 study areas in 2012, while the rare plant pilot sampled at 150 fens and upland forest sites.

Contingent upon full funding, the ABMI intends to continue 'ramping up' the monitoring program across the province. Currently monitoring in the LAPR has reached full capacity, which means that all 235 sites in the LAPR are on schedule to be monitored every five years. The ABMI will complete the first rotation of all 235 ABMI and begin the second round of monitoring in 2015.

INTRODUCTION

The ABMI

The Alberta Biodiversity Monitoring Institute (ABMI) is an arm's-length, not-for-profit scientific organization. The business of the ABMI is to monitor and report on the status (current condition) and trends of Alberta's species, habitat, and human footprint[1]. The goal of the ABMI is to provide relevant scientific information on the state of Alberta's biodiversity to support natural resource and land-use decision-making in the province.

The ABMI is jointly delivered by Alberta Innovates Technology Futures, the Royal Alberta Museum, the University of Alberta, and the University of Calgary. The ABMI Board of Directors includes representatives from the Government of Alberta, environmental non-governmental organizations, the forest, energy and agriculture sectors, and the research community.

The ABMI reports on a range of biodiversity indicators that act as a guide for establishing biodiversity-related management goals and tracking performance against those goals. Notwithstanding, the ABMI is not a management agency and does not make management recommendations. The ABMI generates value-neutral, independent, publically accessible data, and presents knowledge derived from the data in a value-neutral format.

The ABMI is guided by a core set of principles – we are independent, objective, credible, accessible, transparent, and relevant.

Financial support for the Institute comes from Alberta's major natural resource managers and users including: the Government of Alberta, the Government of Canada, the energy sector, the forest sector, and others. Thus far, the financial support received has allowed the ABMI to monitor up to roughly 100 sites per year. Since 2010, increased funding has allowed a large increase in monitoring activities in targeted areas of the province. Discussions to develop a long-term, sustainable funding plan for the full implementation of the ABMI program are ongoing.

ABMI's data is publically available to anyone who wants to use it through the website at www.abmi.ca, in the 'Raw Data' section. The ABMI also periodically releases reports, which include analyses of ABMI data that provide status, trend, and intactness information for species and groups of species, as well as findings on habitat and human footprint. See "Further Reading" at the end of this report.

History of the Institute

In order to promote the responsible management of Alberta's biodiversity, a number of public and private organizations came together to establish the ABMI. The ABMI was initiated in 1997 and developed in three phases: conceptual design (1997 to 2002), prototype proof-of-concept

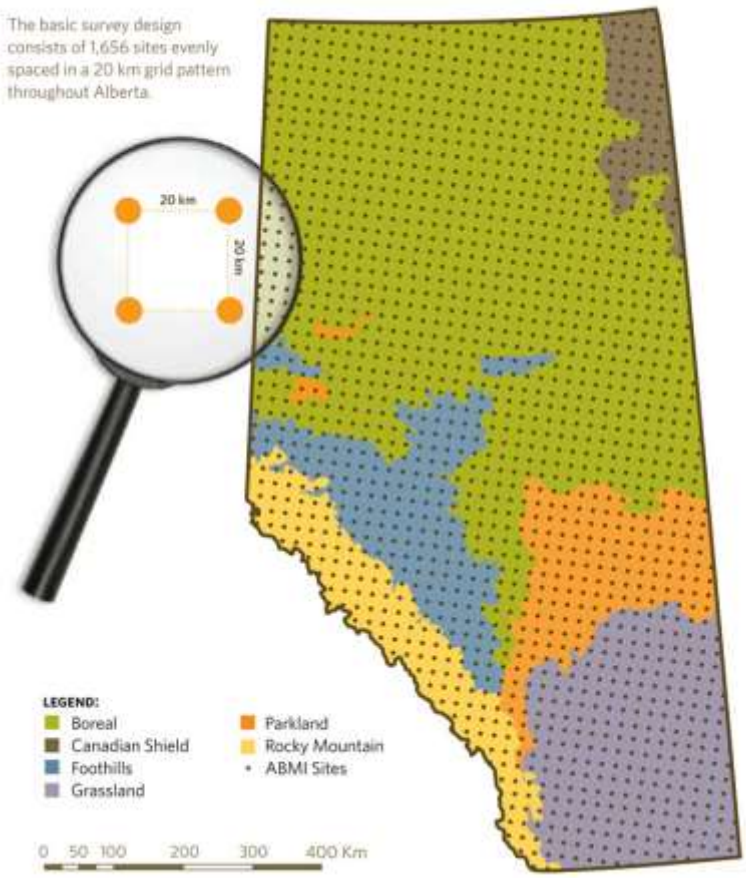
[1] The ABMI defines "human footprint" as the visible conversion of native ecosystems to temporary or permanent residential, recreational, agricultural, or industrial landscapes.

(2003-2006), and operational implementation (2007 and beyond). The purpose of the Prototype Phase was to turn a scientifically credible monitoring design into a cost-effective, relevant, and proven program. The operational phase of the Institute was successfully launched in 2007, beginning Rotation One. Today, the ABMI continues the ramp-up of monitoring activities while working with stakeholders on the application of biodiversity knowledge to decision-making and management.

How the ABMI works

The ABMI monitors biodiversity by sampling 1656 permanent sites distributed evenly across Alberta. Sites are spaced roughly 20 km apart (Figure 1). Each of the 1656 monitoring sites has both a terrestrial and a wetland survey site, which are physically separate, but occur within the same 20 km area.

Figure 1 **ABMI Survey Locations**



At full operational capacity, each wetland and terrestrial site will be surveyed once every five years. Therefore, approximately 330 wetland and terrestrial sites would be surveyed each and every year. Once all 1656 sites are surveyed (Rotation One), repeat visits to each site will begin (Rotation Two). Due to current funding constraints, the ABMI currently runs at less than full operational capacity. From 2007 to 2012 (Rotation One, in progress), the ABMI surveyed 599

terrestrial sites, 520 terrestrial winter snow tracking sites and 588 wetland sites, generally targeted to specific areas of the province, including the northeast and the south.

For operational efficiency, sites are surveyed in clusters of nine. This is time and cost-efficient because one crew is sent out to survey all nine sites at the same time (normally a ten-day shift), rather than sending crews out randomly across the province targeting single sites. Each block of sites is assigned to one of five 'panels' (A through E), staggered throughout the province (Figure 2). The panel design reduces costs and increases efficiency, while still ensuring that data are collected in a statistically rigorous fashion.

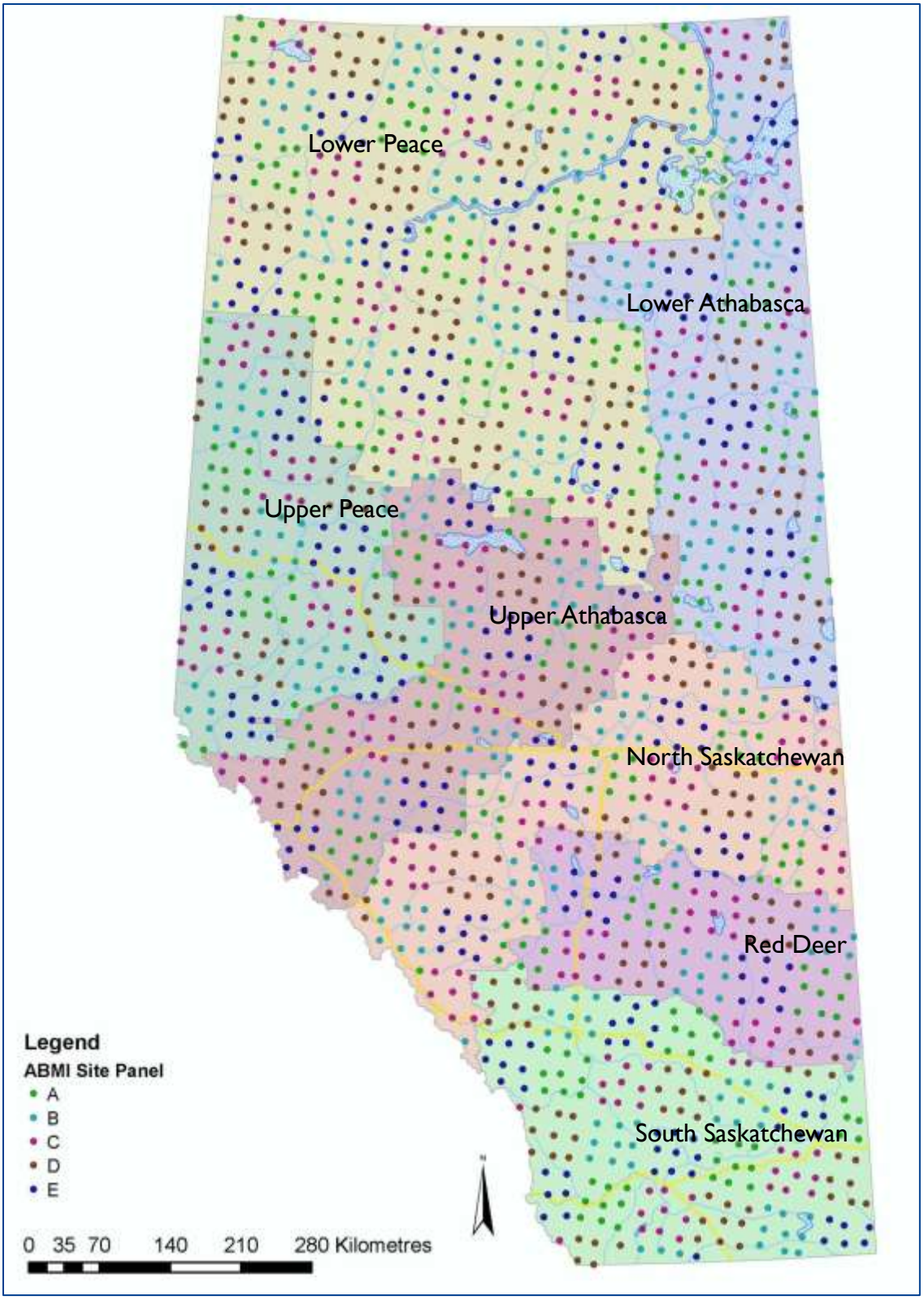


***Figure 2**: ABMI sites, divided by Planning Region and showing the panel design (Panels A through E) and blocks of nine sites.*

Terrestrial and Wetland Survey Sites

The ABMI's survey sites are based on the National Forest Inventory (NFI)'s 20 km systematic grid across the entire province (see www.nfi.nfis.org). ABMI's terrestrial sites are randomly offset from the NFI site by up to 5.5 km in any direction, so are roughly 20 km apart (Figure 2). Since the position of ABMI's terrestrial survey sites is random, habitats are sampled in proportion to their occurrence on the landscape. This means that ABMI's terrestrial monitoring sites exist in cities, public and private lands, industrial installations, protected areas, and sometimes even in lakes. When the terrestrial site lands fully in water, the site is not visited. However, if it is near to the shoreline, the site is surveyed, conducting as many of the protocols as possible. Winter protocols are conducted along transects that are placed as close to the NFI sites as possible (see below).

Wetland survey sites are selected from among the wetlands that are within 10 km of the NFI grid site. The ABMI has specific criteria that it uses to select wetlands suitable for long-term monitoring (see Appendix 2 for details). The ABMI's wetland selection criteria do not exclude human created or modified wetlands.

The Lower Athabasca Planning Region (LAPR)

Alberta's *Land Stewardship Act* (2009) divides the province into seven planning regions (see Figure 2), one of which is the Lower Athabasca Planning Region (LAPR). The LAPR is located in the northeast corner of Alberta, and contains two natural regions (Boreal and Canadian Shield).

The LAPR has large tracts of undeveloped land but also has substantial economic development. The southern area has been developed for agriculture, there are significant forestry resources, and the region includes most of Alberta's bitumen deposits, including almost all of the Athabasca deposit and much of the Cold Lake deposit. Rapid expansion of oil sands development has led to concerns about managing cumulative effects from all sources of economic development, and for this reason, the LAPR was the first of the province's seven regions to have a Regional Plan developed.

ABMI monitors 235 sites across the LAPR, located on private land, crown land, and in protected areas (Figure 3; Table 1). Since much of the northern part of the region is inaccessible by road, and sites must be accessed by helicopter, the LAPR is one of the most expensive parts of the province to monitor.

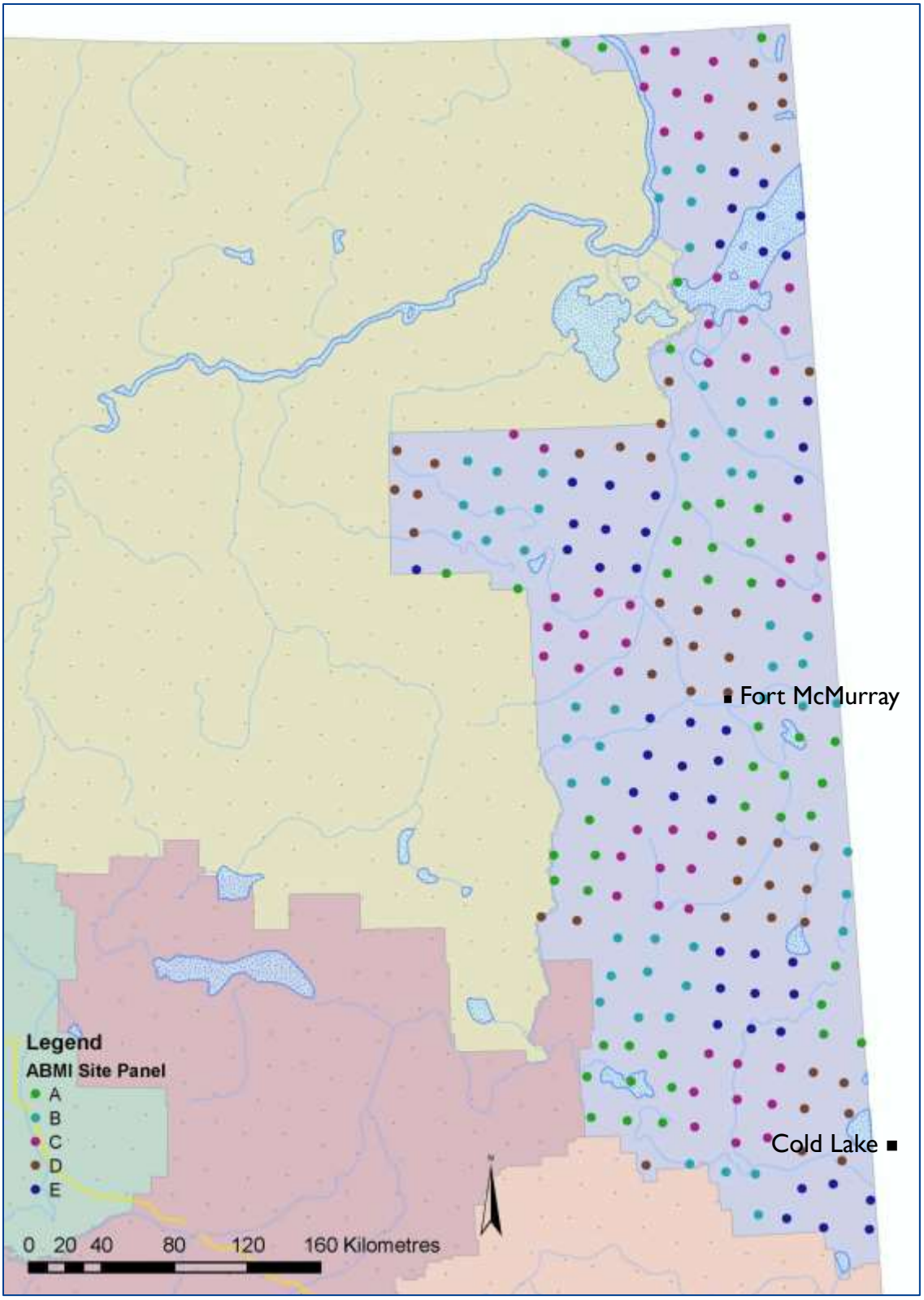


Figure 3: *Map of the LAPR showing all 235 ABMI sites, and their respective panels (A through E; also see Table 1).*

Table 1: *ABMI sites in the LAPR. Shows the number of sites per panel and progress to date (2003-2012).*

Panels	# LAPR Sites	Sites Completed (2003-2012)		
		Terrestrial	Wetland	Winter
Panel A	43*	39	39	39
Panel B	52	52	52	49
Panel C	51*	47	46	42
Panel D	44*	13	8	13
Panel E	45*	8	0	12
Total	**235**	**159**	**145**	**155**

* ABMI is working with government to gain access to sites in the Cold Lake Air Weapons Range. (Number of sites per panel affected by the CLAWR: A= 4, B=0, C=2, D=3, E=6)

Public Access to ABMI Data

ABMI data collected in 2012 is available for download from the ABMI's website at www.abmi.ca. Data is downloaded as a series of .csv files (in zip format) and can be queried by year, geographic area, and/or data type (e.g. specific species, terrestrial habitat data, wetland habitat data).

All species or habitat data that is downloaded is accompanied by relevant contextual data, and a PDF document that provides background information for understanding the data. This includes a summary of the data collection methods and a comprehensive set of metadata that explains the variables and codes found in the dataset.

For example, when breeding bird data is downloaded from the ABMI website, the user receives a set of ten files that includes the data's PDF summary document and nine .csv files: one with the bird observation data, and eight files that include relevant ecological and physical data (e.g. site physical characteristics, human and natural disturbance, surface substrate, ground cover, site suitability, and site capability) that may be useful for data analysis and interpretation.

METHODS: WHAT DATA DOES THE ABMI COLLECT?

Alberta is home to more than 80,000 species including plants, animals, arthropods, bacteria, fungi, and algae. The ABMI's monitoring system tracks changes in a wide range of species, representing a diversity of wildlife from both terrestrial and aquatic ecosystems (Table 2).

In addition to measuring the state of species, the ABMI also tracks changes in habitat structure and composition at two scales: locally using field measurements, and remotely using aerial and satellite imagery. The outcome is a program that monitors change in species, habitats, and human land use activities.

Table 2: *Species and Habitats Monitored by the ABMI*

SPECIES	HABITATS	FOOTPRINT
Terrestrial Species:	**Terrestrial Habitat:**	**Human Footprint:**
• Winter Mammals	• Physical and Ecological Characteristics	• Urbanization
• Birds	• Trees, Snags, and Downed Woody Material	• Agricultural Footprint
• Vascular Plants	• Habitat Structure	• Forestry Footprint
• Bryophytes (mosses and liverworts)	**Wetland Habitat:**	• Energy Footprint
• Lichens	• Wetland Shape, Size and Depth	• Linear Features
• Soil Mites	• Water Physiochemistry	
Wetland Species:	**Landscape Habitat:**	
• Birds and Mammals	• Percent Composition of Habitat Types	
• Vascular Plants	• Diversity of Habitat Types	
• Invertebrates	• Patch Size Distribution	
• Fish**		

** The ABMI plans to collect data on fish in lakes, rivers, and streams as part of a joint program with ASRD and the Alberta Conservation Association, as funding becomes available.

Data Collection

All ABMI data is collected by two-person crews for safety reasons, and because the varied protocols require technicians with different skill sets. Crews travel to monitoring sites by helicopter, truck, quad, or on foot. For remote sites (e.g. helicopter access), crews will camp near the site, whereas for non-remote sites, crews will stay in trailers, housing provided by ABMI partners, or occasionally hotels that are located near the block of nine sites that they are monitoring.

All field technicians have training in biology and/or environmental science. Most technicians have completed at least a bachelor's degree, but in some cases they may be pursuing their degree at the time they work for ABMI, or they may hold a diploma. All technicians have some

prior experience with biological fieldwork, and one technician in each two-person crew must have strong plant identification skills. Technicians are hired in the spring, and begin work in early May. They undergo several weeks of training on safety and specific ABMI protocols prior to beginning data collection.

The ABMI first piloted the use of tablets for field data collection in 2011. Electronic data collection will reduce the amount of time it takes to process data after it is collected and reduce errors or inconsistencies that can be introduced into the data during data entry. In 2012 all terrestrial field crews used tablets for data entry, and wetland tablet data collection was piloted.

Annual Cycle of Field Operations

Since the ABMI monitors such a diversity of species and habitat characteristics, multiple field visits are necessary to collect all of the data. In the year that they are monitored, terrestrial sites require two visits for data collection, and wetland sites require one data collection trip. The winter tracking transect site is visited once. Aerial photographs are flown over each ABMI site during the year that it is surveyed (Figure 4).

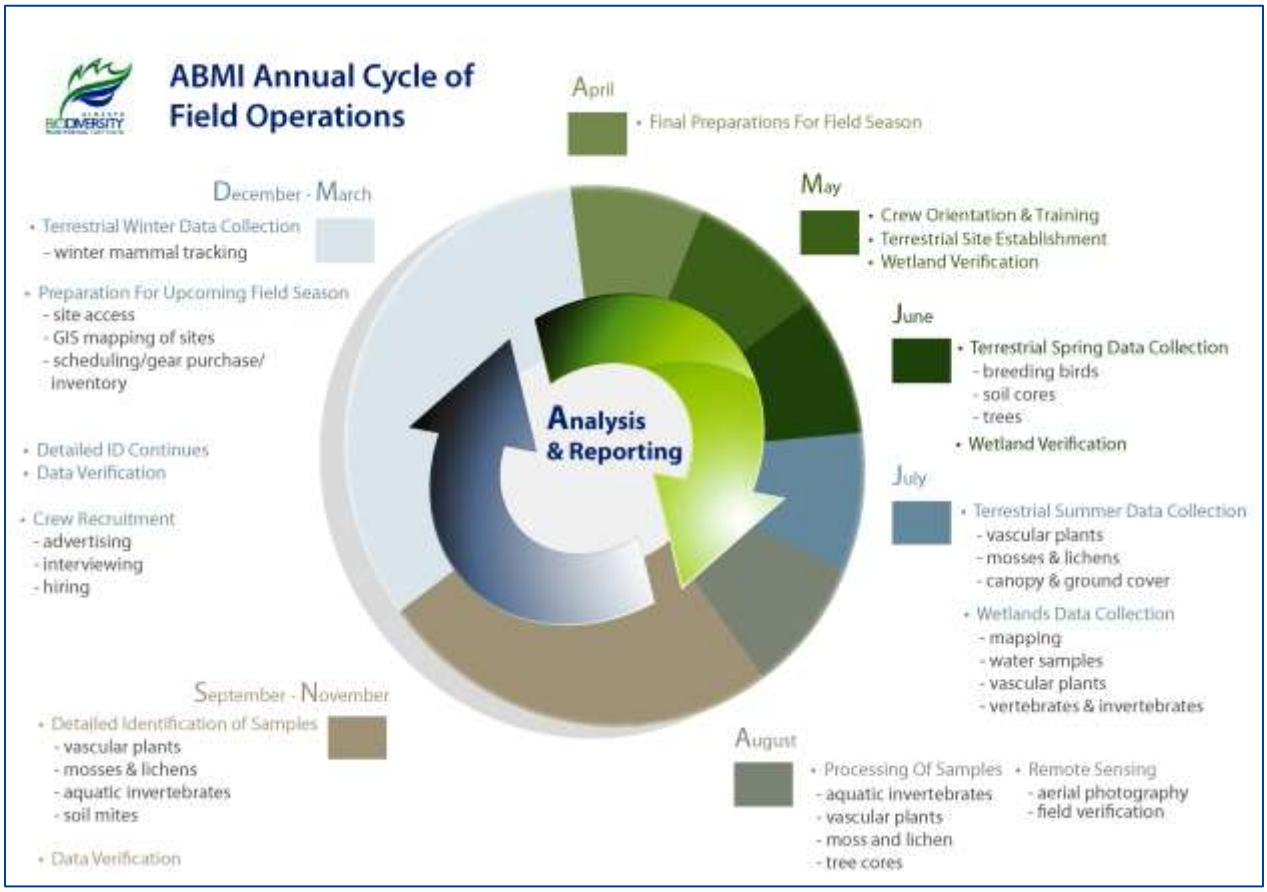


Figure 4: *A schematic representation of the ABMI's annual cycle of field operations*

Terrestrial Protocols - Spring
Starting in mid to late May and through June, the ABMI implements spring protocols at the terrestrial sites to be surveyed that year. At this time, the ABMI collects data on:

- Breeding birds
- Soil cores (mineral and LFH soil; soil arthropods - springtails and mites)
- Trees, snags, and stumps
- Downed woody materials
- Site photographs
- Incidental species

A two-person crew accesses the site using directions provided from site establishment. In spring, the crew arrives at the site very early in the morning, in order to record songbirds for the breeding birds protocol. For non-remote sites, the crew will travel from a central camping spot that morning. At remote sites, the crew will generally have camped within 500 m of the site the night before. Normally, one technician will conduct the breeding birds protocol while the other technician begins the other protocols.

Terrestrial Protocols – Summer
Starting at the end of June through the end of July, the ABMI implements summer terrestrial data collection protocols at each site to measure:

- Vascular plants
- Bryophytes (mosses and liverworts) and Lichens
- Tree ages
- Shrub and canopy cover
- Surface substrate
- Incidental species (same protocol as spring)

Normally, the same crew that monitored the site in spring will return for summer protocols, using the same means of access. In each crew, one technician will have specialized skills and training in identification of vascular plants and will carry out this protocol, while also collecting shrub cover data. The other technician will collect tree age, canopy cover, and surface substrate data. Bryophyte and lichen data are collected at the same time, with one technician collecting bryophytes and the other lichen (consistent for the whole summer).

Terrestrial Protocols – Winter Mammals
The ABMI surveys mammals using snow-tracking surveys. Surveys are designed to detect tracks of mid to large sized mammals. All surveys take place between December 1 and March 31 when there is sufficient snow on the ground to accurately identify mammal tracks. In general, the ABMI strives to snow track the same sites that were surveyed the previous summer, but this is sometimes difficult as snow conditions are often not suitable for tracking.

Wetland Protocols
The ABMI surveys wetlands from late June through to the end of July. During wetland surveys, the ABMI collects data on:

- Vertebrate species
- Wetland physical characteristics (photographs, shoreline sketch and shoreline characteristics, bathymetric map)
- Water physiochemistry and nutrients
- Aquatic invertebrates
- Vascular plants
- Incidental species (using the same protocol as terrestrial sites)

All surveys are conducted by two-person crews. Similar to terrestrial crews, one technician will have specialized training in the identification of vascular plants, and completes this protocol. The other technician completes all remaining protocols.

A description of the Terrestrial and Wetland protocols can be found in Appendix 1. Full protocols are available on the ABMI's website (www.abmi.ca) in the 'Reports' section.

Remote Sensing

In addition to 'in the field' data collection, the ABMI runs an advanced remote sensing program for the province of Alberta. The ABMI Remote Sensing Group researches, develops and implements methods to derive information on habitat and human footprint from remote sensing imagery. This is done at two levels. First, the ABMI develops a fine-resolution, detailed inventory of existing human footprint, vegetation, land, and water features for 3 by 7 km rectangles surrounding each of the 1656 field sites using softcopy interpretation of aerial photography. Second, at a coarser spatial resolution, existing satellite imagery is used to produce and update a wall-to-wall land cover map of the entire province, therefore allowing the ABMI to report on status and changes in land use and vegetation across Alberta.

3 x 7 km Plots

The ABMI collects aerial photographs over all 1656 field sites to derive detailed information on land use and vegetation from a systematic sample of Alberta (roughly 4% of Alberta is sampled).

Aerial photographs are 3 x 7 km in area, and produced at a high-resolution scale (between 1:30000 and 1:50000). The digital images are hand-interpreted by members of the ABMI's Remote Sensing Group or by qualified contractors who collect data on:

- Vegetation. This includes information of the type of vegetation present (including species), height of vegetation layers (canopy, and when possible shrub and ground cover), density of vegetation, and age (using decadal classes, but supplemented with information on fires).
- Land Use. This includes information on the management status of a given piece of land, as well as a general classification (forestry, agriculture, transportation, etc.), detailed information on the type of land use (type of crop, road surface etc.), and the intensity.

Aerial photographs are flown from July into mid-September, when trees are in full leaf. Ideally, aerial photographs are taken in the same summer that the site is monitored (e.g. all Panel A sites are field monitored and photographed the same summer), but because of funding constraints, they are currently often collected within two years.

Wall-to-wall Products

In addition to the detailed aerial photography at individual ABMI sites, the ABMI also produces province-wide remote sensing products referred to as the wall-to-wall mapping products that include human footprint and vegetation data.

The ABMI uses satellite images and base layers provided by the Government of Alberta as the starting point for this product. Human footprint on the government layers mostly focuses on linear features (e.g. roads, pipelines), cut blocks, and well pads. ABMI technicians update this information, and also add other types of features to the layers. These include:

- Rural residences (e.g. acreages)
- Urban areas (e.g. cities and towns)
- Agriculture (e.g. crops, feed lots)
- Other footprint from energy and mining (e.g. borrow pits, mines)

The original vegetation data comes from the Alberta Ground Cover Characterization (AGCC) and the Agricultural Land Cover Classification (ALCC), supplemented with data from the Alberta Vegetation Inventory (AVI) and the Grassland Vegetation Inventory (GVI). Members of the ABMI's remote sensing team combine these layers and carry out additional interpretation to correct and/or re-classify some polygons to more accurate and generalized vegetation types.

THE 2012 SEASON – OPERATIONS

Province Wide

The ABMI ran a very successful season of field operations in 2012. The ABMI surveyed 171 terrestrial sites (due to forest fires in 2011 and 2012, some sites were monitored in the spring or summer, but not both due to access and safety concerns or to complete sites from the previous field season; 164 sites were monitored in the spring and 154 in the summer) and 147 wetland sites (Table 3; Figures 5 and 6). In winter (December 2012-March 2013), the ABMI was able to survey 128 sites for winter mammals (Figure 7).

***Table 3**: Summary of the number of sites monitored by the ABMI during the Prototype Phase (2003-2006) and Rotation One (2007-2012) for the entire province.*

Year	Terrestrial Spring & Summer	Terrestrial- Winter	Wetland
Prototype Phase (2003-2006)	155/125 (63)*	64 (25)*	0
2007	80	37	66
2008	80	105	85
2009	80	43	74
2010	72	117	76
2011	134	95	140
2012	**171**	**128**	**147**
Total Unique Sites Surveyed	**680**	**545****	**588**

* The number of sites monitored during the entire Prototype Phase/the number of unique sites monitored during the Prototype Phase (some sites were monitored more than once during Prototype Phase to validate protocols for consistency). The number in brackets is the number of sites monitored during Prototype Phase that have not yet been re-monitored during Rotation One.
**5 winter tracking sites were revisited during Rotation One.

The 2012 field season was heavily focused in the northern half of the province and in the far south. The majority of field activity took place in the LAPR and smaller focal areas in the South Saskatchewan and Lower Peace Planning Regions.

The ABMI increased their seasonal field staff in 2012 adding 6 more field technicians. There were 21 field crews monitoring sites - 10 wetland crews and 11 terrestrial crews (42 technicians), supervised by six field supervisors, with support from one logistics officer. All field crews working in the northern part of the province began the season based in Athabasca at the Meanook Biological Research Station for training, while southern crews began the season based out of Medicine Hat College in Brooks. Most of the winter site monitoring was contracted out to qualified environmental consultants.

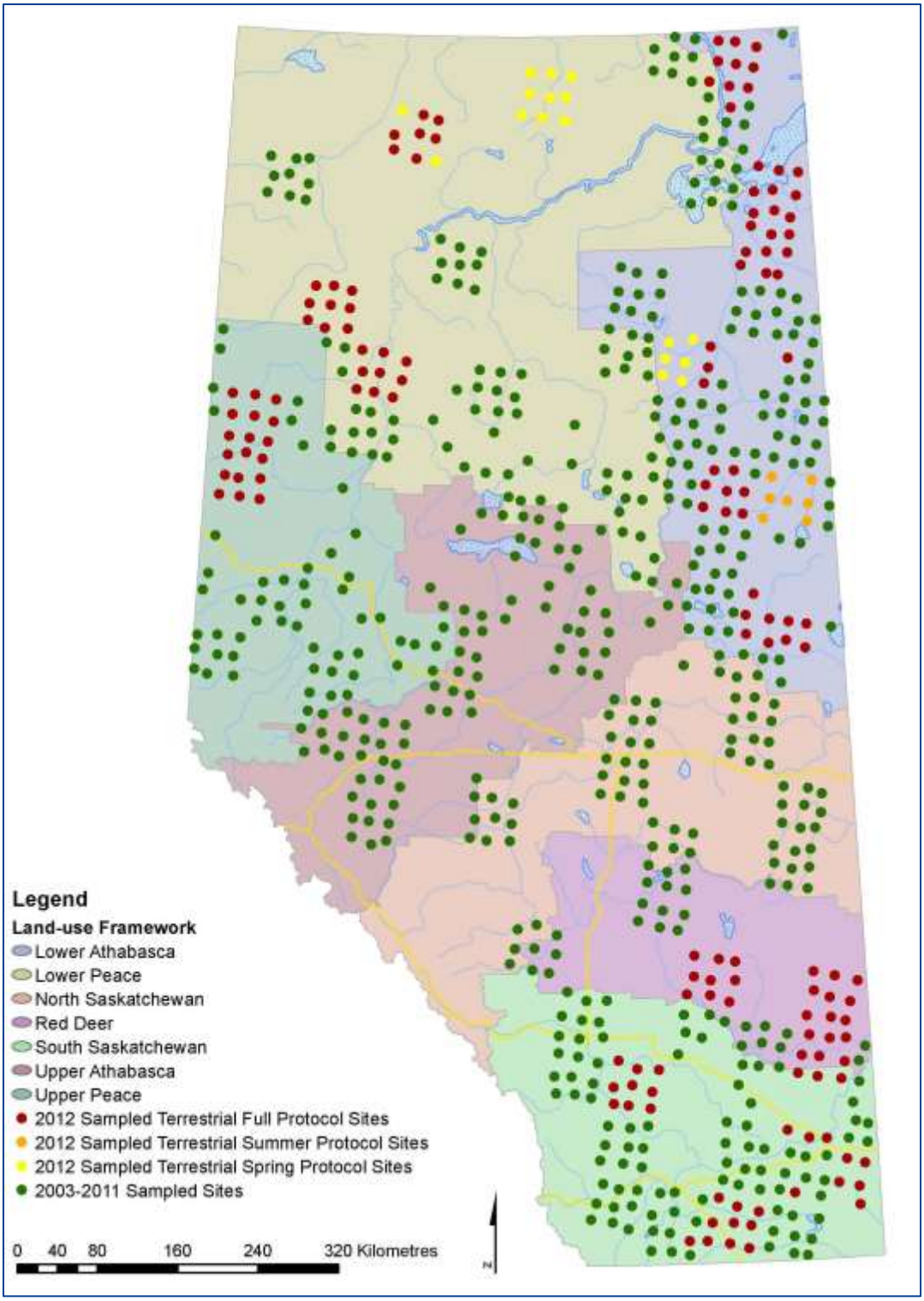


Figure 5: *Provincial map showing all terrestrial sites monitored in 2012 for spring and summer protocols (N=171). Largely due to fires, some sites were surveyed in either spring or summer, but not both (spring, N =164; summer, N=154). Sites monitored prior to 2012 are also shown (green).*

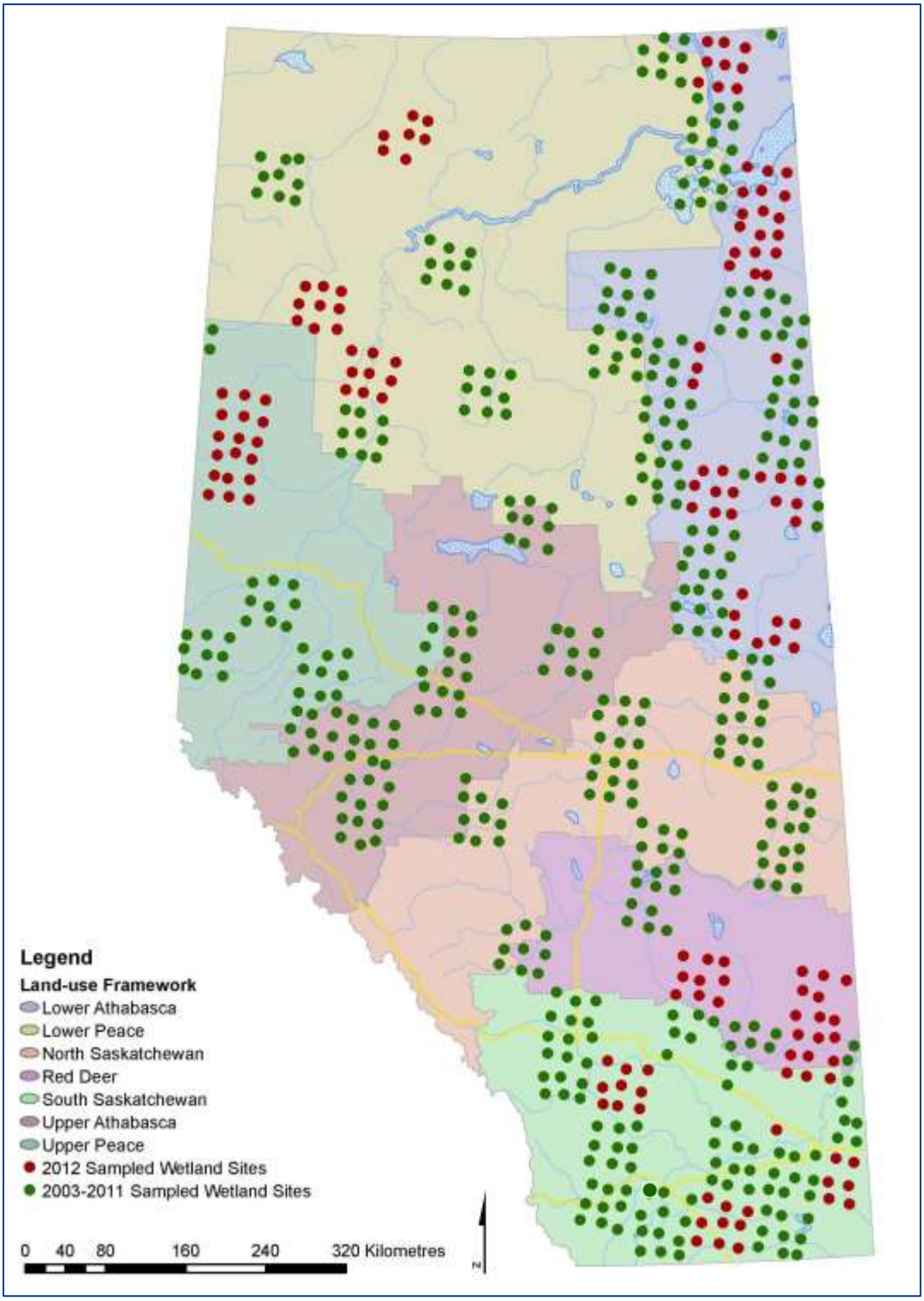


Figure 6: *Provincial map showing all wetland sites that were monitored in 2012 (red, N=147). Sites monitored prior to 2012 are also shown (green).*

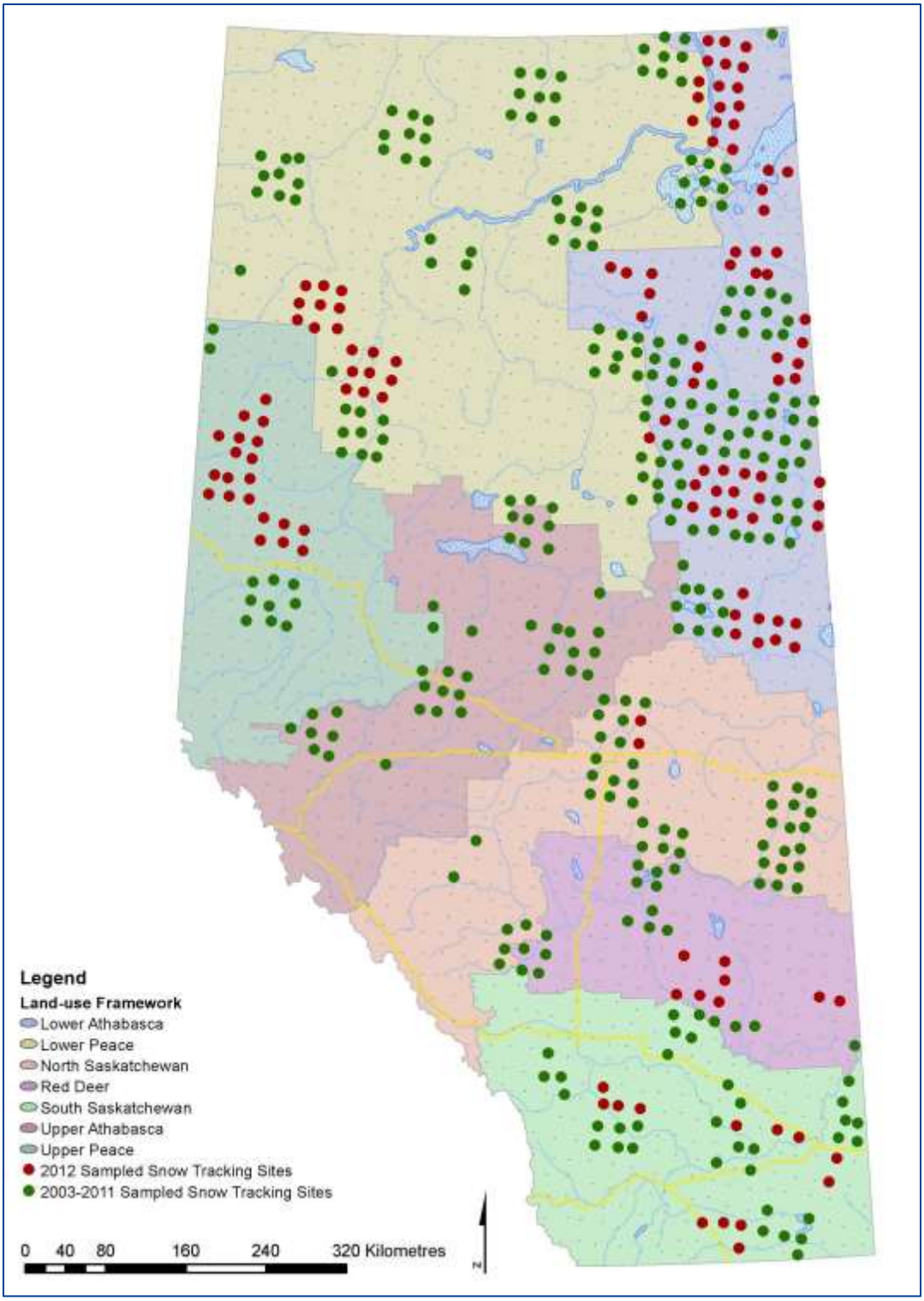


Figure 7: *Provincial map showing all winter tracking sites that were monitored for the 2012 season (December 2012-March 2013; red, N=128). Sites monitored prior to 2012 are also shown (green).*

Lower Athabasca Planning Region

In the spring and summer of 2012, the ABMI monitored 61 terrestrial sites (54 in the spring and 55 in the summer) and 52 wetland sites in the LAPR (Table 4; Figures 8 and 9). The 2012 monitoring crews faced challenges posed by forest fires affecting Northern Alberta for the second year in a row. Although fires did not directly impact any LAPR sites, the number of sites that occurred in the LAPR for summer protocols was impacted by fires found in other areas of Northern Alberta.

Several sites monitored for spring terrestrial protocols (late May-June) in the LAPR became unavailable for summer monitoring (July) due to heavy smoke or proximity of fires. In summer, several new terrestrial sites were visited as replacements in the LAPR, which will need to have their spring protocols completed in 2013. As a result, the 2012 sites visited are a combination of sites needing completion from 2011, sites only partially visited in 2012 and sites receiving complete surveys. From the 2011 field season, five spring sites that could not be revisited in the summer had both spring and summer protocols redone in 2012 and six summer replacement sites from 2011 had their spring protocols completed in 2012. Additionally, there were several sites affected by fires in the Lower Peace Planning Region and seven sites were visited for just summer protocols in the LAPR as replacements.

In addition to the 61 sites inside the LAPR, there was one additional terrestrial and wetland site located on the border with the Lower Peace Planning Region in Wood Buffalo National Park (see Figures 5 and 6; blocks of sites on the boundaries of the LAPR). There were also 5 winter tracking sites near the border of the LAPR in the Lower Peace Planning Region. While not technically in the LAPR, these sites provide important contextual information for interpreting and analyzing LAPR data, particularly the Wood Buffalo sites.

Six crews carried out the spring and summer protocols in the LAPR in 2012 (three terrestrial; three wetland), with help from two additional terrestrial crews during site establishment. In 2012, approximately 65 percent of sites required helicopter access, while the remaining sites were accessible via ground access. Field crews were based out of four different locations in the LAPR: 1) The Leismer Fire Station in Conklin, 2) The Alberta Environment and Sustainable Resource Development (AESRD) bunkhouse in Fort Chipewyan, 3) Rotary Park in Fort McMurray and 4) Fort Smith for sites in the far north. Trailers were parked at the Leismer fire station for accommodation during the field season. ABMI received support from the local Alberta Environment and Sustainable Resource Development (AESRD) office in Fort Chipewyan, which provided accommodation for the crews while they were there; crews also rented vehicles for transportation. Remote crews were supported by an ABMI logistics officer, who remained at base camp and sent food, water, and equipment daily to each crew when they were moved between sites by helicopter. Samples and data sheets were sent out in the helicopter each day.

In winter, the ABMI surveyed 62 sites for winter mammals in the LAPR (Figure 10). Access had been planned for up to 71 sites in the LAPR depending on snow conditions throughout the province. Winter-tracking activities are highly dependent on weather and yearly plans routinely

include more sites than are actually visited to ensure crews can take advantage of areas of the province with the best snow conditions.

Table 4: *The number of terrestrial and wetland sites monitored by the ABMI in the LAPR, 2003-2012. In 2011 and 2012 some sites were not surveyed in both spring and summer, due to fires in the LAPR.*

Protocol	2012	2011	2010	2009	2008	2007	Prototype (2003-06)	Total Unique Sites
Terrestrial- Spring & Summer	61	30^	15	18	2	32	59/45 (12)*	159***
Terrestrial- Spring	54	24	15	18	2	32	59/45 (14)*	154***
Terrestrial- Summer	55	25	15	18	2	32	59/45 (12)*	159***
Terrestrial- Winter	62	14	16	14	8	25	54/54 (20)*	155**
Wetlands	52	26	15	18	2	32	N/A	145

^ Due to fires some sites were visited in either the spring or summer, but not both.
*The first number is the number of sites monitored during the entire Prototype Phase. Some sites were monitored more than once during Prototype Phase to validate protocols for consistency, the second number is the number of unique sites monitored during the Prototype Phase. The number in brackets is the number of sites monitored during Prototype Phase that have not yet been re-monitored during Rotation One.
**Four winter terrestrial sites in the LAPR were repeated during Rotation One.
*** Some sites were visited over two years, so adding yearly site numbers does not equal the total unique sites visited.

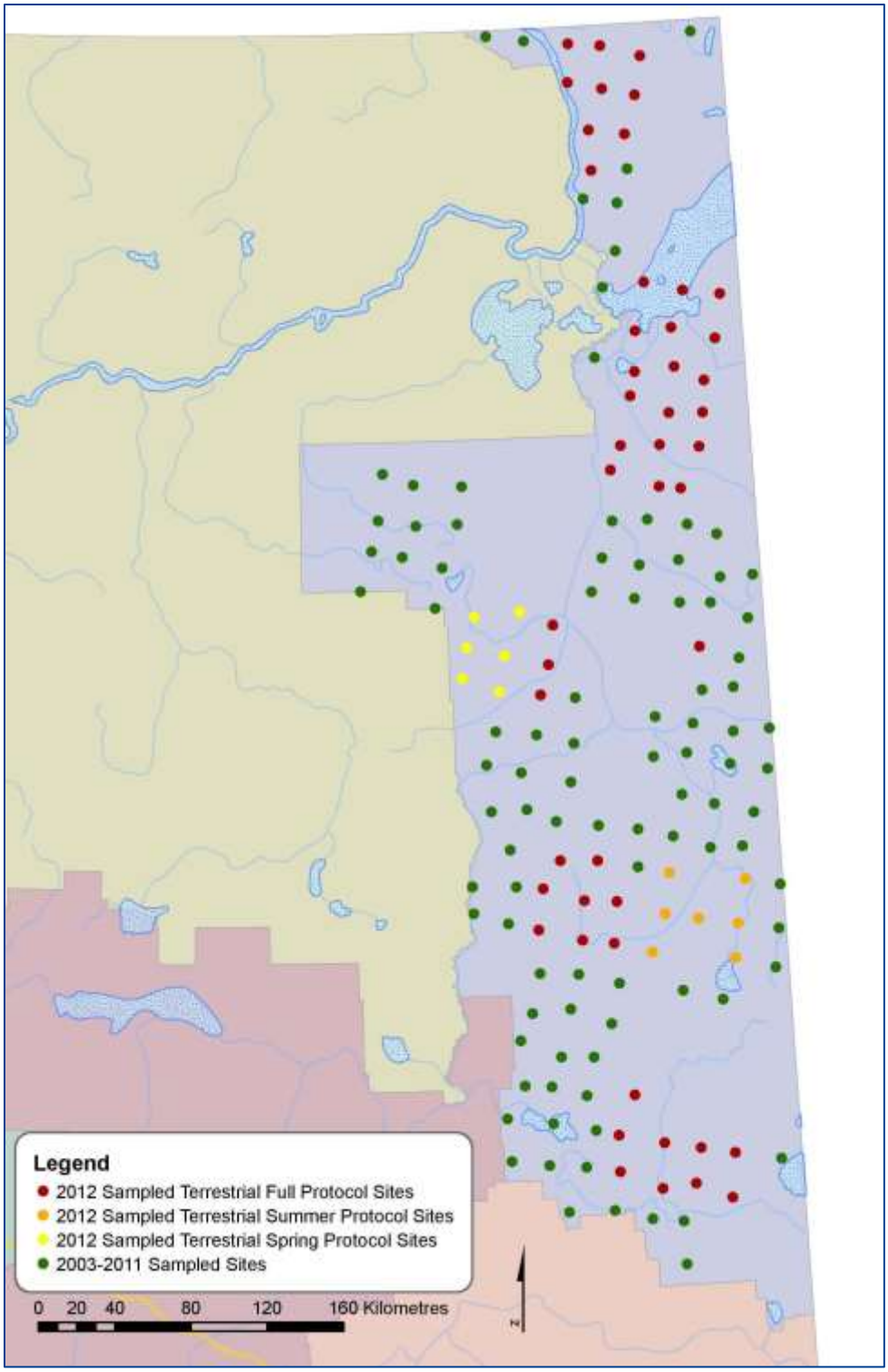


***Figure 8**: Map showing all terrestrial sites monitored in the LAPR in 2012 (N= 61). Previous years also shown. Due to fires, not all sites could be visited in both the spring and summer (spring, N=54; summer, N=55).*

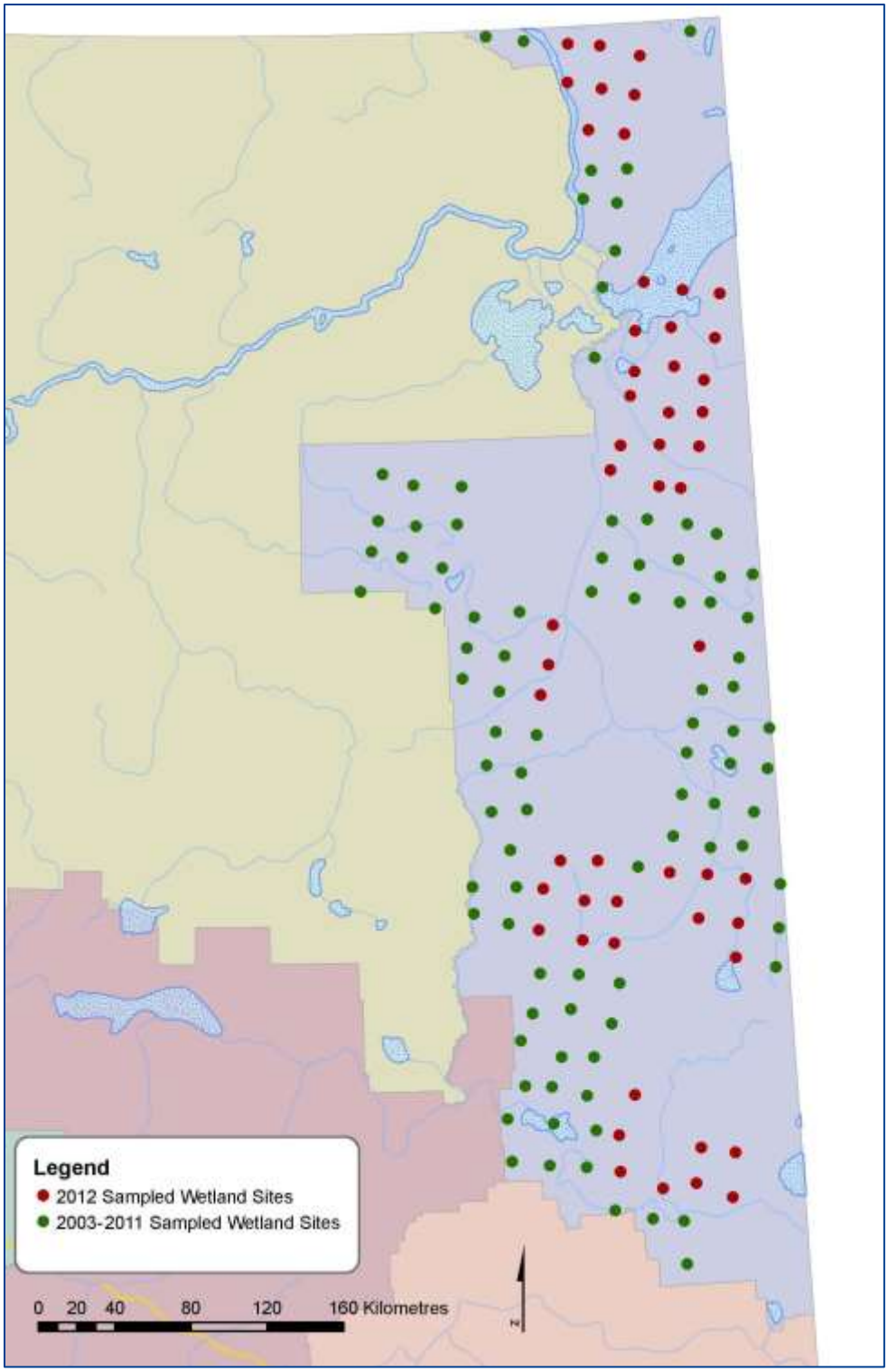


Figure 9: *Map showing all wetland sites monitored in the LAPR in 2012 (N= 52). Previous years also shown.*

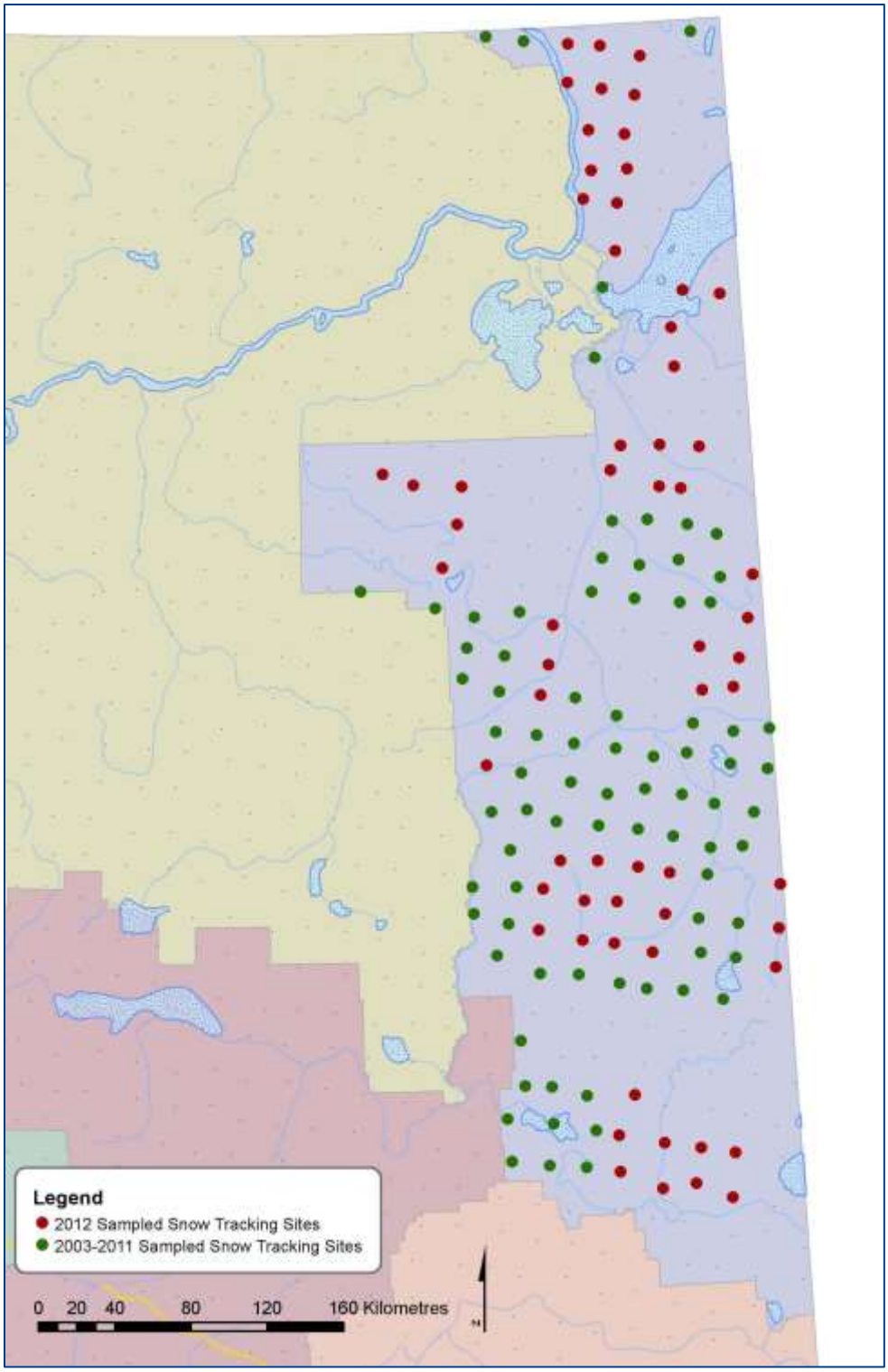


Figure 10: *Map showing all winter tracking sites monitored in the LAPR in 2012 (red; N= 62). Previous years also shown.*

Remote Sensing

3 x 7 km Plots

In 2012, the ABMI obtained aerial photography for 7 Panel B, 21 Panel C and 42 Panel D sites in the LAPR (Table 5). Photography for panels A, B, C and D is complete, with the exception of 1 site in Panel C not captured due to environmental conditions and 9 sites in the Cold Lake Air Weapons Range. ABMI is working with the provincial and federal governments to obtain access to this area. All photographed Panel A, B and C sites in the LAPR have been photo interpreted using the ABMI's protocols.

Table 5: *Progress up to 2012 on 3 x 7 km aerial photograph acquisition and interpretation for the Lower Athabasca Planning Region.*

	# LAPR Sites	Photographs Obtained					Interpreted		
		2008	2009	2010	2011	2012	2009 /2010	2011	2012
A	43*	39	-	-	-	-	6	33	-
B	52	0	0	23	22	7	-	23	29
C	51*	0	0	0	26	21	-	-	47
D	44*	0	0	0	0	42	-	-	-
E	45*	0	0	0	0	0	-	-	-
Total	**235**	**180**					**138**		

* CLAWR sites not flown (15 sites). The ABMI is working with government to gain access. (Number of sites per panel affected by proximity to the CLAWR: A= 4, B=0, C=2, D=3, E=6).

At full operational capacity, aerial photographs would be taken within two years of field sampling (ideally in the same year).

ABMI Wall-to-wall Land Cover Map

The ABMI Wall-to-wall Land Cover (LC) Map is a seamless GIS vector layer with nearly one million polygons describing the spatial distribution of LC across the province of Alberta, circa 2000, at the 1:125,000 scale. It is a blending and generalization of two pre-existing land-cover products: the Canadian Forest Service's Earth Observation for Sustainable Development (EOSD) map of the forested region, and Agriculture Agri-Food Canada's (AAFC's) map of the agricultural zone. It is the best-available complete representation of Alberta's land cover currently available. In 2011 the ABMI produced a beta version of the land cover map and following an assessment of the initial version, has made numerous improvements to the overall quality and accuracy of the preliminary product resulting in the ABMI Wall-to-wall Land Cover Map Version 2.1. In 2012, the map was updated to 2010 and made publicly available in 2013.

ABMI Wall-to-wall Human Footprint Map

In 2012, the ABMI completed an updated version of the Wall-to-wall human footprint map of the entire province circa 2010, available for download in the 'Raw Data' section of the ABMI's website (www.abmi.ca). The ABMI Human Footprint (HF) Map circa 2010 describes the amount

and type of HF across the province of Alberta until 2010. The map is a compilation product of multiple layers: those produced by the ABMI and layers obtained through a data-sharing agreement with the government of Alberta and individual resource companies. The HF map is still preliminary and is continuously being updated and improved. The current release covers the entire province and includes 23 feature types. For further information on the map's construction please refer to Appendix 1.

The Wall-to-Wall map allows the ABMI to document trends in land use anywhere in Alberta. It is also used to support cumulative effects assessment by the ABMI. An updated version of the human footprint map using 2012 satellite imagery is currently underway and should be released in 2014. Future updates to the human footprint products will be produced roughly every two to three years.

EMCLA Pilot Monitoring Projects

The ABMI partners with the Ecological Monitoring Committee for the Lower Athabasca (EMCLA), a joint industry-government group that is tasked with improving the quality of regulatory wildlife and biodiversity monitoring in the LAPR. The EMCLA's first two pilot field projects began in 2012, with operational support from the ABMI.

Rare Animals

The first project is the Rare Animals project, which is developing new monitoring protocols for species that are not monitored by the ABMI, but are of interest in the LAPR because they are considered to be rare or may be impacted by oil sands development. The target species are owls, amphibians, and the Yellow Rail- a cryptic marsh bird that has proven difficult to monitor. All of these species are largely nocturnal, and all vocalize. Therefore, the project team is testing the feasibility of using automated recorders for monitoring.

In 2012, the project team conducted a pilot field season from March until July. In addition to conducting in-person surveys for owls, amphibians and Yellow Rails, the team set up automated recording units (ARUs) at the same locations and recorded in 10 minute intervals throughout the day and night. Surveys and recordings were done in 29 study areas (multiple wetlands and forest sites within each study area) that were matched for habitat type, but had different amounts of oil sands development (e.g. on-lease and off-lease sites).

Rare Plants

The second project is focused on monitoring rare plants. ABMI's timed vascular plant surveys on a systematic grid are efficient for detecting common species, but rare species are easily missed. Rare plants are of interest in the LAPR because of possible threats from human disturbance. The project team has adopted an adaptive sampling approach whereby existing plant location data are used to model the likely distributions of rare plant species. Those models are then used to target new survey sites. Information provided from these new surveys are then used to test and refine rare plant models and the ecological correlates of rarity to better understand their causes. The adaptive approach has previously been shown to be more cost-effective than traditional random or systematic sampling.

For the 2012 pilot field season, the project team:

- Used existing rare plant location data for the Lower Athabasca region to develop predictive habitat models for target rare vascular plant species. The resulting models were used to generate sampling sites for 2012 surveys.
- Designed a sampling protocol to use at targeted survey sites.
- Conducted pilot fieldwork to sample rare plants from McClelland Lake in the north to the Bonnyville and Cold Lake areas in the south. Field crews sampled in July and August a total of 150 fens and upland forest plots measuring a ¼ hectare (50x50 meter) area. At each plot an exhaustive (time-unlimited) vascular plant survey was completed and when rare plants were found they were documented.

THE 2012 SEASON – RESULTS FOR SELECTED SPECIES DATA

Summary of Species Data Collected in 2012

The ABMI collects species data on the following groups:

Terrestrial Sites (Spring/Summer)

- Vascular plants
- Soil mites
- Birds
- Bryophytes
- Lichens
- Incidental vertebrates observed during surveys

Wetland Sites

- Vascular plants
- Aquatic invertebrates
- Vertebrates (10 minute scan and incidentally during other surveys)

Terrestrial Sites (Winter)

- Winter-active Mammals

All of the species data that the ABMI collects comes with corresponding data on habitats and human and natural disturbance. This data is critical for conducting meaningful analysis of ABMI species data, including calculating intactness, uncovering correlations between habitat and/or disturbance and species distributions and abundances, and tracking changes in habitats and disturbance across Alberta.

At all of the LAPR sites surveyed by the ABMI in 2012, the ABMI identified a total of more than 700 different species at terrestrial sites, and more than 400 species at wetland sites (Table 6; many species occur at both terrestrial and wetland sites).

Table 6: *Summary of species data collected by the ABMI in the LAPR in 2012.*

Terrestrial Sites (Spring & Summer)	2012	All Years (2003-2012)
Number of Sites Monitored (Spring/Summer)	54/55	154/159
# Bird Species	131	171
# Mite Species	106	149 (2007-2012)
# Bryophyte Species	141	248
# Lichen Species*	N/A	158
# Vascular Plant Species	326	494
# Incidental Vertebrate Species**	70	155
Terrestrial Sites (Winter)	**2012**	**All Years (2004-2012)**
Number of Sites Monitored	62	155
# Winter Tracking Species	20	25
# Incidental Vertebrate Species	33	40 (2009-2012)
Wetland Sites	**2012**	**All Years (2007-2012)**
Number of Sites Monitored	52	145
# Vascular Plant Species**	282	405
# Aquatic Invertebrate Species**	78	108
# Vertebrate Species^	69	105

*2009 - 2012 lichen species not yet completely identified.
**Includes specimens identified to at least genus, counting genera level identifications only if they are unique.
^ Includes vertebrates identified to at least genus, counting genera level identifications only if they are unique. Identified during initial 10 minute scan and those observed incidentally while conducting other protocols.

Breeding Birds

The ABMI's protocols provide data on the distribution and abundance of breeding songbirds. The ABMI's technicians record vocalizations for ten minutes at nine separate locations surrounding each of the ABMI's terrestrial sites (see protocol description, Appendix 1). Specialists analyze each recording after the field season, recording all species heard and the number of distinct individuals calling, and return this data to the ABMI.

Table 7: *Summary of bird data for the LAPR*

	2012	All Years (2003-2012)
Number of Individuals Detected on Recordings	5884	24,690
Number of Detections Identifiable to Species	5806	24,401
Number of Species Detected	118	158
Number of Sites surveyed	54	154
Average Number of Species/Site	27	30*

*Some sites were surveyed more than once during Prototype Phase (2003-2006) and therefore have higher numbers of detections and a correspondingly higher number of species.

In the LAPR, the ABMI has surveyed 154 terrestrial sites for breeding birds, 54 of these in 2012. In total, 158 bird species have been detected (Table 7), and 118 species were detected in 2012. In 2012, the number of species detected at a site ranged from 12 to 56, with an average of 27 (Figure 11). Two sites from 2012 were completely in water with no land within 200m of each bird point and did not have recordings taken for breeding birds.

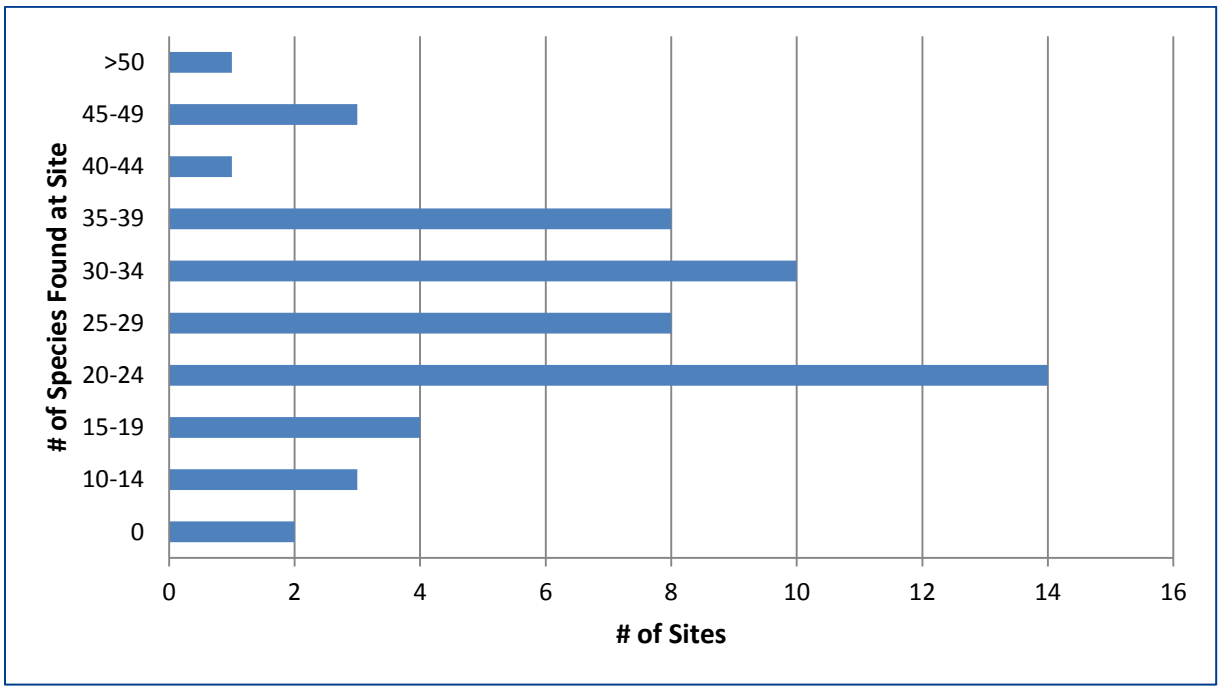


Figure 11: *The number of bird species found per site for the LAPR in 2012 (N= 54). Two sites were completely in water and had no recordings taken.*

In 2012, the ABMI had its first detection of *Coturnicops noveboracensis*, the Yellow Rail, in the LAPR. The ABMI has only detected the Yellow Rail at three ABMI sites across the province.

The most widespread species (found at the highest percentage of sites) are the Chipping Sparrow, Yellow-rumped Warbler and Gray Jay (the sparrow and warbler found at 93% of sites and the jay at 88%, based on 2003-2012 data).

In 2012, the most widespread species were the Yellow-rumped Warbler, Gray Jay and Hermit Thrush, found at 93%, 91% and 89% of sites respectively. Of the 118 species detected in 2012, 37 were detected at more than 15 sites, 17 of them were found at more than 50% of sites (Figure 12), and 16 species were found at only 1 site.

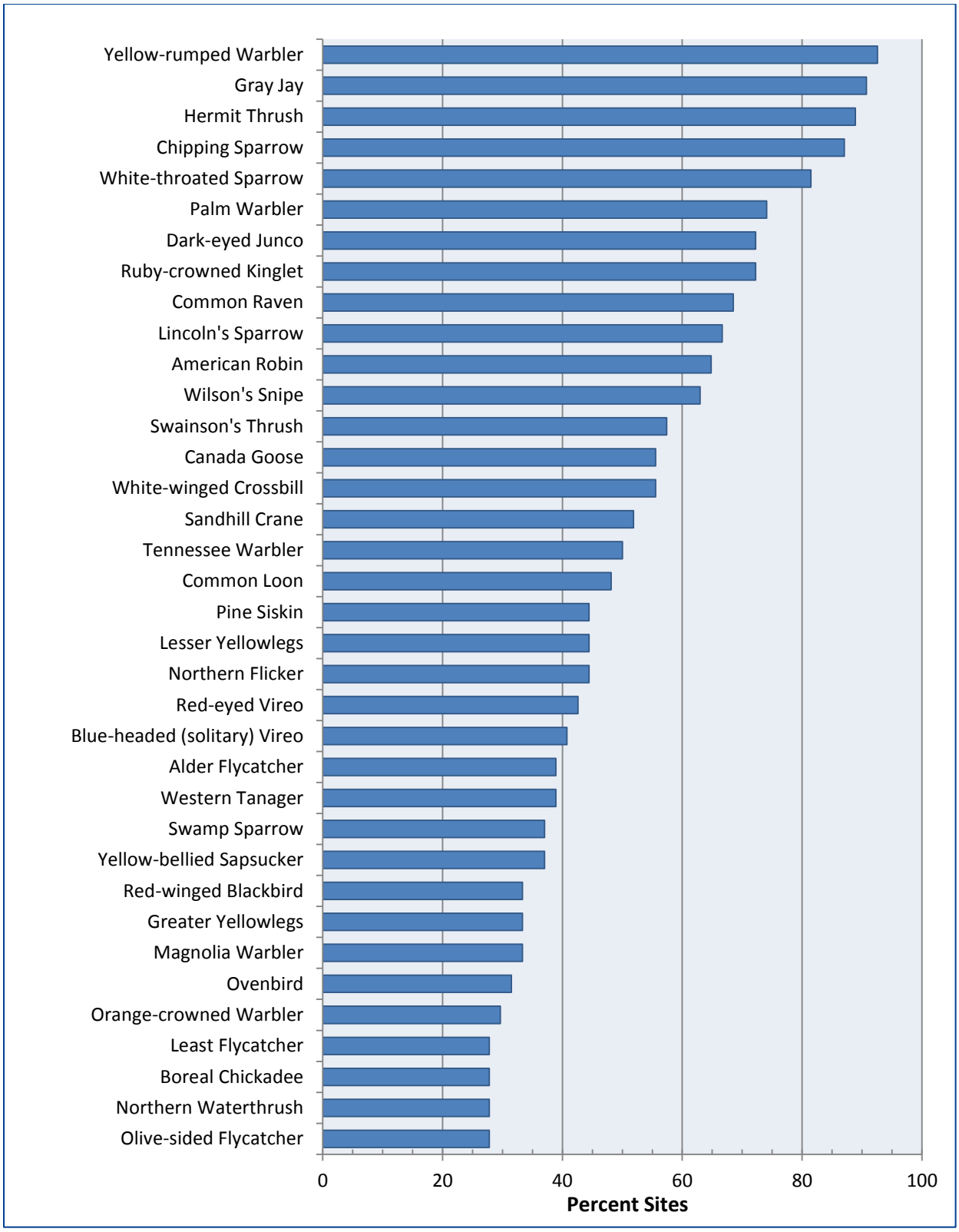
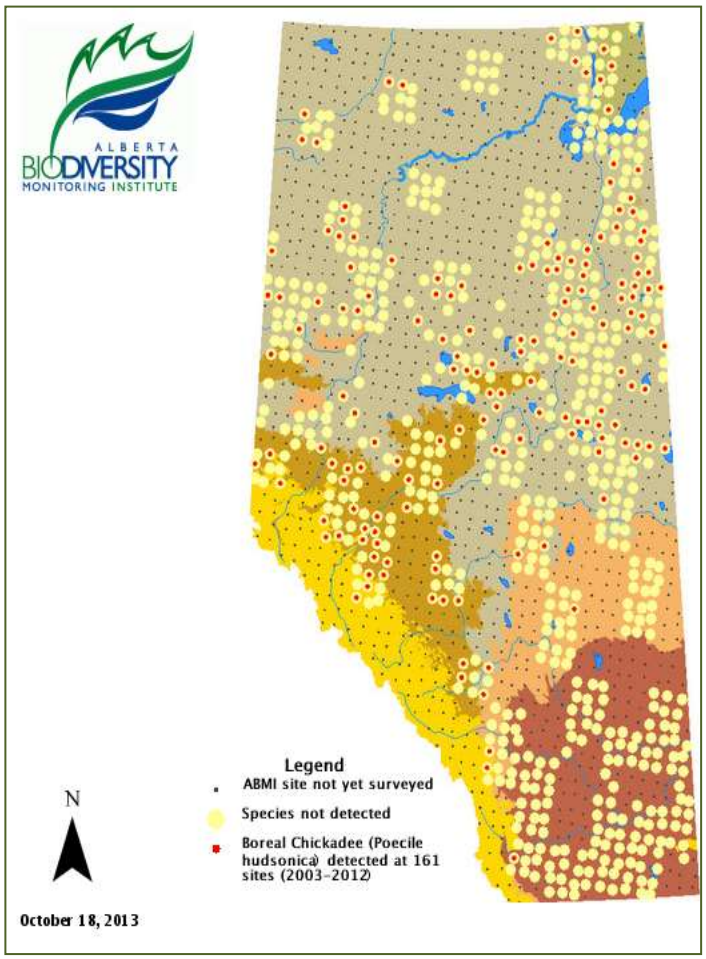


Figure 12: *Bird species detected in 2012 found at more than 15 sites (N= 36 species), showing the percentage of sites where each species was found.*

Species Profile: The Boreal Chickadee

The Boreal Chickadee is one of only a few landbirds in North America that is a permanent, year-round resident of the boreal forest. This species occurs most frequently in the foothills, mountains, boreal forest and Canadian shield, as it is usually associated with coniferous forests. It is rarely found in parkland and grassland areas of Alberta where coniferous trees are less common. Boreal Chickadees rely on conifer trees for both nesting and feeding requirements, as they nest in tree cavities and feed predominantly on insects found on tree branches or under the bark.



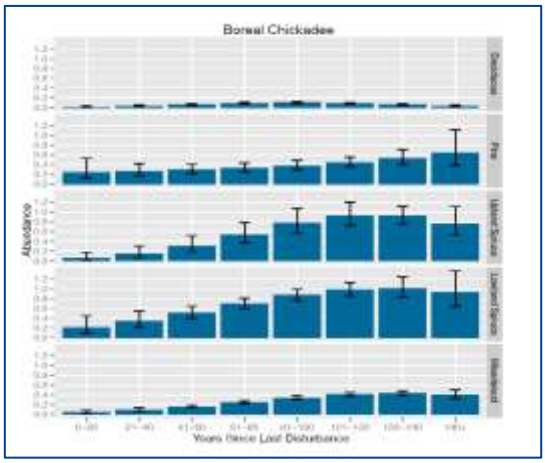
The ABMI measures the Boreal Chickadee as part of the breeding bird protocol that is carried out in May and June. This protocol uses recorders to capture the sounds of different bird species singing during the dawn chorus. Since 2003, the ABMI has found the Boreal Chickadee at 161 different sites across the province and 60 sites in the LAPR (39% of the 154 LAPR sites surveyed to date).

The Boreal Chickadee is listed as Secure by Alberta ESRD, and as Least Concern by IUCN. However in a recent ABMI report, The Status of Landbirds in Alberta's Boreal Plains Ecozone, the Boreal Chickadee was found to be only 76% intact. This means that the Boreal Chickadee populations are only 76% of what we would expect to find in an area with no disturbance. The ABMI will continue to track the status of Boreal Chickadee in Alberta over time.

Species Profile: The Boreal Chickadee

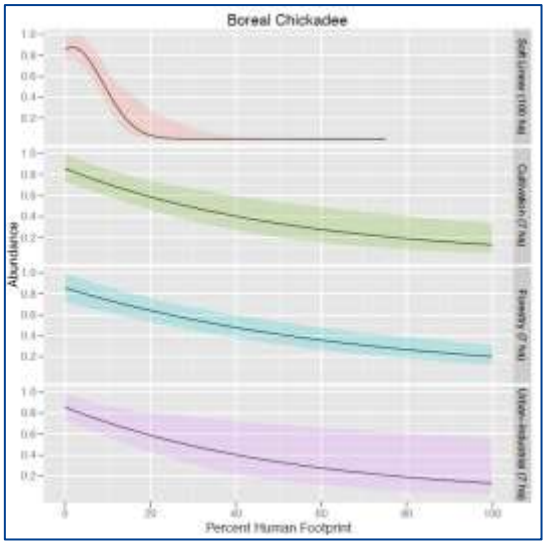
Habitat Associations

ABMI's data in conjunction with data from the Boreal Avian Monitoring Project (BAM) can also be used to map habitat suitability. Boreal Chickadees are found in highest abundance in older coniferous forest habitats. They are found in much lower abundance in deciduous forest types.



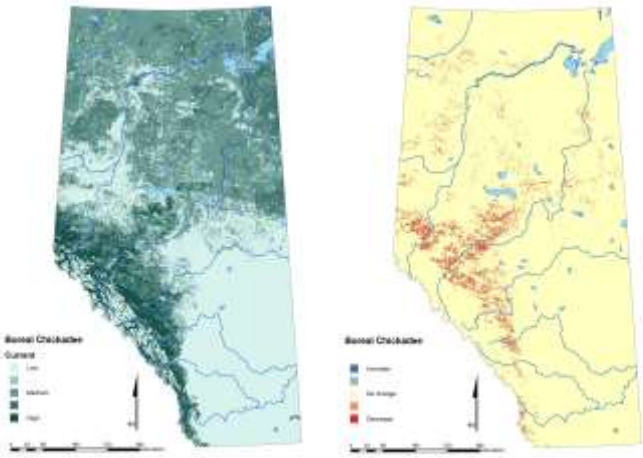
Response to Human Footprint

Using ABMI's breeding bird data and human footprint inventory, the Boreal Chickadee shows a dramatic decrease in abundance in relation to increasing soft linear features (seismic lines and pipelines). Its abundance also decreases with increasing forestry, agriculture and urban/industrial footprint.



Change in Habitat Suitability

ABMI's data can also be used to map current habitat suitability (left) and changes in predicted habitat suitability from reference conditions (right). For the Boreal Chickadee, habitat suitability is predicted to have decreased the most in areas where agriculture, urbanization, and energy-related footprint was highest. Absence of human footprint is predicted to positively influence the Boreal Chickadee.



Wetland Vascular Plants

The ABMI identifies vascular plant species at both terrestrial and wetland sites across the province (see protocol, Appendix 1). Vascular plants are an important group for monitoring ecosystem health. Plant communities form the basis of many different ecological classifications and Alberta's natural regions are largely defined by vegetation cover. Plants represent a large portion of biodiversity in many ecosystems and produce important habitat for other species.

Plants are a diverse group with more than 2000 species in Alberta. In the LAPR, the ABMI has surveyed 145 wetland sites for vascular plants, 52 of these in 2012. In total, 405 plant species have been detected (Table 8), 282 of which were detected in 2012. The number of species detected at each site in 2012 ranged from 15 to 62 with an average of 37 species per site (Figure 13).

Table 8: *Summary of vascular plant data for the LAPR from ABMI's Wetland sites*

	2012	All Years (2007-2012)
Number of Sites Surveyed	52	145
Total Number of Species Identified	282	405
Average Number of Species/Site	37	35

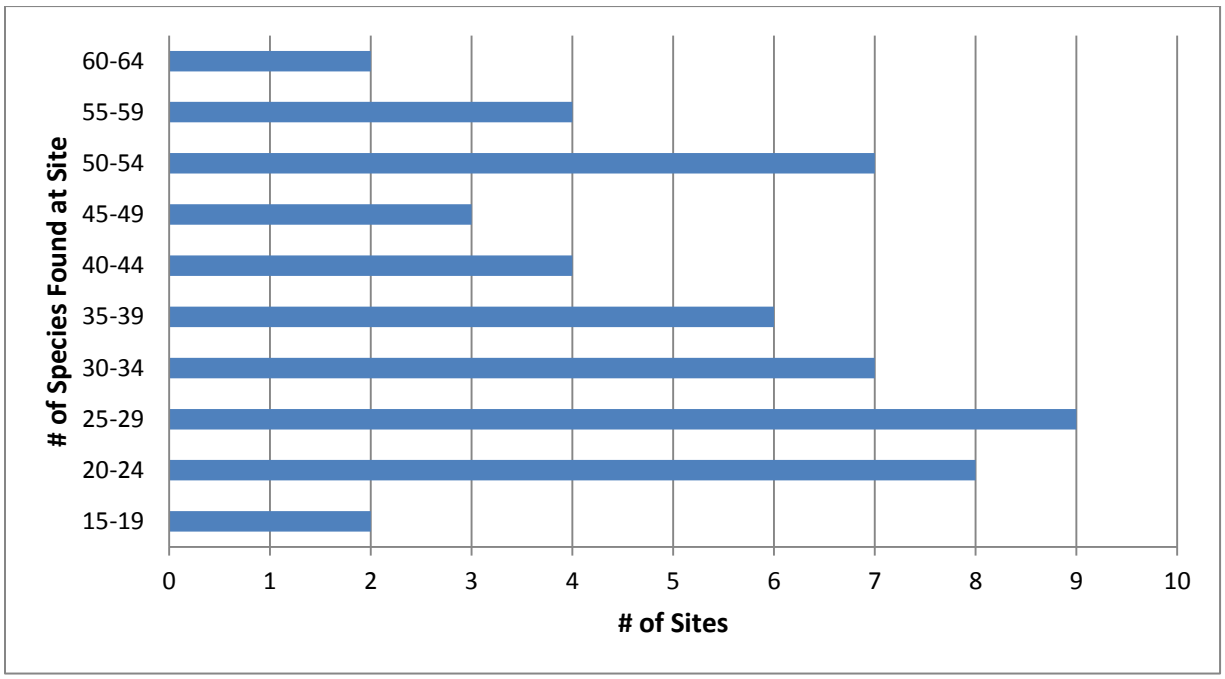


Figure 13: *The number of vascular plant species found per site for 2012 at LAPR wetland sites (N= 52).*

The most widespread plant species in wetlands in the LAPR are Marsh Cinquefoil, Water Sedge, and Bog Labrador Tea found at 78%, 78 % and 76% of sites respectively (based on 2007-2012 data). In 2012, the most commonly found species were Water Sedge and Bog Labrador Tea, found at 79% and 75%, and Black Spruce and Bog Cranberry each found at 71% of sites. Of the 282 species detected in 2012, only 42 were detected at more than 15 sites (Figure 14), while ~65% of the species were found 5 sites or less and ~35% of species were found at only 1 site.

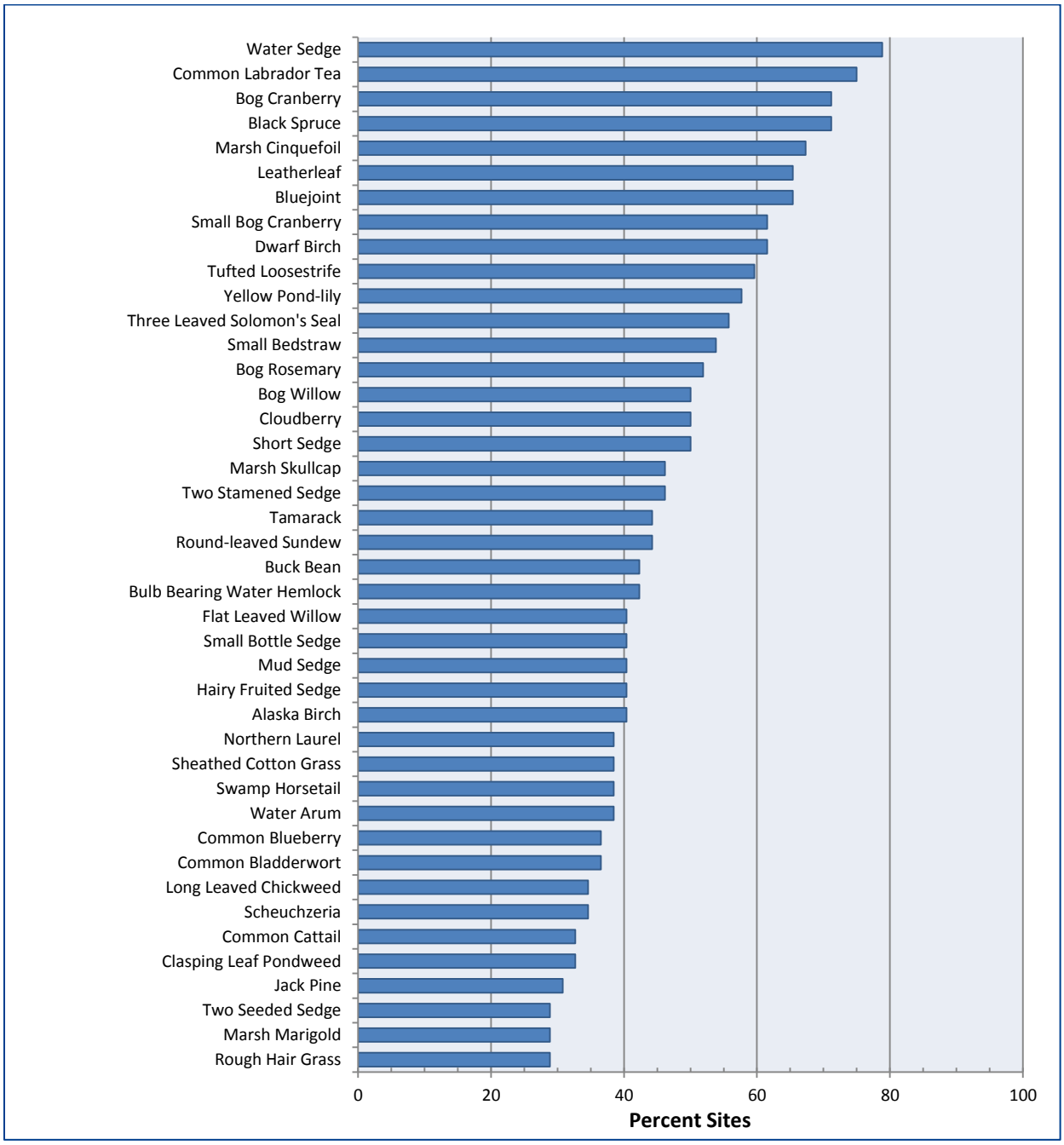
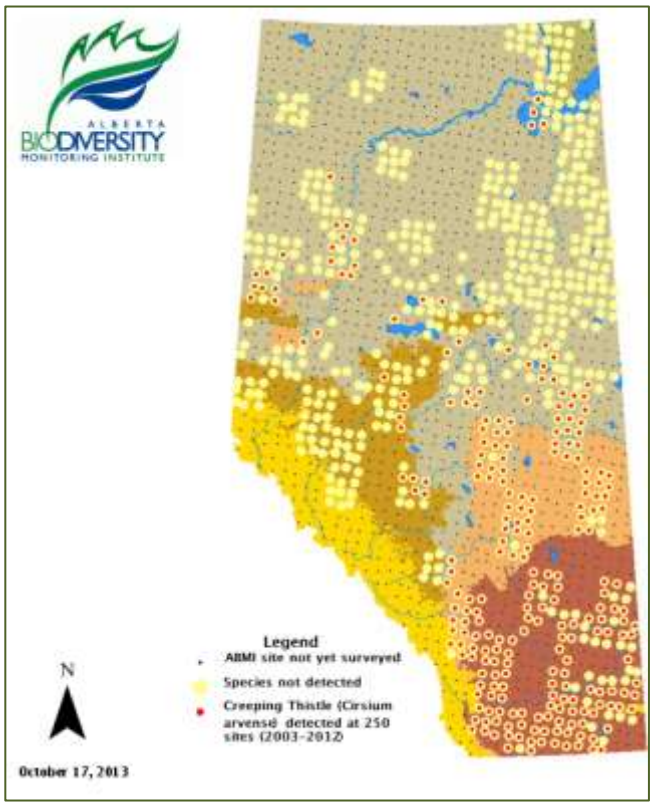


Figure 14: *Wetland vascular plant species detected in 2012 found at more than 15 sites in the LAPR (N= 42 species), showing the percentage of sites where each species was found.*

Species Profile: Invasive Plant Species – *Cirsium arvense*, Creeping Thistle

Cirsium arvense, Creeping Thistle also known as Canada Thistle, is an aggressive colony-forming perennial native to Europe. This non-native species is a prolific invasive plant in Alberta and is currently regulated under Alberta's Weed Control Act as a noxious weed.[2]

Creeping Thistle is found throughout Southern Alberta, and the noxious designation lends to the unlikelihood of eradication. Non-native plants are usually found in areas that have high levels of human activity. The majority of Alberta's population resides in Southern Alberta, but non-native plants like Creeping Thistle are being found in less populous areas in northern parts of the province.



ABMI has identified *Cirsium arvense* at eight wetland sites and 5 terrestrial sites in the LAPR. Creeping Thistle has also been found at four additional sites just outside of the LAPR, in the Lower Peace Planning Region, much farther north in Wood Buffalo National Park.

Creeping Thistle will often reproduce by growing new shoots from existing roots, forming large genetically identical colonies. Dense infestations in and around wetlands can have an impact on wildlife by reducing food and access to nesting and cover for waterfowl. Creeping Thistle will successfully survive adverse conditions when other native plants may not, owing to extensive root systems that can access nutrients and water much deeper in the soil.[2]

[2] Alberta Weed Control Act, June 2010.
[2] Alberta Invasive Species Council Fact Sheet: Canada Thisle (*Cirsium arvense*), accessed October, 2013.

Site Profile: ABMI Wetland Site # 4 – A Wetland in Alberta's Canadian Shield

ABMI Wetland Site 4 is located in the far northeast corner of Alberta in the Canadian Shield. The site is a spruce dominated wetland with typical plants expected of an area with nutrient poor soil conditions and moist soils throughout most of the year. The understory is dominated by moss and vascular plants including Labrador Tea, Bog Cranberry and sedges.

The wetland is small (<10 hectares), with a maximum depth of 1.9m and a wide wetland margin spanning more than 25m. The wetland had a dissolved oxygen concentration of 6.92 mg/L and a pH of 6, typical of other wetlands in the area.

The ABMI characterizes wetlands by mapping the entire wetland, describing the ecosite types present in each of the wetland zones and collecting data on water, aquatic invertebrates, vascular plants, and any vertebrates present while on site. The ABMI found 27 vascular plant species at the wetland and species from 15 different groups of invertebrates. The ABMI will continue to track the biodiversity at this site with repeated surveys every five years.

Vertebrate Species:

- Sandpipers and Allies
- Bonaparte's Gull
- Wood Frog
- Beaver
- Yellowlegs, Willet and Allies

Invertebrate Species (selected):

- Non-biting Midges
- Freshwater Worms
- Predaceous Diving Beatles
- Water Boatman
- Caddisflies
- Backswimmers
- Damselflies
- Hawker Dragonflies
- Whiteface Dragonflies

Vascular Plants (selected):

- Black Spruce
- Dwarf Birch
- Tamarack
- Water Sedge
- Leatherleaf
- Mud Sedge
- Marsh Cinquefoil
- Round-leaved Sundew
- Common Labrador Tea
- Marsh Labrador Tea
- Bog Cranberry
- Fries' Pondweed
- Three Leaved Solomon's Seal
- Clasping Leaf Pondweed
- Bog Rosemary
- Sweet Gale

Human Footprint in the LAPR

The ABMI defines human footprint as the visible conversion of native ecosystems to temporary or permanent residential, recreational, or industrial landscapes. This includes land conversion activities that support agriculture, forestry, energy and mining, commercial, residential and transportation infrastructure.

While natural disturbances impact ecosystems in the LAPR, industrial development is also shaping the region's ecology. Human development is primarily made up of agriculture, energy operations and their associated infrastructure, and forestry activities.

The ABMI reports on the extent of human footprint by determining the area of land directly altered by human activities. In 2012, the ABMI released a wall-to-wall human footprint map for the province of Alberta that classifies human footprint across the province up to the year 2010. The ABMI is currently working on an updated version of the human footprint map that incorporates all human footprint through 2012, which is expected to be released for public use in 2014.

Table 9: *Human Footprint area (km^2) and percentage disturbance by type in the LAPR and across Alberta circa 2007 and 2010.*

Human Footprint Type	LAPR Percent Disturbed		Alberta Percent Disturbed	
	2007	2010	2007	2010
Agriculture	2.67	2.67	19.59	19.58
Forestry	1.79	1.93	3.42	3.69
Energy and Mining	1.76	2.11	1.75	1.89
Commercial and Industrial	0.06	0.08	0.16	0.16
Residential and Recreation	0.22	0.21	0.77	0.78
Transportation	0.32	0.33	1.16	1.20
Total Disturbance	**6.76**	**7.33**	**26.84**	**27.38**

EMCLA Pilot Monitoring Pilot Projects

Rare Animals

The team compared detection levels for in–person surveys with ARUs and found that the recorders are capable of detecting all 3 species of interest to the EMCLA, as well as a wide range of other vocalizing taxa. Detection rates for amphibians were comparable between ARU's and human surveys; while detection rates were slightly lower for owls when using ARU's as compared with call-playbacks. However, these differences can be corrected and compensated for by increasing sampling rate, or by attaching a call-playback unit to the recorder. Detection rates for Yellow Rail were overall quite low. No Yellow Rails were detected using traditional playback methods, while only 3 were detected in 2012 using ARU's. A separate study conducted by Bird Studies Canada in Saskatchewan indicates that detection levels for Yellow Rails are comparable between ARU's and call-playback surveys. For complete results, visit www.emcla.ca.

Rare Plants

Initial results indicate a high potential for this project to contribute valuable information not only on the status and distribution of rare plants, but also an evaluation of different methods for sampling vascular plants. Rare plant crews collected 6408 total plant observations, comprised of 405 individual species observations. Seventy three of these observations were rare species (S1, S2, or S3). A methodological comparison with ABMI's vascular plant protocol was initiated using the 2012 data and will demonstrate the relative role of survey length, site placement, and observer in rare plant detection levels. For complete results, visit www.emcla.ca.

THE 2013 SEASON AND PLANNING FOR 2014 AND BEYOND

2013

The ABMI's 2013 spring and summer season saw further increases in ABMI monitoring activities, with 192 terrestrial sites and 174 wetland sites monitored province wide (Table 10). The ABMI focused its monitoring in the northern half of the province and in the Red Deer Planning Region. There was heavy focus on monitoring in the Lower Peace Planning Region with smaller focal areas in the Lower Athabasca and Red Deer Planning Regions (Figures 15 and 16).

In the LAPR, the ABMI monitored 26 wetland sites, and 34 different terrestrial sites (Table 10; some sites were visited in the spring or summer, but not both due to 'catch-up' monitoring after fires in 2012 resulted in partially surveyed sites). There was also more than ten additional terrestrial and wetland sites surveyed in the adjacent areas of the Lower Peace and Upper Athabasca planning regions. About 50% of sites surveyed in the LAPR in 2013 required helicopter access, with field crews and logistics personnel based in Fort Chipewyan, Fort McMurray and Lac La Biche. Sites accessed by ground transportation were based out of Conklin, Cold Lake and Fort McMurray.

In 2012, fires in northern Alberta affected ABMI monitoring activities. Fires near the boundary of the LAPR affected site access and resulted in an additional block of sites being partially monitored in the LAPR. These sites were fully completed in the 2013 field season.

Winter protocols will begin in December 2013 and continue into March 2014. The ABMI is planning an ambitious winter season, with 84 sites planned in the LAPR, and 268 sites province wide. As always, winter monitoring will be strongly influenced by snow conditions throughout the province.

Table 10: *Summary of sites monitored in spring/summer of 2013 and planned for winter 2013/2014*

Protocols	Province	LAPR
Terrestrial- Spring & Summer Protocols*	192	34
Terrestrial- Spring Protocols	181	34
Terrestrial- Summer Protocols	185	27
Wetland Protocols	174	26
Terrestrial- Winter Protocols**	268	84

*Due to fires some sites were monitored in the spring or summer but not both.
**Access is being arranged for December 2013-March 2014. It is likely that not all sites will be visited due to logistical constraints.

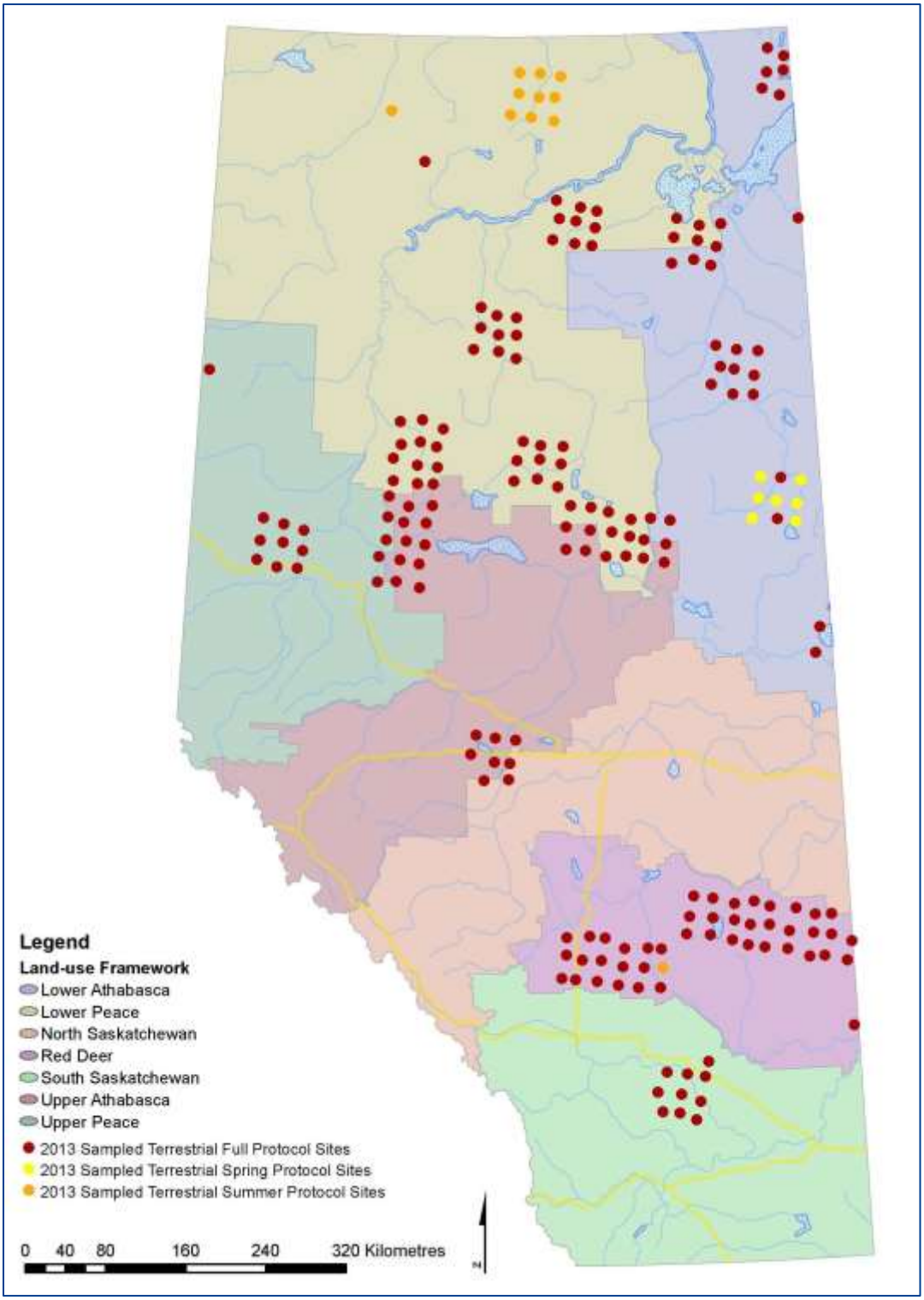


Figure 15: *Provincial map showing all terrestrial sites monitored in 2013 for spring and summer protocols (N=192).Largely due to fires, some sites were surveyed in either spring or summer, but not both (spring, N=181; summer N=185).*

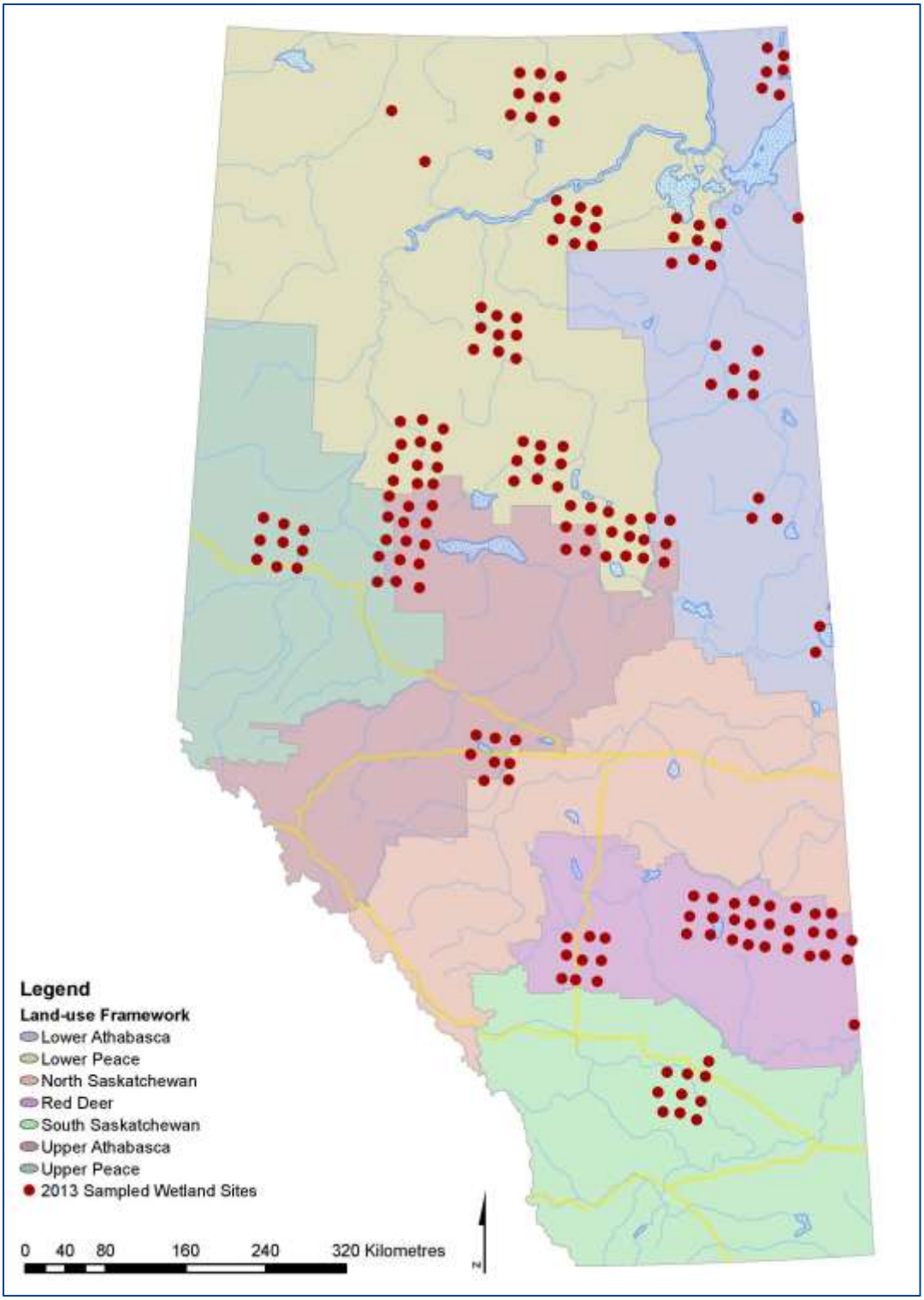


Figure 16: *Provincial map showing all sites monitored in 2013 for wetland protocols (N=174).*

EMCLA Pilot Monitoring Projects

The ABMI's partnership with the Ecological Monitoring Committee for the Lower Athabasca (EMCLA) continued in 2013. Both EMCLA field projects operated for a second year with operational support from the ABMI.

Rare Animals

Fieldwork using automated recording units (ARUs) continued into 2013. Fieldwork began in mid-March and continued until the end of July. The EMCLA tested a deployment design that was compatible with ABMI's monitoring protocols by deploying 5 ARUs in a grid array per site, similar to the ABMI's bird stations. The team tested 2 different grid spacings: an exact duplicate of ABMI's spacing for Yellow Rails (600 m), and a larger spacing for owls (1.6 km). Winter surveys for owls were conducted following a similar design as 2012 (matched habitat types with differing levels of human development) at 14 different study areas, with a total of 42 different sites consisting of 224 individual ARU stations spread across those areas. Wetlands were opportunistically sampled for amphibians by placing a single ARU at a wetland nearby the owl study areas—this occurred at 27 wetlands across the LAPR. Summer surveys were focused on deploying recorders in good potential Yellow Rail habitat. Yellow Rail sites occurred in large wetland complexes, with multiple sites occurring in each complex. This resulted in 22 complexes being surveyed, with a total of 65 sites comprised of a total of 324 individual ARU stations.

Rare Plants

Fieldwork continued and ramped up in 2013. Surveys were conducted using the same model and protocols as 2012 in order to gather enough data to run a second iteration of the adaptive sampling model. Over 220 sites were visited from late June to late August. EMCLA crews also sampled at 5 ABMI sites located in the LAPR to further the methodological comparison between the 2 protocols.

More information on both of these projects can be found at the EMCLA's website – www.emcla.ca.

Remote Sensing

3 x 7 km Plots

In 2013, the remaining LAPR sites from Panel C and all of Panel E are planned for photography (Table 11). The remaining LAPR Panel C site and all of Panel D sites that were photographed in 2012 will be completely interpreted by the end of 2013. Plans for 2014 include completing photography for all of Panel E (if necessary) and interpretation of Panel E, with completion of the entire region expected in 2014 syncing with field activities for the start of Rotation Two.

Table 11: *Progress to date on 3 x 7 km aerial photograph acquisition and interpretation for the Lower Athabasca Planning Region.*

	# LAPR Sites	Photographs Obtained						Interpreted				
		'08	'09	'10	'11	'12	'13	'09/'10	'11	'12	'13	'14
A	43*	39	-	-	-	-	-	6	33	-	-	-
B	52	0	0	23	22	7	-	-	23	29	-	-
C	51*	0	0	0	26	21	(1)	-	-	47	(1)	-
D	44*	0	0	0	0	42	-	-	-	-	(42)	-
E	45*	0	0	0	0	0	(39)	-	-	-	-	(39)
Total	**235**	**180 (220)**						**138 (181)**				

* CLAWR sites not flown (15 sites). ABMI is working with government to gain access. (Number of sites per panel affected by proximity to the CLAWR: A= 4, B=0, C=2, D=3, E=6). Numbers in brackets are planned for completion in 2013-2014 providing sufficient funding is available.

2014 and Beyond

In 2012 and 2013, the ABMI had substantial financial support for work in the LAPR from the Government of Alberta and the Oil Sands Developer's Group (OSDG; funding from commercial oil sands operations in the LAPR). Funding levels were sufficient for full implementation of the ABMI program in the LAPR, and we were able to survey the equivalent of a full panel of sites. Our tentative funding agreements will also permit for full implementation in 2014 and beyond.

The federal and provincial governments have announced a Joint Oil Sands Monitoring Program (JOSM). ABMI is an essential part of the terrestrial biodiversity and habitat monitoring component of this system, and a budget that recommends full funding for the ABMI in the LAPR has been passed to senior levels of government.

Assuming that the ABMI receives full support for the LAPR region, the plan is to continue with full implementation of the ABMI terrestrial and wetland protocols for this region in 2014. Full implementation would mean that a full panel of sites will be monitored each year (e.g. A, B, C, D, or E) and that all 235 sites will be monitored in five years. The preliminary plan for 2014 is to sample 31 sites in the LAPR, completing more than half of Panel E and a few outstanding sites from panels A, C and D (Table 12). Rotation Two would begin in 2015, with a few remaining sites from Rotation One. Note that this plan is contingent on full funding, and on access to all areas of the region (e.g. no major fires or other disturbances that would restrict access to an area). The ABMI is still in the process of negotiating access to the Cold Lake Air Weapons Range (CLAWR) with the provincial and federal governments. Province-wide, the ABMI plans to monitor approximately 225 terrestrial and wetland sites in the spring and summer of 2014.

Table 12: *Tentative plan for field implementation in the LAPR for 2014 and future years, contingent on full funding and access to all areas of the region (e.g. CLAWR)*

Year	Tentative Plan*
2014	Panel A (4 sites), Panel C (4 sites), Panel D (3 sites), Panel E (20 sites); (8 are CLAWR sites)
2015	Panel A (Rotation Two)
2016	Panel B (Rotation Two)

**Outstanding Rotation One sites including CLAWR sites will be scheduled as access permits.*

The ABMI will continue to provide scientific and operational support to the EMCLA's Rare Animals and Rare Plants projects. In 2014, it is anticipated that both of these projects will continue with a third year of fieldwork. Fieldwork for the Animals project will start in March with owl surveys and continue throughout the spring and summer with amphibian and Yellow Rail surveys. Automated recorders will be deployed throughout this period. Plants fieldwork will take place in June, July, and August.

FURTHER READING

ABMI Documents:

All ABMI documents are available at www.abmi.ca under the 'Reports' tab.

Annual Report:

Alberta Biodiversity Monitoring Institute. 2013. 2012 Annual Report. Alberta Biodiversity Monitoring Report, Alberta, Canada.
(see annual reports from previous years as well)

Core Reports:

Alberta Biodiversity Monitoring Institute. 2012. The Status Report of Landbirds in Alberta's Boreal Plains Ecozone (00067), Version 2012-09-26. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Alberta Biodiversity Monitoring Institute. 2009. The Status of Biodiversity in Alberta-Pacific Forest Industries' Forest Management Agreement Area (00103), Version 2009-12-01. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Alberta Biodiversity Monitoring Institute. 2009. Status of Biodiversity in Alberta's Lower Athabasca Planning Region (00102), Version 2009-02-01. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Field Protocols and Data Sheets:

Alberta Biodiversity Monitoring Institute. 2012. Wetland field data collection protocols (10046), Version 2012-06-27. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Alberta Biodiversity Monitoring Institute. 2011. Wetland field data sheets (10036), Version 2011-06-01. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Alberta Biodiversity Monitoring Institute. 2012. Terrestrial field data collection protocols (10045), Version 2012-06-27. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Alberta Biodiversity Monitoring Institute. 2010. Terrestrial field data sheets (10003), Version 2010-04-20. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Laboratory Protocols:

Alberta Biodiversity Monitoring Institute. 2012. Processing Aquatic Invertebrates (10017), 2012-07-20. Alberta Biodiversity Monitoring Institute, Alberta, Canada. Report

Alberta Biodiversity Monitoring Institute. 2008. Processing Mineral Soil Samples (10043), Version 2010-11-01. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Alberta Biodiversity Monitoring Institute. 2010. Processing Tree Core Samples (10011), Version 2010-11-01. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Alberta Biodiversity Monitoring Institute. 2010. Laboratory Protocols for Processing Lichens (10008), Version 2010-05-31. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Alberta Biodiversity Monitoring Institute. 2010. Laboratory Protocols for Processing Bryophytes (10009), Version 2010-05-31. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Alberta Biodiversity Monitoring Institute. 2009. Processing Terrestrial Bird Recordings (10006), Version 2009-11-23. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Alberta Biodiversity Monitoring Institute. 2009. Processing Vascular Plant Samples (10012), Version 2009-06-08. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Alberta Biodiversity Monitoring Institute, 2009. Processing Mites and Springtails (10010), Version 2009-05-08. Alberta Biodiversity Monitoring Institute, Alberta, Canada.

Non-ABMI documents:

Lower Athabasca Regional Plan 2012-2022. 2012. Government of Alberta.

Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring. 2012. Government of Canada.

Annual Report. 2011. Ecological Monitoring Committee for the Lower Athabasca. Available at www.emcla.ca

Annual Report. 2012. Ecological Monitoring Committee for the Lower Athabasca. Available at www.emcla.ca

Land-use Framework. 2008. Government of Alberta.

Canada's National Forest Inventory. 2004. Design Overview v. 3.2. Natural Resources Canada. www.nfi.nfis.org

APPENDIX 1: METHODS

Complete ABMI protocols can be found on the ABMI's website (www.abmi.ca) in the 'Report' Section

Terrestrial Sites
Terrestrial sites are visited **twice** in the year that they are monitored (ideally, once every five years). In addition, most terrestrial sites are visited in May to establish the site and verify that it is accessible.

1) Spring protocols take place in late May through June, to coincide with the songbird breeding season. Additional protocols carried out at this time include identification and measurement of trees, stumps, and snags, collection of soil samples, surveys of downed woody material, and collecting information on general ecological conditions (e.g. ecosite classification).

2) Summer protocols take place in late June and July, to coincide with the peak in vascular plant detectability. Additional protocols carried out in summer include assessing the age of trees, collecting bryophytes and lichens, and measuring shrub and canopy cover.

The **Winter** protocols take place at a different location than the spring and summer protocols, normally along pre-existing linear features in the area of the NFI site. Surveys are completed between December and March, the timing of which depends largely on appropriate snow conditions. The main protocol carried out in winter is mammal tracking. Appropriate habitat data and data on snow conditions are collected at the same time.

Wetland Sites
Wetland protocols are carried out during a single visit to the wetland that takes place in the summer, from late June through July. All data is collected at this time. In addition, most wetland sites are visited in May or early June, to ensure that the wetland meets ABMI's criteria for wetland sites.

Ideal wetlands for the ABMI protocols:

- Are bodies of water with an open surface area between 1 and 100 ha.
- Have a maximum depth between 0.5 and 2 m.
- Have transitional vegetation zones, or the potential to have them.
- As such, have a low probability of complete water evaporation within or between years.

These criteria increase the likelihood that the wetlands that ABMI monitors will persist well into the future, securing the long-term investment in monitoring.

Terrestrial Site Establishment and Wetland Verification

Terrestrial site establishment normally takes place in May. Crews are provided with a GPS coordinate and a series of maps of the area. The crew navigates to the site by helicopter, truck

and/or quad, and eventually on foot. As they proceed, they create (or update) an easy set of directions for future crews to follow. The crew will ensure that the site is safe and available for monitoring (e.g. no locked gates, no industrial activity that may pose safety hazards), and flags the site for spring and summer data collection.

Flagging is used to mark out a one-hectare square, with the site's main GPS coordinate located at the Site Center (Figure 1). Almost all of the data ABMI collects for the site will come from within this one-hectare area. Exceptions include some of the breeding bird data, soil samples, and surface substrate measurements. Soil samples and measurements are taken from outside the 1 ha area in order to not compromise the integrity of the site itself.

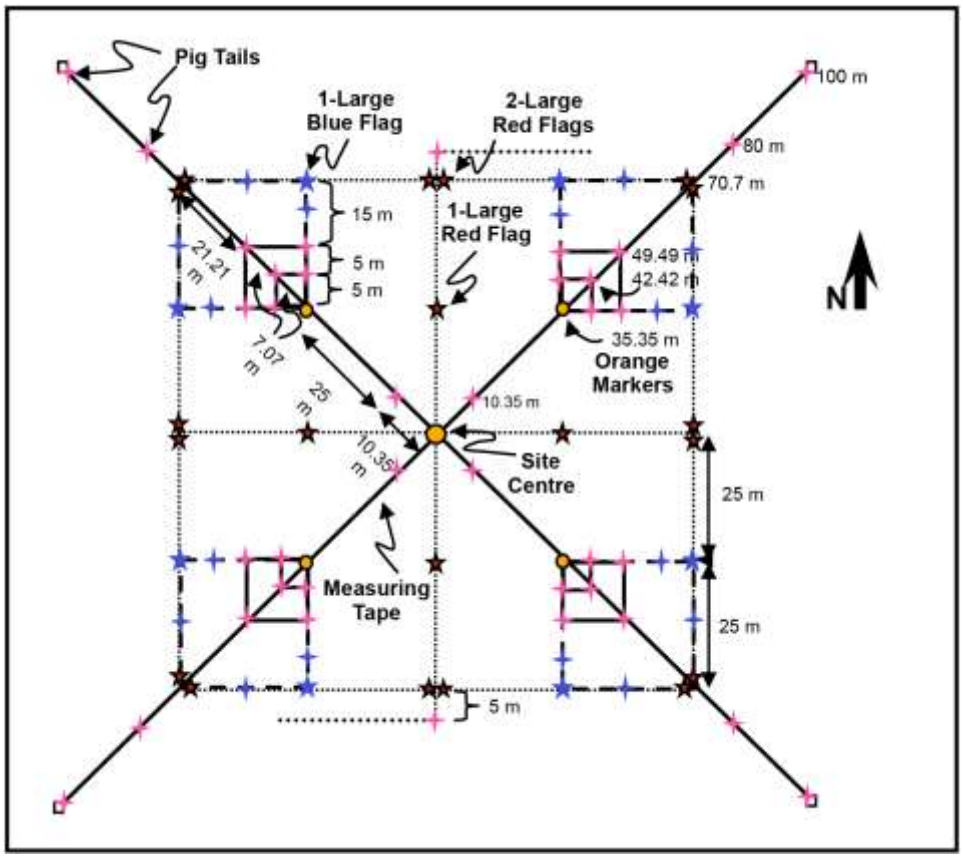


***Figure1**: Diagram showing the layout of the ABMI's 1 ha terrestrial plot.*

Sites are flagged by locating the Site Center, and establishing four sub-ordinal transects from this point, and then marking the N, S, E, and W boundaries of the plot with additional flagging. The 1 ha area is divided into four quadrants (NE, SE, SW, and NW) each with their own quadrant center, located 35.35 m along the sub-ordinal transects from Site Center. This quadrant center marks the innermost corner of three nested tree plots (5 x 5, 10 x 10, and 25 x 25 m) and the center of the vascular plant plot (50 x 50 m). Mosses and lichens are collected from the outermost parts of the quadrants (15 x 25 m plots).

Wetland Sites
Wetland verification normally takes place in May or early June. During verification, a crew visits the wetland to ensure that it meets ABMI's stringent criteria for wetlands to be monitored (above), creates or updates a set of directions to the site, and ensures accessibility and safety. This is more critical in the south, where there are fewer wetlands, and water levels fluctuate more sharply.

Remote Sites
Some remote sites are not visited for establishment or verification, because the cost of sending the helicopter out for an extra trip is prohibitive. For these remote sites, terrestrial sites are established during the spring protocol season, either by the crew that will collect the spring protocol data (usually the day prior to spring data collection), or by a separate establishment crew that is working in advance of the data collection crews. Wetland verification takes place during the spring terrestrial protocol season, since the helicopter is flying over the area. The wetland crew will confirm additional characteristics (e.g. wetland depth) when they arrive at the site for data collection.

Terrestrial Protocols - Spring
Starting in mid to late May and through June, the ABMI implements the spring protocols at the terrestrial sites to be surveyed that year. At this time, the ABMI collects data on:

- Breeding birds
- Soil cores (mineral and LFH soil; soil arthropods - springtails and mites)
- Trees, snags, and stumps
- Downed woody materials
- Site photographs

A two-person crew accesses the site using directions provided during site establishment. In spring, the crew arrives at the site very early in the morning, in order to record songbirds for the breeding birds protocol. For non-remote sites, the crew will travel from a central camping spot that morning. At remote sites, the crew will generally have camped within 500 m of the site the night before. Normally, one technician will conduct the breeding birds protocol, while the other technician begins the protocols that are conducted within the 1 ha plot.

Detailed descriptions of the protocols can be found in the Protocol Documents and Field Data Sheets, available on the ABMI website.

Breeding Birds
Breeding songbird data is collected using high-quality digital recording equipment, rather than by technicians identifying bird calls in the field. This reduces the variability in quality of identifications over space and time, because all recordings can be identified by a small number of 'observers'.

The technician will take nine separate recordings, with the first point count station located at the site center. The other eight point count stations are arranged in a square surrounding site center, and each station is 300 m apart (Figure 2). GPS locations for each point count station are pre-loaded into the crew's GPS units. Songbird recordings must begin between one half-hour before sunrise and sunrise, and all nine stations should be completed as quickly as possible to maximize the number of birds recorded (e.g. early morning). Sunrise at the monitoring location is defined as that given on the GPS unit.

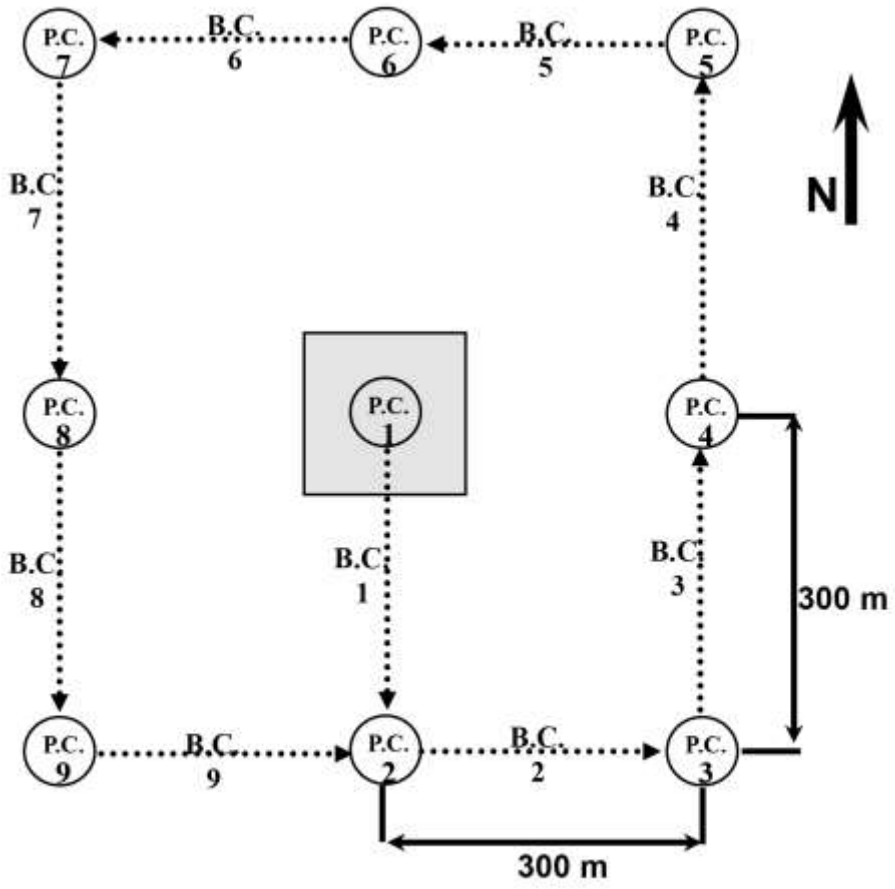


Figure 2: *Diagram showing the layout of the nine bird point count stations at terrestrial sites. Technicians proceed from station 1 to station 9.*

One technician will navigate around to the nine point count stations. At each station, the technician sets up the recording equipment within 5 m of each GPS location and records for ten minutes. While recording, the technician will record detailed information on the physical and ecological characteristics (roughly 150 m radius of the station), as well as conditions that might affect the quality of the recording (e.g. precipitation, wind). Ecological information recorded includes the ecosite type, any human and/or natural disturbance (e.g. cutblocks, fires, roads), the dominant tree species, with corresponding average distance between trees and heights,

and shrub and herbaceous cover. Physical conditions include the slope, aspect, and proportion of bare ground and/or water present. The technician will also record the start time of each recording and note the temporary recording ID. Recordings are backed up to a field computer each day.

Soil Cores

Sore cores are collected in order to sample mites (Order Oribatida) from the organic soil, as well as to take a sample of mineral soil that is analyzed for carbon content and pH.

To minimize disturbance to the ABMI site, soil samples are taken from just outside the 1 ha plot at the NE, SE, SW, and NW corners (Figure 3). At each corner of the plot, the technician collects 500 mL of organic soil and 250 mL of mineral soil from at least four different soil cores, arranged in a circle. Up to 24 cores can be taken, if needed, to make up the 500 mL and 250 mL volumes. If after 24 cores, there is less than 500 mL and/or 250 mL of soil, the technician stops and notes the total amount collected. This is common in bogs (no mineral soil) or in the southern grasslands (little LFH).

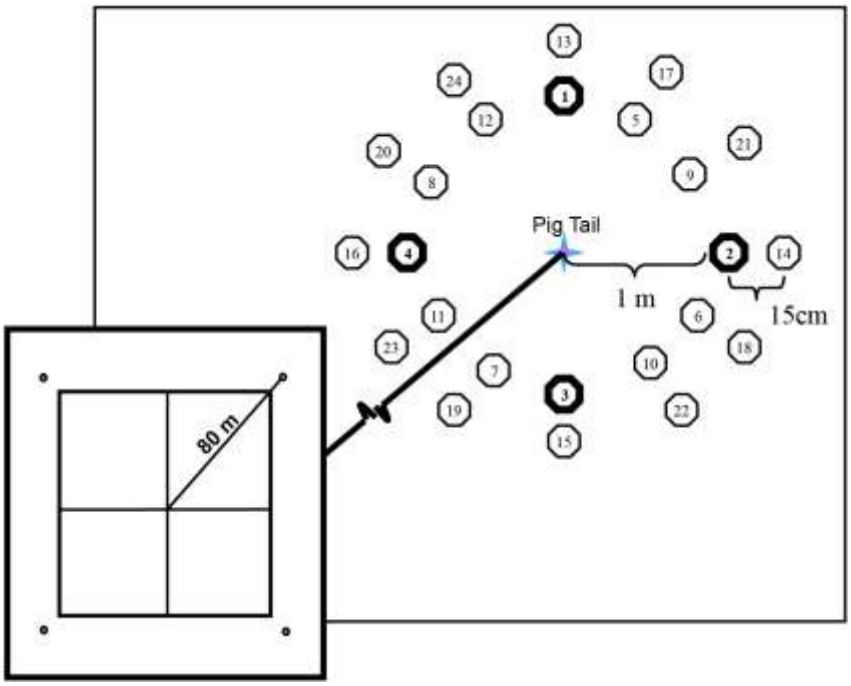


Figure 3: *Soil Core Protocol- note location outside of 1 ha plot and the circular arrangement of soil cores*

The technician uses a 2” diameter soil corer to obtain a core that contains both LFH (litter, fermentation, humus) organic soil and mineral soil. The two soil layers of the core are separated, and collected in different bags. If the first four cores produce more than 500 mL of LFH and 250 mL of mineral soil, the technician combines all cores and takes a random sample of each type of soil. While sampling, the technician notes the slope, aspect, ecosite phase, and any

human disturbance for the 2 m radius area where cores are collected. Cores are never taking in standing water, and if rocks, downed wood or other obstructions are encountered, the technician notes this on the data sheet.

Samples are placed in cloth bags, clearly labeled by site, quadrant, and soil type. To maximize the number of arthropods that can be counted, samples are shipped to the Royal Alberta Museum within three days of collection.

Once samples arrive at the Royal Alberta Museum, soil arthropods are extracted from the LFH soil within six days of collection. Arthropods are extracted using Berlese funnel extractors, and the extraction process lasts for seven days. Once the sample is extracted, and the arthropods are preserved in ethanol, the mites are identified by an expert within 60 days. Mineral soil samples are analyzed for soil organic carbon and pH by accredited laboratories within 28 days of being collected.

Downed Woody Material

As part of the National Forest Inventory protocols, the ABMI inventories all fallen woody debris along four transects at each ABMI site. Transects are located along the four sub-ordinal lines, and are 25 m long (Figure 1).

The technician walks along each transect, recording all pieces of woody debris encountered. Pieces are classified by diameter as Coarse (> 7cm, inventoried along the entire 25 m transect); Small (1-7cm, inventoried only along the last 10 m of the transect); and Fine (<1 cm, inventoried only for the last 5 m of the transect). For pieces of Coarse Woody Debris (>7cm), the technician will record the tree species (if possible) and a decay stage from 1 (recently dead) to 5 (almost decomposed).

Trees, Snags, and Stumps

ABMI measures the size, density, and species of trees, snags, and stumps found at each ABMI site. Trees, snags, and stumps are inventoried in three nested plots for three different size categories of trees in each quadrant of the site (Figure 1). The smallest plot is 5 x 5 m, which is nested inside a 10 x 10 m plot, and both are located inside the 25 x 25 m plot.

- In the 5 x 5 meter plot, the technicians measure ALL trees, snags, and stumps.
- In the 10 x 10 m plot, technicians measure all trees, snags, and stumps that are >7cm DBH (diameter at breast height).
- In the 25 x 25 m plot, all trees, snags, and stumps > 25cm DBH are measured.

Note that stumps are defined as snags that are <1.3 m tall, and the diameter is measured at their top. Both snags and stumps must be standing at > 45 degree angle from the ground, or they are considered downed wood. For each tree, the technicians record the species, DBH, height (measured with a vertex hypsometer), and condition (e.g. alive, dead; if dead, a decay stage is recorded). For very large trees, a base of crown height and crown canopy class (e.g.

veteran, dominant etc.) is also recorded.

Site Photographs
One technician will take six photographs of each site with a 35 mm digital camera. The photographs are:

- Transect photos in each of the four sub-ordinal directions (NE, SE, SW, and NW).
- Canopy photo taken from site center and pointing directly overhead
- Representative site photo taken from anywhere in the 1 ha plot, at a spot that best represents the general physical conditions and vegetation at the site.

The transect photos and the representative photo include a scale (e.g. backpack, tree calipers), and photographs are downloaded to a computer each evening.

Incidental Species
Each technician will record data on any incidental species they encounter during data collection. Incidental species recorded include mammals (including domestic and feral species), amphibians, reptiles, fish, and some birds (woodpeckers, waterfowl and shorebirds, raptors, grouse, and corvids/jays). Technicians are provided with binoculars and relevant field identification guidebooks.

Technicians record a unique species code, the type of observation (e.g. observed, heard, scat, nest, tracks, etc.) and whether the species was observed in the 1 ha plot or 36 ha plot (during bird point counts) on the data sheet. The data sheet also includes a space to indicate the time that the technician entered and left the plot, as a rough measure of survey effort.

Terrestrial Protocols – Summer

Starting at the end of June through the end of July, the ABMI implements summer terrestrial data collection protocols at each site to measure:

- Vascular plants
- Bryophytes (mosses and liverworts) and Lichens
- Tree ages
- Shrub and canopy cover
- Surface substrate
- Incidental species (same protocol as spring)

Normally, the same crew that monitored the site in spring will return for summer protocols, using the same means of access. In each crew, one technician will have specialized skills and training in identification of vascular plants, and will carry out this protocol, while also collecting shrub cover data. The other technician will collect tree age, canopy cover, and surface substrate data. Bryophyte and lichen data are collected at the same time, with one technician collecting bryophytes and the other lichen (consistent for the whole summer).

Detailed descriptions of the protocols can be found in the Protocol Documents and Field Data Sheets, available on the ABMI website.

Vascular Plants

This protocol is designed to detect as many species of vascular plants as possible during a time-constrained search of the 1 ha area. A technician experienced in vascular plant identification in Western Canada, who receives additional training from the ABMI, conducts this protocol. Vascular plants include all angiosperms, gymnosperms, ferns, and club mosses.

Plant surveys are conducted for 20 minutes in each of the four quadrants (80 minutes total). The technician begins by taking approximately 10 minutes to write down the names of all vascular plants s/he can see in the area on the data sheet. This ensures that most of the 20 minute timed searches are spent actually looking for plant species, rather than writing down names.

Timed searches begin in the NE quadrant, and move clockwise through the remaining three quadrants. Each search is 20 minutes, and the technician moves throughout the entire quadrant in a circular pattern, ensuring that all microhabitats are examined. Each time a species from the list is encountered, it is marked with a 'check' for that quadrant. New species are added to the list as required. ABMI does not collect abundance data for vascular plants, but for each quadrant, the technician will note a single dominant species (highest percentage cover in the 10 x 10 m tree plot, excluding tree species) and also note any common species (species present in more than half of the 10 x 10 m plot). There can be multiple common species, or none, in any given quadrant, but only one of the common species can be recorded as the dominant species.

If the technician observes a plant that they cannot identify, they take the following steps:

- Collect a voucher specimen from outside the 1 ha plot, if possible.
- After the 20 minute search is over, use field guides and attempt to quickly identify the specimen in the field
- If more time is needed for identification, the technician presses the plant in their small field press, assigns an ID number, and takes it back to camp for identification in the evening.
- If the technician still cannot identify the plant, they move it to their large plant press, which will be brought to the Royal Alberta Museum for expert taxonomic identification.

Bryophytes and Lichens

The ABMI collects bryophytes (mosses and liverworts) and non-crustose lichens for identification at the Royal Alberta Museum. Bryophytes and lichens are collected in four 15 x 25 m plots located at the outside corners of the four tree plots (Figure 4). In each plot, one technician spends up to 35 minutes searching for and collecting bryophytes, while the other technician collects lichens.

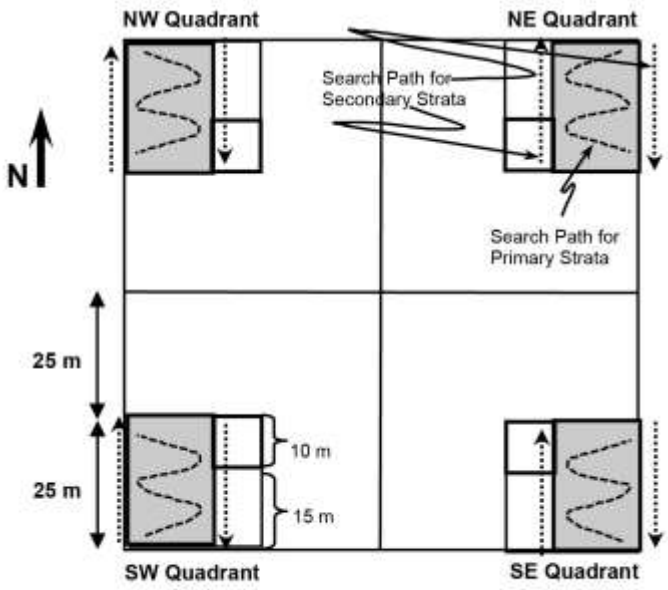


Figure 4: *Diagram showing the layout of the moss and lichen plots, with primary and secondary strata search locations.*

Searching is stratified into five microhabitat types: logs/stumps, trees/vertical structures, wet areas/peatlands, rocks/cliffs, and upland soils. First, the technicians search the three microhabitats that typically contain the most diverse bryophyte or lichen communities (respectively). In most cases, this search will last 25 minutes, with the technician moving in a zigzag pattern throughout the 15 x 25 m plot, searching for microhabitats and collecting bryophytes or lichens as they find them. The search can be terminated early if few of the microhabitat types are encountered (e.g. agricultural areas, human development). Second, technicians complete a 50 m belt transect located on the border of the plot (Figure 4). This search targets the microhabitats that typically contain less diverse communities of bryophytes or lichens, and lasts exactly 10 minutes.

Technicians strive to collect as many species of bryophytes and lichens as possible from each quadrant, without taking duplicates. If in doubt as to whether a sample represents a new species, technicians collect it. Samples are dried, and brought to the Royal Alberta Museum for identification.

Tree Ages

The ABMI assesses the age and rate of growth of trees at each site using tree cores. A maximum of nine trees are cored at each site:

- The largest live tree in the 1 ha plot, regardless of species or location
- The largest live tree of the most common species within each quadrant (4 cores)
- The largest live tree of the second most common species within each quadrant (up to 4 cores; only collected if the second species represents at least 20% of canopy stems).

Largest is defined as the largest DBH (diameter at breast height). All trees must be dominant or co-dominant in the stand, and veteran trees from an older stand are excluded (except for the largest live tree). For each tree that is cored, the technician will record the species, DBH, height (measured by vertex hypsometer), and any significant tree damage that could have affected normal growth and current height of the tree (e.g. insect damage, lightning strikes, forking etc.).

Cores are obtained using an increment borer. If all trees in the quadrant are <10 cm DBH, a destructive 'cookie' sample is taken from a tree that is outside of the plot, but representative of the leading species trees inside the quadrant. Cores and cookies are sent to the Northern Alberta Forestry Center for expert analysis, and the data returned to ABMI.

Shrub and Two-Dimensional Cover

This protocol measures shrub and ground vegetation cover in the four 5 x 5 m plots found adjacent to each of the quadrant centers (Figure 1). At each plot, the technician records the ecosite classification for the 5 x 5 m plot, any human or natural disturbance, the slope, and the aspect. The technician estimates (by eye) the percentage cover of the following categories of vegetation:

- The layer of shrubs and small trees >0.5 - <1.3 m in height, as if a photograph was taken from 1.3 m above the plot.
- The layer of shrubs >1.3 m in height (excluding shrubs less than 1.3 m), as if a photograph was taken from 5 m above the plot.
- 13 other categories of cover: shrubs <0.5 m, grasses, sedges/rushes, moss, lichen, fungi, wood, litter, water, bare ground, and animal matter, as if a photograph was taken from 0.5 m above the ground.

Percentage cover is measured separately for each group as either 0, <1%, or in 5% increments.

Canopy Cover

This protocol measures canopy cover at eight points:

- The four quadrant centers (35.35 m from Site Center along each sub-ordinal transect (see Figure 1).
- The outermost corner of the 10 x 10 m tree plot (49.49 m from Site Center along each sub-ordinal transect).

The technician measures canopy cover using a densitometer held at elbow height and pointed directly overhead. The densitometer has 24 squares, and the technician imagines 4 dots in each square, and counts the number of dots that are NOT covered by leaves or branches (out of a score of 96).

Surface Substrate

ABMI measures the depth of organic material in the soil at all sites. Two 30 m soil transects are measured outside of the 1 ha plot, so the soil inside the site is not disturbed (N and S of the Site Center; Figure 5).

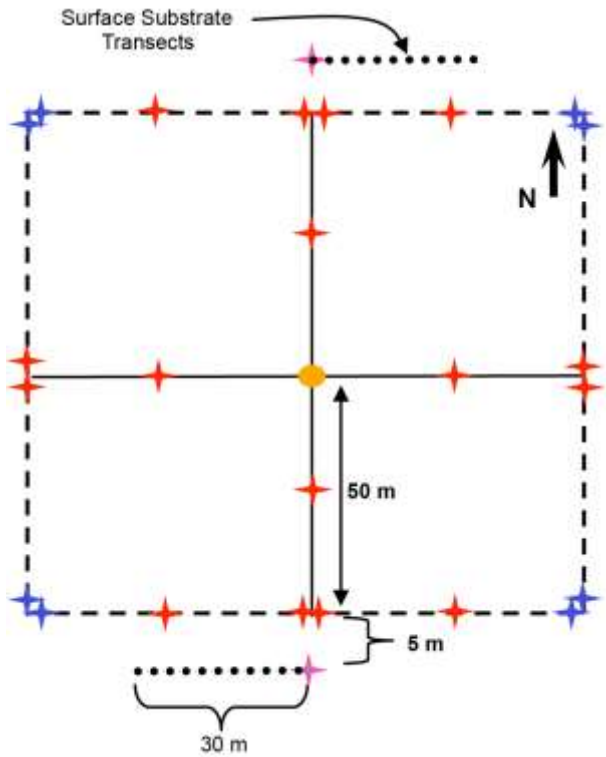


Figure 5: *Diagram showing the location of the surface substrate transects N and S of the plot and extending for 30 m.*

The technician measures the depth of organic matter and/or buried wood every 2 m along the transect, in increments of 0.5 cm. At the beginning of each transect, the slope and aspect, and any human disturbances are recorded. At each sampling location, the technician uses a shovel to expose a soil profile and measures the depth of LFH soil, and also the depth of any pieces of buried wood (at least 10 cm in diameter). If rocks, water, mineral soil or other obstructions are encountered, the technician can move the sample point <1 m away from the original location to measure the depth of organic material. If this is not possible, the technician notes the obstruction on the data sheet.

In bogs or wetlands, a soil probe is used to measure the depth of organic matter, up to a depth of 5 m. The technician measures depth in 10 cm increments and notes if frost or bedrock is encountered.

Terrestrial Protocols – Winter Mammals

The ABMI surveys mammals using snow-tracking surveys. Surveys are designed to detect tracks of mid to large sized mammals. All surveys take place between December 1 and March 31 when

there is sufficient snow on the ground to accurately identify mammal tracks. In general, the ABMI strives to snow track the same sites that were surveyed the previous summer, but this is sometimes difficult as snow conditions are often not suitable for tracking.

The ABMI conducts surveys along one 10 km transect for each monitoring site. Because most surveys are conducted using snow machines, transects generally follow human features, including unimproved roads, cutlines, or seismic lines. Transects should be as straight as possible, with the midpoint located as close as possible to the NFI site (Figure 6). For remote sites without human features, the transect passes from NW to SE as close to the Site Center as possible. For these remote sites, surveys are conducted on skis or snowshoes. A suitable transect is identified ahead of time using high-resolution GIS images, and a back-up transect is also selected, in case the preferred route is found to be impassable when crews arrive on site.

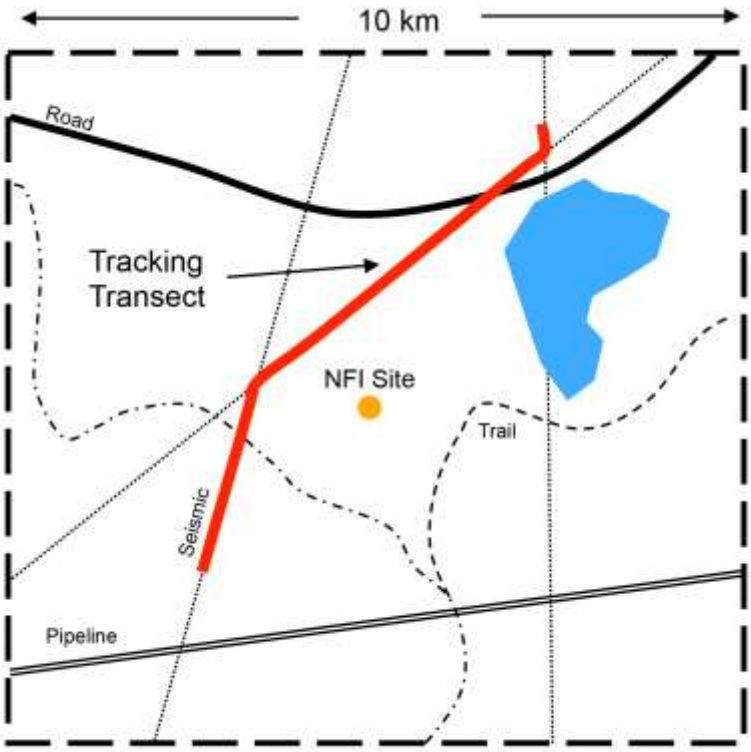


Figure 6: *Diagram showing the layout of the ABMI winter mammal tracking transects. The transect passes as close to the NFI site as possible, and is as straight as possible, while following anthropogenic features.*

All surveys take place within 3 to 6 days of a track obliterating snowfall (defined as >1 cm of snow and/or winds exceeding 30 km/h). The technicians record the days since snow, temperature, weather, snow depth, and snow conditions. The 10 km transect is divided into forty 250 m segments, and a GPS log is recorded during data collection. For each segment, the technician records the primary and secondary habitat types (see protocols for habitat

classification) and any human disturbances. All tracks that cross the transect (within 1 m), or travel along the transect, are recorded.

If a track cannot be identified in the field, the technician takes photographs, measurements and notes that can be used to identify the track in the laboratory. Photographs are taken whenever an unusual species is recorded (e.g. wolverine, swift fox, animals outside of their normal range or not normally observed in winter).

During snow tracking, technicians record any incidental species observed during data collection, using the same methods as in spring and summer.

Wetland Protocols

The ABMI surveys wetlands from late June through to the end of July. During wetland surveys, the ABMI collects data on:

- Vertebrate Species
- Wetland Physical Characteristics (photographs, shoreline sketch and shoreline characteristics, bathymetric map)
- Water Physiochemistry and Nutrients
- Aquatic Invertebrates
- Vascular Plants
- Incidental species (using the same protocol as terrestrial sites; see above)

All surveys are conducted by two-person crews. One technician will have specialized training in the identification of vascular plants, and completes this protocol. The other technician will complete all remaining protocols.

Detailed descriptions of the protocols can be found in the Protocol Documents and Field Data Sheets, available on the ABMI website.

Vertebrate Survey

Before arriving at the wetland, the crew stops at a vantage point where they can see the majority of the wetland. The technician with the best identification skills conducts a ten minute scan of the wetland using binoculars and records all species seen or heard. The data sheet has space for the technician to record the number of individuals, sex, type of observation (e.g. seen, heard), and any comments. The possible list of vertebrate species recorded is the same as for the terrestrial Incidental Species protocol (e.g. corvids/jays, raptors, waterfowl, woodpeckers, amphibians, mammals, reptiles, and fish; excludes songbirds).

Wetland Physical Characteristics

Most physical characteristics are measured relative to the Fixed Transect Line (FTL), which is established the first time the wetland is surveyed. Each wetland is assigned a random start bearing (0-360 degrees). The technicians paddle along the shoreline to the point where this

random bearing is perpendicular to the shoreline, and then walk 60 m along the bearing away from the wetland. The wetland Start Pin is placed at this location, and the Fixed Transect Line extends into the wetland from this point (Figure 7).

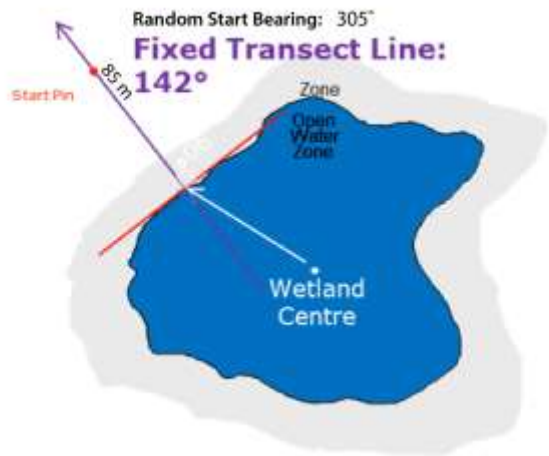


Figure 7: *Diagram demonstrating the layout of the Fixed Line Transect (FTL). The bearing of the FTL is randomly assigned before arriving at the wetland.*

1. Site Photographs

While standing at the interface of vegetation and open water along the Fixed Line Transect, the technician takes four photographs using a 35 mm digital camera:

- Looking towards the open water
- Looking back towards the upland
- Looking clockwise down the shoreline
- Looking counter-clockwise along the shoreline

In addition, the technician takes one photograph looking back to shore along the Fixed Line Transect while standing 50 m into open water. Photos are labeled appropriately and backed up to the field computer every night.

2. Shoreline Sketch

Many vegetative zones are visible on the high-resolution satellite images that ABMI creates of each wetland prior to the field season. Technicians should sketch the rough boundaries of the wetland using the satellite image, and confirm the information in the field by kayaking around the margins of the wetland. Wetlands < 15 ha are sketched completely, but for wetlands > 15 ha, the technician sketches 1200 m of shoreline, centered on the Fixed Line Transect.

The sketch must include:

- The position of the Fixed Line Transect
- The position of all vegetation transects (see below)

- Water sampling points (see below)
- Bathymetric depth transects (see below)
- All wetland zones: Open Water, Bare ground, emergent zone, fen zone, wetland margin, and upland zone)
- Any physical structures within 150 m of shore (e.g. islands, beaver lodges)

Wetland sketches are copied onto the satellite image, which are scanned and digitized for analysis.

3. Collecting general shoreline characteristics and human disturbance

Each wetland is divided into four quadrants:

- For wetlands < 15 ha, the quadrants are centered on the four cardinal directions (see Figure 8a).
- For wetlands > 15 ha, quadrants extend for 300 m each along the shoreline on either side of the Fixed Transect Line (2 in each direction; see Figure 8b).

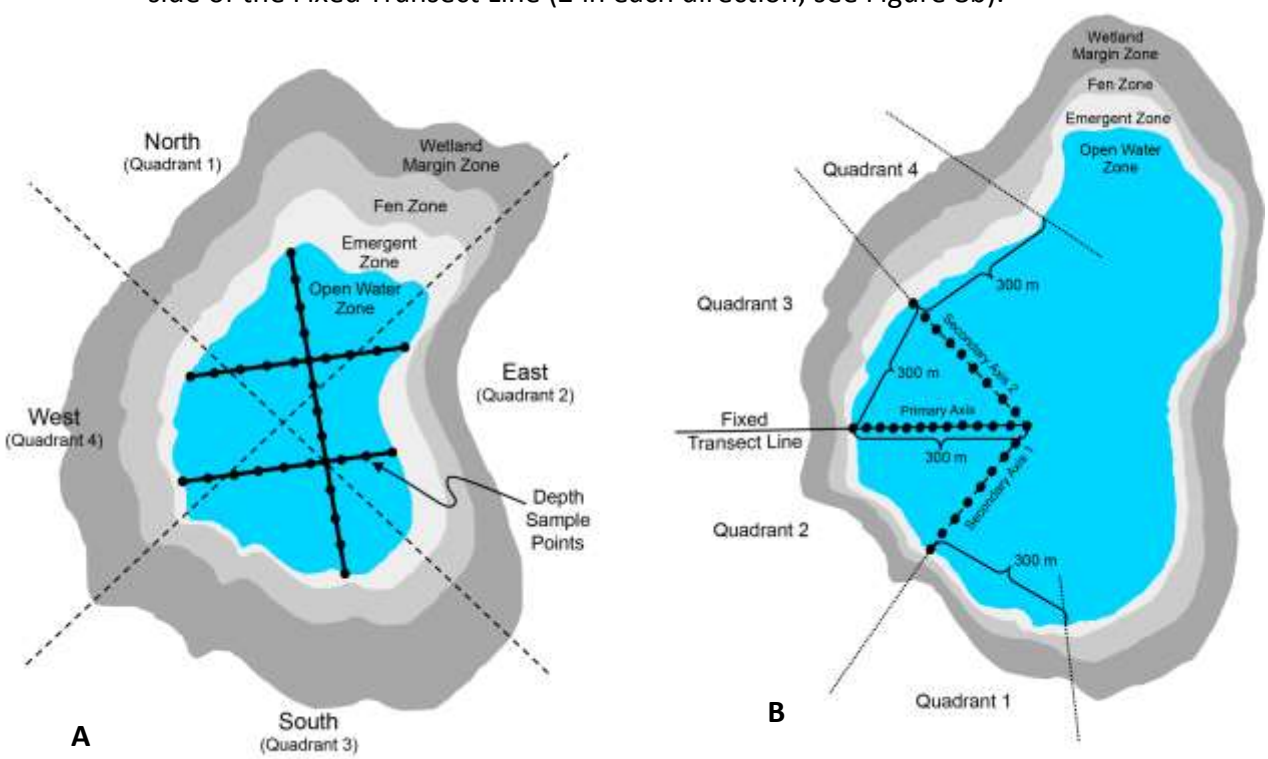


Figure 8a and b: *Wetlands smaller than 15 ha (left) and larger than 15 ha (right) showing quadrants for shoreline characteristics and placement of bathymetric mapping transects.*

In each quadrant, one technician describes shoreline characteristics separately for each quadrant, including:

- Ecosite classification (wetland margin, fen, and emergent zones only)
- Human disturbance
- Natural habitats (e.g. rocks, water, deciduous forest, grasses)
- Percentage ground cover of different vegetation types

4. Bathymetric mapping (water depth)

Water depth is measured along three transects using a weighted measuring tape from a kayak. Transects begin at the transition between Open Water and >10% vegetation cover. Technicians establish these transects in the first year the wetland is surveyed. In subsequent years, the same transects are used, even if the shape of the wetland has changed.

In small wetlands (<15 ha), the primary transect is established along the long axis of the wetland, using coordinates provided from GIS data. Two secondary transects are placed perpendicularly and spaced an equal distance apart, dividing the long axis into three equal length sections (Figure 9). In general, 13 depth measurements are taken along the long axis (spaced equally along the transect, and including one sample at the beginning and end where the transect enters >10% vegetation cover). Nine evenly spaced measurements are taken along each of the secondary transects. All measurements must be at least 5 m apart, so if the wetland is small, less than this number of measurements may be taken.

For large wetlands (> 15 ha), the FTL is used as the primary transect, and two additional transects are placed 300 m on either side of the FTL. All three transects are 300 m long, and depth measurements are taken every 25 m (13 measurements per transect)

Water Physiochemistry and Nutrients

Water samples are taken between 1:00 and 2:00pm from three locations:

- The deepest part of the wetland, as established by the bathymetric transects
- Two additional points spaced 25 m apart and located towards the center of the wetland (Figure 9). If the wetland is small, samples are collected at two equally spaced points between the deepest point and the furthest shore.

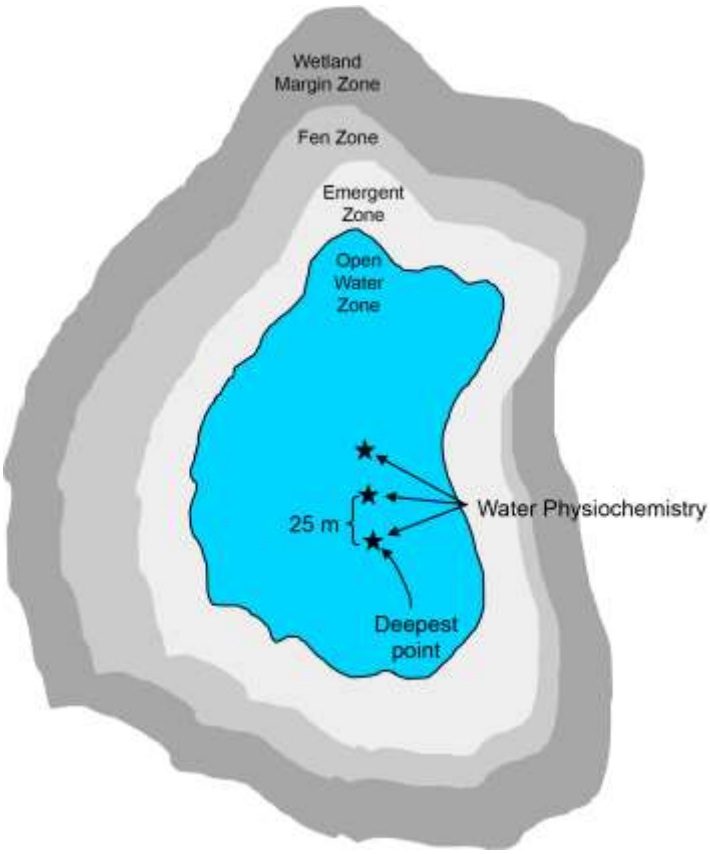


Figure 9: *Diagram showing the placement of water sample points in a typical wetland*

At each point, the technician records the water depth and collects a one-liter water sample from just below the surface. At the deepest point, the technician also collects a 30 mL sample of water for isotopic analysis. At all three points, the technician uses a calibrated Multiprobe to measure water temperature, pH, dissolved oxygen, salinity, and conductivity at a depth of 1 m. If the water is less than 2 m deep, measurements are taken in the middle of the water column.

The three water samples are mixed together and a 1 L sub-sample is placed in a dark Nalgene bottle (the remainder is returned to the wetland). At camp 8 mL of 5% H_2SO_4 is added, and the sample is refrigerated. The 30 mL isotope sample is also refrigerated, and both samples are shipped to the Royal Alberta Museum in a cooler for processing.

Aquatic Invertebrates

Ten samples are taken from the wetland. Invertebrate samples need to be fixed with formalin back in camp, so this protocol is completed just prior to leaving the wetland.

The ten samples are laid out as follows (Figure 10):

- One sample is taken near the deepest point in the wetland.
- Three samples are taken along the fixed transect line at the interface of the shore and open water, 25 m into open water, and 50 m into open water.

- Six samples are taken along two additional transects spaced 50 m apart along the shore in a clockwise direction, at the same distances as the fixed line transect.

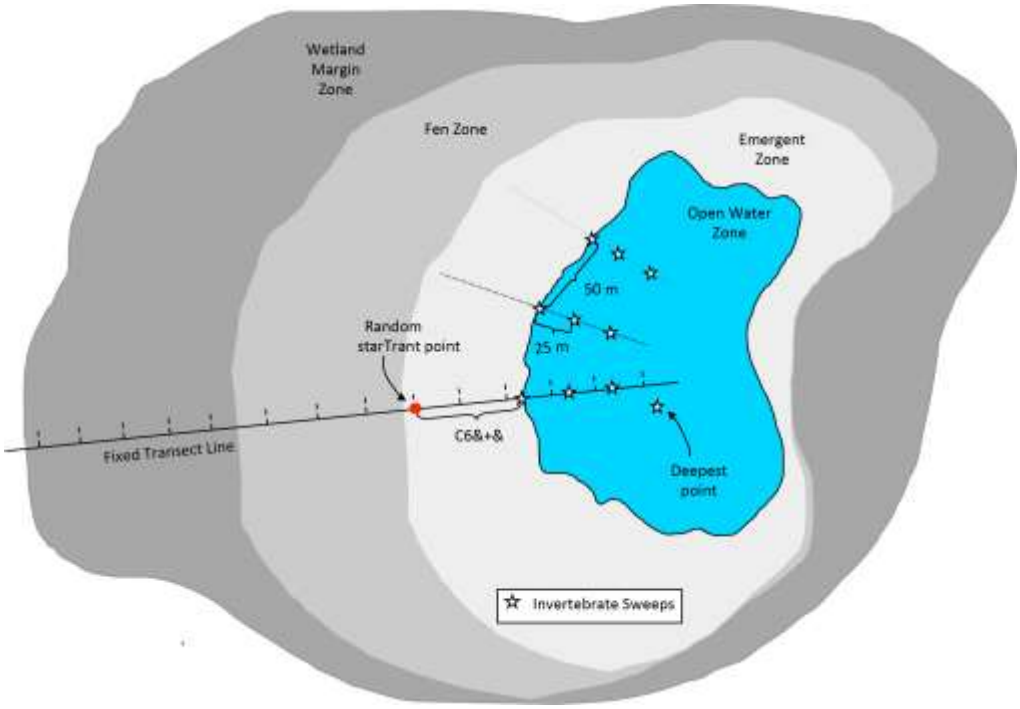


Figure 10: *Diagram illustrating the layout of the invertebrate sampling points along the FTL, along two additional transects, and the deepest point, for a typical wetland.*

To take a sample, the technician inserts a dip net into the water to a depth of ~1 m (or almost to the bottom if the wetland is <1 m deep), and quickly draws the net up. Three sweeps are taken in the same location, and the sample is inverted into a Nalgene bottle, including vegetation. If there is excessive vegetation, the technician 'washes' the sample in the net to dislodge invertebrates and removes vegetation. Samples that contain mud or silt must be discarded and a new sample taken. At camp, at least 250 mL of 10% buffered formalin is added to each Nalgene bottle. Samples are kept in a cooler and transported to the Royal Alberta Museum for processing.

Vascular Plants

One technician surveys for vascular plants on up to fourteen 10 m transects. The ideal number of transects should is as follows:

- 3 in open water
- 3 in the emergent zone
- 3 in fen
- 5 along the wetland margin

Ideally, all transects are located along the fixed transect line at 25 m intervals (Figure 11a). If zones are narrow, it may be necessary to establish additional transects off of the fixed transect line to make up the 14 transects (common for small wetlands; Figure 11b). Supplementary lines

should be evenly spaced at 25 m intervals around the wetland; up to 300 m from the fixed transect line. Vegetation transects are spaced evenly along these supplementary lines, with no more than one vegetation transect for each zone on a single line. Additional supplementary lines are established as needed. If one zone is missing, or zones are extremely small, less than 14 transects may be established.

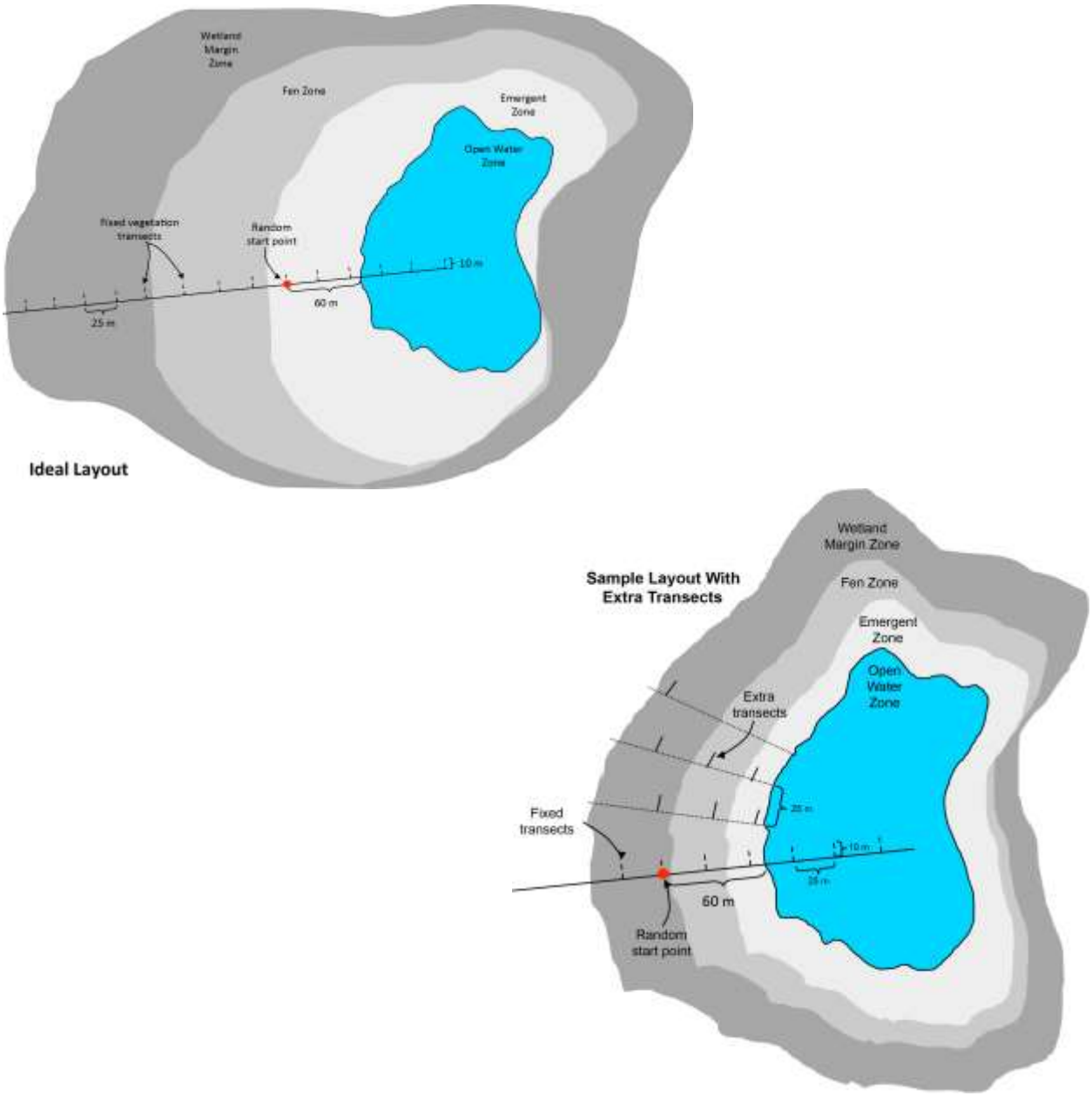


Figure 11a and b: *Diagrams illustrating the layout of the plant transects for an ideal wetland (top) and for most wetlands, where additional supplementary transects must be used (bottom)*

Prior to beginning the vascular plant surveys, the plant technician takes roughly five minutes to create a list of plant species at the site. This ensures that most of the timed searches are spent actually looking for plant species, rather than writing down names.
For each transect, the technician records the water depth in the middle of the transect (open water and emergent zones only), and records ecological and physical characteristics (e.g. location on transect, ecosite, human disturbance, presence of scat piles to indicate grazing, and the % cover of shrubs and trees). Each transect is surveyed five minutes for vascular plants, and the technician notes each species that is found within 1 m of the transect on the data sheet. The kayak is normally used for the open water transects, paddled by the other technician.

If the technician observes a plant that they cannot identify, they take the following steps:

- Collect a voucher specimen from outside the transect, if possible.
- After the 5 minute search is over, use field guides and attempt to quickly identify the specimen in the field
- If more time is needed for identification, the technician presses the plant in their small field press, assigns an ID number, and takes it back to camp for identification in the evening.
- If the technician still cannot identify the plant, they move it to their large plant press, which will be brought to the Royal Alberta Museum for expert taxonomic identification.

Remote Sensing- ABMI Wall-to-wall Land Cover Map

The ABMI Wall-to-wall Land Cover Map Version 2.1 (ABMIw2wLCV2000v2.1) is a polygon-based representation of Alberta's land cover, circa 2000, based on digital classification of 30 m spatial-resolution Landsat satellite imagery. The ESRI file geodatabase is in the Alberta 10 TM projection and describes the spatial distribution of 11 land cover (LC) classes (Table 1) across the province of Alberta. The map consists of approximately 1 million non-overlapping polygons of various sizes with a minimum size of 0.5 hectares (ha) for aquatic features and 2 ha for all others. Each polygon represents a contiguous area relatively homogeneous in terms of LC, where the specific LC class of the polygon is different from that of adjacent polygons.

The cartographic scale of reference (i.e. the scale at which the map would be printed if distributed in hardcopy) is 1:125,000, with a target positional accuracy for polygon outlines of 60 m on the ground (i.e. the true boundary of the polygon must be within 60 m of the outline 95% of the time). The overall Alberta 'Landcover_Polygons' feature class was obtained by merging 48 individual tiles whose frames are provided in the accompanying 'ABMIw2wLCV2000_48tiles' feature class. Each tile is fully encompassed in a single Landsat scene, and its frame roughly coincides with the seam lines used to mosaic the original raster datasets.

Accuracy Assessment

The overall thematic accuracy of the map, as estimated by an extensive validation dataset (see description of the Validation_areas feature class), is 75% with 11 classes and 88% if these classes are grouped into 5 general classes. User and Producer accuracies for the specific classes in each level appear in tables appended to the geodatabase. For a detailed description of the accuracy assessment of the previous (beta) version, which used the same validation areas than for this version, please see the full report available on the ABMI's website (www.abmi.ca).

Caveats:

The width of roads has been systematically exaggerated to a minimum of 60 m (two Landsat pixels); therefore the real extent of the Developed class is greatly overestimated.

1) Roads and other features refer to 2007 conditions. This means that there can be segments of roads that appear in the map but were not yet constructed by 2000.

2) The accuracy of the shrub class is low (30%). Many shrub polygons are in reality forest, especially in the North. This was not possible to correct with the input data at hand.

As a relatively coarse depiction of land-cover, the map is not intended for detailed local-level analyses, but rather provides a regional-level representation that is suitable for spatially explicit, long-term trend monitoring.

GIS Data

The ABMIw2wLCV2000v2.1, is a data product that was derived by combining two raster datasets: the Canadian Forest Service (CFS) Earth Observation for Sustainable Development (EOSD) LC dataset, and the Agriculture and Agri-Food Canada (AAFC) LC dataset. Both datasets

were derived from digital classification of Landsat 5 and Landsat 7 ortho-images acquired circa 2000, and both share the same land cover classes. The EOSD and NLWIS rasters were combined into a single raster according to a ruleset that selects a label for each pixel based on the values for that pixel in the two rasters. In addition, hydrography features from Government of Alberta (GoA) GIS data were used for 'burning in' wetlands, water bodies, and major rivers into the input rasters. The same process was also applied to roads, railways, power lines and pipelines using GoA's access layer, obtained through a data-sharing agreement with Alberta Sustainable Resource Development.

Map Construction

The combined raster dataset was processed by a semantic and spatial generalization algorithm (Castilla et al., in preparation) to create a polygon vector layer depicting land cover variation in a more generalized fashion than the original raster sources. In addition to the land cover raster themselves, the algorithm employs the original satellite imagery that was used as input to the EOSD classification. The process for each tile is as follows:

(1) A morphological segmentation algorithm is applied to the original Landsat image in order to break it down into a mosaic of tiny homogeneous regions (<10 pixels in average) separated by 1-pixel thick boundaries.

(2) Regions having a clearly predominant land cover class (>75% of its pixels belong to that class) are assigned to it, and adjacent regions having the same class are merged together. This results in a large portion of the image, usually more than 90%, already being labeled.

(3) Endmembers, or typical spectral signatures (i.e. mean value in each band of the Landsat image) for each class, are derived from these regions.

(4) Unlabeled regions are assigned to the class of their most similar neighbor, providing the latter is already classified and bears enough similarity to it, otherwise they are assigned to the class with the highest relative abundance within the region, where the latter is abundance weighted by distance in the feature space between the spectral signature of the region and the endmember of each class; once again after the assignment, adjacent regions having the same class are merged together. There are special rules on how to compute abundance for semantically related classes, such as conifer, broadleaf and mixed forest.

(5) Regions are reclassified into the final set of 11 land cover classes using a predefined crosswalk table, after which adjacent regions with the same class are merged together. Note: Treed wetlands (class 81 in EOSD) greater than 100 ha are assumed to be black spruce and thus conifer. Smaller treed wetlands are assigned to the class of the closest forest endmember.

(6) Regions smaller than the minimum mapping unit (MMU: 0.5 ha for water and 2 ha for the rest) are merged to their most similar adjacent neighbour.

(7) Isolated regions smaller than 25 ha that show a low contrast with the encompassing region are eliminated, as they were found in a previous version to mainly correspond to spurious polygons.

(8) Using the center of boundary pixels as initial vertices, the result is converted to an ESRI polygon shapefile using a line simplification algorithm.

Once all tiles were ready, the final product was created by merging and dissolving the individual tiles into a seamless layer. After dissolving, a few seam lines were still visible due to split polygons having a different label on each side of the seam. The labels of polygons affected by these inconsistencies were harmonized using semi-automated GIS procedures, after which a final 'dissolve' was performed.

Land Cover Classes

Table 1: *ABMI Wall-to-wall Land Cover Map Class Descriptions*

LC Class Code	LC Class	LC Class Description
20	Water	Lakes, lagoons, rivers, canals, and artificial water bodies. Shallow open water is included in this category, unless there is more than 20% vegetation cover, in which case it belongs to the relevant vegetated class.
31	Snow/Ice	Areas permanently covered by snow or ice, including glaciers.
32	Rock/Rubble	Bedrock, rubble, talus, blockfield, lava beds, or other natural impervious surfaces.
33	Exposed Land	Bare soil (barren, non-agricultural), river sediments and cut banks, pond or lake sediments, reservoir margins, beaches, landings, recently burned areas, mudflat sediments, surface mining, or other non-vegetated (less than 6% trees, or less than 20% shrub/herb) surfaces.
34	Developed	Urban and built-up areas (including industrial sites), impervious artificial surfaces (e.g. airport runaways), railways and roads. Acreages and farmsteads are included in this class. Oil and gas well pads are included in this class if connected to a road and not abandoned or under reclamation. Urban terrain under development is included in this class, even if the land is exposed. Urban green areas are excluded from this class if larger than 2 ha and if they have less than 2 buildings per hectare.
50	Shrubland	At least 20% ground cover which is at least one-third shrub, with no or little presence of trees (<10% crown closure). Examples of plants belonging to this class are alder, willow, juniper, and sagebrush. Shrubby fens and other non-treed woody wetlands, usually associated with floodplains and the shores of lakes and streams, belong to this class. Note: A dense patch of regenerating young trees is still considered forest and not shrub, no matter that the trees are small.
110	Grassland	Predominantly native grasses and other herbaceous vegetation with a minimum of 20% ground cover; may include some shrub cover (but less than a third of the vegetated area) or a few trees (but the tree cover cannot exceed 10%). Land used for range or native unimproved pasture (e.g., rough fescue) is included in this class. Alpine meadows fall into this class. Marshes and other non-woody wetlands with at least 20% vegetation cover (sedges, cattails, or moss) belong to this class. Note: A forestry cutblock harvested more than a year ago containing seedlings with less than 10% cover, belongs to this class. If the cutblock had no successful regeneration and is covered by more than 20% shrubs, it would belong to the 'Shrubland' class.
120	Agriculture	Annually cultivated cropland, tame pastures (fields planted or sown with non-native grasses/legumes where livestock is directly grazing on them), forage crops (same as tame pasture, but instead cut for hay) and woody perennial crops (fruit orchards and vineyards). Includes annual field crops, vegetables, summer fallow, orchards and vineyards. Bare agricultural soil (i.e., tilled) belongs to this class.
210	Coniferous Forest	Treed areas with at least a 10% crown closure of trees, where coniferous trees (spruce, pine, fir, larch) are 75% or more of the crown closure. Providing crown closure is more than 10% and dominated by conifers, young plantations or regenerating cutblocks (regardless of tree height), and treed wetlands (e.g. black spruce bogs and fens) are included in this class.
220	Broadleaf Forest	Treed areas with at least a 10% crown closure of trees, where broadleaf trees (trembling aspen, balsam poplar and white birch) are 75% or more of the crown closure. Providing crown closure is more than 10% and dominated by broadleaf trees, young plantations or regenerating cutblocks

LC Class Code	LC Class	LC Class Description
		(regardless of tree height), and treed swamps along floodplains or wetlands are included in this class.
230	Mixed Forest	Treed areas with at least a 10% crown closure of trees, where neither coniferous nor broadleaf trees account for 75% or more of crown closure.

Remote Sensing- ABMI Wall-to-wall Human Footprint Map

Human footprint (HF) refers to the geographic extent of areas under human use that either have lost their natural cover (e.g., cities, roads, agricultural land, industrial areas) or whose natural cover is periodically or temporarily replaced by resource extraction activities (e.g., forestry, seismic lines, surface mining). The Alberta Biodiversity Monitoring Institute (ABMI) tracks changes in HF across the province of Alberta. One of the goals of the Institute is to provide credible and understandable information on the amount and location of multiple human footprints to support natural resources management. The ABMI Human Footprint Map (beta version) is a GIS polygon layer that describes the spatial distribution of HF across the province of Alberta up to the year 2007, where each polygon indicates a HF type. Each type of HF was given a 4-digit code; a list of these codes and a brief description is given in Table 2.This GIS polygon layer is continuously being updated, and new versions will be released periodically. The map is available for download on the ABMI's website (www.abmi.ca) in the 'Raw Data' section.

Table 2: *ABMI Human Footprint Map HF type descriptions*

HF Code	HF Name	HF Description
1000 Urban & Industrial Features & Infrastructure		
1100	**Urban & Rural Features**	Habitats where people live, non-industrial
1101	Urban	Residential Urban (residential areas in cities, towns, villages, cottages, ribbon developments, etc; areas that are dominated by dwellings – usually >1 building per ha)
1102	Rural	Residential Rural Dominated by Buildings (usually >1 building per ha; eg. farmstead, ranch, acreages, lodges, etc)
1103	Urban/Rural Greenspace	Urban/Rural Greenspace – grave yards, religious areas, golf courses, campgrounds, shelterbelts, ski hills, DND exercise areas, low vegetation surrounding airport runways, clearings from old industrial activity that is now vegetated, etc.)
1200	**Industrial & Resource Extraction Features**	Habitats associated with heavy industrial development
1204	Heavy Commercial/Industry: High Human Density	Intense industrial & commercial development (airports, industrial parks, factories, refineries, hydro generating stations, pulp & paper mills, pump stations, malls, parking lots, zoos, etc.)
1205	Light Industry: Low Human Density	Bare and/or Vegetated Ground clear for Industry (coal and mineral surface mines, oil and gas well pads, wind mills, CFO, communication towers, gravel pits, heavy oil sand development, spoil piles, etc.)
1300	**Hard & Wide Linear Features**	Length >50 times the width, >10m wide, hard surface /non-vegetated (gravel road, paved road, railway, paved airport runway, etc.)
1301	Lin20Hard	Linear road/rail/industrial features >20 m wide
1302	Lin10Hard	Linear road/rail/industrial features 10-20 m wide
1400	**Hard & Narrow Linear Features**	Length >50 times the width, ≤10m wide, hard surface /non-vegetated (gravel or paved linear feature)
1401	Lin5Hard	Linear road/trail/path/rail/industrial features 2-10 m wide
1500	**Soft & Wide Linear Features**	Length >50 times the width, >10m wide, soft surface/vegetated (packed soil, pipeline right of way, transmission line, etc.), not including roads
1501	Lin20Soft	Linear urban/industrial features >20 m wide
1502	Lin10Soft	Linear urban/industrial features 10-20 m wide

HF Code	HF Name	HF Description
1600	**Soft & Narrow Linear Features**	Length >50 times the width, ≤10m wide, soft surface/vegetated (packed soil, pipeline right of way, transmission line, etc.), not including roads
1601	Lin5Soft	Linear urban/industrial features 2-10 m wide
1700	**Vegetated Roads, Verges and Ditches**	Unimproved vegetated roads and the areas along the edge of roads
1701	Vegetated Road	Roads, trails and paths with unimproved surfaces
1702	Road Verge	Vegetated verges and ditches along roads
1900	**Human-created Water Bodies**	
1901	Dug-out	
1902	Lagoon	
1903	Reservoir	
1910	Canal	
2000 Agricultural Cover Types		
2100	**Cultivated Crops**	Must be evidence of cultivation visible during the photo interpretation
2101	Crop	Annual cereal crop
2102	Irrig	Irrigated land
2103	Other agriculture	Orchard, horticulture, etc
2104	ArgBare	Bare soil that is created as part of agricultural activities
2200	**Pasture & Forage**	
2205	Pasture	
2206	Forage crop	
3000 Managed Forest		
3501	CBClear10	Clearcut block <10 years with no ground disturbance during reforestation (<20% of the live trees retained at harvest
3502	CBStructure10	Structured cutblock <10 years with no ground disturbance during reforestation (>=20% of the live trees retained at harvest, this includes tree retention harvest, thinning, & understory protection)
3503	CBDisturb10	Cutblock <10 years with ground disturbance during reforestation visual on the air photo (ploughing, mounding, etc)
3511	CBClear 20	Clearcut block 11-30 years with no ground disturbance during reforestation (<20% of the live trees retained at harvest)
3512	CBStructure 20	Structured cutblock 11-30 years with no ground disturbance during reforestation (>=20% of the live trees retained at harvest, this includes tree retention harvest, thinning, & understory protection)
3513	CBDisturb20	Cutblock 11-30 years with ground disturbance during reforestation visual on the air photo
3521	CBClear30	Clearcut block >30 years with no ground disturbance during reforestation (<20% of the live trees retained at harvest)
3522	CBStructure30	Structured cutblock >30 years with no ground disturbance during reforestation (>=20% of the live trees retained at harvest, this includes tree retention harvest, thinning, & understory protection)
3523	CBDisturb30	Cutblock >30 years with ground disturbance during reforestation visual on the air photo
3531	CBClearUnknow	Clearcut block unknown years with no ground disturbance during reforestation
3532	CBStructureUnknow	Structured cutblock unknown years with no ground disturbance during reforestation
3533	HumanDisturbUnknow	Human modified forests unknown years with ground disturbance

HF Code	HF Name	HF Description
		during reforestation visual on the air photo

GIS Data

The ABMI Human Footprint Map (beta version) is the product of multiple sub-layers (Table 3) many of which were obtained through a data-sharing agreement with Alberta Sustainable Resource Development. The sub-layers were processed using the ArcGIS command "UPDATE" to create a single layer. The layers were organized according to their order of precedence (A-S) such that a sub-layer with high precedence (e.g. sub-layer A) would mask all layers of lower precedence (e.g. sub-layers B-R). Table 3 provides a brief description of the layer contents, the source of the data, geometric shape type (i.e., polygon, linear, point), any modifications made by ABMI, the order of precedence and the associated human footprint codes the data is represented by. Note that a given sub-layer may contribute to multiple human footprint codes.

Table 3: *ABMI Human Footprint Map source GIS layers, order of precedence, and modifications*

Order	Layer	Layer Contents	Source Data	Shape Type	Modifications	HF Code
A	Reservoirs	Water reservoirs.	SRD Base Layer Database (Hydropoly).	Polygon	Data were not verified against 2007 SPOT image. All features were included regardless of date.	1903
B	Dug-outs	Dug-outs.	SRD Base Layer Database (Hydropoly).	Polygon	Data were not verified against 2007 SPOT image. All features were included regardless of date.	1901
C	Roads	All paved and gravel roads, does not include vegetated margins.	SRD Base Layer Database (Roads).	Linear	Features dated Dec. 31, 2007 or earlier were retained as were features without dates. Features dated Jan. 1, 2008 or later were removed. Data were not verified against 2007 SPOT image.	1301 1302 1401
D	Rail Lines Hard Surface	Railway tracks and associated gravel pad; does not include vegetated margins.	SRD Base Layer Database (Rail Line).	Linear	Features dated Dec. 31, 2007 or earlier were retained as were features without dates. Features dated Jan. 1, 2008 or later were removed. Data were not verified against 2007 SPOT image.	1301
E	Canals	Canals, human-created water passageway.	SRD Base Layer Database (Hydropoly, Streamline).	Polygon, Linear	Data were not verified against 2007 SPOT image.	1910
F	Vegetated Surfaces of Roads, Trails, and Railways	Green margin (verge) of roads, trails, and railways. Does not include the hard surface (e.g., paved portion of roads, or rail/gravel portion of railways).	SRD Base Layer Database (Roads).	Linear	Features dated Dec. 31, 2007 or earlier were retained as were features without dates. Features dated Jan. 1, 2008 or later were removed. Data were	1701 1702 1501 1502 1601

Order	Layer	Layer Contents	Source Data	Shape Type	Modifications	HF Code
					not verified against 2007 SPOT image.	
G	Mine Sites	Areas of ground that were consistently open and/or expanding over multiple years, usually close to lakes or rivers, were considered to be mines/gravel pits.	SRD Base Layer Database (Access Polygon Layer), additions by ABMI using 2007 SPOT image.	Polygon	No mines were deleted from the SRD base layer. Mine sites identified in the 2007 SPOT image that were missing from the SRD layer were added by ABMI.	1205
H	Industrial Sites	Industrial sites.	SRD Base Layer Database (Access Polygon Layer) additions by ABMI using 2007 SPOT image.	Polygon	Added industrial clearing features	1204 1205
I	Well Sites (Energy)	Well sites.	SRD Base Layer Database (Well Sites), additions by ABMI using 2007 SPOT image.	Point	Features dated Dec. 31, 2007 or earlier were retained as were features without dates. Features dated Jan. 1, 2008 or later were removed. Well sites within the SRD base layer were not verified against the 2007 SPOT image. No well sites were deleted from the SRD base layer. Well site features identified in the 2007 SPOT image that were missing from the SRD layer were added by ABMI.	1205
J	Recreation & Other Vegetated Facility	Unpaved aircraft runways, grave yards, golf courses, campgrounds, baseball diamonds, parks, shelterbelts, ski hills, DND exercise areas, low vegetation surrounding airport runways, and clearings from old industrial activity that is now vegetated. This layer was also used to identify green-space that did not fit into other categories such as storage areas and parking lots.	Created by ABMI using 2007 SPOT image.	Polygon	None. Created by ABMI.	1103
K	Wind Generation Facility	Wind turbines.	Created by ABMI using 2007 SPOT image. The SRD Base Layer database was used as a reference in interpretation.	Point	Turbines were typically located in southern Alberta and were identified by their long shadows with three blades.	1205
L	Transmission Lines	Electrical transmission lines.	SRD Base Layer Database (Powerlines).	Linear	Features dated Dec. 31, 2007 or earlier were retained as were features without dates. Features dated Jan. 1, 2008 or later were removed. Data were	1501

Order	Layer	Layer Contents	Source Data	Shape Type	Modifications	HF Code
					not verified against 2007 SPOT image.	
M	CFO, and Other High Density Livestock	Confined feeding operations (CFO), interpreted as the presence of large buildings and fenced pens appearing to be used for the purpose of feeding and confining pigs, chickens, or cows.	Created by ABMI using 2007 SPOT image.	Polygon	None. Created by ABMI.	1205
N	Urban and Rural Residential	Urban Residences: A polygon was drawn around areas having >100 buildings per quarter section, including both residential and industrial development. Areas within the urban/residential polygons >5ha with natural vegetation were excluded. Acreages: Includes developments having a density of 10 - 100 buildings per quarter section, including both residential and industrial development. Areas within quarter sections not associated with the development (i.e., natural spaces) were not included. May include industrial sites if these could not be distinguished from acreage developments. Rural Residences: Includes all rural dwellings and buildings that are of a density less than ten buildings per quarter section. The area mapped was the "yard" and did not include crops. May include industrial sites if these could not be distinguished from rural development.	Created by ABMI using 2007 SPOT image. Urban residential features from SRD base layer database (city and town), ALCC, and a layer from ALCES group were referenced.	Polygon	None. Created by ABMI.	1101 1102
O	Cultivation	Agricultural areas used for cultivation.	Created by ABMI using the 2007 SPOT image. GVI and AVI were used for reference when available.	Polygon	None. Created by ABMI.	2000
P	Pasture/Agriculture Clearing	Non-cultivated agriculture including clearings for grazing and future cultivation.	Created by ABMI using the 2007 SPOT image.	Polygon	None. Created by ABMI.	2205
Q	Cutblocks	Areas where forestry operations have occurred (clearcuts, selective harvest, salvage logging, etc.).	SRD and individual companies, additions by ABMI using 2007 SPOT image.	Polygon	AVI data was updated by individual company data where available.	3501 3511 3521 3531
R	Pipelines	Oil & Gas Pipelines.	SRD Base Layer	Linear	Features dated Dec. 31,	1501

Order	Layer	Layer Contents	Source Data	Shape Type	Modifications	HF Code
			Database (Pipelines).		2007 or earlier were retained as were polygons without dates. Features dated Jan. 1, 2008 or later were removed. Data were not verified against 2007 SPOT image.	
S	Seismic Lines	Seismic Lines.	SRD Base Layer Database (cutline).	Linear	Features dated Dec. 31, 2007 or earlier were retained as were polygons without dates. Features dated Jan. 1, 2008 or later were removed. Data were not verified against 2007 SPOT image.	1601