Alberta Biodiversity Monitoring Program—Monitoring Effectiveness of Sustainable Forest Management Planning

J. John Stadt, Forest Ecologist, Forest Management Branch, Alberta Sustainable Resource Development, Edmonton AB T5K 2M4 Canada
Jim Schieck, Research Ecologist, Integrated Resource Management, Alberta Research Council, Vegreville AB T9C 1T4 Canada
Harry Stelfox, Senior Manager Intergovernmental Relations and Resource Policy, Policy and Planning, Alberta Sustainable Resource Development, Edmonton AB T5K 2G8 Canada

Abstract—*The Alberta Biodiversity Monitoring Program is a rigorous science-based initiative that is being developed to monitor and report on biodiversity status and trends throughout the province of Alberta, Canada. Forest management plans in Alberta are required to monitor and report on the achievement of stated sustainable forest management objectives; however, the effectiveness of these objectives in maintaining biodiversity is not directly addressed in this operational monitoring. The Alberta Biodiversity Monitoring Program will provide this effectiveness function at provincial and regional scales, supporting the ongoing assessment and revision of resource management objectives in an adaptive management process.*

The basic survey design consists of 1650 sites, 20 km apart, evenly spaced on a grid pattern across Alberta. Sites will be sampled over a five-year period at a rate of 350 sites/year. Standardized sampling protocols will be used to cover a broad range of species and habitat elements within terrestrial and aquatic environments, as well as broader landscape-level features. The ABMP will have a 90 percent power to detect a 3-percent yearly change within a region after three visits to a site.

In addition to forest management, the petroleum and agriculture sectors also have significant influences on biodiversity in Alberta ecosystems. Planning regimes vary widely among these sectors creating a significant challenge in managing their cumulative effects on biodiversity. The ABMP is designed to provide a comprehensive monitoring system that will detect changes to biodiversity, act as an early warning system, and help Albertans and various resource sectors make improvements to their management practices.

Introduction

The conservation of biodiversity has become an important component of sustainable resource management. The Canadian Council of Forest Ministers (CCFM 2003) and various forest certification organizations such as the Canadian Standards Association (CSA 2002) have included the conservation of biodiversity in their definitions of sustainable forest management. The forest industry in many parts of Canada, including Alberta, are moving from sustained yield systems in which wood fibre volumes are maximized, to sustainable forest management systems in which a range of forest values, including biodiversity, are co-managed for sustainability.

Any management system, including forest management, requires monitoring to ensure that desired outcomes are achieved. In this paper, we discuss the linkage between sustainable forest management planning and monitoring using Alberta as a case study. This case study will highlight the system of operational forest planning in Alberta and its potential linkage with the Alberta Biodiversity Monitoring Program (ABMP). The challenges of integrating forest planning and biodiversity monitoring systems will then be discussed.

Context

Alberta is a diverse province ecologically and includes Canadian Shield, Boreal Forest, Parkland, Foothills, Rocky Mountain, and Grassland natural regions (fig. 1). This natural diversity supports a wide variety of life and provides internationally significant habitats for migratory birds and large mammals such as grizzly bear and

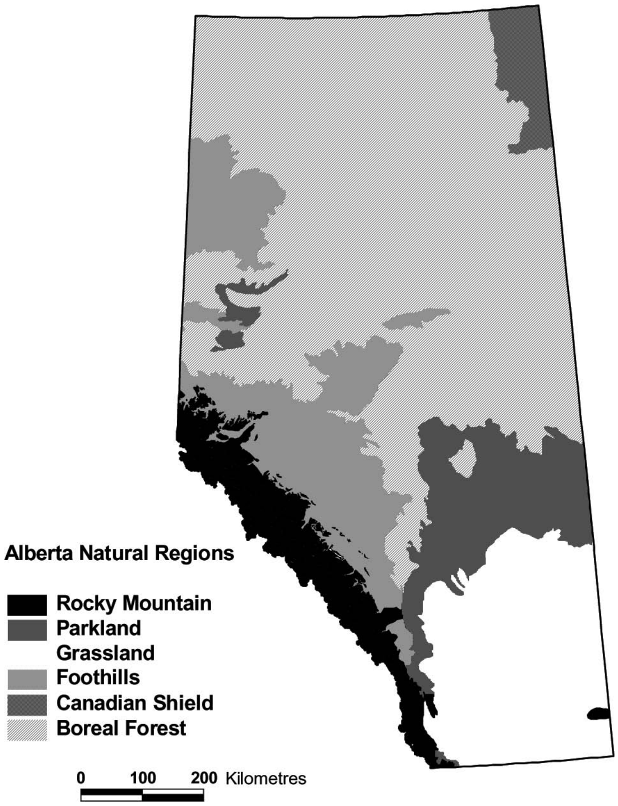

Figure 1. Natural regions of Alberta, Canada.

caribou. Species rare in Canada are seen in the northern reaches of the Missouri watershed. This diversity is part of the "natural capital" that has attracted many people to this part of the world. A growing human population has resulted in significant changes to these ecosystems over the last 100 years. The Grassland and Parkland natural regions have been heavily influenced by agriculture and settlement. The Boreal Forest, Parkland and Rocky Mountain natural regions are experiencing extensive development of their forestry resources. The oil and gas industry is the economic driver of Alberta and is a significant factor in all natural regions in the province. Impacts result from seismic exploration programs, the development of road, wellhead, and pipeline networks, and large oil-sand projects. The pace of oil and gas developments is expected to continue, if not increase, as these resources become more valuable on world markets and new extraction technologies are introduced to access previously inaccessible reserves such as coal bed methane and deep tar sand deposits.

This increasing human intervention in these natural regions has led to more scrutiny over how we manage our natural resources. As a society, we want to benefit economically from these natural resources but also realize that maintaining a healthy society requires maintaining healthy ecosystems. Biodiversity is one important measure and component of healthy ecosystems and therefore managing for biodiversity is crucial to meeting the wide range of human needs and aspirations.

The discussion of how biodiversity can be conserved begins with a look at forest management planning in Alberta. While forestry is only one human activity affecting biodiversity, operational forest planning provides an example of one of the required components of biodiversity conservation. The ABMP is then highlighted as the effectiveness-monitoring component of biodiversity conservation assessing forest management impacts in the larger context of the full suite of human and natural impacts on the landscape.

Forest Management Planning in Alberta

Before describing forest management in Alberta, it must be acknowledged that forest management does not equal landscape or ecosystem management. As noted above, forestry is only one player on the landscape and operates in a context that includes oil and gas, agriculture, and human settlement. True ecosystem management requires a strategic planning framework in which society sets landscape and even region-wide objectives so that tradeoffs can be made to balance environmental, social, and economic values. Strategic planning is a crucial part of management for the conservation of biodiversity (fig. 2); however, the focus in this paper will be on forest management planning and its linkage to biodiversity.

Most of the actively managed forests in Alberta are on crown land and the primary land manager is therefore the Government of Alberta. Through Forest Management Agreements (FMAs), the Government of Alberta has authorized forest companies to manage fibre production in these forests in a manner that maintains other values including biodiversity. The Government of Alberta, through newly proposed forest planning standards, will be providing FMA holders with its expectations for sustainable forest management. The standards place a strong emphasis on forest management by well-defined objectives and measurable results, with a reduced reliance on regulatory constraints. Forest management plans will include the statement of values, objectives, indicators, and targets (table 1). Standards for establishing biodiversity objectives are included in the proposed forest planning policy (table 2). In order to be able to set values, objectives, indicators and targets that will contribute meaningfully to the conservation of biodiversity, an understanding is needed of what we want forests of the future to look like. This requires an understanding of forest dynamics, such as the natural disturbance regime, as well as an understanding of what forest attributes are

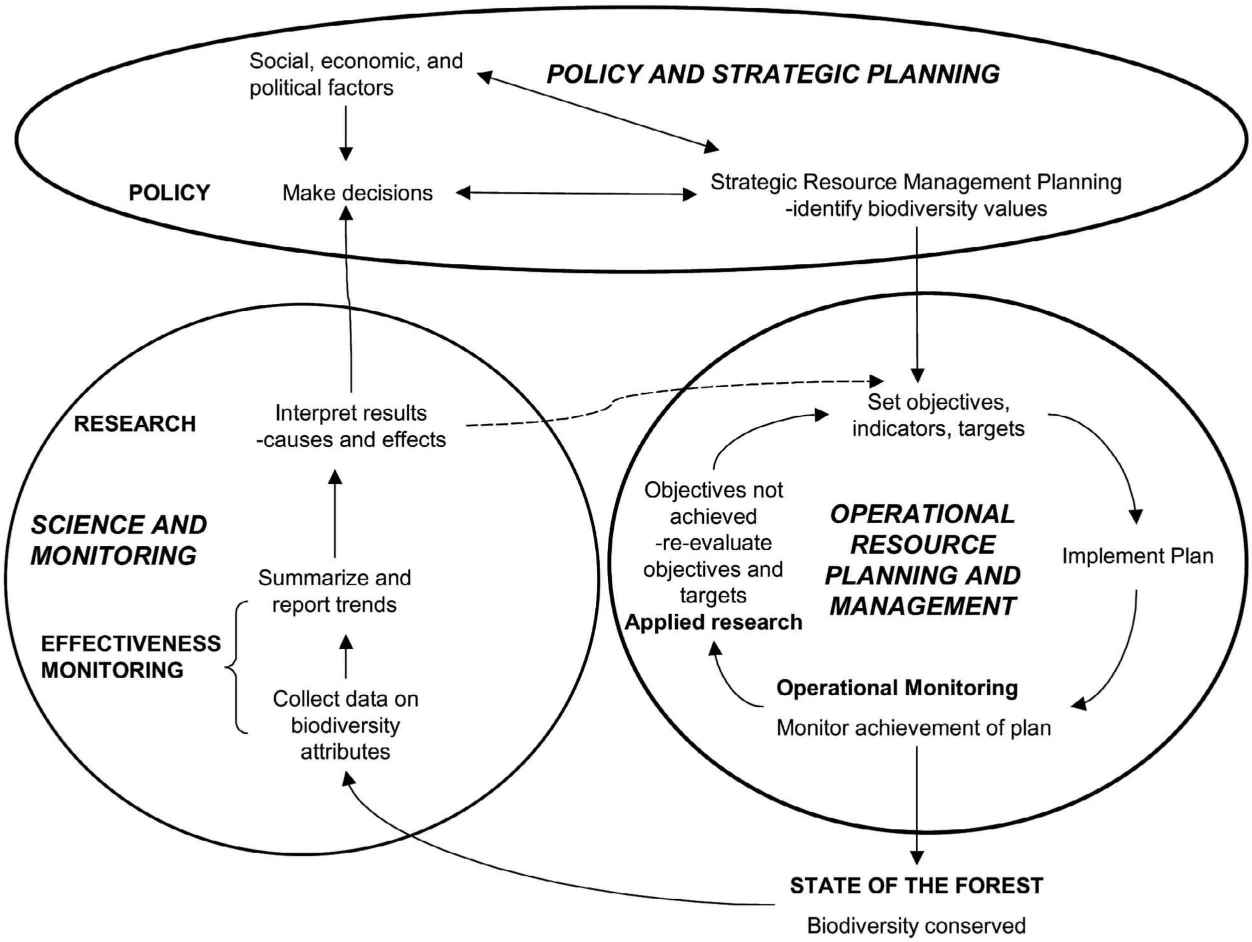

Figure 2. Forest resource planning cycle as it relates to the conservation of biodiversity including operational planning, operational monitoring, biodiversity effectiveness monitoring, and research.

Table 1. Forest Planning Manual Values, Objectives, Indicators and Targets.

Values	Forest area quality considered important
Objectives	Broad statement describing desired future condition or state of a value
Indicators	Variable describing state or condition of a value
Targets	Specific statement describing future state or condition of value, quantified if possible

required to maintain the full suite of forest biodiversity. Scientific research that links a fundamental understanding of forest ecosystems to practical cause-and-effect relationships is therefore crucial for developing objective-based sustainable forest management plans (fig. 2).

Monitoring and Forest Management

Monitoring is an integral and necessary component of any plan and sustainable forest management plans are no different. Alberta's forest planning guidelines require reporting on the achievement of all objectives in 5-year stewardship reports. This operational monitoring assesses the success in achieving the targets set for each objective. Adjustments to operations can then be made if it is demonstrated that current management activities are not achieving certain targets (fig. 2). Operational monitoring will sometimes also trigger a re-assessment of the objectives themselves if it becomes apparent that it is impossible to achieve certain objectives because of unforeseen factors, factors not under the control of the forest manager, or because some of the objectives prove to be mutually incompatible.

Table 2. Proposed Alberta forest planning standards for conservation of biodiversity objectives in forest management plans.

Element	Value	Objective	Indicator
Ecosystem Diversity	Landscape Scale biodiversity	Seral Stage and cover type	Area of old, mature and young forest
		Fragmentation	Patch size distribution of harvest openings
			Area of old interior forest
		Access	Open forestry road density
		Uncommon plant communities	Area/occurrence of community
		Burned and windthrow habitats	Area of unsalvaged burned or windthrow forest
		Riparian areas	Application of required buffers
	Stand scale biodiversity	Stand level structure	Volume/area of standing merchantable trees
			Volume of downed woody material
		Sensitive sites	Number or percentage maintained
		Water crossings	Strategy to minimize
			Compliance with crossing regulations
Species Diversity	Viable populations of identified species	Species habitat or populations	Habitat area or number of individuals
Genetic Diversity	Tree genetic diversity	Wild populations of each species (*in situ*)	Number and area of tree genetic conservation areas
		Ex situ conservation of tree genetic resources	Number of provenance and genetic lines in ex situ gene banks and trials

Operational monitoring cannot determine the effectiveness of a forest management plan's objectives in achieving the broader value of biodiversity conservation. This is a crucial issue in sustainable forest management as it is entirely possible to have successfully achieved all the forest management objectives related to biodiversity and still not be conserving biodiversity at all. How is this possible? One reason may be that the objectives, with their indicators and targets, did not address the full requirements for biodiversity, either because they failed to address certain necessary attributes (missing objectives) or because they did not provide enough of the required attribute (target inadequate). The other possibility is that factors not under the control of forest management practices, and therefore not addressed in forest management plans, are impacting biodiversity. These other factors are diverse and include the impact of other industries on the landscape (for example, seismic lines created by oil and gas), impacts in other jurisdictions outside the forest management area (for example, pesticide use or habitat loss in migratory bird wintering areas), or the effects of natural variability and climate change on species and their habitats.

For these reasons it is clear that operational monitoring is not enough. Biodiversity must be directly measured. This requires a comprehensive monitoring program in which significant trends in biodiversity can be detected. A biodiversity monitoring program would simply show what is happening; it would not be expected to make cause-and-effect conclusions (fig. 3). Such conclusions could only be made through research in which specific cause-and-effect hypotheses are tested. These hypotheses could very well be suggested or inferred by the trend data collected by a biodiversity monitoring program.

In this way a carefully designed biodiversity monitoring program can complete the planning cycle by providing inputs to research which in turn allows planners to set objectives to manage toward a future forest that meets desired values (fig. 2).

Alberta Biodiversity Monitoring Program

ABMP (Shank and others 2002) is designed to be a comprehensive, long-term monitoring program that will directly measure status and trends of biodiversity in Alberta, within the context of multiple resource developments across the province. The program objectives are as follows

1. to develop and implement a scientifically credible, long-term biodiversity monitoring program,

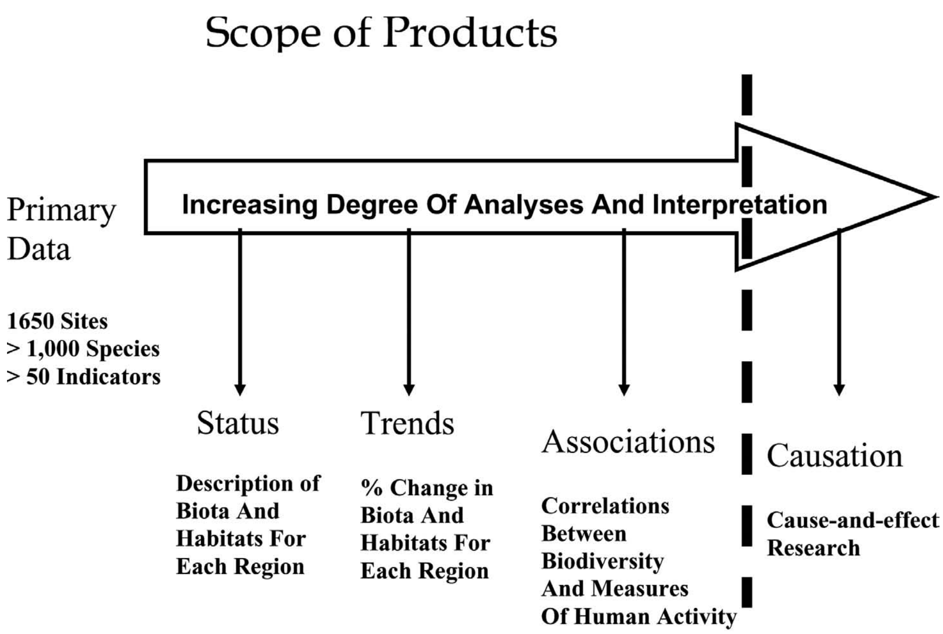

Figure 3. Scope of analysis and interpretation of the Alberta Biodiversity Monitoring Program and its relationship with research.

2. to measure status, differences, and temporal changes in selected measures of biodiversity, habitat, and anthropogenic disturbances at provincial and regional scales, and
3. to provide access to primary data and summary information reports. The ABMP has three phases. Phase 1, completed in 2002, developed the technical design of the program. Phase 2, currently underway and scheduled for completion in 2006, is the prototype testing phase in which the data collection protocols will be refined and the data management and reporting systems developed and tested. Phase 3, scheduled to begin in 2007, is the implementation of the full program across the province.

Survey Design

Before the design of the ABMP is described, it is important to understand the difference between a monitoring program and a research study. In environmental research, the objective is to develop a generalization about the way nature functions. Cause-and-effect relationships can be determined through hypothesis testing in which all factors are controlled for other than the one under consideration. In environmental monitoring, the objective is to determine if some characteristic of nature has changed in a significant way over time at a particular place or region. The primary purpose of monitoring is not to determine why the change occurred. There is no attempt to control for, or necessarily even to understand, the spectrum of causal factors. No generalization is possible outside the area being monitored; a statement is simply made about what has happened within that area. This allows monitoring to be independent of assumptions of cause-and-effect relationships and to detect unanticipated changes (Shank and others 2002). Later in this paper the synergistic relationship between monitoring and research will be described.

The ABMP survey design is a systematic placement of permanent survey locations on a 20-km grid across the whole province of Alberta resulting in about 1650 sites (fig. 4, see http://www.abmp.arc.ab.ca for full documentation). The sampling return interval is five years with 350 sites sampled yearly. This survey pattern and intensity is designed to detect a change in measured attributes of at least 3-percent per year after three visits to a site (Shank and others 2002).

The systematic distribution of sampling sites is an important feature of the ABMP. Alternative sampling regimes include random and stratified networks of sampling sites. However, random site locations were not deemed appropriate for long-term monitoring as concentrations of sites in certain locations of the study area can result in other areas being undersampled. Although stratifying locations based on some pre-determined spatial criteria avoids this problem, other issues then arise. Stratification of locations is inappropriate for long-term monitoring programs such as ABMP because it requires an initial determination of what spatial stratification criteria is most important and this determination will bias the data collected. The boundaries of any zoning framework used to stratify sampling effort are expected to change over the multiple decades that the ABMP is expected to run. Only a systematic system of sampling removes the bias inherent with stratified sampling while providing flexibility to address questions not anticipated today (Shank and others 2002).

Figure 4. Systematic 20-km grid layout of sampling locations in the Alberta Biodiversity Monitoring Program. Boundaries denote Alberta natural regions shown on figure 1.

Development of the ABMP sampling protocols focused on the question of "how does one measure biodiversity?" It is obviously impossible to measure all the attributes of ecosystem, species, and genetic diversity that comprise biodiversity. Therefore, the first task of protocol development involved selecting a suite of ecosystem and species attributes that would provide a reasonable measure of biodiversity in a cost-effective manner. Separate protocols were developed for terrestrial and aquatic habitats. The protocol to be used at a site depends on local site characteristics. A remote sensing protocol was developed to provide a picture of the landscape attributes around each site.

The terrestrial and aquatic protocols require the collection of both ecosystem and species attributes (table 3, fig. 5). The selection of these attributes and species was based on their having a high probability of responding to human disturbances. Some biodiversity monitoring programs select a number of "indicator species" or "key habitat types" to reduce sampling cost and assume that changes detected are indicative of changes in a broad spectrum of species. The ABMP has taken a different approach and instead monitors a large number of species from a wide range of taxonomic and functional groups (table 3). This approach was taken to increase the ability to detect a change that may affect only some species. This approach also limits the need to make a priori assumptions of how systems will respond to environmental change and therefore increases the long-term resilience of the program to monitor and detect unanticipated events and responses.

The remote sensing protocol will use satellite imagery to document status and change in the aerial extent of land cover types at regional and provincial scales. This protocol will also document landscape scale changes in landscape structure to provide a context for interpreting biodiversity data at each site. Large extent imagery (30-1000 m resolution) covering the entire province will be used to monitor broad landscape patterns. Elements monitored here include the area of major land cover types, percentage of forest as coniferous, deciduous and mixedwood, and large human and natural disturbances. Medium extent imagery (1-5 m resolution) centred on each sample site with a 1% provincial coverage will be used to detect smaller scale attributes such as vegetation patches down to 0.1 ha, species composition of vegetation patches, and small human disturbances such as seismic lines.

Data Assessment and Interpretation

The large amount of point and map data generated by the ABMP will be stored in a data management system designed to provide long-term data security while facilitating easy access by many groups. A secure, internet-based, interactive interface is being developed to allow external users access to data and summary information that they require.

Data analysis procedures are currently being developed that will be used to provide management insights that are not obvious within the raw data. For each biotic group, habitat, or landscape metric monitored by the ABMP, researchers are designing analyses that are effective at detecting change over time and describing differences in biodiversity status between geographic areas.

A critical component of making ABMP data useful to a wide audience will be the delivery of quality

Table 3. Summary of terrestrial and aquatic field sampling protocols in the Alberta Biodiversity Monitoring Program.

	Protocol	Description
Terrestrial Sites		
Species Protocols	Low vegetation	Plots
	Tall shrubs and saplings	Transects
	Trees	Plots
	Terrestrial arthropods	Pan and Lindgren traps
	Breeding birds	Point counts
	Winter birds	Point counts and playbacks
	Snow tracking	Transect
	Rare and elusive biota	Transects, plots
	Tree genetic material	Leaf and needle material
Habitat Protocols	Habitat structure	Slope, elevation, drainage, vegetation type, phenology, site origin, photographs
	Soil carbon	Pits
	Down deadwood material	Transects
	Tree canopy cover	Spherical densiometer readings
Aquatic Sites		
Species Protocols	Phytoplankton	Euphotic zone (standing water)
	Zooplankton	Water column (standing water)
	Benthic algae	Scrape sample (flowing water)
	Benthic macroinvertebrates	Corer/grab (standing and flowing water)
	Fish	Gill net (standing water)
Electrofishing (flowing water)		
Habitat Protocols	Water physiochemistry	pH, temperature, dissolved oxygen, conductivity, light attenuation, nutrient characteristics, depth (standing and flowing water), velocity (flowing water)
	Basin/channel characteristics	Surface water width, area, shape (standing and flowing water)
Substrate composition (standing and flowing water)		
Dead wood (flowing water)		

information products at regular intervals. The following baseline products will be created:

- Summaries of data collected and archived during the year.
- Annual reports reviewing program performance measures.
- Five-year reports providing interpretation of, and trends in, biodiversity status.

Data summaries and five-year reports provide a way to report biodiversity stewardship for both researchers and the general public. In this way the ABMP contributes to the public accountability of natural resource managers.

Integration of ABMP into Natural Resource Management

The ABMP is designed to monitor status and trends in biodiversity but does not indicate what causal agents are affecting biodiversity (fig. 3). However, the biodiversity data produced in the ABMP will be correlated to both stand- and landscape-scale attributes that may suggest possible cause-and-effect relationships. These correlations can then provide the basis for generating hypotheses that can be tested in scientific research programs. The result of this linkage between monitoring and research is a more effective way of focusing limited research resources to questions of real significance to biodiversity conservation (fig. 2). Knowing what questions to ask will make research more relevant. The knowledge generated from more focused research will allow strategic and operational planners to develop and refine objectives related to the conservation of biodiversity.

Once cause and effect relationships between human actions and biodiversity are more clearly understood, the ABMP will be able to provide more direct effectiveness monitoring of the success of operational plans in achieving conservation of biodiversity objectives.

Conclusion

The ABMP's systematic sampling design, and its direct approach to measuring biodiversity without a priori assumptions, makes it resilient to unanticipated developments and relevant to planning at both strategic and operational scales. Forest managers will be able to set conservation of biodiversity objectives based on scientific research, which in turn has been directed by a

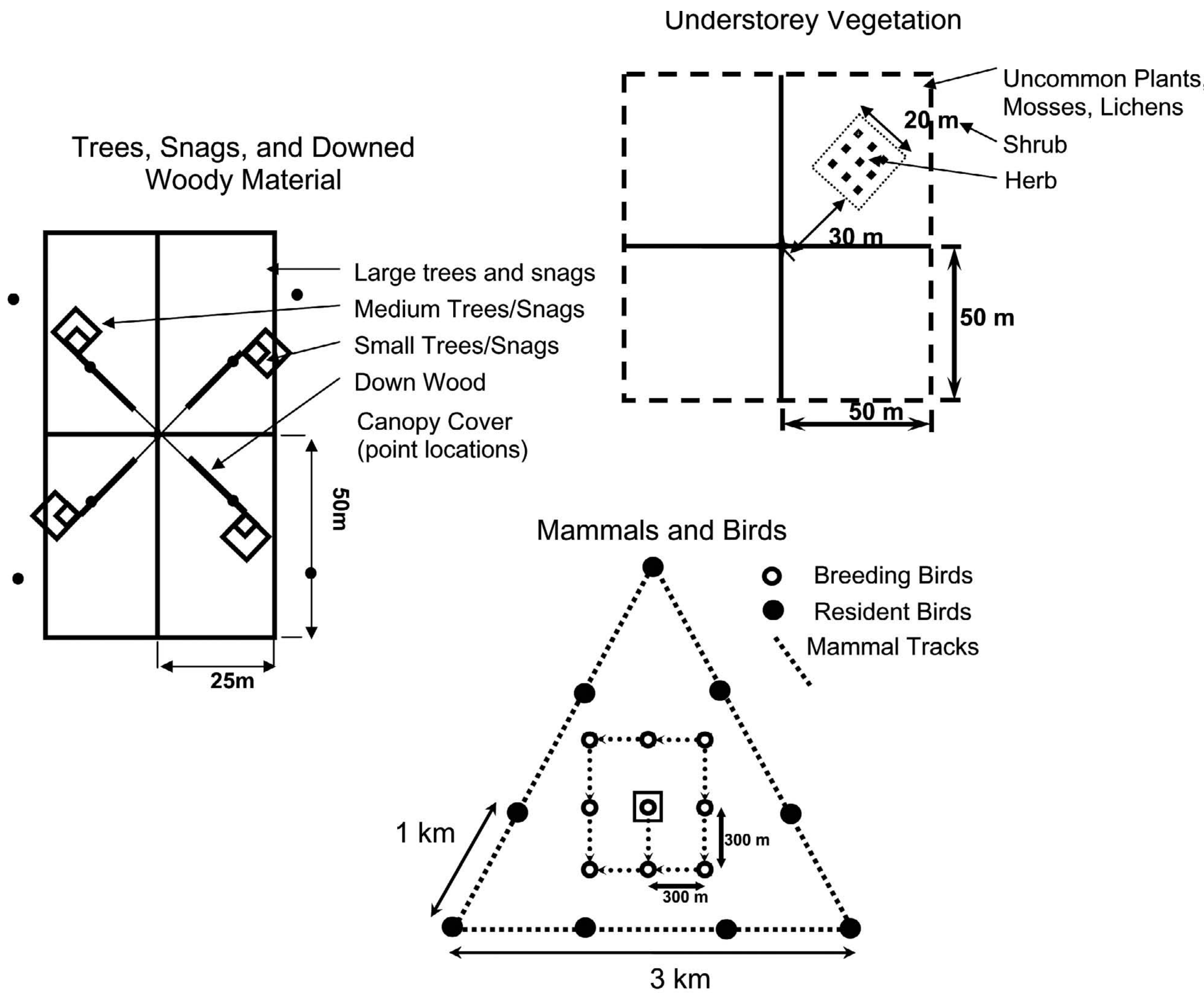

Figure 5. Terrestrial field sampling layout protocols for overstorey and understorey vegetation and for mammals and birds. The three layouts shown above are centred on the same point and therefore would be superimposed in the field.

greater understanding of the status and trends in biodiversity. Effectiveness monitoring will also now complement operational monitoring of these objectives.

The establishment of measurable biodiversity objectives required by Alberta's proposed forest planning standards and the effectiveness monitoring function provided by the ABMP are key links in the forest planning cycle and will therefore contribute to the ultimate goal of conserving biodiversity in Alberta's forests.

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