THE ALBERTA BIODIVERSITY MONITORING PROGRAM:

UPDATED TECHNICAL SUMMARY

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The views, statements, and conclusions expressed in this report are those of the authors and should not be construed as conclusions or opinions of the ABMP. This report was produced in October 2002, and due to development of the ABMP since that time, some aspects may have subsequently changed.

ABSTRACT

This document updates the Alberta Forest Biodiversity Monitoring Program Technical Integration chapter (Chapter 18; URL http://www.abmp.arc.ab.ca/Documents.htm) that summarized and integrated 17 previous chapters of objective-setting and technical recommendations. Approaches and philosophy current to late 2003 are presented here.

In 2003, the geographical scope of the project was enlarged from the Green Zone to encompass the entire province. Accordingly, the program's name was changed to the *Alberta Biodiversity Monitoring Program* (ABMP). In 2003, the program moved into Phase II—a Prototype Project intended to make the program operational by 2007.

The goal of ABMP is to monitor status and trend of biodiversity throughout Alberta. Sampling locations will be placed on a systematic grid at a 20 km spacing leading to 1656 sites over the 660,000 km² landbase of Alberta. Stratified sampling would enhance ABMP's efficiency but would make the program inflexible over the long term and will not be employed. Each site will be resurveyed every five years, with 20% of the sites monitored in consecutive years to allow statistical connectivity between years. The statistical design criteria entail a 90% probability of detecting selected changes in biodiversity at a statistical significance of 0.90. ABMP has a conceptual time frame of approximately 100 years.

ABMP will monitor biodiversity in terrestrial upland, standing water, and stream habitats. Protocols are divided into 6 suites: fall site preparation, spring terrestrial, summer terrestrial, standing water, winter terrestrial, and flowing water. The following biotic and habitat elements will be sampled:

	Terrestrial	**Aquatic**
Biotic Elements		
	Vascular Plants	Phytoplankton
	Bryophytes	Zooplankton
	Lichens	Amphibians
	Birds	Benthic algae
	Terrestrial Arthropods	Benthic macroinvertebrates
	Rarer terrestrial biota	Fish
Habitat Elements		
	Forest structure	Water physiochemistry
	Dead wood	Stream channel and basin attributes
	Tree canopy cover	Dead wood

A Pilot Project in summer 2002 identified difficulties with the aquatic and terrestrial arthropod protocols and these are currently being reviewed.

ABMP also includes a remote sensing component to address landscape scale changes at two scales; patch sizes of ca. 2 - 10 ha (large extent) and ca. 10 - 100 m² (medium extent). A "backcasting" strategy, using five year-old imagery as the basis of comparison, is used to evaluate changes over five year periods..

Landscape components to be measured include:

Land cover type	Water Resources
Forest Type	Forest stand characteristics
Community type	Natural disturbance
Patch Metrics	Human disturbance

ABMP is entering Phase II, a Prototype Project designed to position ABMP for full implementation starting in 2007. The Prototype Project aims to test the feasibility, cost-effectiveness and statistical effectiveness of ABMP protocols, develop a web-based platform for data management, develop standard analysis and reporting procedures, and develop business plans and communication strategies.

Documentation from Phase I describing the Alberta Biodiversity Monitoring Program
1. Overview of Monitoring Forest Biodiversity in Alberta
2. Alberta Forest Biodiversity Monitoring Program: Conceptual Framework and Rationale
3. Criteria and Indicators for Monitoring Biodiversity in Alberta's Forests: Review of Legislation, Policies, External Agreements, and Programs
4. Ecological Land Class and Benchmark Representation for Different Sampling Networks
5. Test of Field Procedures for Terrestrial Ground Plots
6. Statistical Power In The Alberta Forest Biodiversity Monitoring Program
7. Approaches for Monitoring Landscape Composition and Pattern Using Remote Sensing
8. Monitoring of Forest Biodiversity Using Remote Sensing: Regional Landscape (Medium and Low Spatial Resolution) Protocol and Examples
9. Monitoring of Forest Biodiversity Using Remote Sensing: Forest Stand (High Spatial Resolution) Protocol and Examples
10. Forest Ecosystem Monitoring in Saskatchewan and Alberta: Identification of Aquatic Elements and Sampling Protocols

11. Comparison of Sampling Techniques to Monitor Stream Amphibian Communities in Forested Regions of Alberta
12. Monitoring Protocols for Elements of Non-vascular Plant Diversity in Alberta's Forested Zones
13. Monitoring of Terrestrial Vascular Plants and Structure in the Forested Regions of Alberta: Background, Indicators and Protocols
14. Identification of Potential Monitored Elements and Sampling Protocols for Terrestrial Arthropods
15. Arthropod Pilot Study
16. Monitoring Terrestrial Vertebrates in the Alberta Forest Biodiversity Monitoring Program: Selection of Target Species and Suggested Protocols
17. Developing Monitoring Protocols For Aquatic Ecosystems in Forested Regions of Alberta
18. The Alberta Forest Biodiversity Monitoring Program: Technical Integration

1 INTRODUCTION

1.1 Background

Planning for the Alberta Biodiversity Monitoring Program was initiated in 1998 to provide a comprehensive, long-term monitoring program that would directly measure the impact on biodiversity of multiple resource developments in the forested area of Alberta. In 2003, the scope of the program was expanded to encompass the entire province of Alberta, the name was changed to the *Alberta Biodiversity Monitoring Program* (ABMP). At this time the program moved from the Technical Design Phase (Phase I) to the Prototype Phase (Phase II). The goals and direction of the program remain unchanged.

This paper is a summary and update of the program integration chapter (Cheaper 18) written in summer 2002. The chapter was in itself a summary and distillation of the preceding 17 chapters (see adjacent text box) into a recommended course of action. It provided an overview of the protocols to be used to survey terrestrial, standing water, stream, and remote sensing elements in the main text, while the detailed field methods were provided in a series of appendices. For details, the reader is referred to Chapter 18, the previous chapters on which it was based, and documents developed during the Prototype Phase. These documents are all available at http://www.abmp.arc.ab.ca/Documents.htm.

The integrated program described here is currently being tested through a Prototype Project undertaken by the Alberta Research Council and the University of Alberta. Over the next three years, logistical difficulties will be addressed, protocols changed as needed, statistical power investigated, data storage and reporting protocols developed and remote sensing systems evaluated.

1.2 Rationale

Biodiversity refers to the variety of life at the ecosystem, species, and genetic levels of organization. Reasons to conserve biodiversity fall into a number of classes:

i) Maintaining availability of biodiversity products directly or potentially useful to humans, such as food, drugs, and building materials.
ii) Providing "ecosystem services" such as decomposition of dead biomass, purifying air and water, and providing nutrients needed for plant growth.
iii) Addressing moral and ethical responsibilities to care for all living species, and
iv) Maintaining quality of life enriched by access to natural environments.

The goods and services provided by biodiversity are largely unpriced and outside the market system making it difficult to provide a compelling economic argument for their conservation. However, biodiversity is one of many aspects of our social and physical milieu that we recognize as being valuable without necessarily being able to place a price on it. Numerous indicators suggest that Albertans and Canadians value biodiversity, and recognize that their quality of life depends on maintenance of biodiversity in ways they cannot effectively articulate.

Industrial development is proceeding rapidly throughout Alberta and its effects on native biodiversity are difficult to evaluate. Most ecological research and monitoring initiatives are targeted at species designated at risk, harvested species, small areas of interest, and specific habitat manipulations or experiments. Data collected from these small-scale and short-term studies cannot be readily combined to create a comprehensive overview of biodiversity or biodiversity change. In addition, much of the data currently collected are proprietary and are not readily available for broad comparisons. Consequently, there is currently no comprehensive picture of the status of biodiversity in Alberta or how it is changing. ABMP will rigorously, efficiently, and systematically monitor trends in biodiversity at large spatial and temporal scales to provide the information required by land use managers and decision-makers to either modify practices or to justify their practices as being appropriate.

1.3 Guiding Principles For The ABMP

The ABMP was designed based on the following Guiding Principles:

i) Support existing commitments for biodiversity monitoring.
ii) Develop a common, standardized methodology that could be applied across all jurisdictions within Alberta.
iii) Have monitoring that:
    a. occurred in both aquatic and terrestrial systems.
    b. occurred across a hierarchy of spatial scales.
    c. occurred in locations having a wide range of land use histories, including those with limited human influence.
    d. included ecosystem elements that represent life forms from diverse taxonomic groups and trophic levels.
iv) Estimate natural variability to assist interpretations of the significance of any changes

observed.

v) Be transparent and subject to rigorous technical review.

vi) Provide data and information freely to everyone.

1.4 Program Goal

Monitor status and trend of Alberta's biodiversity.

1.5 Program Objectives

i. Develop and implement a scientifically credible, long-term biodiversity monitoring program.

ii. Measure status, differences, and temporal changes in selected measures of biodiversity, habitat, and anthropogenic disturbance at the provincial and regional scales.

iii. Provide public access to all data collected and report on the status and trend in Alberta's biodiversity.

1.6 Program Design Criteria

ABMP has been designed to have the following capabilities:

1) To be able to detect, with at least 90% ($\beta = 0.1$) certainty, a change of 3% per year within a region, after 15 years of survey (i.e., after 3 visits to all sites). Elements to be tested include:
    a. species richness of target groups,
    b. population density for selected species, and
    c. physical/structural characteristics of the habitat.

2) To be able to detect, with at least 90% ($\beta = 0.1$) certainty, a two-fold difference between regions after one complete set of surveys within each region. Elements to be tested include:
    a. species richness of target groups,
    b. population density for selected species, and physical / structural characteristics of the habitat.
    c. to have less than a 10% probability of declaring a difference when there really was none ($\alpha = 0.1$).

The power analysis in Chapter 6 was based on an a literature review of a broad array of species and concludes that the ABMP sampling design will meet the statistical criteria if there are 25-100 sites within each region. Assuming a sampling grid of 20 km, regions must be 10,000 – 40,000 km^2 in size to meet the statistical criteria.

This is a broad generalization because it will be easier to detect changes in some aspects of biodiversity than in others, resulting in statistical power being higher for some aspects than others.

2 NETWORK DESIGN

2.1 Spatial Design

2.1.1 Systematic Site Placement

A central tenet of sampling theory applied to environmental monitoring and research is that random selection of sites reduces the possibility of bias being introduced into the data. However, random site locations can result in concentrations of sites in certain portions of the study area. Ecologists often overcome this problem by sampling systematically. In general, systematic designs do not result in bias unless there is spatial periodicity in the characteristic being surveyed that matches the spacing interval of the sites.

An alternative to a systematic or random network of sampling sites involves stratification in which different areas are sampled at differing intensities based on the size or the variance of what is being sampled. In a stratified scheme, if a certain number of samples is required to address a statistical question, then that number of sites is located in all land units, regardless of their size. The advantage of stratification is that a given level of precision can be achieved without the waste of effort entailed in excess sampling of larger areas.

However, there are two reasons that stratification is inappropriate for a long-term monitoring program such as the ABMP. First, there are many possible criteria upon which stratification could be based (e.g., ecological zonation, human land use zonation, industrial allocation, political administrative units) and the optimal site placement would be unique to each. Second, all ecological and administrative boundaries are expected to change during the 100 years that ABMP is anticipated to run. Ecological zones will change due to global warming moving the southern limit of the boreal forest further north and altering the boundaries of other ecological zones. In addition, ecological maps are ever-changing reflecting better analytical capabilities and growth in understanding of landscape patterns. Any stratification chosen today will be inefficient at answering tomorrow's questions and will therefore entail loss in ABMP's explanatory power. For these reasons, ABMP has been designed to deploy a systematic grid of sampling locations (Figure 1 below).

We recognize that a systematic network of sites will undersample some geographical units (e.g., small Forest Management Units, protected areas, and smaller ecological zones). However, rather than reduce the density within the general ABMP sampling network, we recommend enhancing sampling density in those areas that are considered important enough to warrant the extra expense. Although ABMP will appear to oversample some areas, over the longer term this apparent oversampling will provide flexibility to address questions not anticipated today.

AFBMP Is A Monitoring Program And Not A Research Study

Monitoring and experimental research are fundamentally different processes.

In environmental research, the objective is to develop a generalization about the way that nature functions. In the simplest sense, research attempts to falsify the hypothesis through controlling all potential causal factors except the one under consideration. If the hypothesis cannot be falsified, a causal link is tentatively identified in which the results are generalized.

In environmental monitoring, the objective is to determine if some characteristic of nature has changed at a particular place. Monitoring may evaluate change caused by a particular event, or evaluate the cumulative effects of change that result from a multitude of usually undefined circumstances. In its strictest sense, the intent of monitoring is not to understand why the change occurred. There is no attempt to control for, or necessarily even to understand, the spectrum of causal factors. No attempt is made to generalize results universally, but only to describe what has occurred in the area of interest.

Research can establish broadly based principles about how elements of biodiversity respond to specific environmental stressors. However, research cannot enumerate all the myriad of idiosyncratic stressors affecting biodiversity uniquely throughout the various regions of the Province. Thus, research alone cannot establish how Alberta's forest biodiversity is responding to development. Effective monitoring throughout Alberta's forest, can document changes in biodiversity.

Environmental monitoring and experimentation are synergistic. ABMP has been designed to monitor changes in biodiversity throughout Alberta. Information from ABMP will be rigorous enough to detect changes in biodiversity over time and among regions. Results may be analyzed and interpreted by scientists to suggest hypotheses regarding why things have changed. Experiments can then be designed to test these hypotheses, and to determine what is actually causing the changes. ABMP will serve a role of suggesting potential causal relationships that can be pursued by experimental research.

2.1.2 Offsetting Sites from the Systematic Grid

ABMP sampling sites will not be protected from development. For ABMP to adequately reflect trends in biodiversity, development must occur on sampling locations with the same likelihood as any other area of the province. If the location of ABMP sites were to become known, the location of development activities might be influenced. That would greatly reduce the value of the program.

Two measures could be implemented to ensure that development is not influenced by site location. First, sites could be moved randomly between sampling periods so that a different area was surveyed at each revisit. However, this would confound between-year variance and between-site variance and significantly reduce the power of the program to detect change. Alternatively, site locations could be fixed through time but placed at random distances and directions from the systematic grid point with the exact locations distributed only to individuals that are conducting surveys.

We have randomly located ABMP sites within 3 km of grid points that are spaced 20 km apart.
ABMP sites will remain fixed through the course of the program.

2.1.3 Aquatic Sites

Initially, the plan was to sample standing water at each systematic grid location. The expectation was that approximately 20% of the sites would have at least some standing water represented. However, initial testing during the 2002 Pilot indicated that very few ABMP sites actually meet the standing water protocol requirements.

It was also recognized early in the ABMP development process that very few systematically placed sites would be located in flowing water. To preserve the notion of a systematic location of sample sites, the original proposal was to sample the closest occurrence of flowing water to the ABMP site. However, the 2002 Pilot demonstrated the difficulty of finding appropriate stream sites near ABMP sites.

These difficulties have prompted a review how aquatic sites will be situated and of the protocols that will be used for aquatic sampling.

2.2 Number of Sites

Choosing the number of sites, and hence the spacing pattern, entails a compromise between providing a large enough sample of sites to achieve statistical power in a geographic area while also limiting survey costs. A 20 km grid spacing provides the optimal compromise between cost and the ability of the program to detect biodiversity change within regions in Alberta. A 20 km grid spacing results in 1,656 sites over Alberta's 660,000 km² area. The grid spacing chosen by the ABMP is identical to the grid spacing that was decided on independently by the National Forest Inventory program, and the NFI sites were used to determine the grid for the ABMP.

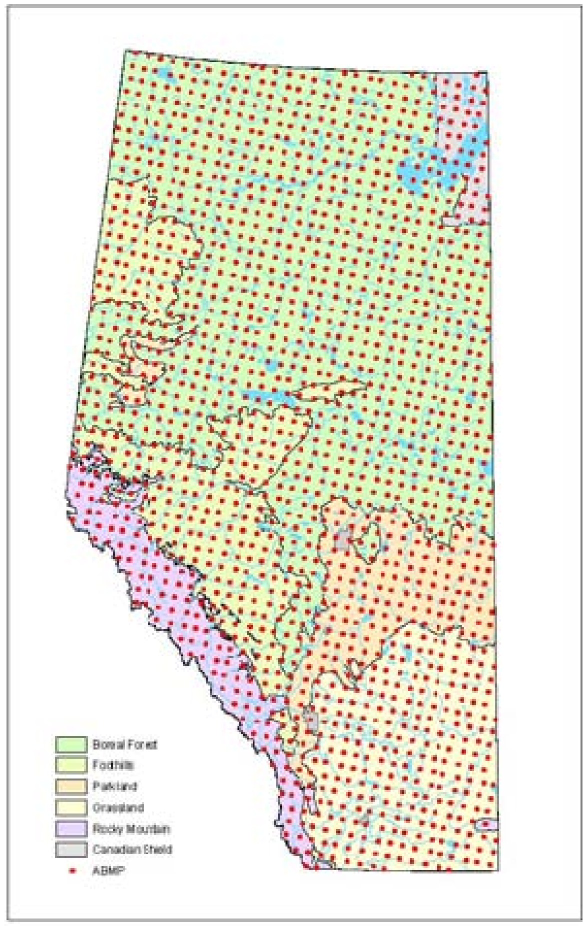

Figure 0. Systematic grid of ABMP site locations.

2.3 Temporal Design

The power analysis discussion presented in Chapter 6 indicates that the statistical power goals could be reached in 15 years by adopting an interval of 5 years between site revisits. Assuming a return interval of 5 years and a total of 1656 sites, it follows that a panel of 331 sites must be visited every year. However, sampling some sites in consecutive years greatly increases power to detect trend by providing statistical connectivity between panels. Consequently, ABMP will use an "augmented panel" design (Table 1) in which 266 new sites are visited each year and 65 sites are revisited in consecutive years. During the next three years, this panel design will be fine-tuned to determine the optimal number of consecutive re-visits, based on analysis of data from the Prototype Project.

Table 1: Number of sites and timing of re-visits for sites for the ABMP panel design. This design assumes that the entire province will be sampled every five years.

Panel	N	Year of the Monitoring Program														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	266	X					X					X				
2	266		X					X					X			

3	266	X			X		X	
4	266		X		X			X
5	267		X			X		X

A	65	X	X				X	X				X	X			
B	65		X	X				X	X				X	X		
C	65			X	X				X	X				X	X	
D	65				X	X				X	X				X	X
E	65					X	X				X	X				X
Total Sample Size	1656	331	396	396	396	397	396	396	396	396	396	397	396	396	396	396

X – Sites that are to be surveyed during a given year.

2.4 Time Horizon

Cumulative effects analyses have suggested that the rate and diversity of industrial development of Alberta will increase greatly in the future. Impacts of these developments can be expected to affect biodiversity over the long term, but without careful management these effects are likely to be exacerbated. ABMP has been designed to operate continuously throughout the next 100 years so that slow, small changes can be detected as they occur. Consequently, all information and samples collected as part of ABMP will be archived so that they can be easily retrieved and used as needed in the future. This long time horizon for ABMP necessitates that program management, information storage, and specimen archive must be conducted by an organization that is not affected by short-term changes in social, political, or industrial activities.

3. SAMPLING PROTOCOLS

In Chapters 7 - 17, scientists reviewed monitoring methods for a very wide range of biota and physical habitat characteristics. In Chapter 18, we took the recommendations from these chapters and attempted to integrate them into a mutually compatible set of protocols that provide the best return for the money invested. These protocols are being tested and revised during the Prototype Project and details on the latest designs can be found at
http://www.abmp.arc.ab.ca/FieldProtocols.pdf.

3.1 Selection Criteria

Seven characteristics were evaluated when deciding which biota and habitats to include within ABMP.

3.1.1 Taxonomic Diversity

Myriads of species are present in every ecosystem, and the complex hierarchical organization of these species and their habitats makes it impossible to fully characterize everything. Some biodiversity monitoring programs have sought to overcome this problem by monitoring a small number of "indicator species" or "key habitat types" and assuming that monitored changes are indicative of changes in a broad spectrum of species. This assumption is usually made based on partial information and can lead to bad management decisions.

We recommend monitoring of many species within a taxonomically and functionally broad array of species assemblages to include species from a wide diversity of habitats, species from a wide diversity of life history strategies, species from a diversity of trophic levels, and species with a diversity of life spans. This will increase the probability that some species will respond to each type of disturbance, regardless of the types of disturbances (some of which are presently not known) that occur in the future. In addition, monitoring multi-species assemblages allows the creation of multi-species biodiversity indices and these will have lower variance, and hence higher statistical power to detect change, than single species abundance.

3.1.2 Relationship to Stressors

To be included within ABMP, the biota and physical habitat characteristics must have a high probability of responding to anthropogenic stressors expected to affect the Alberta landbase during the next 100 years. These stressors include all forms of increased human use (e.g. oil and gas exploration and extraction, forestry, agriculture, tourism, urban and rural development) that are expected to affect the environment at a variety of spatial and temporal scales. However, very little data currently exist quantifying the responsiveness of biota and habitat characteristics to environmental stressors. Thus a breadth of species groups were chosen with emphases on groups that were thought to be good indicators of change. *Post hoc* interpretation will suggest relationships between environmental change and biodiversity that can feed back to management action or form the basis for developing research hypotheses.

3.1.3 Emphasis on the Species Level of Biological Organization

Biodiversity is usually defined as including variability within species, between species and of ecosystems. Although all three of these levels of biodiversity organization are important, it is beyond the capabilities of ABMP to effectively measure and monitor all levels. Species represent the most measurable units of biodiversity because they are complete, self-generating genetic ensembles, are valued by the public, are often characterized by considerable scientific knowledge, and can be explicitly linked to planning efforts. Therefore, monitoring of species and species groups will be the primary focus of ABMP. Effort will be directed at monitoring and describing spatial and temporal variability in species groups as surrogates of monitoring genetic and community diversity.

3.1.4 High Profile Species

Certain components of biodiversity, such as large carnivores and sport fish, are highly valued by the public. This interest warrants inclusion of some of high public profile species in the program.

3.1.5 Monitoring Biodiversity Elements Versus Monitoring Physical Elements

There are three potential reasons why ABMP might monitor changes in physical habitat characteristics. First, habitat characteristics such as water chemistry, road density, and snag size all influence biodiversity by altering the suitability of species' living conditions. Considerable value would be added to ABMP by investing a portion of field time to collecting data that could be used to interpret how habitat changes have affected biodiversity. The second reason to monitor habitat characteristics is that they reflect characteristics of biodiversity itself. For example, degree of forest fragmentation indicates how plant communities are distributed over the landscape. The third reason is that habitat provides a coarse filter indicator of biodiversity. For example, if there are very few large dead trees remaining in a landscape, Pileated Woodpecker populations may be expected to be at low levels. As such, a significant proportion of the effort in ABMP is directed at monitoring changes in physical habitat characteristics.

Two criteria were evaluated when choosing which habitat characteristics to include within ABMP. First, there had to be a reasonable expectation of causal linkage between the characteristics that were chosen and the numbers or distribution of species. This link will allow for both interpretation of biotic change and coarse filter inferences about other aspects of biodiversity. Second, the habitat characteristics had to be inexpensive to accurately and precisely sample, and be compatible with other components of the program.

3.1.6 Division of Effort Among Field Data Collection Protocols

To obtain the most cost-effective monitoring program, it was necessary to choose field data collection protocols allowing rapid assessments, while at the same time producing high quality data. However, even with techniques suitable for rapid assessment, there is usually a trade-off between data quality and survey effort.

3.1.6.1 NUMBER OF VISITS

Traveling to and from sites is a major program expense because it is time consuming and, in some cases, requires helicopter access. Therefore, we attempted to limit the number of protocols requiring multiple site visits, and choose suites of protocols that could be combined easily. When multiple visits within a year were unavoidable, we reduced overall costs by choosing that protocols could be conducted in conjunction with other activities.

3.1.6.2 NUMBER OF MEASUREMENTS IN EACH PROTOCOL

Many of the protocols suggested by the authors of Chapters 7-17 require multiple sub-samples (e.g., transects, plots, etc.) in order to increase accuracy and decrease variation within sites. However, several studies have shown that temporal changes are more readily detected by allocating effort to increasing the number of sites surveyed rather than the number of measurements within a site. Accordingly, within-site repeat measurements will be minimized. Optimal survey intensity is being investigated as part of the Prototype Project.

3.1.7 Spatial Lay-out of Sample Plot Locations at Each Site

To the extent possible, we adopted a spatially systematic sampling design that did not target specific habitat elements such as down logs or rock outcrops. For example, plots, transects, and points will be located at a set distance and direction from site center. The distances that plots, points or transects are from site center depend on the most robust spacing for the taxonomic group. However, moss and lichen species were surveyed in specific microhabitats because these species are associated with specific microhabitats. Currently the choice of sampling scheme for aquatic sites is under review as part of the Prototype Project.

3.2 Terrestrial field Protocols

A total of 23 protocols for sampling terrestrial biota and habitat conditions were described in Chapters 11 - 16. Of these, 20 species sampling protocols and 9 habitat sampling protocols, plus two new protocol, were recommended in Chapter 18. Testing during the 2002 Pilot led to several protocols (soil carbon, tree genetic material) being eliminated, and re-examination of the terrestrial arthropod protocol. The current terrestrial protocols are listed in Table 2.

Table 2. Summary of terrestrial field sampling protocols presently included in ABMP.

Chapter	Suite[1]	Description reference

Species protocols			
1. Low vegetation 2. Tall shrubs & saplings	5, 12, 13 5, 13	SU SU	18 x 0.25 m^2 plots 9 x 4.0 m^2 plots
3. Trees and snags	5, 13	SP	4 x 25 m x 50 m plots (large live trees) 4 x 10 m x 10 m plots (medium live trees) 4 x 5 m x 5m plots (small live trees)
4. Terrestrial arthropods	5, 14, 15	SU	Currently under review
5. Breeding birds	5, 16	SP	9 point counts, each 10 min duration
6. Winter birds	16	WI	9 km transect with 9 playback locations
7. Mammal snow tracking	16	WI	9 km triangular transect
8. Uncommon plants, mosses, & lichens	5, 11, 12 new	SU	Timed searches in four 50 m x 50 m quadrants targeting specific microhabitats
9. Incidental observations of high profile biota	New	SP, SU, WI	Incidental observations while doing other surveys weighted by time spent in the field
Habitat protocols			
1. Habitat structure 2. Down deadwood material 3. Tree canopy cover [1]	5 5, 13 5, 13	SP SP SU	Slope, elevation, drainage, vegetation type, site origin, photographs, stand age 4 x 25 m transects 8 spherical densiometer readings

SU = Summer Suite, SP = Spring Suite, WI = Winter Suite

3.3 Aquatic field Protocols

Chapters 10, 11, and 17 described a variety of protocols for sampling biota and habitat conditions in standing water environments (bogs, wetlands, marshes, fens, lakes) and flowing water environments (streams, rivers). Of these, 7 species sampling protocols and 11 habitat sampling protocol were recommended in Chapter 18. The 2002 Pilot found these approaches to be generally suitable, but difficulty was encountered in finding suitable locations. The aquatic protocols are therefore under review during the Prototype Project.

4. SPATIAL & TEMPORAL INTEGRATION OF FIELD PROTOCOLS

In Chapter 18, protocols for sampling species and habitat conditions in terrestrial and aquatic environments were combined into 5 "suites" of protocols (Table 4). The efficiency gained by integrating multiple monitoring protocols across a single sample network is one of the many advantages of ABMP over the assortment of uncoordinated monitoring approaches currently in place in Alberta and elsewhere.

Table 4 Number of field protocols recommended for each suite.

Suite	# Protocols
Fall Site Preparation	0
Spring terrestrial suite	5
Summer terrestrial suite	5
Winter suite	3
Standing water suite	Under review
Flowing water suite	Under review

4.1 Fall Site Preparation

In the fall, access will be established to the sites that will be surveyed in the subsequent year. Site preparation includes studying maps and imagery to determine the conditions at the site and the best manner to access the site. Trails to both the terrestrial and flowing water sites will be flagged and described. Approximately 10-20% of ABMP sites are expected to require cutting a small helicopter pad to facilitate access.

4.2 Spring Terrestrial Suite

The spring suite of protocols will be undertaken after the snow has melted, but before understory vegetation is well developed. This temporal window will move north throughout the province and is expected to begin about 27 May in the south and finish around 21 June.

The spring suite currently consists of site characterization, migratory birds, dead woody material, large tree/snags and incidental observations of high profile biota.

4.2.1 Site Characterization

Photographs of the site will be taken and slope, drainage, tree characteristics, and stand disturbances data will be recorded.

4.2.2 Migratory Birds

The migratory bird protocol will be applied in both terrestrial and standing water habitats. Terrestrial birds will be identified primarily by vocalizations during point counts, while species associated with standing water will primarily be identified by sight during point counts. The protocol entails recording bird songs at 9 locations with an omni-directional recorder and identifying as many species by sight as possible. All new species detected while walking between locations will be recorded.

4.2.3 Down Woody Material (DWM)

This protocol entails counting the number of pieces of DWM intersecting transects and measuring their diameters.

4.2.4 Tees and Snags

This protocol entails three sub-protocols designed to measure large, medium and small trees and snags as well as determining their size and age. Snags are counted at the same time as large trees.

4.2.5 Spring Observations of High Profile Biota

Some species of animals are of significant concern to society but are difficult to survey. A set of species will be monitored by recording sightings and signs of occurrence while conducting the other protocols. Unknown scat samples will be collected in plastic bags for expert identification. These data will be recorded incidentally to the prescribed protocols.

4.3 Summer Terrestrial Suite

The summer suite of protocols will be undertaken during the period of full herbaceous cover, and plant flowering. This will occur from 22 June to 5 August.

The summer suite currently consists of protocols for non-vascular plants, lichens, low vegetation, tall shrubs and saplings, canopy openness and incidental observations of high profile biota. A revised terrestrial arthropod protocol is presently being evaluated.

4.3.1 Low Vegetation

The low vegetation protocol is designed to evaluate species composition and cover of vascular plants (<0.5 m tall) within a 20 m x 20 m area. The procedure entails Braun-Blanquet cover measurements of 18 plots each 0.25 m^2 in size. These cover measurements provide the ability to track changes over time in abundance for common species.

4.3.2 Tall Shrubs and Saplings

The shrub/sapling protocol is designed to evaluate species composition and cover of vascular plants (>0.5 m and less than 1.3 m tall) within a 20 m x 20 m area. Cover measurement estimations will be made in 9 plots each 4.0 m^2 in size. These measurements provide the ability to track changes over time in abundance for common species.

4.3.3 Canopy Openness

Canopy openness is measured as the percentage of sky visible through the forest canopy during the leaf-out period of the summer months. Eight measurements are taken using a spherical densiometer.

4.3.4 Arthropods

The arthropod protocol described in Chapter 18 is currently being revised. Technical review of the original protocols suggested that the intrinsic variability in arthropod emergence dates, interacting with variation in sampling windows, would lead to such high variances and low statistical power to detect temporal change.

4.3.5 Elusive plants/mosses/lichens

This protocol has evolved during the 2002 Pilot. It now entails targeted searches of microhabitat occurrences in four quadrants. Searches for vertebrates have been dropped from the program.

4.3.6 Summer Observations of High Profile Biota

(see description in Spring Protocols above).

4.4 Winter Terrestrial Suite

The winter suite of protocols monitors elements that cannot be surveyed effectively during spring or summer. It consists of three protocols -- snow tracking for mammals, playbacks for winter birds, and incidental observations of high profile species. The winter suite will be undertaken from 1 January – 28 February.

4.4.1 Snow Tracking

Snow tracking is an effective means of monitoring relative densities of large- and medium-sized carnivores, snowshoe hares, and ungulates. In addition, abundance information can be gained for small carnivores, squirrels, porcupines, and grouse. The protocol entails snowshoeing a 9 km of transect and recording the number of tracks left in the snow by animals intersecting the transect.

4.4.2 Winter Bird Playbacks

Year-round resident bird species are particularly sensitive to changes in local environments. Of particular significance are owls, woodpeckers, and several passerines (corvids, chickadees, nuthatches, and finches). All birds detected during the track transect will be recorded. In addition, recorded playbacks of Chickadee mobbing calls and woodpecker drumming will be broadcast at 9 points along the track transect.

4.4.3 Winter Observations of High Profile Biota

(see description under Spring Protocols above).

4.5 Standing Water Protocols

The standing water protocols are conducted in stationary water >0.5 m deep. For the most part, the protocols worked well, but finding appropriate habitats proved to be difficult during the 2002 Pilot. Standing water protocols are currently under review.

4.6 Flowing Water Protocols

Flowing water protocols are conducted in streams with permanent flowing water. Some of the protocols worked and others required changes, but finding appropriate stream habitats proved to be difficult during the 2002 Pilot. Flowing water protocols are currently under review.

5. REMOTE SENSING PROTOCOLS

The primary objective of remote sensing in ABMP is to document status and change in aerial extent of land cover types at the regional and provincial scales. Secondary reasons for undertaking remote sensing work are:

1) to document landscape scale changes in landscape structure as context for interpretation of biodiversity change at the site, regional and provincial scales, and
2) to provide detailed field maps to aid site visits.

The remote sensing protocols are currently undergoing review and refinement as part of the Prototype. The following descriptions should therefore be viewed as interim.

5.1 Backcasting

Remote sensing technology is advancing rapidly. Major advances in improved spectral and spatial resolution occur every 5 – 10 years rendering previous technology obsolete for some purposes. This presents a challenge to a trend detection program such as ABMP. Systematic change in measurement introduces a directional bias into the analysis and consequently invalidates the results, but ignoring increasing detection capability would make ABMP methodology obsolete. ABMP will address this issue through adopting a "backcasting" strategy to detect change at 5-year intervals using the combined discriminatory ability of the current data set and data that were available 5 years earlier.

5.2 Spatial Scale

ABMP will adopt remote sensing at two spatial scales – coarse and medium resolution.

Coarse resolution analysis will cover the entire province using Landsat TM imagery with resolutions in the order of 30 m. "Wall-to-wall" coverage provides a powerful decision-making tool and avoids problems resulting from sampling and spatial autocorrelation biases. Coarse resolution elements recommended for monitoring include:

1) area of major land cover types,
2) percentage of forest types,
3) patch measures, and
4) human and natural disturbances.

Medium resolution imagery will cover areas immediately surrounding ABMP sites, using Quickbird imagery or other platforms with resolutions in the order of 2 m or better. Medium resolution imagery provides the ability to:

1) detect small vegetation patches,
2) discriminate species composition of vegetation patches,
3) measure tree density, gappiness, and heterogeneity of forest patches,
4) delineate small anthropogenic disturbances such as cutlines and buildings, and
5) plan site access and operations.

6. IMPLEMENTATION

6.1 A Centralized Program with Linkages

The most efficient and effective model for implementation of ABMP, is for data collection to be conducted by a group of seasonal employees supervised by permanent staff using a research facility as a base for logistical support. An alternative data collection model would be to have ABMP as the organizing body for a diffuse network of volunteers, researchers, and company monitoring programs that feed their information into a central repository.

Programs such as the Environmental Monitoring and Assessment Network (EMAN) recruit existing researchers and co-ordinate them through a loose network. Programs such as Frogwatch and the Audubon Christmas Bird Count rely on the efforts of ordinary citizens to collect simple data based on standardized protocols. Such programs are very cost effective in mobilizing large numbers of workers, requiring resources only for co-ordination of efforts and for processing data.

ABMP, on the other hand has adopted a centralized approach rather than depending upon volunteers and co-operators because:

1) Many ABMP sites will be relatively inaccessible and will therefore require logistical resources far beyond the capabilities of most volunteers or independent researchers. Altering the monitoring design to facilitate access would result in biased data being collected and reduce the value of the program.
2) ABMP is labor intensive and represents a greater commitment than most volunteers, researchers and independent organizations are willing to make.
3) ABMP protocols are diverse and technically demanding and will require dedicated, specialized training.
4) The success of ABMP depends upon minimizing measurement error by collecting data in a consistent manner at all sites. This is difficult to achieve even with specially trained staff and is not possible with volunteers and independent researchers who are acting on their own motivations.
5) Monitoring and research undertaken by researchers, industry and government agencies tend to be narrowly focused on defined priorities that are generally of short duration, whereas ABMP must be broad-scale, long-term, and broadly focused.

Organizations such as forest or energy industries, national or provincial governments will be encouraged to contribute to ABMP by dedicating staff to undertake the full ABMP protocols either within or outside the prescribed network of study sites. However, for data to be included in the ABMP database, staff must be properly trained, so that protocols are rigorously followed, and data meet standards of quality assurance and quality control. In addition, the resulting data must be made available to ABMP in standardized format, and permission given to make the data public. This represents a beneficial situation for all parties because the data will augment the ABMP database while providing the organization with a large amount of compatible data for context and comparison.

Several full-time personnel will be required to fulfill the tasks of project management, financial control, communications, training, taxonomic identification, statistical analysis and information management. Employment arrangements may be established through permanent employment, term contractual arrangements, or collaborative agreements with existing organizations.

Critical links to existing organizations capable of providing necessary human, physical, and financial resources include:

a. Alberta Environment, Sustainable Resource Development
    i. Spatial data, taxonomic expertise
b. Alberta Research Council
    i. Senior technicians, research scientists
c. Natural Resources Canada, Canadian Forest Service
    i. Northern Forestry Centre research scientists, National Forest Inventory
d. Provincial Museum of Alberta
    i. Arthropod specimen processing, identification, and archiving
    ii. Information management system
e. Foothills Model Forest
    i. Research scientists
f. Universities of Alberta, Calgary, and Lethbridge

i. Graduate students and faculty for analysis and validation research projects
ii. Undergraduate students for seasonal positions to acquire field data

g. Devonian Botanic Garden
   i. Plant material identification and archiving

h. Earth Observation Systems Laboratory (U of Alberta) for
   i. Image archiving, data distribution

i. Sustainable Forest Management Network Centre of Excellence (U of Alberta)
   i. Graduate students and faculty for analysis and validation research projects

Developing a scheme of program governance is a major component of the Prototype Project and the above recommendations will be modified as necessary.

6.2 Data Handling, Analysis and Reporting

A central tenet of ABMP is that all data will be freely available to the public. Open access to the data and rigorous descriptions of data collection protocols will ensure that no particular interest group will be able to use or withhold data selectively or inappropriately. The data will be an invaluable source of information that can be used to evaluate existing policies and practices and to provide early warning of changes to biodiversity.

ABMP will summarize the data and distribute products in standardized formats. All data will be publicly accessible via a website and all sectors of society will be encouraged to use this data, with acknowledgement, to address their information needs. In addition, the program may have staff available to conduct additional analyses on a contractual bases for particular organizations. A Data Management System is currently being developed as part of the Prototype Project.

Chapter 18 sketched out a proposed reporting framework for ABMP. Subsequent discussions suggested that much more thought and consultation with stakeholders will be required to develop a reporting system that meets the needs of all users. The Prototype Program will be addressing this issue as a matter of priority. In keeping with the central tenets of ABMP, reporting will be objective and avoid value-laden judgments on the state of Alberta's biodiversity.

6.3 Quality Assurance and Control

Quality assurance and quality control (QA/QC) will be an integral component of ABMP. The program will estimate the magnitude of errors in the data, and the source of these errors (from field sampling through to reporting and posting on the Internet). Understanding these errors will allow corrective action. We recommend that a quality assurance team will resample 10 sites per year and that five percent of data entries be traced back to assess their integrity at each stage of the process.

6.4 Annual Schedule of Activities

Table 6. Schedule of annual activities.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Site preparation									X	X		
Hiring seasonal staff	X	X	X									

Logistical planning	X	X	X	X	X							
Seasonal staff training					X							
Fieldwork--spring suite						X						
Fieldwork--summer suite							X					
Fieldwork-- stream & lake suite								X				
Fieldwork-- winter suite	X	X										
Data Entry	X	X	X	X	X	X	X	X	X	X	X	X
Specimen ID and processing								X	X	X	X	X
Remote Sensing	X	X	X	X	X	X	X	X	X	X	X	X
Annual Report Preparation	X	X	X									

In September and October of the year prior to fieldwork, sites will be prepared for access.

Employment ads will be circulated in November to each of Alberta's universities and colleges, with interviews in January, and hiring of all seasonal staff by the end of February. Two weeks of training will be provided in May to ensure that field staff are well-versed in safety procedures and monitoring protocols, including field identification of plant species.

November 2002 Update The remaining two weeks of May will be devoted to logistical arrangements for the field season and training to standardize data collection.

Acquisition of field data in terrestrial sites will occur from 27 May through 5 August. Acquisition of field data in standing and flowing water sites will occur during the month of August. Winter field-work will occur when snow conditions are favorable (January – March).

Field data will be recorded onto field data forms. These data will be transcribed into standardized site-specific electronic forms during the fall. Identification of common moss, lichen, and vascular plant specimens that were collected in the field will occur during August by field staff. Unknown specimens sent to taxonomic experts for identification. Bird vocalizations, arthropods, algae, and benthic invertebrates, plankton, and water chemistry analyses will be on-going throughout the year by dedicated, full time lab staff.

Coarse resolution remote sensing will be done at 5-year intervals as part of the Alberta Ground Cover Classification (AGCC) program of the Alberta Government, and is not included in ABMP scheduling or costs. Analysis of medium resolution imagery will be a year-round activity with acquisition of site-specific data in the summer preceding fieldwork and the analysis done by in-house staff to ensure that images are completed for use in the subsequent field season.

Annual reports will be prepared by 31 March summarizing the work done in the previous year.

6.5 ABMP Prototype Project

The phased start-up recommended in Chapter 18 is being implemented as Phase II of ABMP; the ABMP Prototype Project. This project is designed to position the program for full implementation in 2007. The following goals will be met during the Prototype:

1) Test the feasibility and cost-effectiveness of ABMP field and remote sensing protocols.
2) Develop a web-based platform for data management that will effectively store, handle, retrieve, and distribute data.
3) Develop status and trends measures for a wide range of biota and biodiversity multimetrics, and determine how these measures are related to resource development activities.
4) Test the statistical adequacy of ABMP protocols and sampling design.
5) Develop standard analyses, reports, and other products and services that will empower land managers and other end-users to draw reliable inferences from ABMP information.
6) Develop a business plan and communication strategy to move ABMP to operational implementation.

Data will be collected at approximately 6% of ABMP sites and used to demonstrate how biodiversity change can be measured and portrayed. Resource managers will be able to evaluate products and services produced during the ABMP Prototype and to assess the degree to which they can be used to make practical, management decisions.

During each year of the ABMP Prototype, sampling will be conducted at 34 ABMP sites and remote sensing data will be acquired for four sites. The sites surveyed will be located across a broad range of forest ecosystems and land use intensities. Based on these field and remote surveys, survey protocols will be refined to become more feasible and cost effective.

Multi-metric indices of biodiversity will be developed for terrestrial biota, aquatic biota, forest structure (trees, snags, downed wood), and landscape metrics (vegetation types, patch size). In addition, human activities will be combined into an integrated metric capturing cumulative impacts and allowing sites to be ranked according to the degree of human disturbance. Relationships between biodiversity multi-metrics and human disturbance metrics will be established using two-thirds of the sites with the remaining third providing independent validation.

An innovative web-based data management system, with query/filtering and analysis tools, will be developed to distribute both raw and summarized data. Algorithms will be integrated into the data management system to allow resource managers to visualize and map biodiversity metrics, and to predict potential impacts of resource development.