A Framework for Ecosystem-Based Management in the Manitoba Model Forest

Prepared for the
Manitoba Model Forest Inc.

by

Chris Wedeles
ESSA Technologies Ltd.
#308, 9555 Yonge Street
Richmond Hill, ON L4C 9M5

and

Dr. Jeremy Williams
33 Kelsonia Avenue
Toronto, ON M1M 1B2

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1.0 Introduction

1.1 Background

The overall mission of the Manitoba Model Forest is to develop a working model of ecologically sustainable forest management and use through partnerships of diverse interests and values. As one means of working towards this goal, the Model Forest decided to pursue the development of a framework for an approach to forest management called Ecosystem-Based Management (EBM). Although the Model Forest stakeholders had identified many of the EBM principles and had developed a number of tools and inventories that would support the implementation of EBM, the Model Forest felt that some elements were missing and that there were missing linkages between individual projects and initiatives.

This report documents the key results of a project designed to assist the Model Forest in developing a framework for the implementation of EBM. The report is divided into five sections. This first section provides a context for the project by discussing its goals. The second section explores definitions and principles related to EBM documented in the scientific and forest management literature. The third section presents some ecological and forest management concepts related to EBM. The fourth section reviews the Model Forest's progress to date by discussing some of the key results of a Model Forest EBM workshop held in April 1995, and by reviewing how the Model Forests existing projects relate to EBM. The fifth and final section presents a possible framework for EBM for the Model Forest.

1.2 Project Goals

This project is intended to bring together the desires of the Manitoba Model Forest (Model Forest)to manage the forest in an ecologically wise manner with recent scientific and philosophical advances in EBM. The goal of this project (as stated in the original Request for Proposal) is to *design a framework for EBM that is appropriate for the Manitoba Model Forest and its stakeholders.* This goal statement likely has somewhat different meanings to different people since the word "framework" is used in many contexts and is subject to broad interpretation.

In this project, the framework for EBM will consist of:

- a definition and explanation of EBM in the context of the Model Forest;
- a description of the goals and objectives, in the context of the Model Forest;
- an explanation of background and related concepts and how they apply to the Model Forest;
- an explanation of the interrelated aspects of EBM; and
- a description of the priorities for action.

1.3 Work Completed to Date

This report is the third major product of this project. In March 1995, an initial report on EBM was prepared, which explored some of the concepts related to EBM and presented a simple framework. Much of that report is reproduced in this document. The initial report was also designed to set the stage for the second major project activity: a workshop held in Pinawa in April 1995. The intent of the workshop was discuss some of the concepts related to EBM as they apply to the Model Forest, and to further develop the framework. Most of the discussions from the workshop are documented in this report.

2.0 What is Ecosystem-Based Management

In recent years, many people have attempted to define the terms and concepts related to Ecosystem-Based Management (EBM). Although there is no universally accepted definition of EBM, at the core of the various definitions is a strong common element related to maintaining the ecological integrity of a geographic area under management.

2.1 Why Define EBM?

Defining EBM is clearly a difficult task. This has led some people to ask "why bother attempting to define it?". An argument can be made that EBM is a concept, like justice, which although difficult to articulate, is clearly worth striving for (Euler 1993), although struggling to define it may be an exercise in semantics. However, we believe that it is important for managers to define their understanding of EBM for two related reasons. First, defining EBM ensures clarity in communication. If two people are discussing or attempting to implement EBM, but are not using a common definition, problems related to misunderstandings are sure to arise. Second, explicitly defining EBM avoids misuse of the term. We have heard some forest managers proclaim "We've been doing EBM for years: we used to call it IRM and constraint management, now we just call it something different." This underscores the concern that EBM is just the latest in a string of resource management buzzwords that reflect only a change in terminology and not management philosophy (see Miller 1995, Rauber 1995). A clear definition would make such misuse of terms difficult.

In searching for a definition of EBM, it is appealing to imagine that its essence can be captured in one or two sentences, or that a sequence of phrases exists which can sum it all up neatly. Such a definition would, however, lead to oversimplification of the ideas behind term. A definition of something as complex as EBM should include not just a summarizing sentence or two, but an explanation of its important principles, components and/or objectives. The summary sentence, while important, is insufficient for a comprehensive definition.

2.2 Definitions and Principles

Several recent publications point out that although the notions behind EBM have captured much recent attention, they are not new. Perhaps the most notable older work on EBM-like concepts is that of Aldo Leopold who, in his Sand County Almanac, discussed a concept he called the "Land Ethic" (Leopold 1949). The land ethic "changes the role of *Homo sapiens* from a conqueror of the land-community to plain member and citizen of it. It implies respect for his fellowmembers, and also respect for the community as such." The land ethic emphasized our ethical responsibility to the land, or environment, and advocated a shift in mentality from exploiter to careful user/guardian. This same ethical evolution is apparent in much of the recent literature on EBM.

Even though concepts similar to EBM have been around for decades, their influence on forest management initiatives has only been felt recently. In Canada, literature on EBM as a discipline or science only began appearing in the 1990s (e.g. Booth et al. 1993; Methven 1992; Slocombe 1992, 1993). There is a much larger body of literature from the U.S.A., which pre-dates the Canadian literature (e.g. Hunter 1990a, Franklin 1989, Agee and Johnson 1988, Franklin and Forman 1987, and others). Studies on topics which are now viewed as components of EBM have been around much longer (e.g. Allen and Starr 1982, Soulé and Wilcox 1980, Holling 1978)

Many definitions or synopses of EBM have been offered in recent years. Some of note includes:

- "...the maintenance of sustainable ecosystems while providing for a wider array of uses , values, products and services from the land to an increasingly diverse public" (Overbay 1992);

- "... sustain diversity as well as productivity and to fit management practices at different geographic scales to suit best the characteristics of the land and the specific purposes for which different areas are being managed." (Robertson 1992, cited in Salwasser 1993);

- "... integrates scientific knowledge of ecological relationships within a complex sociopolitical land values framework toward the general goal of protecting native ecosystem integrity over the long term." (Grumbine 1994);

- "....regulating internal ecosystem structure and function, plus inputs and outputs to achieve socially desirable conditions..." (Johnson and Agee 1988);

- "... attempts to maintain the complex processes, pathways and interdependencies of forest ecosystems and keep them functioning well over long periods of time, in order to provide resilience to short-term change." (Society of American Foresters 1993);

- "....the efforts of humans to select, plan, organize and implement programs designed to achieve specified goals on an ecosystem basis; activities can range from protective measures to ensure that nature remains uninterrupted by human influence, on into ever-more manipulative tasks required to maintain diversity, install facilities, control populations, or eradicate exotics." (McNeely et al. 1990).

Although there is overlap in each of these definitions, each has unique aspects. An obvious question might be "Which is correct?" There is as yet, no commonly accepted single definition of EBM. (This contrasts with some other topical concepts in resource management: Tansley's (1935) definition of "ecosystem" has stood the test of time reasonably well, and the most frequently cited definition of "biodiversity" is that provided by the Office of Technology Assessment (1987).)

We believe there are two possible reasons for the lack of a single, widely accepted definition of EBM: 1) the concept has only recently been the subject of considerable attention, so it may simply be a matter of time before a widely accepted definition evolves; but more likely 2) EBM means different things to different people, and in different resource management contexts: the concept may be so broad or malleable as to permit different practitioners, scientists, and resource managers, to put different "spins" on the definition they choose to use. This is not necessarily a bad thing, provided that people identify the definition and principles behind their use of the term so as to avoid the communication difficulties discussed earlier.

Edward Grumbine (1994) reviewed the definitions and dominant themes of EBM, which he referred to as ecosystem management, as documented in 33 different reports and scientific papers. (Although only one of these papers had any Canadian content, we found this work to be the most useful to date in finding common elements in EBM definitions and terms. We will draw on it heavily in this report.) In his analysis, Grumbine (1994) identified 10 dominant themes of EBM which recurred on a regular basis in the works he analysed. These themes are noted in Table 2.1, along with an attempt to link them to the context of the Manitoba Model Forest.

Table 2.1Dominant Themes of EBM, as identified by Grumbine (1994), in a Manitoba Model Forest Context

Theme	Explanation	Manitoba MF Context
1. Hierarchical Context	EBM efforts should cross all levels of the biodiversity hierarchy (genes, species, populations, ecosystems, and landscapes).	Managing a suite of individual species, be they jack pine, black spruce, fungi, or woodland caribou is not sufficient for EBM. Management efforts should be directed at coarse hierarchical levels (i.e. ecosystems), and fine levels (e.g. species) depending on particular situations.
2. Ecological Boundaries	EBM requires working across administrative and political boundaries, and using ecological boundaries at appropriate scales.	The Model Forest's boundaries are not based on ecological criteria. To work best, some aspects of EBM may need to cross beyond the Model Forest's boundaries.
3. Ecological Integrity	Involves conserving viable populations of native species, maintaining natural disturbance regimes, and the reintroduction of native extirpated species.	Conservation efforts should be directed at rare native species (e.g. woodland caribou), as well as representative ecosystems. Efforts should be taken to understand, maintain and replicate natural disturbance regimes.
4. Data Collection	EBM requires more research and data collection as well as better management and use of existing data.	Basic research and data needs for the Model Forest include inventory/habitat classification, disturbance regime dynamics, and baseline population assessments.
5. Monitoring	In practising EBM, managers must track the results of their actions.	Monitoring processes such as regeneration assessment, moose population surveys, fish population surveys should be followed in a timely manner and feedback loops instituted. New monitoring processes (e.g. for natural disturbance events) may also be needed.

Theme	Explanation	Manitoba MF Context
6. Adaptive Management	Adaptive Management is a structured, scientific approach to conducting science that allows for learning while practising resource management. See Holling (1978), Baskerville (1985), and Walters (1986).	Opportunities to practice Adaptive Management on the Model Forest include using existing monitoring processes to verify that current management (or a new management approach such as EBM) impacts are as expected. Opportunities for additional monitoring processes abound.
7. Interagency Cooperation	Using ecological, rather than administrative boundaries will require cooperation between various management agencies.	Implementing EBM in the Model Forest Ecosystem will require cooperation from the MNR, Provincial Parks, Abitibi Price, and perhaps several agencies in Ontario. Agencies whose mandates are not specific for resource management will need to be included too.
8. Organizational Change	Implementing EBM will require changes in the structure of management agencies ranging from simple (e.g. forming interagency committees) to complex (e.g. changing professional approaches, altering power relationships).	The Model Forest organization is a multi-stakeholder group that has driven some changes in organizational structure, but more changes can be implemented, concerning such aspects as moose management, water flow, and recreation and tourism.
9. Humans Embedded in Nature	Humans are fundamental influences in ecological processes. They cannot be considered as external influences.	The evidence of impacts are widespread and pervasive. For example, human activities have altered disturbance regimes, animal population levels, etc. and human impacts should continue to be factored into management approaches.
10. Values	Human values and ethics play a dominant role in directing EBM initiatives and setting goals.	Human values will continue to influence management objectives and the Model Forest has some latitude in selecting how EBM is implemented and over what proportion of the forest.

Grumbine (1994) also noted five specific goals which were frequently endorsed in publications on ecosystem management:

1. Maintain viable populations of all native species in situ.
2. Represent, within protected areas, all native ecosystem types across their natural range of variation.
3. Maintain evolutionary and ecological processes (i.e. disturbance regimes, hydrological processes, nutrient cycles, etc.).
4. Manage over periods of time long enough to maintain the evolutionary potential of species and ecosystems.
5. Accommodate human use and occupancy within these constraints.

It is interesting to note that most of the goals identified by Grumbine relate to values and maintaining natural systems and processes, rather than the production of goods and services, which has been the long-standing objective of natural resource management. The fifth goal suggests that human use (presumably including the production of goods and services) should be accommodated, but only within the limits of the previous four goals. This approach of accommodating human use within the constraints imposed by natural dynamics and protecting and maintaining natural systems is in contrast to many previous management paradigms in which the protection of natural systems was accommodated within the primary goal of producing goods and services.

2.3 EBM and Natural Disturbance Regimes

In considering the goals of EBM, as stated by Grumbine (1994), or similarly by others, the obvious question is "How can the forest be managed so as to achieve these goals?" As it is impossible to manage explicitly for all species, and communities which comprise forest ecosystems, much attention has been focused recently on the objective of emulating natural disturbance regimes. This objective rests on the assumption that since boreal ecosystems and species evolved and survived with a pattern of natural disturbances, forest management that mimics those disturbances will maintain the integrity of the ecosystems.

All forests have developed in the context of a set of disturbances, which include pests, fire, disease, and windthrow at the stand or forest level. The frequency with which these disturbances occur may allow the forest to be reasonably stable over long periods of time; climate shifts may induce slow fluctuations that span many decades, if not centuries. The frequency and size of disturbances in any given year may depend on past levels of disturbance - for example, widespread pest infestations may cause conditions which favour windthrow or very large fires. Forest species have developed strategies for coping with disturbances of various severities and spatial extents. The ecological health of the forest, which is considered in an inclusive sense to comprise flora and fauna, can be said to be maintained under such conditions.

In contrast, the management practices followed in most forests have in many cases caused ecological imbalances of varying magnitudes. As evidence of this, certain forest types have become absent in many of our managed forests and there have been reductions in the populations of some species and large increases in the populations of other species. Questions should be raised regarding the sustainability of forest management; especially where the use of pesticides and herbicides is concerned and where intensive management is practised. Further concerns exist regarding the maintenance of genetic diversity.

Advocates of EBM argue that since current practices are demonstrably failing to sustain the ecological health and balance of the forest, we should instead concentrate on trying to emulate a pattern of disturbance that is synchronized with the attributes of the forest ecosystems, which is the natural disturbance pattern.

However, *strict* adherence to natural disturbance patterns is likely not practical, nor absolutely necessary. From a practical perspective, large scale disturbances are unlikely to be socially permissible (Hunter 1993) and numerous small scale disturbances are unlikely to be economically feasible. From a necessity perspective, it is important to keep in mind that mimicking natural disturbance patterns is not a goal of EBM. *The practice of emulating natural disturbance patterns may be an important means to an end, but it is not an end in itself.* While maintaining healthy ecosystems, genetic diversity, etc. are the goals of EBM, mimicking natural disturbances is not. Natural disturbance patterns provide a model for management practices to imitate, but some variations on the model may not compromise achievement of the goals. For example, some intense natural fires burn to the water's edge of lakes and rivers and thereby cause siltation and fouling of the waters. Cutting to the water's edge is likely unnecessary (and undesirable) for the achievement of EBM goals.

2.4 EBM Examples and Attempts

EBM has been studied in other jurisdictions, and a small number of attempts at implementation have recently begun. The following brief review of EBM examples and attempts is intended to provide some insight into other ongoing attempts to grapple with EBM, and to provide some broad context for the Model Forest's activities in this area.

The U.S. Forest Service offers a pragmatic view of EBM in their recent attempts to come to grips with the shifting focus of forest management. They present EBM as the intersection of goals and actions which take into account human desires and needs of the forest, the ecological potential of the land, and economic (i.e. affordability) and technological considerations (Jensen and Everett 1994, Salwasser 1993). Figure 2.1 shows this conceptual framework for EBM. This vision portrays EBM as a compromise or the establishment of middle ground between competing forces.

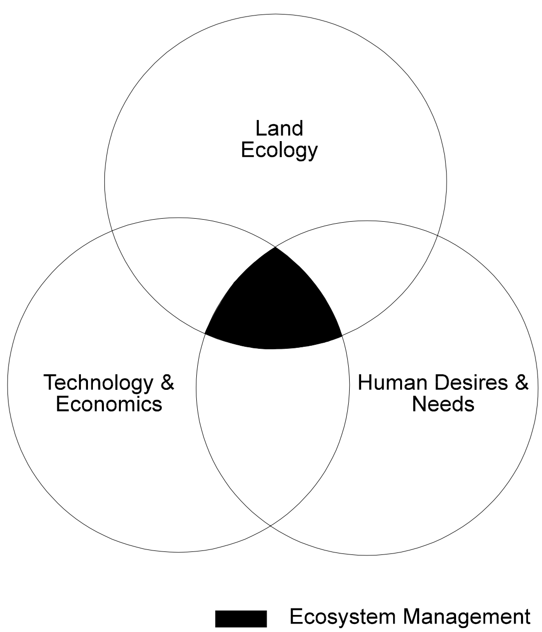

Figure 2.1 The ecosystem management model of the US Forest Service (after Salwasser et al. 1993 and Zonnenveld 1990).

Figure 2.2 portrays how this conceptualization of EBM can be applied to the objective of mimicking natural disturbance regimes. The natural distribution of disturbance sizes in boreal forests approximates a negative exponential distribution (see section 3.1) with many small disturbances and only a few very large ones. Strictly mimicking this pattern, however, would likely not be socially acceptable. As discussed earlier, the prospect of very large clearcuts that approach the size of large natural forest fires would not be palatable for a significant portion of the population. In most jurisdictions this is evidenced by the upper limit prescribed for clearcut sizes. From an economic perspective, very small and very large cuts may not be appropriate, but a range of in-between cut sizes are likely feasible. The overlap of these three forces (ecological viability, social acceptability, and economic feasibility) results in an EBM (as defined by the U.S. Forest Service) distribution of cut sizes that consists only of sizes that all three aspects have in common.

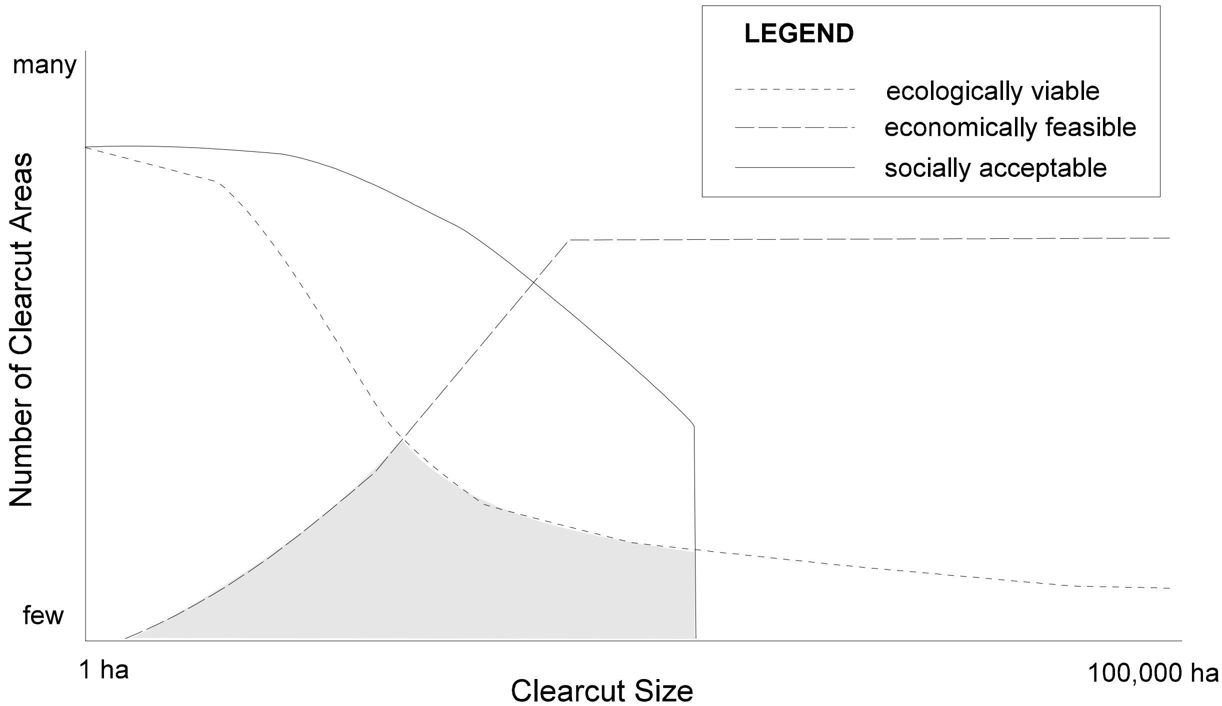

Figure 2.2 Hypothetical application of the US Forest Service ecosystem management model to the issue of clearcut size distribution.

Slocombe (1992, 1993) offers one of the few Canadian-based views of EBM. (His work was not included in Grumbine's (1994) assessment). Slocombe's work appears to have its basis in the discipline of planning, as it stresses the institutional and socio-economic aspects of EBM over its ecological aspects. He focuses on several aspects of EBM including:

- the definition of units for planning and management - the boundaries of an EBM area;
- the need for interagency cooperation and integration in planning and management;
- the need for stakeholder involvement in EBM efforts;
- the need for knowledge of the interaction of ecosystems, societies and economies; and
- the need for a "greater ecosystem" concept upon which to base EBM.

The Newfoundland Forest Service (Newfoundland Forest Service 1994) has developed an "Environmental Protection Plan for Ecologically Based Forest Management". The plan, which was based on an extensive consultation framework (Blackmore et al. 1992), has four goals:

1. Manage forest ecosystems so as to maintain their integrity, productive capacity, resiliency, and biodiversity.
2. Refine and develop forestry practices that reflect all forest values in an environmentally sound manner.
3. Develop public partnership/networks to facilitate meaningful public participation in forest resource management.
4. Promote and conduct forest management research focused on integrated resource management techniques and systems.

Table 2.2Guideline Structure in Newfoundland's Plan for EBM

General Guidelines
Planning
Operations
Timber Harvesting Guidelines
Planning
Operations
Forest Access Roads Guidelines
Planning
Operations
Silvicultural Practices and Forest Regeneration
Site Preparation
Scarification
Prescribed Burning
Planting
Pre-commercial Thinning
Forest Protection Guidelines
Pesticide Application Planning
Weather
Buffer Zones
Herbicides
Insecticides
Storage, Handling and Transportation
Processing Facilities and Support Services
Special Measures
Forest Operation Within Protected Water Supplies
Forest Road Construction
Stream Crossings
Buffer Zones
Fuel/Oil Handling and Storage
Forest Operations within Planning Areas and Municipal Areas

A series of guidelines that direct forest management operations are the core of the plan (Table 2.2). The guidelines are reductionist in nature, and although they are comprehensive at the site and operational level, important characteristics of EBM are absent. The most obvious of these is the lack of consideration of landscape-level effects or influences: little direction is offered to guide landscape or forest-level planning activities. The plan also pays very little attention to supporting activities (such as data collection, monitoring, Adaptive Management, etc.). Although lacking in these aspects, the plan's comprehensiveness at the site level and its willingness to make its assumptions explicit provide a concrete and useful basis for comment criticism.

In Ontario, no single integrated plan for EBM exists. Rather, a number of separate initiatives are underway, which, when considered together provide elements of an EBM framework. For example, the Forest Fragmentation and Biodiversity Project (Perera and Schnekenburger 1993) of the Ontario Ministry of Natural Resources, has produced a landscape diversity analysis software package which examines the composition of forest landscapes and estimates diversity at the landscape scale. The system is designed for use in forest management and policy analysis and could be an important EBM support tool. Also in Ontario, the recent decision in the class environmental assessment of timber management (Koven and Martel 1994) contains a number of terms and conditions which, when implemented, could contribute to an EBM framework. These include the development of featured species guidelines for species which use overmature boreal forests (pine marten and pileated woodpecker), the development of guidelines for site protection during timber management operations, and directions on the establishment and operation of local citizen's committees to participate in forest management decision making.

Although lacking a coherent provincial strategy, the Northeast Region of the Ontario Ministry of Natural Resources has developed an "Interim Strategy for Biodiversity Considerations in Timber Management Planning" (Duckworth and Flemming 1993). The strategy provides simple but clear direction of forest harvesting and management considerations at both the landscape and stand level. Key elements of the strategy include:

- harvest blocks should be distributed so that they come close to mimicking natural disturbance patterns;

- landscape diversity measures should be attempted, monitored, and compared over time to a logical benchmark;
- a cutover analysis which quantifies all harvest blocks should be completed for each TMP;
- conservation of biodiversity requires the maintenance of older stands; a "normal" forest (i.e. with an economically driven distribution of stand ages) should not be an objective of forest management as this precludes the maintenance of older age classes;
- stand conversions are discouraged where they reduce the diversity of forest units within the forest or where they cause common forest units to become rare;
- structural heterogeneity (i.e. leaving snags, green trees, dead and downed woody debris) should be retained on harvested sites;
- species at the extremes of their distributional ranges should be targeted for special management practices;
- distinct populations of genetic material should be conserved by collecting seed; and
- seed sources should be left on site whenever possible.

One of the most practical attempts to implement EBM is taking place on the White River Forest in northern Ontario. Domtar Forest Products, the FMA holder, has recently submitted a new Timber Management Plan for the five year period 1993-1998. The conceptual approach of the EBM portion of the Plan is based on attempting to mimic, as closely as reasonable, natural disturbance patterns (primarily fire). Guidelines have been developed that address both stand-level and forest-level issues. Specific stand-level management measures have been identified that address concerns related to:

- forest composition (forest ecosystem community types are not to decline beyond a given amount from baseline level);
- stand age (some stands are to be retained past rotation age); stocking (understocked and overstocked stands are to be created);
- structure (several mechanisms are presented to preserve, and manage for structural elements); and
- productivity (measures which guard against long-term degradation are included).

Forest-level measures focus on managing for landscape patterns that mimic the size, shape, and frequency distribution of natural disturbance and patterns within disturbances. (A synopsis of the White River Forest Ecosystem Management Plan accompanies this report.)

Other provinces are in a situation similar to Ontario in that they lack a centralized EBM policy but possess a number of initiatives which could be part of an EBM framework. In British Columbia, for example, the following initiatives are underway or recently completed:

- a Biodiversity field guide has been produced to assist managers, planners and field staff in establishing landscape units and landscape biodiversity objectives;
- new regulations regarding pre-harvest silvicultural prescriptions require that soil, wildlife, and climate be taken into account;
- the Committee on Resources and the Environment (C.O.R.E.) process has made major recommendations for land use (including setting aside protected areas). This process involved significant public participation; and

- a new Forest Practices Code has been developed, and is directed primarily at the enforcement of harvesting standards.

The government of Alberta has developed a draft Ecosystem Management Strategy (although we have not reviewed it) which defines ecosystem management as "the optimum integration of ecological potentials, societal values and expectations, and economic plus technical considerations". This definition is obviously based on that developed by the U.S. Forest Service.

In Saskatchewan, the major activity somewhat related to EBM is the Forest Habitat Project, a project undertaken by a number of partners (CFS, Weyerhauser, Univ. of Sask.). In broad terms, this project is studying how forest harvesting can be better integrated with wildlife habitat needs. Six indicator species are being used to assess effects on wildlife.

Forestry and Wildlife representatives from New Brunswick referred us to their Forest Habitat project as the flagship EBM project in the province. Under this project, habitat supply models for mature conifer habitat and deer winter habitat are integrated into the province's harvest allocations for all public land forest management. This practice of including wildlife values in timber allocations is a legislative requirement in the province. Although New Brunswick is likely the country's leader in practical application of wildlife habitat supply models, this project in itself does not comprise EBM.

In Manitoba, a provincial ecosystem management initiative has been underway for some time. Although an initial report has been prepared, it is apparently under review by the province and is not yet available for public distribution.

A related initiative in Manitoba has been the development of a "Sustainable Development Forest Strategy", also called the Land and Water Strategy (Government of Manitoba 1992, Manitoba Round Table on the Environment and Economy 1991) undertaken in response to the Bruntland Commission's report on sustainable development "Our Common Future". The Forest Strategy consists of eight policies and many sub-policies intended to guide the management of the province's forests. The eight policies and primary objectives are:

1. Environmental Protection - To ensure and promote forest activities that are environmentally sound and that maintain the environmental integrity of the forest ecosystem.

2. Supply and Allocation - To supply and allocate forest resources on a sustainable basis which balances environmental, social, and economic benefits and opportunities to Manitobans.

3. Fire, Insects and Disease - To protect human life, property, employment opportunities and valuable forest resources.

4. Growth and Development - To promote an integrated and diversified economy which includes an efficient and environmentally sound use of forest resources.

5. Agro-Forest Development - To foster and promote increased development and management of woodlots and shelterbelts for commercial and conservation purposes on private and Crown lands in the agricultural zone of Manitoba.

6.Urban Forests - To foster and promote establishment, expansion and protection of urban forests on public and private lands.

7.Planning and Integrated Management - i) To ensure plans are prepared and implemented for Manitoba's forests and that these plans recognized the interests and concerns of all forest users and the needs and characteristics of the forest ecosystem; and ii) To improve the quality of information used in planning, decision making and integrated forest management.

8.Public Awareness - To improve understanding of the inter-relationships between the global environment, the forest ecosystem, and the economy to enhance informed decision making.

Although these policies are much broader than an EBM initiative, they are obviously related. The importance placed on maintaining "the environmental integrity of the forest ecosystem" in the first policy underscores this. Several sub-policies and commitments on applying the policies made in the strategy also reinforce the connection between the strategy and EBM. For example, under the first policy, the government commits to "develop sustainable reforestation guidelines and practices which will protect natural species diversity" and "gather baseline data for other forest resources and values (for example wildlife, fish, heritage...)". Although these commitments and some others could be shared attributes with an EBM initiative, most of the policies and commitments in the Strategy relate to managing the economic development of forests and the commercial wood supply. Therefore, although the strategy contains some elements of EBM, it is clearly not an EBM initiative per se.

3.0 Concepts related to Ecosystem-Based Management

3.1 Natural Disturbance Patterns

An important concept in recent discussions on EBM, as noted above, is the belief that emulating natural disturbance patterns is a useful means by which to achieve the goals of EBM.

The disturbances which characterize much of the boreal forest are fires and insect epidemics. Fire intervals range from about 30 to 135 years in the boreal forest, with drier climates experiencing more frequent and hotter fires (Ward and Tithecott 1993, Cogbill 1985). However, most authors suggest that fire regimes fluctuated greatly over historic periods based on climatic fluctuations in temperature and moisture.

Not only does the likelihood of fire change through time, but it is also influenced by the landscape itself. Areas of high topographic relief with many lakes and ridges provide numerous natural barriers to fire spread, resulting in smaller fires (Hunter 1993). Fires tend to be more frequent in these areas, however, because there is almost always some part of the forest in fire-prone successional stages (Bergeron 1991). In large areas of low topographic relief (i.e. flat areas), fires tend to be much larger and less frequent. Upland forests, which are more prone to drought, burn more readily than lowland forests. However, when lowland (peatland) forests do burn, they tend to burn in large fires.

Boreal forest fires range in size between fractions of a hectare, through to very large fires in excess of 100,000 hectares. As discussed earlier, the natural distribution of disturbance sizes in boreal forests is something approximating a negative exponential distribution (Van Wagner 1978), with many small disturbances and only a few very large ones. Hunter (1993) examined the distribution of fire sizes in boreal Quebec and Labrador and found average fire sizes of 7,764 ha and 12,710 ha respectively. Although most fires were less than 1,000 ha in size, far more area was consumed by fires between 10,000 and 100,000 ha. Fire suppression has generally reduced both fire occurrence and size, but fires in northern boreal conditions, where fires are not vigorously suppressed, result in a broader distribution of size classes than in areas where fire is intensively managed (Ward and Tithecott 1993).

Fires are clearly not the only disturbance influencing boreal ecosystems. Insects and disease are common features of boreal forests, and epidemics of spruce budworm and other insects continue to affect very large areas. The area of boreal forest experiencing moderate or severe insect infestation each year is considerably greater than the area commercially harvested (Canada Council of Forest Ministers 1992). Although often only influencing selected species within a vegetation community, defoliation and tree mortality alter the composition and structure of stands and may also make forest stands more prone to fire and windthrow.

Blowdown or windthrow can be a major disturbance affecting forest stands in the boreal forest. In some cases windthrow can be both stand-replacing and cover immense areas (e.g. over 100,000 ha in the Red Lake, Ontario area in 1992). Windthrow of individual trees within a stand leaves openings that can be further enlarged by subsequent windthrow in those openings. In some black spruce communities, windthrow may be the primary disturbance factor.

Windthrow, insects, and disease may be more important disturbances than we currently acknowledge because their history is more difficult to unearth. The evidence of insects, disease, and windthrow are often eliminated by subsequent fires.

3.1.1 Relevance to the Model Forest

Fire is the dominant natural disturbance mechanism in the Model Forest. Between 1968 and 1990, 234,670 ha or 23% of the Model Forest area burned (the Model Forest is 1,047,069 ha) (Manitoba Model Forest 1994a), representing an average rate of 1% per annum. Figure 3.1 shows the distribution of numbers of fires and area burned by fire size class. Most of the fires were small, but the few large fires consumed much more land in total than did the small ones. This is consistent with the general pattern seen in other boreal forests. In the Model Forest, the smaller fires occur more frequently on the jack pine ridges, while the black spruce lowlands usually burn in the larger fires.

The importance of very large fires is obvious: the average fire size in the > 1000 ha category was roughly 8,250 ha and on average there was one fire of this size per year. Large fires (i.e. greater than 1000 ha) accounted for almost 90% of the area burned in the Model Forest.

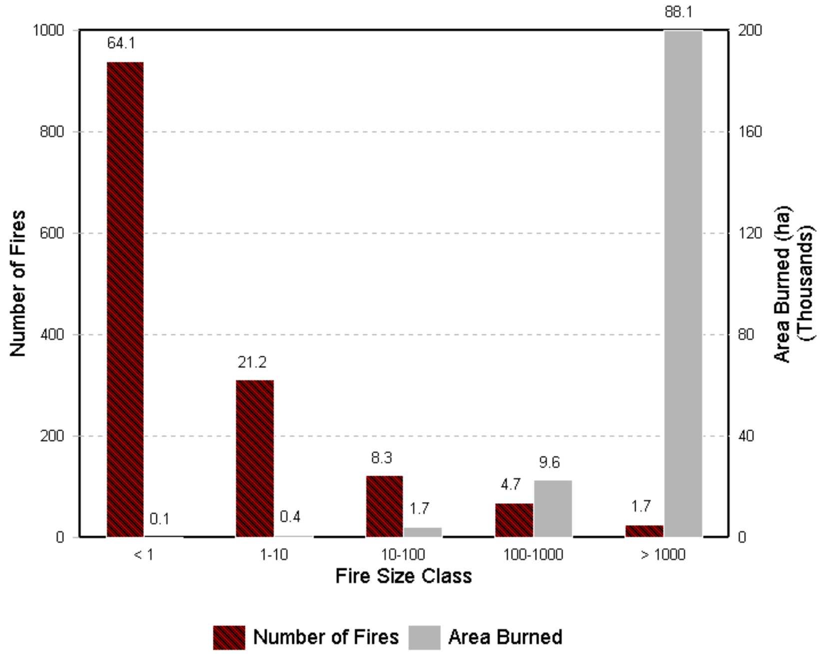

Figure 3.1 The distribution of numbers of fires, and area burnt by size class in the Model Forest 1968-1990. The numbers atop the columns are the proportion in each size class.

Although large fires burn extensive areas, they rarely result in huge burnt swaths of forest. More typical is a pattern of unburnt areas, or skips, occurring within the larger burnt areas. The skips are ecologically important, offering refugia and dispersal areas for plant an animal species. Small fires may also be ecologically important as they introduce and maintain various elements of spatial heterogeneity in the forest in the same manner as do the skips in large fires. This ecological situation raises several issues with regard to how such a disturbance pattern can be emulated. These issues are discussed in more detail in Section 5.2.

3.2 Hierarchy Concepts, Coarse and Fine Filters

Hierarchy theory is guiding much of the current thinking about biodiversity conservation, and is therefore seen by many as an important aspect of EBM (e.g. Grumbine 1994, *others*). Whittaker (1972) classified the various levels of diversity as alpha, beta, and gamma diversity. In a forestry context these are roughly equivalent to within-stand diversity, between-stand diversity, and across-region diversity. From a practical perspective, many biologists find it easier to think in terms of another version of the biodiversity hierarchy which explicitly includes the levels of genes, species, communities, and landscapes (e.g. Noss 1990).

Franklin et al. (1981) recognized three primary attributes of ecosystems which shape the biodiversity of an area: composition, structure, and function. Noss (1990) summarized these attributes as follows:

"Composition has to do with the identity and variety of elements in a collection, and includes species, lists, and measures of species diversity and genetic diversity. Structure is the physical organization or pattern of a system, from habitat complexity as measured within communities to the pattern of patches and other elements at a landscape scale. Function involves ecological and evolutionary processes, including gene flow, disturbances, and nutrient cycling. "

Noss (1990) developed a conceptual model of biodiversity merging the concepts of composition, structure, and function with the various elements of the biodiversity hierarchy (Figure 3.2), and then used this model to help select indicators of biodiversity. This model is also useful to show the interconnection between the various hierarchical levels and aspects of biodiversity.

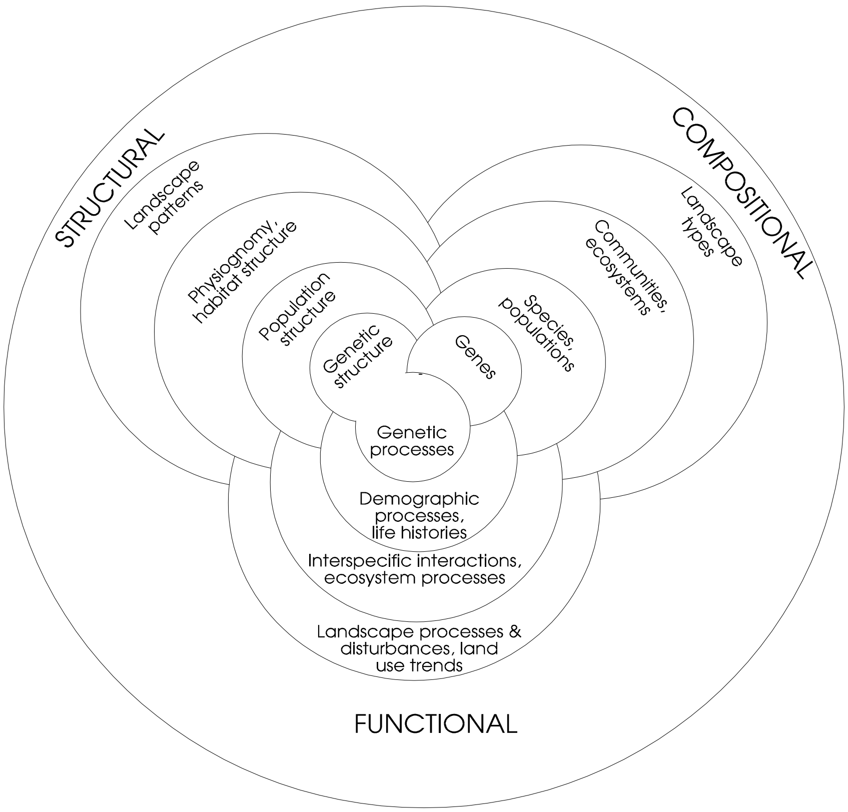

Figure 3.2 Compositional, structural and functional biodiversity, shown as interconnecting spheres, each encompassing multiple levels of organization. From Noss (1990).

Managing for biodiversity requires consideration of each of the levels of the biodiversity hierarchy. Clearly, however, it would be impossible to manage explicitly for all gene pools, or even all species in a forest. How, therefore, can forest managers attempt or claim to manage for biodiversity, without managing for each level explicitly? The answer lies in another aspect of hierarchy theory which suggests that higher levels of organization (e.g. ecosystems) incorporate and constrain the behaviour of lower levels (e.g. species) (Urban et al. 1987, Allen and Starr 1982). For forests this implies that the events in a forest ecosystem contain and control all the events of the communities within the ecosystem. In other words, a fully functional ecosystem will contain fully functional communities, species, and gene pools within it. So, it may not be necessary to manage for all levels of biodiversity or to explicitly manage for biodiversity. If we manage for higher levels, we assume that the lower levels are also being accounted for. (Note, however, that this is an assumption!)

A management approach which applies this aspect of hierarchy theory uses the metaphor of coarse and fine filters (see Hunter 1990a, 1990b; Hunter et al. 1988). The coarse-filter approach involves maintaining a variety of ecosystems, and assumes that a representative selection of ecosystems will in turn maintain a diversity of species. In a forested ecosystem, for example, one might choose to manage the forest such that a historical (or "natural") distribution of forest community types is always maintained across the stands of a landscape. One then assumes that species within the communities will also be maintained at their historical levels across this landscape.

This is a potentially dangerous assumption, however, as some species or gene pools may pass through the coarse filter. This is where the fine-filter approach can be applied, as the fine filter is directed towards important individual species that may have passed through the coarse filter. A species such as woodland caribou, for example, which may have additional requirements that are not met through the coarse-filter management approach, can be managed specifically in certain parts of the ecosystem. However, the use of a fine-filter approach is generally expensive and requires a great deal of information. As a result, a combination of coarse and fine-filter management is likely the best approach for most ecosystems, where the majority of species are preserved through the coarse-filter approach, and some of the more prominent species that are missed with the coarse filter are managed for specifically (Hunter 1990).

3.2.1 Relevance to the Model Forest

In pursuing EBM through emulating natural disturbance patterns, the Model Forest will, in effect, be practising the coarse aspect of the coarse and fine filter approach. Emulating natural disturbance patterns is a means of creating and maintaining a natural mix of vegetation communities, distributed across the landscape in natural patterns. The emphasis is clearly placed on maintaining communities with the assumption that the processes and elements of the community will remain intact. Although this approach is practical, two significant issues still need to be considered:

1. Management practices for species or populations of specific interest will still be needed even when the practice of emulating natural disturbances is adopted and;

2. Monitoring programs for individual species and populations will be needed to ensure the basic assumption of the approach (that if you "look after" communities you are also "looking after" species and populations) is not being violated. Monitoring programs for communities will be needed too.

There are some obvious candidates for fine-filter management, such as woodland caribou and the nationally and provincially rare plant species identified in the plant inventory project (No. 2-06). There are many examples of locally rare species, such as white pine which is found on one island within the Model Forest. The issue of identifying plant and animal species in need of fine-filter management is discussed more fully in Section 5.2.6.

3.3 The Triad Concept

The Triad Concept of forest management (Thompson 1993, Seymour and Hunter 1992) advocates allocating forest land into three different classes, each subject to different management practices. One portion of the forested land in an area would be allocated to intensive forest management, another portion to reserves, and the third portion to "enlightened" forest management practices such as those advocated by EBM.

Application of the Triad Concept to boreal forests has some unique aspects. High yield plantations would be fostered on productive sites with no special ecological characteristics. For high-intensity forestry an agricultural analogy would fit well. Plantations could be fostered using aggressive herbicide and maintenance operations. An obvious question is "how much extra production can be coaxed from boreal lands using these techniques compared to less intensive practices?". In other forest zones (e.g. the southern U.S.) production increases could be many times those compared to passive or unmanaged tree growth. With a short growing season, and perhaps marginal soils, would comparable increases be possible in boreal forests?

The second leg of the triad is represented by areas of unique ecological value which would be managed as reserves with no forest management (i.e. fibre production) activities. In recent years, much attention has been focused on setting aside about 12% of lands for reserves in all ecosystems (see Hummel 1989). In boreal forests, it can be argued that the percentage should be much larger because the scale of disturbances is so large and because so many important species (e.g. caribou, wolves) operate at large scales. On the other hand, even in managed boreal forests the disturbances will be relatively light compared to other land uses. Since sizable portions of the landscapes will be undisturbed, the overall percentage need not be so high.

The third leg of the triad, which would ideally occupy lands between reserves and highly managed forests, acting as a buffer, would be the EBM forests. In boreal forests, these lands would likely occupy most of the forested areas.

3.3.1 Relevance to the Model Forest

The triad concept offers a vision of how EBM could be integrated into a broader forest land management strategy. The EBM leg of the triad, the focus of most of the discussion here, seems a good fit for the Model Forest. The reserve leg of the triad also seems a good fit. Atakaki Provincial Park is a wilderness area, closed to all commercial activities, and forestry operations in Nopiming Park are generally restricted, and totally closed in certain specialized zones. A total of 20% of the Model Forest is in Parks, and 47% of this area (9.4% of the Model Forest) is closed to harvesting. The third leg, or intensive forestry portion of the triad, however, is problematic. Many participants at the Model Forest EBM workshop expressed strong reservations as to whether significant additional productivity could be realized from the Model Forest's lands using intensive techniques. If significant gains cannot be achieved on a rational (i.e. economic) basis, then the triad concept is not a useful model. Further documentation or investigation may be warranted to confirm the (lack of) utility of intensive forestry.

3.4 Old Growth - A Boreal Context

Almost all of the discussion of "the old growth issue" in both scientific and popular literature is in reference to the forests of western North America, particularly the coastal forests. In these forests, tree age is routinely measured in centuries (and in some cases millennia). The temporal context changes significantly in discussions of boreal forests. Natural disturbance regimes are such that few forests achieve ages greater than 150 - 200 years. Nonetheless, the concepts of old-growth stands which have arisen in the context of western forests cannot be dismissed on the basis of differences in the natural life-span of the trees of natural disturbance frequency.

Old forests in boreal regions do have unique or special habitat features that are uncommon in younger forests. These features include a richness of dead and downed woody material, more epiphytes and lichens, and a greater number of open and shrub-rich patches. These and other features make old forests the preferred habitat for many vertebrate, invertebrate and plant species.

The most noted of these are pine marten (Thompson 1991 and others), and woodland caribou (Cumming 1992). Many birds such as the golden-crowned kinglet, red-breasted nuthatch and black-throated green warbler also prefer old forests (Welsh 1987).

Old growth forests merit special attention for at least three reasons: 1) they have unique assemblages of species associated with them; 2) they probably have greater species diversity than other forest types; and 3) they are increasingly uncommon due to the frequency of natural disturbances as well as timber management practices (Thompson and Welsh 1993, Thompson 1987).

3.4.1 Relevance to the Model Forest

Old Growth in the Manitoba Model Forest? As noted above, boreal forests need not be centuries old to be considered old growth in an ecological context. An "old growth" jack pine ridge in the Model Forest may be only 125-150 years old, and an "old growth" black spruce lowland may be only 150-200 years old. Although these areas are uncommon because of the fire frequency in the forest, they do contain unique ecological value. Areas such as this likely exist in the protected wilderness areas of the Model Forest, but they are undoubtedly much less common in the commercial zones. If the Model Forest adopts EBM principles such as maintaining biodiversity and ecological integrity, special attention will need to be given to old forests because of their high ecological value. This may translate into practices such as leaving some areas to age well beyond normal rotation age, or managing stands so as to foster the development of old-growth characteristics (e.g. wide-spacing, vegetation structure at many heights, etc.). These practices are discussed in more detail in section 5.2.7.

3.5 Adaptive Management[1]

Forest management decisions affect long periods of future time and large landbases. Moreover, they are expensive to implement and subject to significant uncertainties. Thus, it is inevitable that forest managers will make mistakes. Forest-management mistakes may be large, but they are usually not tragedies, although it is indeed tragic if people do not learn from their errors.

Learning occurs when we recognize and study mistakes or errors. In this context, an error is the divergence between expectation and reality. The expectation is a forecast of how one assumes a system will unfold in the future, given certain conditions, and reality is the measured condition of the system of interest. Because the goal of learning is reliable knowledge, not just hunches or feelings about the way the system operates, learning cannot occur unless both the expectation and the reality are known in explicit and unambiguous terms.

Adaptive Management (see Lee 1993, Walters 1986, Baskerville 1985, Holling 1978) is management with specially designed, built-in learning processes. It explicitly recognizes the dilemma of having to manage large ecosystems, or portions of them, to keep local and regional economies going, even when we lack essential understanding of how human actions affect critical ecological structures and processes. Adaptive Management recognizes that traditional research

[1] This section is largely extracted from Wedeles et al. 1994.

approaches (e.g. laboratory experiments and field trials) will not generate the critical information needed for confidence in EBM. It rests on the principle that the knowledge needed for ecosystem and natural resource management can only come from shrewd experimentation with real-scale elements of the managed system itself, and that learning occurs best when one has strong evidence of the divergence between expectation and reality (so forecasting and monitoring of ecosystem conditions become necessary and complementary activities (Duinker 1989)).

Baskerville (1985, 1993) has noted protocols for Adaptive Management as it applies to forests. Summarizing his propositions, Adaptive Management of natural resources and ecosystems should include or contain:

- explicit system-level objectives for all key values of the system being managed;
- one or more quantitative indicators defined for each objective;
- explicit models used to create forecasts of the expected future for each indicator in response to alternative action sets;
- implementation of one or more of the analysed action sets;
- measurements taken of action implementation, subsystem response to individual actions, and whole-system response to the whole action set;
- comparisons of measured data and forecast data, differences noted, and reasons for the differences unearthed; and
- new objectives and action sets designed and implemented based on the new knowledge.

Lee (1993) emphasized the vital dimension of experimentation in his description of the practice of Adaptive Management. He argued for proper statistical control in design of management scale experiments. While he admitted that it was difficult to establish and finance this level of control, he pointed out its importance in maintaining the quality of scientific evidence of the effectiveness of specific management actions or strategies.

Why is it that traditional experimentation cannot provide the information needed to understand ecosystem responses to management action? The key reason is one of scale. Many ecosystem-scale processes are essentially emergent properties in that they are unique to a large scale and cannot be understood simply as the sum of processes operating at finer scales. For example, it is doubtful that lab experiments or field trials can determine whether boreal-forest caribou can withstand habitat change caused by timber-management activities. Useful evidence to address this question can only come from a strong combination of simulation modelling and landscape-scale experimentation where a caribou-occupied forest is managed for timber in the traditional way; another is managed for timber with caribou-habitat guidelines in place, and another where no timber management actions are taken. Science must be scaled to the level at which effects actually occur on the ecosystem components of interest.

Adaptive Management, given the above descriptions of required steps and actions, is rare. Adaptive Management is not simply learning from trial and error as one manages a forest - most forest managers are at least doing that. For Adaptive Management to have integrity, explicit forecasts of the expected behaviour of specific ecosystem components must be compared with actual measurements of the same components, in search of divergence and reasons for it. For forests, this usually means working over decades, but such an approach is the only way to be sure to gain the knowledge needed for confident management of forest ecosystems.

3.5.1 Relevance to the Model Forest

Adaptive Management is commonly accepted as a desirable component of EBM (Bunnell 1995, Grumbine 1994, Ontario Forest Policy Panel 1993). However, as noted by Lee (1994) and Bunnell (1995), the discipline of forest management has done poor job of embracing Adaptive Management, frequently confusing learning by trial and error for Adaptive Management. Given the mandate of all the Model Forests (to be, roughly speaking, examples of sustainable development, and testing grounds for scientific research and innovative procedures), they seem to be ideally positioned to attempt real Adaptive Management. Other factors which favour the implementation of Adaptive Management in the Manitoba Model Forest include:

- new procedures and practices will be needed to implement EBM;
- the commercial forestry operations in the Model Forest must continue to be economically viable;
- monitoring of results will be a clear requirement;
- the Model Forest's access to scientific expertise is high; and
- the Model Forest is well positioned technologically (i.e. in-house GIS and access to computer modelling ability).

Several specific issues related to the use of Adaptive Management in implementing EBM are discussed further in section 5.2.8.

3.6 New Forestry

In the late 1980's, concerns over the fate and management of old-growth forests in the Pacific Northwest led to the development of a series of new management practices that could maintain the unique features and biological legacy of these forests while practising commercial timber management (Maser 1990, Franklin 1989). These ideas were collectively called "New Forestry". New Forestry blazed the path, in some respects, for the development of EBM ideas. The initial focus of New Forestry was on stand-level considerations. Practices advocated by New Forestry included leaving some large living trees, standing dead snags and downed woody debris after harvesting and renewal efforts. Pacific Northwest New Forestry also advocated paying attention to the design of harvest blocks, primarily to address concerns regarding forest fragmentation. Many New Forestry practices are embodied in EBM. In the United States, the New Forestry initiative has led to (or at least contributed significantly to) the adoption of Ecosystem Management as a standard approach by the U.S. Forest Service.

The Pacific Northwest version of New Forestry is not simply transferable, as originally developed, to other forest types. The ancient forests of the Pacific Northwest are vastly different from boreal forests. They have very different disturbance regimes at the site, stand, and landscape scale. Trees in the Pacific Northwest live for centuries, and therefore gap-type disturbances are less frequent (although more dramatic). Forest fires are much less frequent and are generally smaller than boreal forest fires. Simply put, the ecosystems are very different. This is not to imply, however, that some of the concepts which emerged from New Forestry are not appropriate elsewhere.

Seymour and Hunter (1992) discussed how New Forestry ideas and practices could be modified to be applicable in the spruce-forests of Maine. Although these forests have a greater diversity of tree species than boreal forests and are subject more to insect disturbance than fires, they are similar enough to boreal forests so that some of the principles discussed by Seymour and Hunter (1992) may be applicable to true boreal forests.

At the stand level, Hunter (1990) and Seymour and Hunter (1992) identified several practices with roots in New Forestry that could apply to ecosystems similar to boreal forests. A few examples are discussed below.

Harvesting Systems and Retention of Within-Stand Diversity

Leaving standing live trees and snags provide structure not usually available after an area has been clearcut, and also serve to provide a genetic legacy of the stand. Windfirmness is a key consideration in this notion for boreal species, as isolated live trees and snags are much more susceptible to blow down than patches.

Hunter (1990) suggests that to manage a stand for structural diversity, forest managers should use fine-scale, uneven-aged management: in other words, selection harvesting. This management approach is often mentioned in reference to the hardwood forests of the northeastern U.S. or the Great-Lakes St. Lawrence forests of Ontario. For boreal Manitoba, the obvious question is: are any systems other than clearcutting suitable? For black spruce lowlands, or jack pine forests, the use of systems other than clearcutting may not be practical or consistent with natural disturbance patterns. However, a selection system may be practical for mixedwoods. Although single-tree selection may be difficult given the intolerant nature of some mixedwood species, group selection could be a reasonable alternative. Such an approach might foster within-stand structural diversity, while providing a viable alternative to clearcutting in some situations.

In the continuum of harvest systems from clearcutting to single-tree selection there are a range of effects on strand structure. Group selection may be one point on the continuum that provides a reasonable trade-off between silviculture goals and diversity goals. Another point may be slightly farther along the continuum toward clearcutting. In keeping with the approach of mimicking natural disturbance patterns, a harvesting system which leaves a number of small patches within stands may be useful. The structural diversity of a stand as a whole would be reduced using this approach, although it would not be as extreme as when clearcutting is used.

Harvesting Techniques

Full-tree harvesting removes not only the tree bole, but limbs and foliage (usually to a road-side where delimbing occurs). Tree-length systems that delimb at the stump are more likely to help maintain biodiversity for several reasons: the nutrient content of foliage and limbs is not removed from the site, greater ground-level structure is provided by the foliage and limbs, and more seeds are left on the site to maintain the stand's genetic legacy.

As they are generally used, mechanized felling and skidding systems usually destroy most of the advanced regeneration on a site. Recent studies in mixedwood forests (Brace Forest Services 1992, Sauder 1992) have shown that it is possible to use this machinery in ways that preserve much of the advanced regeneration. Such practices not only help maintain the diversity of a site, but are economically viable because of the shorter rotation times and greater total harvests that result.

Planting and Seeding

Most planting operations attempt to space the planted trees in a highly regular manner. Even-spaced stands generally lack the structural diversity of a "naturally-spaced" stand. Some deviations form the traditional approach may be warranted in areas where diversity objectives are important. Vertical structure can be built into stands by establishing the planted trees at different time intervals (Hunter 1990), and age classes could be established as individuals or groups. Keeping the site free from competition may be a challenge in implementing this approach.

Genetic diversity of a site can be maintained not only by using harvesting practices that protect advanced regeneration, but by using local genotypes as planting/seeding stock.

3.6.1 Relevance to the Model Forest

Several of the stand-level techniques which comprise "New Forestry" may be useful in implementing EBM in the Model Forest. Their potential role in the Model Forest's attempts to implement EBM are discussed in more detail in section 5.2.7.

3.7 Decision Support Systems

In recent years, considerable effort has been devoted to developing computer software for use in forest management. This software includes simulation models of the dynamics of forest ecosystems, Geographic Information Systems (GIS), databases of forest stand attributes, etc. In many instances, these types of software are combined to form more powerful software. Software tools developed to assist in making resource management decisions have come to be called Decision Support Systems (DSSs).

DSSs have the potential to be very useful tools in resource management. Currently, however, relatively few are being used in operational modes as most are still under development or are the subject of research activities. (Historically, most DSS, or computer modelling activity has been aimed at developing growth and yield models - models which predict how commercial tree species will grow, and how much merchantable volume they will produce.) DSSs have the potential to be useful for several reasons:

- They can be powerful integrators of knowledge. The dynamics of forest ecosystems are so complex that it is very challenging, if not impossible, to retain a "model" of how the systems work in one's head. Computer software offers the ability to integrate the many and complex interactions in one place - they can keep processes and sequences of calculations straight far beyond the ability of humans.

- They perform calculations quickly. Even if we could keep a model of forest dynamics in our heads, we could not simply "run" the model, or carry out the calculations necessary to simulate how the forest changes in response to management actions. Needless to say, computers can perform these calculations more quickly than humans can.

- Improved understanding of natural resource systems through identification of research and information needs. Nothing forces us to come to grips with our understanding of complex systems better than attempting to describe them. When we attempt to build a computer model, or DSS of a system, we are forced to state how the system works in very explicit and quantitative terms. This process can be very useful in identifying research and information needs. Furthermore, if we use DSSs or models to predict how a system will behave and the computer predictions do not match our own, we are then forced to reconcile the predictions, and so confront our lack of understanding of the system as we attempt to improve upon it. This is the essence of Adaptive Management, as described earlier.

Based on our research for this and other projects, we have identified a number of initiatives whose goals are to develop DSSs that could be of use in EBM. These are identified in Table 3.1 below.

Table 3.1DSS Initiatives that apply to EBM

DSS Name & Developer	Purpose	Description	State of Development	Inputs/ Outputs	Scales	Actions	Comments
ARC/Forest *ESRI Canada*	Assist in spatial aspects of forest mngmt	ARC/INFO based spatial database management system, tailored for "traditional" mngmt of forests, but adaptable for use in EBM activities	Prototype is complete, about to be implemented in Ontario	Spatial and tabular stand level FRI info	Stand-level No temporal scale as system does no simulation	Designed for harvest and silviculture planning	- a sophisticated and complex spatial database manager, developed specifically for use in planning traditional forest management activities - can be linked to external models - expensive (approx. $45,000)
Biodiversity Impact Assessment *MacMillan Bloedel Ltd.*	To analyse habitat supply determination with respect to harvest schedule impacts on biodiversity	Evaluates habitat quality & fragmentation by looking at the landscape from the perspective of species movement	Field test stage; possible completion in 1996	Input: forest age, site index, species, stand-level habitat attributes Output: maps of habitat"goodness" & fragmentation; # of ha of habitat	Watershed; up to 200 years in increments >= to one yr	Clearcut harvest schedules	- does not yet examine alternative harvesting methods; linked to harvest optimizer - uses ARCINFO platform
Coastal Temperate Rainforest Model *ESSA Ltd.*	To simulate forest dynamics & impacts of harvesting on timber & non-timber indicators	PC based, spatial model intended for use at macro-level to examine long-term trends and compare mngmt scenarios	Developed as a demo; requires additional work to be used operationally	Input: GIS data and parameters describing wildlife habitat, fish populations, harvest scheduling, etc. Output: maps of spatial indicators & changes over time	Landscape-level model; resolution of 1 yr on a horizon of 50 yrs or more	Natural forest dynamics, harvest scheduling, protected areas	- integrates timber & non-timber indicators with economic indicators to allow for the exploration of alternative scenarios
COVER	To predict understory	PC based extension to	Completed & in	Input: stand & tree	Single	Natural	- incorporates models specific to

DSS Name & Developer	Purpose	Description	State of Development	Inputs/ Outputs	Scales	Actions	Comments
US Forest Service	vegetation composition, abundance and cover in timber stands	FVS model; aims to link vegetation changes to non-timber resources; potential application for wildlife habitat, hydrology, forest insect pest modelling, succession modelling	use by US Forest Service	data Output: structure of tree crowns, understory composition, overstory & understory cover & biomass	stands; 10 yr intervals	disturbance and forest mngmt	conditions in northern Rockies, but can be calibrated to local conditions
DDTSL: Dynamics of Dead Trees at the Stand Level	To capture mortality information from TASS and TIPSY (growth and yield models) and translate into standing dead tree info	PC or Unix based empirical spreadsheet (?) model of tree mortality over time	Prototype	Input: # of dead trees/ha by diameter class Output: # of standing dead trees/ha in each diameter class, decay class, & time period	Stand level; life of a snag & yearly increments	Silvicultural actions	- not applicable to individual trees, it produces a probabilistic average over a wide range
EBB Economics *ESSA Ltd*	To compare the costs of EBM to "traditional forest management"	Project recently underway, in which DSS will be developed to compare scenarios of mimicking natural disturbances with traditional forest mngmt	Design about to begin	Input: spatial FRI info. at the stand level Output: costs of harvesting activities	- stand level input, forest level output - model to run for approx. 20 yrs at 5 yr intervals	Forest harvesting only	- a recently initiated project, test application site is northeastern Ontario
Ecosystem	To predict habitat	Based on generic land	Pre-prototype	Input: spatial FEC	FEC unit; no	Forest	- the value of bird habitat is not

Supply for Forest Bird Populations *Canadian Wildlife Service*	value for birds based on ecological land classification	classification system & includes very rich calibration data based on extensive field work		data & bird-habitat relationships Output: relative habitat value of individual FEC units for 20-30 bird species	simulation of changes through time	harvesting	related to regional trends (i.e. does not change as population changes through time)
Foothills Forest Decision Support Systems *Weldwood*	Stores information on a wide range of values, allows users to predict effects of natural disturbances & forest mngmt, and assesses inventory projections based on resource suitability and socio-economic impacts	A series of linked models on a range of timber & non-timber values, including wildlife habitat, timber supply, landscape forecasting, watershed, recreation, risk and carbon budget	Some of the models are complete and others are underway	Input: spatial forest description data at stand and/or ecosystem classification level + additional info for models. Output: specific to each model. HSI for wildlife; water yield & flow impacts for watershed; forest type by spatial unit for landscape.	Depends on the model: generally forest stand or ecological classification unit; min. temporal resolution is 1 yr.	Depends on the model: generally, harvesting and silvicultural activities	Perhaps one of the most comprehensive of non-timber resource models in Canada. Wildlife modelling began in mid-late 1980s and is very well-developed. The development of the other models is following the same systems-level approach.
Moose habitat & population spatial analysis model *OMNR, Lakehead University, ESSA Ltd.*	To predict population effects on moose of forestry-caused habitat changes	One of the few models to link habitat simulation with population simulation	Underway: currently working on modifying spatial scale of habitat model & linking to pop. model	Input: spatial FRI data + data on moose Output: age-structured moose population & density info	Habitat supply unit (100,000 ha); 5 seasons within year	Forest harvesting & renewal, hunting	- dynamic habitat model (based on a wood supply model) that is linked to a life-table based population model via energetics

New Brunswick Habitat Models *NB Dept of Natural Resources*	To integrate wildlife habitat into forest mngmt planning	Mature Coniferous Forest Habitat model addresses needs of marten & other "mature forest" species; Deer Winter Cover model accommodates deer wintering areas	Non-spatial versions are being used across the province; spatial versions are under development	Input: growth & yield relationships, forest inventory, spatial definition of habitat, habitat supply curves Output: hectares of suitable habitat	Forest; predictions of forest state each 5 yrs.	Harvesting (clearcutting), plantations, thinning, herbicide application	Used by every forest management company operating on crown land for 1992-1997 FMP
SIM Forest *UBC Dept of Forestry*	To assess impact of forest mngmt on biodiversity	PC based system under development; used for forest and landscape level biodiversity (vertebrate) assessments	Prototype is being field tested on Vancouver Island with Macmillan Bloedel	Input: harvest plan, mapped bloc layout Output: ha of suitable habitat for selected species & landscape-level indicators	5000 to 50,000 ha; 1 yr. resolution	Logging (trad. & alternative), silvicultural treatments	- calculates habitat considering spatial distribution of forest attributes; does not include economics
Snag Recruitment Simulator *US Forest Service*	To simulate in-stand dynamics of dead trees	User-friendly, PC based deterministic spreadsheet model, designed for west-coast forests, but could be adapted for other places; single stand focus	Currently being used in various National Forests in the Pacific Northwest	Input: mortality rate of trees based on growth & yield model Output: # of snags of various size & decay classes in a stand growth cycle	Stand level; 10-yr. intervals	Stand mngmt	- model focuses on single stands, - well-developed, user-friendly model

3.7.1 Relevance to the Model Forest

Computer models and DSSs could be important components of the Model Forest's EBM plans. The implementation of Adaptive Management is best achieved when computer models are used to refine our understanding of natural processes (and impacts on natural processes) and make predictions of the effects of management. Some existing computer models could be adapted for use in the Model Forest. The obvious advantage of adapting rather than custom developing models is one of expediency - it's quicker and cheaper to adapt an existing product. The downside of this approach is that the advantages associated with development (of developing greater understanding, and identifying information needs) are often not as great when one uses a product developed by others.

4.0 EBM in the Manitoba Model Forest - Progress to Date

4.1 Fundamental Aspects

At the April 1995 workshop in Pinawa, considerable effort was devoted to identifying some of the fundamental aspects of the Model Forest's interest in EBM. The following sections provide an overview of some of the key discussions that took place at the workshop.

4.1.1 Valued Ecosystem Components and Objectives

Valued Ecosystem Components (VECs) are those aspects or attributes of ecosystems which are held in esteem. This definition is intentionally broad so as to encompass all possible characteristics of ecosystems to which individuals may attribute value of any sort. VECs may include individual species or groups of species, particular aspects of ecosystem function, or some individual or group of ecosystem "products", etc. By their definition, VECs are anthropocentric, that is to say, because we are identifying them, we must recognize that they represent our (human) considerations of value. At the workshop, participants identified a number of VECs and corresponding objectives (Table 4.1).

Table 4.1 List of Valued Ecosystem Components and related objectives identified at Model Forest workshop.

Valued Ecosystem Component	Objective
•Biodiversity	•Maintain at present level
•Genetic biodiversity	•Maintain at present level
•Floral biodiversity	•Maintain unique qualities of Model Forest
•Landscape pattern	•Provide a natural mix of FEC types across the landscape
•Diversity of age and species groups of trees	•Maintain at natural levels
•Forest health	•Maintain at both landscape and site scales
•Hydrological cycle	•Maintain natural functioning
•Air quality	•Maintain Forests's contribution to maintaining high quality air
•Water quality	•Maintain high quality
•Fungi - mycorrhizae/decomposers	•Maintain so that ecological function not impaired
•Unburned forest	•Maintain at natural levels
•Caribou	•Maintain viable populations
•Snowshoe hare	•Maintain at ecologically viable levels
•Migratory birds	•Maintain/improve diversity and habitats
•Recreational opportunities	•Maintain at present level
•Wilderness experience	•Provide opportunities for
•Aesthetics	•Maintain at high levels
•Commercial timber supply	•Maintain at sustainable levels
•Secondary forest products (berries, mushrooms, etc.)	•Manage availability and production of
•Employment	•Maintain at a sustainable level

Many of the objectives listed in Table 4.1 emphasize the maintenance of natural, present, or sustainable levels, and all are expressed in non-quantitative terms. This is understandable given the forum in which they were identified. However, in many, if not most instances, the values for these levels are unknown and there is little information available to assist in determining them. However, objectives for forest management should be set in quantitative terms, because it is much more practical to assess progress in working towards a quantitative as compared to a qualitative goal. If one's objectives are to "improve", or "work towards" something, the rate of progress cannot be judged, nor can success or failure be truthfully ascertained. Furthermore, qualitative objectives offer little basis for challenge or refinement. If one's objectives are to "improve" it is difficult to argue that the objective should really be to "improve a lot". On the other hand, if one's objective is to attain a value of 100, a reasonable discussion may be had about whether this value is appropriate or if it should be increased to 120.

We believe, therefore, that objectives for the Model Forest's implementation of EBM should be cast in quantitative terms to allow for the measurement of progress and the refinement of objectives. This, in turn, suggests that indicators or practical measures need to be identified for a refined set of VECs and corresponding objectives. The development of a refined set of objectives and indicators is identified as a priority for implementing EBM on the Model Forest in section 5.2.1.

4.1.2 Qualities and Requirements of EBM

At the Model Forest EBM workshop, qualities and requirements of EBM that apply to the Model Forest were identified. These qualities and requirements have been summarized into the following themes:

- Maintenance of ecological integrity
- Need for multiple scales of management
- Adaptive Management
- Human values and stakeholder input
- Needs for increased knowledge
- Needs for Actions

Table 4.2 presents the qualities and requirements of EBM that are associated with each of these themes.

Table 4.2Qualities and requirements of EBM noted at the Model Forest Workshop

Theme	Qualities of EBM
Maintenance of Ecological Integrity	•ecosystem health is primary objective •involves maintaining ecological processes while being compatible with human needs (i.e. timber production) •maintenance of functional integrity of forests •recognizes all forest values and the need to modify forest management practices to manage for non-timber resources •baseline conditions should be preserved in reserves
Multiple Scales of Management	•requires due consideration of aspects of scale •entails management of landscape and site-level processes •not all values are to be managed for at all places on the landscape •ecological boundaries should be used in management design •all seral stages should be maintained
Adaptive Management	•involves continuous learning •specific quantitative objectives should be set •attempts to predict impacts of interventions over time and space •requires documentation of management impacts in order to improve management
Human Values and Stakeholder Input	•encompasses human and non-human values •recognizes that humans are part of the ecosystem •involves stakeholders setting priorities and making trade-off decisions
Needs for Increased Knowledge	•requires resource inventories to establish baseline conditions •increased knowledge of decompositional processes needed
Needs for Actions	•new tools needed, but in the meantime existing tools should be used to the best of our ability •requires high level of public understanding and efforts to educate public •requires information sharing and co-operation among stakeholders and resource managers •requires restructuring of resource management agencies

Theme	Qualities of EBM
	•design/implementation of new harvesting practices is needed

Although categorized somewhat differently, all of the ten dominant themes which Grumbine (1994) discerned in his literature review are present in the themes and qualities discussed at the Model Forest workshop and noted in Table 4.2. This is not to imply that the Model Forest list is "right" or complete, but some comfort may be taken in the similarities between the Model Forest notions of EBM, and those developed elsewhere.

The themes form the basis of the Model Forest's definition of EBM (see section 5.1).

4.2 Review of the Model Forest's Present Capacity to Engage in EBM

The Model Forest has undertaken a variety of projects since 1993-94, some of which are completed, while others are still underway. This section evaluates the potential contribution of these projects to the development of an EBM framework and its subsequent implementation. The assessment is based on the Model Forest 1993-94 Annual Report, a series of individual project reports, the Final Report by Symbion Consultants entitled: "Review and Revision of the Manitoba Model Forest EBM 1994 Workplan and Projects", and telephone discussions with the leaders (or other involved parties) of a number of projects.

The ten EBM themes outlined by Grumbine (1994) and discussed in section 2.2 above were used as the criteria for evaluating the suitability of each project to support EBM progress. (As Grumbine's themes encompass those identified at the Model Forest workshop, a separate effort was not made to evaluate the projects according to the themes identified at the workshop.) Tables were constructed with the ten themes represented by separate rows and the individual projects by separate columns. An "X" in the tables indicates those instances where a project made a substantial contribution to a theme, or strongly reflected a particular theme. Some projects supported two or more themes. Projects that did not directly support any of the themes were omitted from the table. Table 4.3 shows how the 1993-94 Integrated Resource Management projects supported EBM themes, Table 4.4 summarizes how 1993-94 projects in other Model Forest programs contributed, and Table 4.5 shows the contribution of 1994-95 projects. The assessment of 1994-95 projects was based on the project description given in the Symbion report, supplemented with selected interviews. Final reports of these projects are not yet available.

Specific evaluation principles, outlined below, were developed to ensure that the evaluation was precise and informative:

1. A project's direct support of EBM was evaluated, but indirect support was not. This distinction was made because otherwise all projects could be seen to be supportive or potentially supportive of EBM in some manner or other. For example, the funding contributed by the Model Forest to the University of Winnipeg chair of Forest Ecology was not considered to support EBM. Although there will be some indirect benefits from whatever work is done by the Chair-holder, this expenditure is not directly linked to any specific research activity.

2. In any assessment framework, there will be many projects which can be said to contribute to a number of the themes, especially Data Collection and Stakeholder Cooperation themes. One

could view the entire Model Forest effort as a management approach that addresses the Stakeholder Cooperation theme, as well as the Adaptive Management and Organizational Change themes, since all projects result in the gathering of new information and are being carried out cooperatively. An individual project was considered to support only the themes that were significant features or objectives of the project. Thus, only those projects that emphasized data collection were judged to support this theme and only those projects which had a specific objective of encouraging cooperative management with non-traditional partners were considered to address the Stakeholder Cooperation theme.

The application of this principle injects a subjective element into the project assessment, since the consultants had a qualitative reference level in mind when deciding whether a project's contribution to a theme was "strong" or not. Despite this element of subjectiveness, the project assessment was felt to be a worthwhile undertaking, as subsequent discussion will show.

3. A number of EBM themes do not lend themselves to being addressed in individual projects, including Hierarchical Context, Humans Embedded in Nature and Organizational Change. However, the moose and caribou HSI projects were seen to address the Hierarchical Context theme since they are efforts to manage from an integrative, landscape perspective which is frequently talked about but is rarely explored in practice.

Some multi-year projects show up twice in the three tables. In such cases, these projects have been assessed based on the entire project and so these projects received the same assessment in both years. However, the activities of each project year may not significantly contribute to all project themes.

When looking at how projects were assessed, the reader should remember that this is not an evaluation of project quality. Not all projects were designed with an EBM orientation and therefore it is to be expected that some projects will not assist in the development of an EBM approach.

Table 4.31993-94 Integrated Resource Management Projects (2-XX Series) in the Manitoba Model Forest and Their Relationship to EBM

Theme	03	04	06	07	08	09	10	11	12	15	16	17	18
Hierarchical Context					X	X							
Ecological Boundaries		X			X	X							
Ecological Integrity		X		X	X	X							
Data Collection	X	X	X	X			X	X			X	X	
Monitoring				X							X		
Adaptive Management				X							X		
Stakeholder Cooperation								X		X	X		X
Organizational Change											X		X
Humans Embedded in Nature											X		
Human Values							X					X	

Projects listed in Table 4.3 are:

2-03 - Age of Origin Project
2-04 - Forest Ecosystem Classification
2-06 - Plant Inventory
2-07 - Experimental Watershed
2-08 - Moose Habitat Suitability Index Model
2-09 - Caribou Habitat Suitability Index Model
2-10 - Valuation of Non-market Forest Outputs from the Model Forest
2-11 - Annotated Bibliography on Conflict Resolution
2-12 - Vacant Agricultural Land
2-15 - Forest Fire Management Strategy
2-16 - Cooperative Moose Management
2-17 - Design and Implementation of the Model Forest Bird Monitoring Program
2-18 - Role of First Nations in Forest Management

The following projects in the Integrated Resource Management (IRM) program were judged to make no direct contribution to the development and implementation of EBM and so were omitted from Tables 4.3 and 4.4:

2-05 - Mineral Development in the Manitoba Model Forest
2-13 - Chair in Forest Ecology at University of Winnipeg
2-14 - Strategic Plan
2-21 - Evaluation Framework

The mineral development project examines the history of mineral development in the Model Forest, old mining sites and prescribes rehabilitation measures as required. This project has little applicability to the implementation of EBM.

Table 4.41993-94 Advanced Forestry Management Projects in the Manitoba Model Forest and Their Relationship to EBM

Theme	3-01	3-02	3-03	3-04	3-05	3-06
Hierarchical Context						
Ecological Boundaries						
Ecological Integrity						
Data Collection	X	X		X		
Monitoring	X			X	X	X
Adaptive Management	X		X	X		X
Stakeholder Cooperation						
Organizational Change						
Humans Embedded in Nature						
Human Values						

The projects listed above are:

3-01 - Alternative Harvesting
3-20 - Dwarf Mistletoe
3-03 - Resource Road Management Plan
3-04 - Alternative Vegetation Management Trial
3-05 - Black Spruce Regeneration Assessment
3-06 - Regeneration on Difficult Sites

Table 4.51994-95 Manitoba Model Forest Projects and Their Relationship to EBM

Theme	2-03	2-07	2-08	2-09	2-16	2-17	2-?1	2-?2	2-?3	2-?4
Hierarchical Context			X	X						
Ecological Boundaries			X	X						
Ecological Integrity										
Data Collection	X	X			X			X		
Monitoring		X								
Adaptive Management		X				X		X		
Stakeholder Cooperation										
Organizational Change										
Humans Embedded in Nature										
Human Values										

Some of the 1994-95 projects had no firm project numbers. Table 4.5 used the following notations to identify these projects:

2-?1 - Forest Community Dynamics phase 1 - concept development & phase 2 - research design
2-?2 - Integrated Caribou Project
2-?3 - GIS database
2-?4 - Residents' Values

The projects represented in Table 4.3, Table 4.4 and Table 4.5, which had the capability of supporting the identification of an EBM framework, are briefly described below. Those projects which had significant EBM linkages, or the potential for significant linkages, have their project titles in printed ***bold-face italics***. Those projects with lesser EBM linkages have the project title in *italics* only.

2-03 - Age of Origin Project: The main aim of this project was to examine inventory techniques that could be used to determine the stand origin age. Data collection was undertaken in two townships, using largely ground surveying. The scope of the surveys expanded to include tallying snags, amount of downed material, and other stand attributes, which raised the survey cost to prohibitive levels. Colour infrared photography was being used in 1994 as an alternate technique for estimating age of origin. Since this project was not designed to examine disturbance patterns, little information of this type has been generated. Pine Falls Paper has fire records that date to 1890, although earlier records list only large fires (roughly larger than two or three townships). The Department of Natural Resources has pest infestation records which are not based on 100% sampling but are the best data source available.

2-04 - Forest Ecosystem Classification: A "first approximation of an ecological forest site classification field guide" was developed for Manitoba. A literature survey and data from three pilot studies in Manitoba were used to develop a first draft and identify knowledge gaps. Field surveys were run to collect additional data and test the robustness of the initial Forest Ecosystem Classification (FEC) system. These data and the test results were incorporated into an updated version of a FEC system. The results of this study enable the Model Forest to estimate frequency and distribution of ecosystem type occurrence, and gain insight into successional pathways.

2-06 - Plant Inventory: An annotated checklist of the vascular plants in the Model Forest was compiled from existing records and reports along with a ground survey.

2-07 - Experimental Watershed: Three watersheds, one on a large river (Moose) and two on streams, were identified. Each is roughly 30 ha in size. Water flows, quality, and amount of soil erosion were measured for one season, then 30% of the forests in each watershed were clearcut using two logging systems. Water quality, flow, and erosion were again measured. Regeneration will proceed next year, with continued monitoring. Some selection cuts will also be undertaken and monitored. Estimates of impacts on fish populations were modelled. This project is very supportive of ecosystem management in that it attempts to assess aquatic ecosystem impacts of several logging methods.

2-08 and 2-09 - Moose and Caribou Habitat Suitability Index Models: These projects align themselves well with EBM principles. HSI models were developed for these two species. The moose HSI was keyed to early winter habitat requirements and the caribou HSI to winter habitat, as both were generally thought to be the limiting factors. The moose HSI was derived from aerial inventory data and radio collar information, related to FRI characteristics. The Delphi technique was used to estimate the caribou HSI. Projects 2-08 (Caribou HSI) and 2-09 (Moose HSI) have follow-up monitoring in the 1994-95 period.

2-10 - Valuation of Non-Market Forest Outputs from the Model Forest: A review of existing, relevant forest valuation studies and the methodologies used, plus an assessment of the data available for such studies in the Model Forest.

2-11 - Annotated Bibliography on Conflict Resolution: The bibliography identifies conflict resolution approaches and strategies applicable to the Model Forest.

2-12 - Vacant Agricultural Crown Land: The location, size, and relative fertility of vacant parcels of agricultural land that have reverted to the Crown are identified.

2-15 - Forest Fire Management Strategy: Project made some recommendations for training cottagers and First Nations people in fire suppression techniques and forwarded these to the Department of Natural Resources. No follow-up has been made.

2-16 - Cooperative Moose Management: This project arose out of project 2-18. Unexplained moose population declines in some parts of the Model Forest have caused friction among various parties and this project was an attempt to develop a mutually agreeable solution. The issue has been approached by upgrading the level of informed-ness of concerned parties and then holding round table discussions. No commitments have been given, for a wide variety of reasons ranging from intra-stakeholder politics to lack of trust and disagreement on specific objectives. This project continues but appears to be in need of fresh stimulus, such as a proposed demonstration area. This project relates to many of the ten ecosystem management themes in the contextual zone of themes (see previous section). The difficulties experienced on this relatively well-defined problem indicate the importance of the contextual themes.

2-17 - Design and Implementation of the Model Forest Bird Monitoring Program: The abundance, distribution, and habitat use of the migratory songbirds within the Model Forest is being recorded.

2-18 - Role of First Nations in Forest Management: This project was a workshop in which members of the First Nations in the Model Forest area, other Model Forest partners, and a variety of experts met to discuss examples of how other First Nations bands had developed forest management programs. The workshop was well-received and seemed to raise peoples' awareness of the importance of determining an appropriate role for First Nations in management. This project led to the development of the cooperative moose management project.

3-03 - Resource Road Management Plan: This project has focused on inventorying and mapping existing roads and examining their condition. A series of roads where access is to be restricted has been identified and plans made to remove the road or use various measures to block access (e.g. build berms, remove bridges, install gates, etc). Plans are being made to undertake the proposed measures. This project falls somewhat short of EBM support, since the approach to road (and access) planning was not examined and the parties who seek access (hunters, anglers) were not participants.

The advanced forestry practices project area (Table 3.2) aimed at testing various alternative practices, monitoring the impacts of others, and attempting to solve targeted, small-scale timber production problems through improvements or changes to practice (the exception may be the resource road planning project). While these projects have some of the flavour of Adaptive Management, they generally attempt to further the attainment of current management goals and systems instead of exploring new or large-scale management alternatives. Therefore, while the understanding gained from these projects will contribute to practice under EBM, the projects do not test or adapt the overall management approach or principles.

The economic development projects have no direct bearing on forest management and hence do not contribute to the identification of an EBM framework. The technology transfer projects expose people to some of the tools that may be useful for implementing EBM (e.g. the modelling and GPS workshops) and the woodlot owner's workshop begins to bring private owners into the management planning process. Similarly, some of the educational, cultural, and public awareness projects can be said to indirectly contribute to EBM by facilitating cooperation and understanding between stakeholders (especially the teachers' guide to sustainable development and the cross-cultural workshop).

4.2.1 Summary

The entries in Tables 4.3, 4.4, and 4.5 are summarized below in Table 4.6; multi-year projects were tallied only once. The results show that the Model Forest projects have tended to emphasize data collection. The themes of monitoring and Adaptive Management have been supported to a moderate extent. Other themes have had very minor support. The themes which have not been supported strongly by projects are inherently difficult to capture in individual projects. This observation reveals the value of proceeding with EBM once an initial framework has been developed and not waiting for more data or project results before beginning.

Table 4.6Summary of the Model Forest Projects in Relation to EBM

Theme	Number of Entries
Hierarchical Context	2
Ecological Boundaries	3
Ecological Integrity	4
Data Collection	12
Monitoring	6
Adaptive Management	7
Stakeholder Cooperation	4
Organizational Change	2
Humans Embedded in Nature	1
Human Values	2
Core Themes	9
Shell Themes	18
Context Themes	16

The strong emphasis on data collection reflects our lack of knowledge concerning many aspects of forest ecosystems. In part, this state of affairs reveals how narrow the focus of timber-based management is, since we have fairly good knowledge of many timber-related topic areas but little information on other aspects of the forest resource which are now recognized to be extremely important. As Model Forest partners would likely agree, there are some areas where additional data collection would be helpful for implementing EBM, and these gaps will be discussed below.

Adaptive Management is a theme of seven projects. Most of these projects are concerned with implementing alternative practices and are not particularly concerned with changing the broader approach to management. However, the contemplated changes in practice do tend to support EBM, which is why the projects were listed in the EBM context.

The monitoring theme was associated with projects that involved either multi-year data collection processes or phases where a model or approach was validated through observations and adjusted if necessary. Monitoring is closely related to the Adaptive Management theme since monitoring provides the basis for the feedback loops that Adaptive Management depends on. Historically, monitoring has been a weakness in forest management programs and it is often one of the first activities to be cut during periods of fiscal restraint (after research and development). Thus, it is encouraging to see monitoring components in many Model Forest projects, although expanded monitoring is envisaged under EBM.

The Model Forest has also undertaken six scoping studies organized around the following topic areas: Biophysical Characteristics, Aquatic Ecosystems, Forestry, Wildlife, Recreation and Tourism, and Culture. These studies are very extensive and identify information sources that are relevant to the Model Forest under each of the subject areas. Information sources cited range from books, journal papers, and reports to experts, libraries, agencies, and databases. These studies should prove to be of great value as the Model Forest moves forward with EBM and other initiatives.

5.0 An EBM Framework for the Manitoba Model Forest

The first three sections of this report reviewed EBM in a broad context, based on experiences in other jurisdictions, and general concepts related to EBM. The fourth chapter focused on the progress that the Model Forest has made to date in grappling with EBM. This chapter attempts to bring the previous chapters together by focusing on identifying several important aspects of EBM which will form key pieces of future attempts to implement EBM in the Model Forest.

5.1 Definition and Goals

Earlier in this report, we stated that defining EBM is important, primarily to ensure clarity in communication. For that same reason, it is important for the Model Forest to define EBM in its particular context. The broad definition of EBM for the Model Forest includes all the VECs and qualities documented in Section 4. Although, as stated earlier, a simple sentence or two is not sufficient for defining a broad concept such as EBM, a summary of the broad definition which captures its essence can be important in conveying its key qualities to an audience without the opportunity or inclination to delve more deeply into the subject.

At the Model Forest EBM workshop, considerable effort was spent attempting to define EBM. The following summary definition was tabled:

EBB is an approach to forest management appropriate for:
•maintaining ecological integrity and health;
•maintaining biodiversity;
managing for forest sustainability.

The simplicity of this summary definition is appealing. However, as it is likely to be a featured aspect of the Model Forest's EBM initiative, we suggest including specific reference to the means by which EBM will implemented. The following three definitions offer progressively more detail:

1. EBM in the Manitoba Model Forest is an approach to forest management which, in consideration of human needs and values, strives to maintain the forests' ecological integrity, biodiversity, and sustainability.

2. EBM in the Manitoba Model Forest is an approach to forest management which, in consideration of human needs and values, and the natural dynamics of forests, strives to maintain their ecological integrity, biodiversity and sustainability.

3. EBM in the Manitoba Model Forest features the use of Adaptive Management in considering human needs and values and the natural dynamics of forests and strives to maintain their ecological integrity, biodiversity and sustainability.

Each of the definitions above identify the recognition of human needs and values as a component of EBM. At the Model Forest EBM workshop the aspect of human needs which featured most prominently in discussions was that of commercial timber supply. Several discussions focused on the desire not to diminish harvests from their present levels, or to increase harvests. Many other discussions centred on the need to manage the forests with greater consideration of non-timber values than traditionally has been the case. These two desires must be reconciled if the EBM initiative (and framework) is to have a clear focus. EBM cannot be all things to all people. It is difficult to imagine how a forest management initiative could focus on increasing timber supply, while at the same increase the consideration given to non-timber values. Discussions at the workshop revealed that many Model Forest stakeholders believed that the primacy of wood supply should be recognized in an EBM initiative; others, however, believed that biodiversity issues were, if not more important, certainly not less important than wood supply issues.

Others have also grappled with this issue when developing progressive forest management approaches. For example, the Ontario Forest Policy Panel's first principle for using forests states: "Long-term viability and sustainability of communities and forest-based businesses are vital. This is second only to the sustainability of forest ecosystems." The primary focus here is on ecosystem sustainability with socio-economic sustainability a highly regarded second priority. More striking is the view advocated by Grumbine (1994) who identified four goals of ecosystem management which relate to maintaining ecosystem integrity and a fifth which states "Accommodate human use and occupancy with these constraints." (see section 2.2), clearly placing human use secondary to ecological goals.

The definitions of EBM developed by the U.S. Forest Service are more utilitarian in nature. Kessler et al. (1992), for example, stated that ecosystem management "must not diminish the importance of goods and services, but instead treat them within a broader ecological and social context". Those agencies who advocate a definition such as this have been the subject of criticism by some scientists and advocacy groups for the lack of distinction between their views of EBM and its predecessor philosophies of integrated resource management and sustained yield management, which emphasized the human use and timber production aspects of forest management (see Miller 1995, Rauber 1995).

Although the differences between these views are subtle in some respects, the philosophies put forth by the Ontario Forest Policy Panel and Grumbine represent a more fundamental shift in forest management. *The recognition of the ultimate goal of managing for ecosystem integrity is the true hallmark of EBM.* This recognition does not imply abandoning human economic or social use of the forest. As noted by several workshop participants, human values are integral to the development and implementation of EBM. EBM does, however, clearly place the maintenance of an ecosystem's integrity and health as a primary goal. Ecologically sound (i.e. sustainable) human use is to be accommodated within this higher ambition.

A Conceptual Model

Earlier in this project, a conceptual model of EBM, showing three concentric circles was introduced (Figure 5.1). The model is based on the notion that there are three distinct, but interrelated aspects of EBM. The innermost circle or **core** of EBM contains the biological and ecological aspects. This includes the ecological goals (maintenance of ecological integrity, viable populations, etc.) and the ecological or biological aspects of management (e.g. managing to mimic natural disturbance patterns). The second circle, or **shell**, consists of those supporting activities which guide the implementation of EBM (e.g. data collection, monitoring). The third circle provides the **context** of EBM: those sociological and economic activities or circumstances which facilitate the core and shell activities (e.g. interagency cooperation, organizational change).

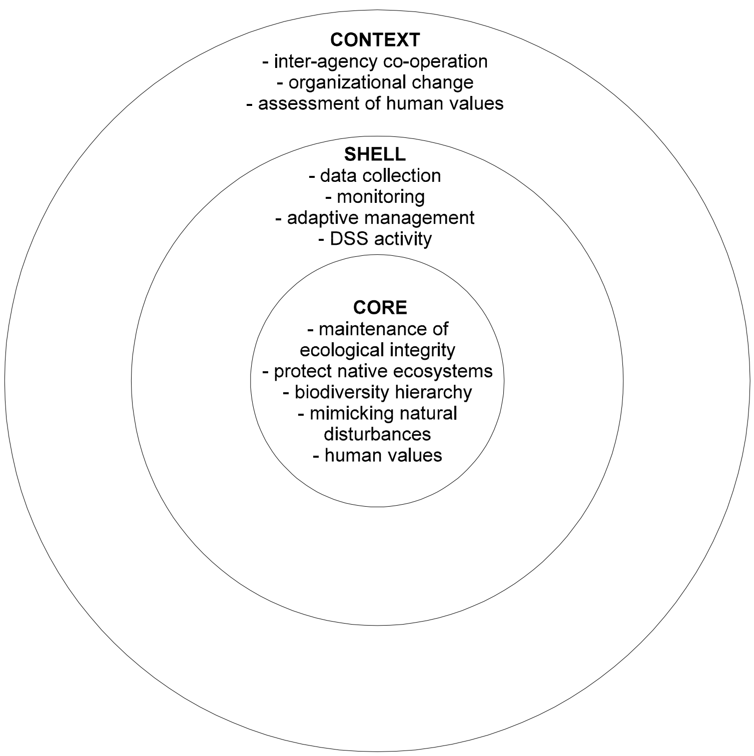

Figure 5.1 A conceptual model of EBM.

This model is a simplistic representation of EBM, and is useful primarily for categorizing activities, or for giving them perspective relative to one another. To be useful in a Model Forest context, priorities for action for each layer are needed. Most of these priorities are dealt with in section 5.3.2, but it is appropriate here to identify the most important aspects of the core, which are the goals of the Model Forests EBM undertaking.

In the development of the definition of EBM above, and in discussing the VECs of the Model Forest (see Section 4.1.1.), several EBM goals have been implicitly identified. For clarity, they are stated here explicitly. The goals of EBM in the Manitoba Model Forest are:

1. To maintain the ecological integrity and health of the Model Forest. The Model Forest's ecological integrity can only be maintained by maintaining biodiversity at all levels (i.e. genetic, populations, species, and communities). The following goals are all components of this primary objective.

2. To maintain a natural mix of all native forest communities in the Model Forest.

3. To maintain self-sustaining populations of all wild native plants and animals in the Model Forest at "natural" levels.

4. To maintain the natural functioning of all ecological processes in the Model Forest. These ecological processes include hydrological and carbon cycles, decomposition, and predation.

5. To provide opportunities for sustainable human use of the Model Forest and to ensure that human use of the forest does not damage its health.

5.2 Design and Implementation Issues

The following sections identify some important issues which should be addressed before the Model Forest implements EBM. Others less apparent issues are noted and summarized in brief, together with those discussed here, in section 5.3.2.

Before discussing some of the most critical implementation issues, it is important to review the roles of various agencies and stakeholders in the Model Forest. The Pine Falls Paper Co., a Model Forest stakeholder, holds the licence to harvest and manage the timber on the Crown land which comprises most of the Model Forest. Thus, while the Model Forest may make suggestions regarding how the forest could be managed, Pine Falls Paper Co. has to buy into the recommendations and priorities or they will likely not be implemented. In addition, the Manitoba Department of Natural Resources (DNR) is the ultimate administrator of Crown land and is responsible for overseeing the management of Crown lands and forests. Thus, DNR also has to agree with any proposal as far-reaching as the implementation of EBM.

Since a current role of the Model Forest is to be a catalyst for change, the text in this section of the report suggests that the Model Forest will actually implement EBM. Although this will not technically be the case, Model Forest representatives will certainly be involved in varying degrees, in most aspects of implementation. Should the Model Forest prepare a proposal to adopt EBM, Pine Falls and the DNR would need to approve the new management approach and Pine Falls would be responsible for implementing it.

5.2.1 Defining Objectives and Indicators

In Section 4.1.1 we stated that the objectives for the Model Forest's implementation of EBM should be cast in quantitative terms to allow progress to be measured, and objectives to be refined. This, in turn, suggests that indicators or practical measures are needed for a refined set of VECs and corresponding objectives. Table 5.1 shows an example set of objectives and indicators that correspond to some of the EBM goals identified in section 5.1.

Table 5.1 Example set of objectives, indicators and data needs, which may be applicable to EBM implementation.

Goal	Objectives	Indicators	Data Needs
Maintain biodiversity at present level	1) Landscape pattern to not vary significantly from “natural” pattern 2) No species to decline more than 25% from long-term “natural” levels	1) Landscape Diversity Index (as in Perera and Schnekenburger 1993) 2) Population levels of several indicator species compared to natural levels	• present size and distribution of all landscape units (FEC types) on the Model Forest; • baseline size and distribution of landscape units ; • present population levels of indicator species; • baseline population levels of indicator species
Provide a natural mix of native forest communities	All FEC types to be maintained at ± 50% of baseline proportions	Distribution of FEC types relative to baseline	• baseline distribution of FEC types; • present distribution of FEC types
Maintain high quality water	Target levels to be set for each of the indicators of water quality	Average levels (from several key water bodies) of: • Sedimentation • Nutrients • Turbidity • Heavy Metals	• periodic measurements of indicator levels at several key water bodies
Maintain viable populations	Caribou population to be maintained at ± 25% of historic level	Caribou population	• present caribou population; • historic caribou population

The development of a refined set of objectives and indicators is a priority for the Model Forest. By working towards these targets, the process of implementing EBM will remain on track. Indicators are used to measure progress and to provide feedback on the management attempts. The development of quantitative objectives and indicators will be a very significant early step in the implementation of EBM in the Model Forest.

Recommendation: *The Model Forest should develop a refined set of objectives and indicators related to the goals of EBM adopted for the Model Forest.*

5.2.2 Scope of Implementation

One of the first issues to resolve is the scope of the management plan. The key question is "Should the Model Forest implement EBM on all or merely a portion of the Model Forest lands?"

We believe that implementation should proceed in a gradual manner on the entire Model Forest area.

Since the implementation of a full-blown version of EBM requires knowledge and a capacity for planning that few organizations possess, gradual implementation seems a practical approach. Although the style of management may not change immediately, as the Model Forest's managers and stakeholders gain further experience and understanding, additional elements may be incorporated into planning. Thus, implementation can be marked by experimentation, learning, and successes as well as mistakes. In this context, the question of the scale of implementation loses some of its urgency. However, there are substantial reasons for pursuing EBM on the entire Model Forest.

A practical reason for pursuing EBM on the entire Model Forest is to avoid situations which could make it more difficult to implement EBM or interpret its results. If the Model Forest were to be divided into EBM and non-EBB areas, management issues would arise which would compromise the EBM initiative and confound its evaluation. For example, it is likely that plans for harvest volume changes in one area would be offset by counterbalancing volumes in the other. A "soft" approach to EBM in one area could lead to more aggressive practices in the other, making it difficult to accurately assess the costs and benefits of EBM.

Perhaps the most significant reason for implementing EBM on the entire Model Forest relates to Grumbine's (1994) first and second themes, which focus on the need to manage at different hierarchical levels and within ecological boundaries at the appropriate scale. In the boreal forest, the appropriate scale for some ecological factors (e.g. fire, large predators) is very large. Implementing EBM on only a part of the Model Forest would hinder the ability to fully integrate management with these factors.

A very large area is required to permit the adequate representation of a natural distribution of fire sizes and burn intensities, which is important in maintaining a natural pattern of habitats and large-scale processes. Since fire is a large scale disturbance factor, the larger the ecosystem the greater the likelihood that management can approach the replication of a natural fire disturbance regime.

The advantages of a larger scale are also great where wildlife requiring large home ranges are concerned. The recognition that many "reserve" areas are smaller than the area required for viable populations of large animals has been a driving force behind the development of ecosystem management principles and their rapid, widespread acceptance. Populations of animals with large home ranges, such as moose, wolves, caribou, bear, wolverine, and certain birds of prey would be fully included within the scope of an EBM plan applied to the whole Model Forest area. Furthermore, larger populations contain a wider range of genetic material, hence a larger EBM area promotes gene conservation and exchange of genetic material that drives adaptation and evolutionary processes. The maintenance of genetic diversity and ecological processes are among the goals of EBM noted in section 5.1.

***Recommendation**: The Model Forest should plan to begin gradual implementation of EBM on the entire Model Forest area.*

5.2.3 Identification of Critical Ecosystem Types and Maintenance Levels

The maintenance of ecosystem types provides a coarse-filter approach for maintaining species diversity (see section 3.2 for more discussion). Therefore, it is important to: 1) assess the frequency of ecosystem types within the Model Forest, 2) identify critical ecosystem types, and then 3) develop an appropriate series of habitat-level goals. Knowing which ecosystems are rare or uncommon will help the Model Forest identify potentially rare species and set the scope for management steps designed primarily for their conservation.

This series of tasks will allow the Model Forest to exploit the well-documented link between habitat and species occurrence (Scott et al., 1991). As noted earlier, since the resources to survey and manage the populations of many species are not available, a second-best approach is often to manage and monitor the availability of habitat. Related pilot projects recently completed or underway by the Model Forest include attempts to improve the quality of the forest inventory, develop a "first approximation" of an FEC system (Project 2-04), and a survey of vascular plants (Project 2-06).

Once ecosystem types have been identified and inventoried, it will be obvious which ones are rare or unusual within the Model Forest. How to treat these areas depends on how widely represented such ecosystems are outside the Model Forest.

Any provincially unusual or native ecosystems on small areas should probably be set aside. The plant inventory project (Project No. 2-06) identified 50 provincially rare and 3 nationally rare plants; these might indicate the presence of unusual ecosystems. Non-native ecosystems could be converted back to natural ones or left untouched; it is likely unworthwhile to make efforts to conserve them. Ecosystems which are rare in the Model Forest but are well-represented outside the forest may represent extremities of species ranges. Duinker (1990) suggested that species adjustments to global climate change can be facilitated if range extremes are maintained, since this is where adaptation is likely to occur at a relatively rapid rate. Thus it may be desirable to devote additional attention to the management of these areas.

Treatment of special ecosystems also depends on how the distribution of ecosystem types compares to their "natural" distribution. Restoration may be appropriate in some cases.

While there are many sources of dispute over the natural distribution of ecosystem types, a reasonable approximation for the Model Forest can be obtained from old inventories made before large-scale cutting was practised, or from the adjacent parks or nearby areas that have experienced little harvesting. The age-of-stand-origin project may also yield useful insights on this issue.

The natural distribution of ecosystem types is an important benchmark for the management of common ecosystem types within the Model Forest. One common objective of ecosystem management is to replicate, to the greatest extent possible, the "natural" distribution of ecosystem types, as defined by age, cover type, stocking, and various relevant site features. The disturbance regime of the Model Forest suggests that the proportions of ecosystem types are always changing. The fluctuation of ecosystem types over time can have important ecological values and should be encouraged within limits. The approach taken on the White River Forest (Eason 1994) may be instructive: they used the 1963 forest resource inventory as the basis for approximating the natural distribution of ecosystem types. Since the scale and frequency of disturbance can cause rapid shifts in the balance of ecosystem types, a goal of maintaining the distribution of major ecosystem types within +/- 50% of 1963 levels was set.

Recommendation*: The Model Forest should undertake an assessment of the type and prevalence of different forest ecosystems and compare these to estimated "natural" levels. This can be used as a* *basis for identifying some quantitative objectives concerning forest ecosystem maintenance, for both common and uncommon ecosystem types.*

5.2.4 Integration of Harvesting with the Disturbance Cycle

A common theme in this report is the desirability of emulating natural disturbance regimes. The fire regime is the focus of this issue on the Model Forest. Other than setting more fires, the obvious way for management to attempt to mimic fire is through harvesting. For this purpose, clearcutting will be a primary harvest method on the Model Forest. The fire regime can be described in terms of:

- the distribution of fire frequency by size class;
- the periodicity of fire, including annual levels and the distribution of return times by ecosystem type; and
- the spatial distribution and geographic orientation of fire.

The current harvesting level is much smaller than the area lost to fire. Between 1979 and 1989, fire accounted for 86% of the total area depleted while harvesting accounted for the remainder (Manitoba Model Forest 1994). However, this does not necessarily mean that the current harvest level is benign within an EBM framework. As discussed earlier, many advocates of EBM place a higher value on the goal of ecosystem maintenance than timber harvest volume. It is important to assess how the current level of depletions compares to the "natural" level. This can only be done by estimating the average "natural" burn area (rather than the burn area under the fire suppression program) and comparing it to current depletion levels.

The second data element for the Model Forest to assess is the size distribution of fires in the era when the Model Forest area was essentially unchanged by colonizing Europeans (assuming that the impacts of aboriginal peoples on the fire cycle are almost impossible to identify). Hunter (1993) hypothesizes that there is a connection between average fire size and average size of areas surrounded by water bodies. Hence, the Model Forest may wish to examine the size distribution of areas unbroken by water.

By comparing the distribution of clearcut sizes plus burn areas under the current fire-suppression regime versus the distribution of natural fire sizes, the Model Forest stakeholders can begin to see whether harvest sizes should be adjusted. Perhaps one of the most difficult questions is "what maximum clearcut size should be allowed?" The few very large fires that occur may be ecologically significant at a landscape level but many people will disagree with the notion of planning clearcuts that cover thousands of hectares. This issue is further complicated by the fact that there are often numerous "skips" (i.e. unburned or lightly burned patches within the outer boundary of the fire), many of which occur along water bodies and lowlands.

Hunter (1990) suggests that it is appropriate to ask at what size the ecological characteristics of a clearcut or burn reach a qualitatively stable level. That is to say, there is some size at which the ecological quality of the area at the middle of the burn or clearcut does not change if the burn or cut is enlarged. This size should represent the upper limit on clearcut size. Hunter (1993) also discusses the importance of harvest layout. Relatively smaller clearcuts can be clustered so that they are only separated by narrow strips of forest. This increases the effective ecological size of each clearcut and the narrow leave strips may imitate linear "stringers" left along watercourses.

Recommendation*: The Model Forest should undertake to estimate the frequency of burns by burn size when the region was essentially unchanged by people. This should be compared to the current distribution of burns and clearcuts to help determine a distribution of cutover sizes appropriate for EBM.*

It may turn out that the combined area of burns and clearcuts is significantly lower than the average "natural" burn area. This raises the question of whether some fires should be allowed to burn unchecked, which may be desirable for a number of ecological reasons. Fires have some characteristics (e.g. nutrient cycling) particularly at the site level, that are not well-emulated by clearcutting (Thompson 1993). It may be possible to identify water-bounded areas where it would be acceptable to allow a fire to burn without immediate suppression effort.

A second timber harvest issue concerns the harvesting patterns on the Model Forest. A very high percentage of Pine Falls' harvest volume is black spruce. Relatively little jack pine is cut. However, the Model Forest is made up of an alternating series of thin soiled ridges and poorly drained depressions. The black spruce is mainly found in the depressions, while the jack pine thrives on the dry ridges. Thus, the harvesting activities concentrate heavily on the lowland site type while leaving the upland areas. Since black spruce is likely to regenerate on the lowland cutovers, this harvest pattern may not cause a shift in species composition. However, the fire return time on the ridge sites would be shorter than on the lowland areas as the lowland areas would be burnt only during relatively severe fires.

Therefore, the sites emphasized by harvest operations are exactly those which have the longest fire return intervals. To determine whether harvesting operations result in excessive withdrawals from lowland sites, the disturbance pattern or average fire return time should be estimated for the lowland site type (and also for upland sites). The average fire return time on these sites could be derived by estimating the average age of lowland stands prior to commercial exploitation.

If there are significant differences in the historical periodicity of burns on the upland and lowland site types, this will complicate harvest scheduling and layout. Beyond this, it is difficult to proceed with the discussion until the work recommended below is undertaken.

Recommendation*: The Model Forest should estimate the pre-logging fire return periods on upland and lowland sites and compare these to the rotations currently in use. If the return periods exceed the current rotations, these should be lengthened. Otherwise, the rotations could be shortened to bring them more in line with rates of disturbance frequency of burns by burn size when the region was essentially unchanged by people.*

5.2.5 Socio-Economic Impacts of Ecosystem Based Management

Any shift in the forest management approach will have some repercussions on wood supply, silvicultural and management costs, and employment, as well as on the types and qualities of other forest uses, such as recreation. It is prudent to try to estimate these beforehand.

Although much literature has developed around ecosystem management, there have been very few studies made that attempt to quantify the impacts. Of the few studies that have been done, most were undertaken in the coastal forest of B.C. and the U.S. Pacific Northwest. These results are unlikely to correspond well with boreal-forest impacts. A draft study by Williams et al. (1995) identified and assessed a set of indicators to describe the impacts of shifting from a sustained-yield timber management approach to an ecosystem management approach. Although this was done for a generic application ecosystem management in the boreal forest region, the results are relevant to the Model Forest at present.

The study estimated that the costs of harvesting and access would rise while silvicultural costs were likely to fall, and that the value of wood was expected to rise. The effects on harvest volume, the area of land available for commercial operations, and the timber harvest yield per hectare were judged to be indeterminate. All of the social indicators, such as level of employment, job skill requirements, worker safety, diversity of products, participation in decision-making by both indigenous and non-indigenous people, aesthetic qualities, and opportunities for recreation and tourism were expected to increase.

Being qualitative in nature, this study was limited in its assessment of situations where there were countervailing tendencies. For example, it was not reasonable to definitively forecast whether the net impact of changes in costs of harvest, access, and silviculture would be positive or negative. The same difficulties arose in the examination of wood supply volume. Some ecosystem management measures were estimated to increase the wood supply whereas others were thought to reduce it. The net effect cannot be determined without the use of a simulation model.

More work is needed to make quantitative estimates of the financial and social impacts of implementing ecosystem managements. These will have to be weighed against other types of impacts that are still more difficult to measure, such as the value of changes to recreation opportunities or improvements in ecosystem health. The most likely next step in this process is to use simulation tools to estimate impacts on costs and timber supply. Computer models have been available for some time but many of those currently used in Canada are best suited to fairly standard forest management scenarios, such as clearcutting, and use fairly coarse sub-divisions of the forest. The amount of data needed to use these models to evaluate ecosystem management impacts will be larger than is normally the case.

Recommendation: *In the design or start-up phase of implementation, the Model Forest should attempt to estimate some of the short-term financial and social impacts of shifting the management approach. Such a study might alleviate some unfounded fears and it might also assist the Model Forest in revising its prescriptions somewhat should the severity of the impacts warrant. Computer models are the most likely tool for undertaking such efforts, but the exercise will require significant resources for model development and for data preparation.*

5.2.6 Identification of Candidates for Fine-Filter Management

In general, there are two classes of wildlife for which fine-filter management measures are appropriate: those which are rare or endangered and those which require a number of different habitat types during the day, year, or their lifetime.

As noted earlier (see section 3.2), if rarity is used as a criterion, there are some obvious candidates for fine-filter management in the Model Forest, such as woodland caribou and the nationally and provincially rare plant species identified in the plant inventory project (No. 2-06). However, rarity is not the sole rationale for determining which species may be considered for fine-filter management. Some rare species may be accommodated by coarse filter management, and some common species may not. In many cases however, rare species are not accommodated by coarse-filter management because their habitat needs are extraordinary, or they are strongly influenced by factors not associated with habitat.

Due to their very scarcity, there are often very few data on rare species. This can lead to a confusing situation because not all species for which there are few data are rare or in need of fine-filter management. In the absence of better information, Soulé (1991) suggests that abundance and variability of population size or growth rate should be considered as indicators of vulnerability. High variability is associated with increased risk of extinction. Species with highly variable populations may, therefore, warrant fine-filter management.

In the absence of data on abundance, one may make use of the fairly consistent relationship between the body size and population density of mammals, which holds especially well for carnivores (Soulé 1991). Larger animals have larger home ranges and lower densities. Soulé (1991) reports that in most cases, the rarest animals in a region will be large carnivores, followed by large herbivores. According to this rule of thumb, the rarest animals in the Model Forest are wolf, lynx, and wolverine as well as black bears. Caribou are known to be rare (moose much less so). Large birds of prey might also be included in this list. Large animals are often "keystone" species, which strongly interact with many other members of the community despite their relative rarity (Soulé 1991). Soulé (1991) advises that it may be worthwhile undertaking expensive measures aimed at maintaining keystone species since their loss often leads to the decline and extirpation of many smaller animals.

Throughout this discussion there has been an emphasis on population data, not habitat availability. Despite the current emphasis on habitat supply, for uncommon species there are many instances in which there may not be a good correspondence between habitat and abundance. Thus, abundance data are greatly preferred to habitat supply information.

Once a list of potential fine-filter species has been compiled, the next step is to rank the species. This is a necessary step when the resources required to devise a set of fine-filter management strategies for all listed species exceed the resources available to the Model Forest. Species which are historically scarce may have a lower priority than species which were formerly more abundant, or are presently in decline.

Another criterion which will help in ranking the list of fine-filter candidates is the potential of management practices to positively affect the species. One way to assess the potential could be to map out the life-cycle requirements of the high priority species and determine how well these are met within the Model Forest. Limiting habitat elements, if any, should be identified. Some species' needs (e.g. winter habitat for neotropical migrant birds) can clearly not be met within the Model Forest. Other needs may be available relatively near the Model Forest (e.g. in Nopiming Park). Still other elements could be created through changes to management practices. It is this group of life elements that should be targeted in the development of fine-filter practices and guidelines. (The moose and woodland caribou habitat suitability index projects (Nos. 2-08 and 2-09 respectively) represent good examples of this sort of work.)

Recommendation: *Identify and rank a list of species within the Model Forest which are candidates for fine-filter management approaches.*

5.2.7 Modification of Site-Level Forestry Activities

The adoption of EBM will likely result in modifications to the various management activities that are undertaken within the Model Forest. Many of the management activities currently in place reflect the view that timber production is "a woody analogue of agriculture" (Hunter 1993).

The Model Forest should implement a broader range of management activities. Hunter and Seymour (1990) list a number of stand level applications suited to the eastern spruce-fir forests, which we have modified for the Model Forest below:

- increased use of natural regeneration and maintenance of species diversity;
- retention of residual trees;
- expanding the range of rotation ages; and
- expanded applications of non-standard silvicultural systems -- two aged stands maintained by irregular shelterwood cutting.

We also recommend two additional applications:

- increase the use of prescribed burning; and
- investigate the potential roles of herbicides and determine appropriate guidelines.

Applying these practices would result in a number of significant modifications to current harvesting practices, as discussed below:

Expanded Use of Partial Harvesting on Lowland Black Spruce Sites

Although this report has emphasised the role of fire within the Model Forest, lowland sites are less subject to catastrophic burns. While determining the frequency of fire in lowland areas is a matter of some significance, there will be a certain proportion of older lowland stands where the dominant natural processes are windthrow and losses to insects and disease. These stands frequently contain a mixture of age classes and have luxuriant moss layers on the forest floor. The structure of these stands can be partially recreated using a harvesting system such as group selection, which is midway between the traditional single-tree selection and shelterwood systems. The level of harvesting in a single tree selection system is probably too light to promote sufficient regeneration whereas a true shelterwood system would not be appropriate because the crowns of the main stand do not form a canopy that is sufficiently high to allow operators to work beneath it. However some mixture of the two methods, such as a group selection method, should provide reasonable opportunities for regeneration while minimizing the incidence of windthrow and retaining sufficient cover to prevent the moss layer from drying out.

Recommendation*: The Model Forest should consider using a broader range of partial cutting techniques on lowland areas. This would permit the development of a greater diversity of stand types, maintain site conditions, and result in natural regeneration. However, the cost and wood supply implications should also be examined.*

Use of Modified Seed Tree Method to Promote White Spruce on Upland Sites

White spruce does not represent a significant proportion of the growing stock volume or forest area within the Model Forest but its industrial and ecological values outweigh its relatively small presence.

White spruce rarely forms pure stands. In some upland mixed wood stands, it may comprise up to 30% of the volume but it is rarely the dominant species in the stand. The importance of white spruce may be largely attributed to its long lifespan (under normal conditions, it lives much longer than many boreal species) and its height, which frequently exceeds that of the surrounding canopy, thus adding a unique vertical structural component to these stands. Eason (1995) reports that some insectivorous songbirds, such as the Cape May warbler, are found almost exclusively on large white spruce during low budworm years, suggesting that these trees may serve as refugia for budworm-eating bird species. In contrast to other spruces, white spruce is also reasonably windfirm. These characteristics make it an appropriate species for the application of the seed tree harvesting method, in which scattered white spruce are left on the cutover. Recommended rates for leaving trees range from 5 - 15 per hectare, depending on tree size (Eason 1995).

Many of the seed trees should be left throughout the next rotation. These trees will not survive, but will die intermittently and form snags, which are valuable to wildlife. The retention of these trees also provides some insurance in case fire destroys the new stand while it is young. Such a fire is unlikely to kill all white spruce residuals and in any case, the fire-killed residuals can be expected to release stored seed.

Recommendation*: The Model Forest should consider the application of the seed tree system to some proportion of upland areas, leaving white spruce to serve as seed trees and provide vertical structure over the entire subsequent rotation.*

Expanded Range of Harvest Ages

Although fire return times are relatively short on upland sites in the Model Forest, it is likely that a certain proportion of stands in the forest reach ages where other factors begin to alter the stand composition. These overmature stands provide important habitat for species such as pine marten and may also provide winter cover for moose and others animals. Similarly, some lowland sites will also provide unique ecosystem elements. Therefore, the Model Forest should consider moving away from standard rotation ages for various stand types and instead consider harvesting stands over a range of ages and leaving a proportion of stands to become overmature. Ultimately, the new range of harvest ages should encompass younger stands as well as older ones. The proportion of stands in any given age class can be subject to guidelines and manipulated by harvest scheduling.

In order to implement this suggestion, it is important that the Model Forest have far better information on stand ages (and other stand characteristics) than at present. The Age of Origin project of the Model Forest and other initiatives have laid the groundwork for an improved inventory but a concerted effort has to be made to cover the entire forest. At present, the general quality of inventory information is insufficient to meet the demands of today's forest manager and the deficiencies will be even more severe when ecosystem management is implemented.

Recommendation: *The Model Forest should investigate the implications of moving away from the use of a single rotation age for each cover type/site class combination. The implementation of this recommendation will be greatly hindered by the current forest inventory. A more comprehensive forest inventory should be carried out over the entire Model Forest as soon as possible. A more accurate and comprehensive inventory will aid the stakeholders in almost all forest management tasks - the quality of management is heavily dependent on the quality of information available.*

Determine Appropriate Roles for Herbicides in Ecosystem Management

The use of herbicide by forest managers has become widespread in recent years. Many boreal forest managers frequently apply one or two herbicide treatments to remove competing vegetation ranging from grasses and herbaceous species to brush and hardwoods. Many of these unwanted competitors provide food and habitat for a wide variety of birds and animals. Chemicals may also be applied to kill and dry vegetation in preparation for prescribed burns and may also be used as a means of site preparation. The role of herbicides has expanded in timber-oriented forest management because they are relatively inexpensive, effective, and can be chosen to target various types of vegetation.

In spite of the advantages of herbicides, one might expect that they would not be used in an ecosystem management context. Most people would agree that it is better to avoid putting chemicals into the environment if possible. However the matter does not appear to be so simple.

It is widely agreed that harvesting does not leave a site with the same conditions that one would find after a burn (Thompson 1993). In particular, the duff layer and organic matter levels of the soil are disturbed and redistributed during logging but not reduced as is the case after all but the lightest burns. Also, unlike logging, fires generally kill the herbaceous plants and their seeds. As a result, there are differences between the vegetation that develops on post-burn and post-harvest sites. It may be that the only methods of creating post-harvest sites that more closely resemble post-burn sites is to use prescribed burning shortly after harvest or apply herbicide.

Another potential role for herbicides is in the mimicking of light burns. Mimicking the pattern of fire disturbance should consider the range of intensities, as well as the range of temporal and spatial distribution. The matter of different intensities has mainly been discussed above in terms of leaving residual timber. The use of herbicides, however, represents a method of approximating light burns. What is the ecological significance of light burns and is it worthwhile or necessary to try to reproduce these? The answers are far from obvious, which means that herbicides may be useful in ecosystem management.

A third potential role of herbicide use within an EBM framework is to help the Model Forest maintain the proportion of ecosystem types within certain pre-set ranges. If it appears that the proportion of hardwood cover on some site or ecosystem type is set to exceed the tolerance ranges set for it, then the Model Forest may choose to use herbicide to convert some sites to mixed wood conifer cover types.

In summary, there are a number of circumstances where using herbicides may represent the most reasonable means of achieving certain ecosystem-related goals. This is a complex issue and there is unlikely to be much data existing in a format that permits a ready investigation of them. At this point, the Model Forest should begin to consider potential roles for herbicides within the context of EBM. This investigation may prompt the Model Forest to undertake some experiments or gather additional data.

Recommendation*: The Model Forest should begin to investigate the current role of herbicide use from an ecosystem perspective and begin to consider possible changes in their role.*

5.2.8 Ecosystem Management in an Adaptive Management Framework

Section 3.5 described the essence of Adaptive Management and summarised protocols for designing and implementing an Adaptive Management approach at a system level. This is a very significant task, requiring large inputs of time and other resources. In a sense, the decision to implement EBM can be viewed as an experiment that will test our hypotheses and expectations. In an Adaptive Management framework, practices and processes should be designed to facilitate the evaluation of this experiment. However, given that there will be a transition period while EBM is being introduced, it is not clear what length of time will have to elapse before one could begin to assess its merits in total. It is likely that flaws will be identified in certain subsets of activities and that these activities will be adjusted as appropriate. It is most appropriate for the Model Forest to design a small number of Adaptive Management experiments around fairly specific practices that are part of the EBM approach.

Adaptive Management is an ideal framework to use in implementing various aspects of EBM, because of the large number of uncertainties surrounding the outcomes of practices and policies it has inspired. The best way to approach the use of Adaptive Management is to determine which actions or assumptions within the management prescription are the riskiest. In this context, a risky action or assumption is one for which there is a great deal of uncertainty and for which the consequences of error (i.e. the loss function) are severe.

The discussions in the preceding sections have raised many examples of assumptions with significant risk. For example, fine-filter management procedures will likely be adopted for some rare or threatened species. The rarity of these species is often accompanied by little information regarding abundance, range, and habitat requirements. Thus, prescriptions designed to increase the abundance of a species by increasing the carrying capacity of the Model Forest are critically dependent on assumptions regarding limiting habitat elements and appropriate locations for mitigative action. Additionally, habitat must be a limiting factor for these measures to have the desired impact. If a procedure was designed to promote wolves, for example, then this may entail creating some large clearcuts to improve their hunting success. However, this will not work if prey animals do not use the large clearcuts. Another ideal opportunity to implement Adaptive Management might be to test the hypothesis that a program to increase the wolf population will have some specified level of impact on the moose population (or moose hunting success rates).

There are a great number of opportunities to use Adaptive Management approaches to test the ability of harvesting to mimic fire, or even to test the hypothesis that a certain pattern of harvesting will mimic natural fire patterns.

The following simple example illustrates the general steps involved in implementing an Adaptive Management framework. The Model Forest wished to design a harvest strategy that would provide suitable summer habitat for woodland caribou. Research revealed that there is very little documentation on what qualities the caribou prefer in this habitat type. The Model Forest has used global positioning collars to obtain evidence that caribou are extensively using cutovers from the early 1980's during the summer. Field surveys will be done to sample the current qualities of these sites and to estimate how they were originally cut. Based on these results, a harvest prescription will be designed for future use. However, there will be great uncertainty surrounding the effectiveness of these cuts. As described below, this situation is an excellent example of how Adaptive Management can be used to ensure that a suitable harvest prescription is produced.

1.Specify the hypothesis that will be tested, explain what results are expected, and clearly state the reasons for the expected outcome.

In this example, the hypothesis is that the prescription will result in areas that are attractive to caribou within a period of 10-15 years after harvesting. Key factors in the experiment may include the pre-harvest condition of the stands (since this will affect how the cutovers develop), the harvesting technique and the condition of the post-cut area, and the behaviour of other processes (such as climate) during the post-harvest period. Of these factors, only the first two are subject to managerial influence.

Computer models could, and probably should, play an important role, even in this early step in the Adaptive Management process. Ideally, the Model Forest would be able to use a successional model to work backwards from the current summer habitats to predict the condition of the post-harvest area. Models should also be used to make quantitative predictions about the outcome of the management practices. The predictions should be recorded and used as a basis for challenging and revising our understanding of the ecology of caribou and clearcuts as the adaptive management exercise proceeds. Modelling activities will extend into future steps in the Adaptive Management process. For example, as sites are selected, their precise descriptions can be incorporated into the model and predictions revised.

2.Identify sites in the forest where the hypothesis can be tested.

This requires that the Model Forest identify stand types where suitable harvesting can be implemented to create or provide the requisite summer habitat qualities. Obviously, stands that are very similar to those that were cut in the 1980's would be candidate test sites. However, it may also be possible that a somewhat wider range of stands can be harvested in such a way as to produce suitable habitat. The exact prescription may require some modification through the range of potential stand types.

Once suitable stand types are identified, they should be selected. In this process, the spatial relation of these sites to neighbouring stands might be considered.

3.To the greatest extent possible, survey key features of the test sites to provide data which may have explanatory power.

An inventory of the selected test sites should be undertaken before the harvest. Besides an inventory of trees by species and structural position within the stand, the survey should also record the abundance of brush, herbaceous plants, sedges, and grasses. These components, where possible, should be incorporated into the computer model and used as a basis to refine its predictions.

4.Undertake the harvests on the selected sites.

5. Assess the post-harvest condition of the test sites and then monitor them as appropriate.

Shortly after harvest, another survey should be undertaken, structured along the lines of the pre-cut survey but including records of disturbance to the site. Then, depending on the qualities judged to be most important in providing summer habitat, subsequent monitoring is required. For example, if the availability of certain browse species is suspected as being a key quality determinant, then surveys of these species every two-three years may be appropriate. Monitoring should continue for 10-15 years, until either caribou begin to use the habitat or it becomes clear that the caribou will not use it.

6.Once sufficient data have been collected to assess the hypothesis, test it. Based on the results, modify the description of the process and modify the practice as required.

If the caribou do move into these sites and the anticipated habitat components were present as expected, then the hypothesis cannot be rejected. Based on this knowledge, the Model Forest may wish to perform subsequent experiments widen the number of stand types that can be harvested to produce summer habitat.

It may be that the caribou use these sites but the expected habitat features are absent. Alternatively, perhaps the expected habitat features are present but the caribou do not use the site. In either case, the wrong features were chosen to indicate habitat quality. In the former case, the Model Forest can revisit the site characteristics and identify other features or combinations of features that the caribou might be relying on. In the latter case, the original records should be revisited, along with data describing current caribou summer habitat.

Finally, perhaps neither the expected habitat features nor the caribou appear on the site. In this case, the prescription did not create the proper post-harvest conditions. This may call for a revision to the prescription or a choice of different site types, or a combination of the two measures.

7.If further experimentation is required, the process should be repeated using the revised hypothesis.

Throughout the process described above, monitoring is of critical importance. Monitoring provides the feedback that is used to evaluate the assumptions upon which the hypothesis is based. While it may seem an unduly expensive process, the cost of not monitoring is the loss of the ability to understand how actions affect forest elements. This reduces opportunities to correct problems in a timely manner before the negative impacts become very severe, which may be an important consideration in the caribou example. If it becomes evident early on that the expected key habitat elements will not appear, then the prescription can be modified or different types of stands can be cut. In either case, the manager may not have to wait 10-15 years to determine whether the harvest prescriptions failed, which could of great importance to efforts to maintain caribou.

***Recommendation**: The Model Forest should consider the use of Adaptive Management inspired processes for improving the understanding of forest management impacts on the forest. While many elements that are useful for adopting an Adaptive Management approach are already in place, what is required is an overall framework for integrating them to achieve the desired results.*

5.3 Recommendations

5.3.1 General Overview

This report has summarized the concept and underlying principles of ecosystem management, evaluated the progress to date in implementing EBM in the Model Forest, suggested some appropriate goals, and discussed some of the issues involved. The recommendations presented in section 5.2 have been expressed in general terms, since the manner in which they are to be implemented depends on many factors.

There are several research issues that underlie these recommendations which should be discussed before the recommendations are ranked. Perhaps the most important of these is the need for much more accurate and extensive baseline data in the Model Forest. The present forest inventory is generally insufficient for the purposes of ecosystem management, since the resolution of the age and cover information is excessively coarse. The Model Forest has developed a procedure for undertaking a new inventory and has tested it with general success on a number of townships. This process **must** be extended to cover the entire Model Forest. Further, the nature of the current inventory has also had the effect of suppressing investigations into the development patterns of the forest stands. This information is required to predict the vegetative outcome of different treatments on different sites. Without it, the quality of prescriptions will suffer and the Model Forest will lack the ability to test and evaluate potential prescriptions intended to meet the various objectives.

A similar need relates to information on the abundance and status of non-timber species and populations. This information is missing for all but a few of the commercially important wildlife species. (Although this point is related to the completion of the forest inventory as discussed above, it is repeated here to focus on the non-timber aspect of the inventory.) In this respect too, the Model Forest is in much the same position as many other forests. Again, however, the greater information needs of ecosystem management (as well as general trends in social responsibility) have rendered inadequate the set of knowledge needed to undertake traditional, timber-driven management. This need is particularly important for those species or populations which are included as indicators of the objectives.

Another glaring gap in the available data concerns the nature of general disturbances on the Model Forest, particularly fire. While occurrence data exist for present circumstances, there has been little investigation of the "natural" cycle of fire. These data should be integrated with harvest data to form an overall picture of the present disturbance regime and to form a better understanding of how our activities have altered the natural patterns. The disturbance pattern is complex, involving temporal and spatial components, as well as variances in intensity. An understanding of how the pattern varies by site and stand type would also be helpful. This is a tall order; there are few if any examples of forests where this entire body of data exists. However, in order to meet one of the primary goals of EBM (i.e. mimicking natural disturbance patterns), more work has to be done.

5.3.2 Priorities

In this section a number of broad priorities for action are identified which incorporate the recommendations made earlier. Some new recommendations, which are logical extensions of the priorities are noted here. Following each recommendation is an indication of the layer of EBM to which the recommendation corresponds.

Priority #1 ***Clarify the context for undertaking EBM on the Model Forest***. The two main aspects of this are resolving the area over which EBM is to be implemented, and developing a refined set of objectives and indicators. Depending on the perspectives of the stakeholders, resolving the issue of the area over which EBM is to be implemented may require an assessment of the potential impacts of implementing EBM. Such a study would provide a better understanding of the costs and gains from doing so, and will also help the Model Forest tailor the implementation in such a manner that will mitigate "negative" impacts where feasible. Such a study would also reveal which stakeholders are impacted in which manner.

Recommendation 1.1:The Model Forest should plan to begin a gradual process of implementing EBM on the entire Model Forest area. EBM can be implemented gradually and the Model Forest stakeholders can expand and adjust the mode of implementation as they gain experience and become more comfortable with it. **(CORE)**

Recommendation 1.2: The Model Forest should develop a refined set of objectives and indicators related to the goals of EBM adopted for the Model Forest. **(CORE)**

Recommendation 1.3: Before implementing EBM, it would be prudent for the Model Forest to attempt to estimate some of the short-term financial and social impacts of shifting the management approach. Such a study might alleviate some unfounded fears and it might also assist the Model Forest to revise its prescriptions somewhat should the severity of the impacts warrant.

Computer models are the most likely tool for undertaking such efforts, but the exercise will require significant resources for model selection and for data preparation. **(CONTEXT)**

Priority #2 ***Collection of baseline data and preparation of monitoring plans***. Assuming that the Model Forest proceeds with implementation, the next step is to begin improving some of the baseline data, particularly the forest inventory. Baseline data should also be collected for those variables or ecosystem elements identified as indicators, and those which are to be the focus of special management practices. Information on indicators will be necessary to allow for the monitoring of the results of the implementation.

Recommendation 2.1 Priorities for baseline data collection should be identified, and plans developed to collect the information. **(SHELL)**

Recommendation 2.2 The Model Forest should undertake an assessment of the type and prevalence of different forest ecosystems and compare these to estimated "natural" levels. This can be used as a basis for refining some quantitative objectives concerning forest ecosystem maintenance, for both common and uncommon ecosystem types. **(SHELL)**

Recommendation 2.3 Plans to monitor the indicators of progress towards meeting the objectives of EBM should be developed. **(SHELL).**

Priority #3 ***Confirm the use of Adaptive Management in implementing EBM.*** The collection of many baseline data will take a considerable amount of time and one cannot wait for it to be fully prepared before embarking on ecosystem management. Thus, the implementation of EBM will involve a great deal of learning and experimentation. This should be done in the spirit of Adaptive Management.

Recommendation 3.1 The Model Forest should consider the use of Adaptive Management inspired processes for improving the understanding of forest management impacts on the forest. Many elements that are useful for adopting an Adaptive Management approach are already in place, although an overall framework for integrating them to achieve the desired results is still required. **(SHELL)**

Priority #4 ***Increase the understanding of the natural disturbance regime, and integrate natural dynamics with harvesting systems and approaches.*** As implementation

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of EBM on the Model Forest will largely be based on emulating natural disturbances, a greater understanding of the dynamics of these disturbances is imperative.

Recommendation 4.1 The Model Forest should undertake to estimate the frequency of burns by burn size when the region was essentially unchanged by people. This should be compared against the current distribution of burns and clearcuts and a distribution of cutover sizes appropriate for EBM should be determined. **(CORE)**

Recommendation 4.2 The Model Forest should estimate the pre-logging fire return periods on upland and lowland sites and compare these to the rotations in use currently. If the return periods exceed the current rotations, these should be lengthened. Otherwise, the rotations could be shortened to bring them more in line with rates of disturbance frequency of burns by burn size when the region was essentially unchanged by people. **(CORE)**

Priority #5 ***Identify candidates for fine-filter management***. Fine-filter management will likely be necessary for some of the Model Forest's species. Management plans for these species should be developed, focussing on integration of species management with forest management.

Recommendation 5.1 Identify and rank a list of species within the Model Forest which are candidates for fine-filter management approaches. **(CORE)**

Recommendation 5.2 Management plans should be developed for high-priority fine-filter species. These management plans should focus on ways to integrate species management with forest and timber management. **(CORE)**

Priority #6 ***Identify modifications to present management practices, and implement appropriate new ones.*** Some of the present timber management practices on the Model Forest may need to be modified to be best suited for EBM.

Recommendation 6.1 The Model Forest should consider the appropriateness of using a broader range of partial cutting techniques on lowland areas. Doing so would permit the development of a greater diversity of stand types, maintain site conditions, and result in natural regeneration. However, the cost and wood supply implications should also be examined. **(CORE).**

Recommendation 6.2 The Model Forest should consider the application of the seed tree system to some proportion of upland areas, leaving white spruce to serve as seed trees and to provide vertical structure over the entire subsequent rotation. **(CORE)**

Recommendation 6.3 The Model Forest should investigate the implications of moving away from the use of a single rotation age for each cover type/site class combination. **(CORE)**

Recommendation 6.4 The Model Forest should begin to investigate the current role of herbicide use from an ecosystem perspective and begin to consider possible changes in their role. **(CORE)**

Priority #7 Develop programs to broaden the involvement of others in the Model Forest's implementation of EBM. Implementing EBM on the Model Forest will be facilitated by increasing the understanding of others in the initiative and nurturing their interest in it.

Recommendation 7.1 The Model Forest should develop an extension program to I) facilitate the involvement of agencies and organizations with interests and responsibilities for resource management, in implementing EBM, and ii) educate the public as to the goals, and intent of implementing EBM. These programs will likely grow and be tailored for specific aspects of EBM as the initiative develops. **(CORE)**

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