Monitoring Methodology

Monitoring Area

The Alberta Biodiversity Monitoring Institute (ABMI) is a provincial program that measures biodiversity throughout Alberta, Canada (latitude: 49°–60°, longitude 110°–120°). Alberta is 661 000 km^2 and makes up 6.6% of Canada. Alberta spans 1223 km north to south and 660 km east to west. Comparatively, Alberta is about twice the size of Japan or Germany, and half the size of South Africa. Average temperatures range from −8°C in the south to −24°C in the north during January and from 20°C in the south to 16°C in the north during July. Elevation ranges from 3747 m in the southwest mountains to 152 m in the northeastern boreal forest. Annual precipitation ranges from 30 cm in the southeast to 60 cm in the central west.

Alberta has 6 major Natural Regions (Natural Regions Committee 2006; Figure OB00001). The Rocky Mountain Natural Region makes up 7% of Alberta and is dominated by rock, ice fields, and coniferous forest. The Foothills Natural Region makes up 10% of Alberta and is dominated by rolling topography with deciduous, mixed wood, and coniferous forests. The Grassland Natural Region makes up 15% of Alberta and is dominated by grasses and shrublands. The Parkland Natural Region makes up 9% of Alberta and is dominated by deciduous forests and willow shrublands. The Boreal Forest Natural Region makes up 58% of Alberta and, is dominated by deciduous, mixedwood, and coniferous forests. Finally, the Canadian Shield Natural Region makes up 1% of Alberta and, is dominated by exposed bedrock, and open deciduous and coniferous forests.

Monitoring Approach

The ABMI employs a cumulative-effects monitoring approach that is targeted at detecting the ecological effects of a diverse set of environmental stresses on broad suites of indicators (Manley et al. 2004). Cumulative-effects monitoring is designed to expose correlative relationships between stressors in a system and the many indicators that are monitored (Thornton et al. 1994; Noon et al. 1999). As such, the ABMI is designed to assess the performance toward management objectives such as "regional sustainability" or "ecological integrity" (Mulder et al. 1999). This monitoring approach remains relevant over long time frames as new human activities and environmental stresses are introduced to landscapes (Watson and Novelly 2004). However, caution is required when interpreting ABMI information because strong causative relationships can rarely be determined from this correlative information; manipulative research is necessary to fill this function.

Biodiversity Indicators

Noss (1990) proposed viewing the organization of biological diversity as a hierarchy that included four levels: regional landscapes, communities-ecosystems, species-populations, and genes. He also suggested that Franklin's three primary ecosystem attributes (composition, structure, and function; Franklin et al. 1981) be applied to all four levels of biotic organization. While Noss' hierarchy of biological diversity and organization has become widely accepted (Salwasser 1993; Noon et al. 1999; Haufler et al. 2002), fiscal realities make it impractical to build monitoring programs that include adequate representation of all twelve organizational levels (Franklin 1993; Lautenschlager 1997).

It is more practical to use a condensed organizational structure when choosing indicators for biodiversity monitoring programs. Amounts and patterns of landscape vegetation types can be

monitored cheaply through remote sensing, and these measures correlate with ecosystem integrity (Franklin 1993). If the amount and spatial distribution of vegetation types are similar to that found naturally, then biotic communities are also expected to be similar to those found naturally (Attiwill 1994; Lindenmayer and Franklin 1997). However, landscape metrics are not sufficiently detailed to document changes in local habitat structure (Lindenmayer et al. 2000; Hunter 2005). Thus, it is also necessary to monitor structures within vegetation types (Hunter 2005). Finally, since species may not be tightly linked to particular landscape or habitat characteristics, some species should be monitored to ensure that biota are responding as predicted from the landscape and habitat monitoring (Franklin 1993; Haufler et al. 2002; Hunter 2005). Species monitoring has additional importance to stakeholders because species are independent, self-replicating units that cannot be recreated (Bunnell 1998). This simplified framework focuses on monitoring the composition attributes outlined by Franklin et al. (1981), although, structure and function may be assessed indirectly based on the relative amounts of species and habitat indicators (Karr 1981; Kremen 1992; Bonada et al. 2006).

Although not part of Noss' (1990) twelve levels of biodiversity organization, stakeholders often require biodiversity monitoring programs to also track changes in human land use activities so that potential mitigation strategies can be evaluated (Forester and Machlis 1996).

Species Identification

The ABMI collects data on thousands of species across Alberta. Many of these species can only be accurately identified by taxonomic experts. As a result, the ABMI relies heavily on the collection of specimens in the field that are later identified by qualified personnel in a laboratory setting. Vascular plants, mammals, and incidentally-detected birds are the only taxonomic groups that are subject to species-level identification in a field setting. Where practical, the ABMI's goal is to identify specimens to a species level of taxonomic resolution.

Monitoring Design

The ABMI monitors biodiversity by sampling 1656 permanent terrestrial and wetland sites, and 105 permanent river and lake sites, distributed evenly across Alberta (Figures OB00001 and OB00005). Each site is surveyed once every 5 years, within a 2-week window based on a Julian date to reduce seasonal variation. Terrestrial and aquatic species and habitats, and landscape elements, are sampled.

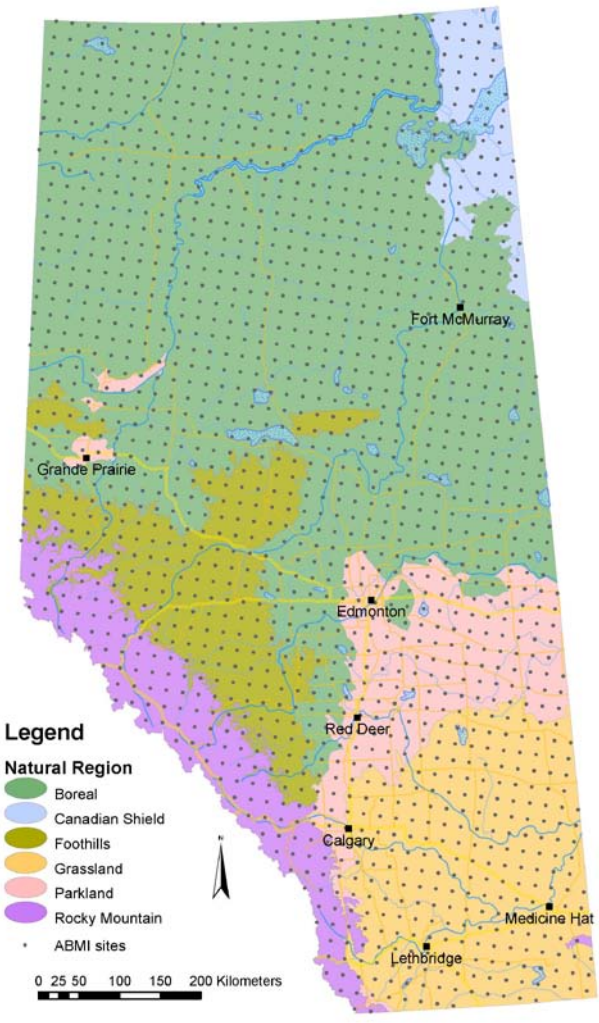

Figure OB00001. Location of the 1656 permanent ABMI terrestrial monitoring sites.

Survey Sites

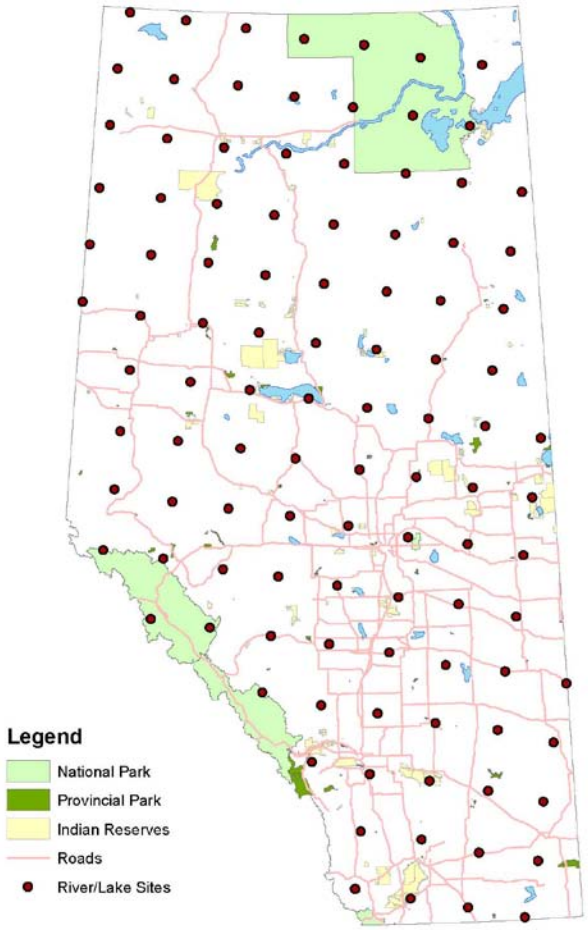

Figure OB00005. The location of the 105 permanent ABMI river and lake monitoring sites.

Terrestrial survey sites are established on a 20 km systematic grid with a random distance and directional offset of up to 4 km from the 20 km systematic grid (Figure OB0001). Terrestrial survey sites are not stratified and, therefore, environmental conditions are sampled in proportion to their availability on the landscape. For example, biodiversity monitoring sites exist in cities, public and private lands, industrial installations, protected areas, and lakes. Wetland survey sites are determined by selecting the nearest wetland to the terrestrial site. The ABMI defines wetlands as bodies of water with an open surface area between 1 and 100 ha, with a maximum depth between 0.5 and 2 m, and as having a low probability of complete water evaporation within or between years. The ABMI's wetland selection criteria do not preclude human created or modified wetlands, and exclude wetlands that are maintained or altered by active beaver dams.

Of these 1656 sites, one sixteenth, in a grid with 80 km spacing, represent the 105 permanent lake and river monitoring sites (Figure OB0005). Each river and lake site is determined by selecting the closest suitable lake and river reach to the terrestrial site. ABMI prefers to sample lakes 300 to 5000 ha in size, and greater than 2 m at the deepest point. ABMI defines rivers as those defined as a "river" by Alberta's GIS hydropoly layer and which averages <100 m in width over the 2.5 km reach.

The precise geographic location of ABMI monitoring sites is confidential (ABMI 00012). Public geographic coordinates for each ABMI survey site location are publicly accessible (ABMI 00001, ABMI 00003). Public coordinates identify the location of terrestrial and aquatic survey sites to within approximately 5.5 km of the precise geographic coordinate (or 95 km^2; i.e., the ABMI's precise geographic survey coordinate is within 5.5 km of the public geographic coordinate).

Survey Sites Sampled to Date

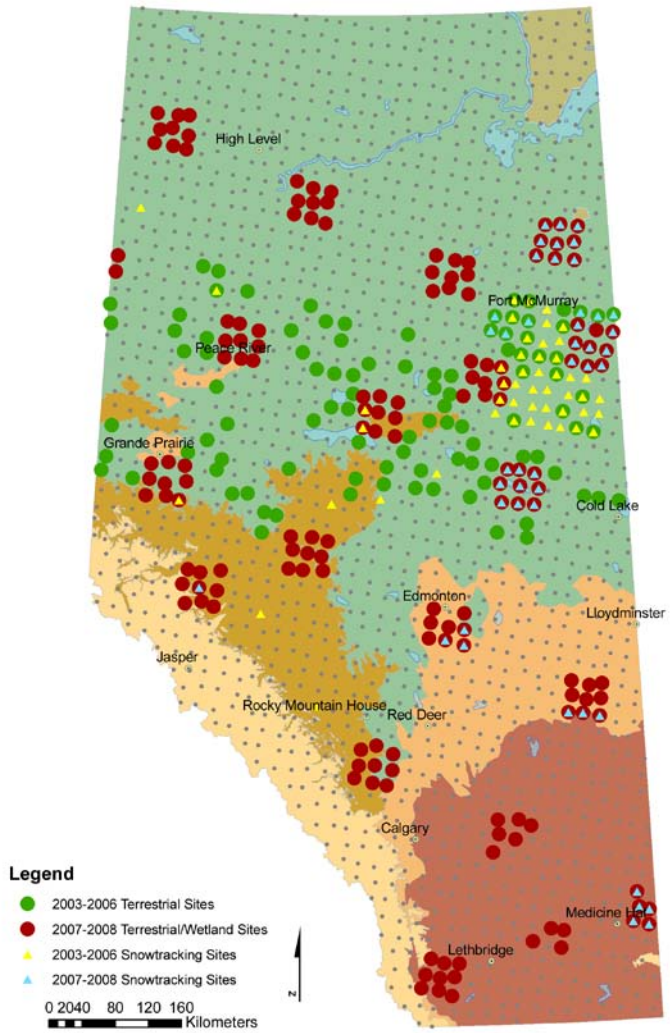

Figure OB00029. The location of terrestrial and wetland sites surveyed to date.

Terrestrial and Wetland Sites

During Data Rotation 1 (2007–8), the ABMI successfully surveyed 160 terrestrial sites, 160 wetland sites, 14 river reaches and 14 lakes from across Alberta.

At each terrestrial site we implemented all terrestrial survey protocols (for details see Table OB00030, below and ABMI 10001—Terrestrial Data Collection Protocols). All data collected is available for download from Raw Data.

During the 4-year prototype program (2003–2006), we collected information at 125 terrestrial sites using a subset of ABMI protocols: vascular plants, mosses, lichens, birds, live and dead trees, down logs, shrub cover, litter, and landscape characteristics. We selected these 125 sites to ensure that field protocols were tested across a gradient of ecosystem types and human disturbances; therefore, data collected during the prototype may not be entirely representative of the landscapes from which the data was collected. We collected data in 4 consecutive years at 10 of the sites while the remaining sites were sampled in a single year.

Table OB00030. Terrestrial protocols implemented during Data Rotation 1 (2007–12).

Spring Protocols (May–Jun)	Summer Protocols (June–Aug)	Winter Protocols (Nov–Feb)
Physical Characteristics (elevation and slope)	Surface Substrate	Snowtracking
Site Capability (ecosite)	Shrubs and 2-D cover	
Site Suitability (veteran, canopy, sub-canopy tress)	Tree Ages	
Trees, Snags and Stumps	Canopy Cover	
Downed Woody Materials and Trees	Vascular Plants	
Soil Arthropods (springtails and oribatid mites)	Polypore Fungi	
Breeding Birds	Bryophytes and Lichen	
Incidental Vertebrate Observations	Incidental Vertebrate Observations	

At each wetland site we implemented all wetland survey protocols (for details see ABMI 10035—Wetland Data Collection Protocols):

- Physical Characteristics (bathymetry, wetland zones)
- Site Capability (ecosite)
- Riparian Characteristics (vegetation, snags, and percent area covered by water, rock, bare soil, bare soil, lichens and non-vascular plants, forbs, grasses, shrubs and trees)
- Human-caused Site Disturbance
- Water Physiochemistry.

All data collected is available for download from Raw Data.

River and Lake Sites

During Data Rotation 1 (2007–8), the ABMI successfully surveyed 14 river reaches across Alberta. At each site we implemented all river survey protocols (for details see ABMI 10030—River Data Collection Protocols):

- Physical Characteristics (width, riffles, runs, and pools)
- Bank Characteristics (stability, undercut)
- Riparian Characteristics (area covered by water, rock, bare soil, non-vascular plants, forbs, grasses, shrubs, trees)
- Human-caused Site Disturbance.

All data collected is available for download from Raw Data.

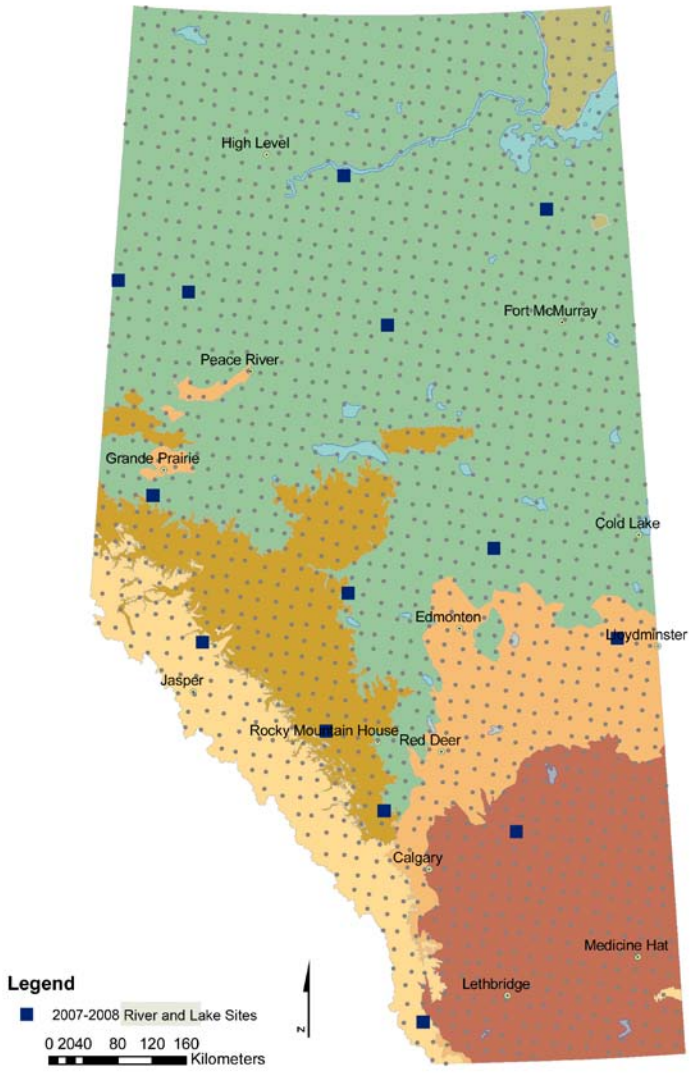

Figure OB00030. The location of river and lake sites surveyed to date.