4.0 FOREST ECOSYSTEM MANAGEMENT

4.1 BACKGROUND CONCEPTS AND RATIONALE

4.1.1 ECOSYSTEM MANAGEMENT GOALS

In this document, "ecosystem management" means the careful and skillful use of ecological, economic, social and managerial principles in managing human activities within forest ecosystems to produce, restore, or sustain ecosystem integrity and desired conditions, uses, products and services over the long-term. The essential goals of ecosystem management are:

- ❑ Maintain biodiversity, productivity, structure and function of ecosystems within historical ranges of variability (see Sections 4.1.3, 4.2 & Glossary); and
- ❑ Maintain the optimum sustainable flow of renewable resource products and values to meet the current and future needs of society.

4.1.2 BASIC THEMES OF ECOSYSTEM MANAGEMENT

The following eleven themes capture the basic rationale for ecosystem management and characterize the initial components of the approach (Overbay 1992; Grumbine 1994).

1. Multiple use and sustained-yield management of lands and resources depends on sustaining the diversity and productivity of ecosystems at many geographic scales. A focus on any one level of the biodiversity hierarchy (e.g., genes, species, populations, stands, ecosystems, landscapes) is not sufficient. When working on a problem at any one level or scale, managers must seek the connections between all levels. In short, what is done at any scale will depend on what is known about all geographic scales.

2. Recognition of natural dynamics and complexity of ecosystems suggests future conditions are not perfectly predictable and that any ecosystem offers many options for uses, values, products, and services, all of which can change over time. Ecosystem management as envisioned here, requires maintenance of options for the benefit of future generations.

3. Descriptions of desired future conditions for ecosystems at various geographic scales should integrate ecological, economic and social considerations into practical statements that can guide management activities.

4. Management planning and actions must span sufficient periods of time to ensure maintenance of the evolutionary potentials of species and ecosystems.

5. Effective management requires working across administrative and political boundaries (i.e., forests, provincial parks, national parks) and defining ecological boundaries at appropriate scales. Coordination of plans and management actions is essential to the success of ecosystem management.

6. Ecological classifications, inventories, data management and analysis tools should be included in the integrated management of lands and resources.

7. Ecosystem management requires research and data collection (i.e., habitat inventory/classification, disturbance regime dynamics, baseline species and population assessment) as well as better management and use of existing data.

8. Monitoring and research should be integrated with management to continually improve the scientific basis of ecosystem management. Managers must track the result of their actions so that success or failure can be evaluated quantitatively. Monitoring creates an ongoing feedback loop of useful information.

9. Adaptive management will be employed. Adaptive management assumes that scientific knowledge is provisional and focuses on management as a learning process or continuous experiment where incorporating the results of previous actions allows managers to remain flexible and adapt to uncertainty.

10. Humans are an integral part of ecosystems. People cannot be separated from nature. Humans are fundamental influences on ecological patterns and processes, and are in turn affected by them.

11. Regardless of the role of scientific knowledge, human values play a dominant role in forming ecosystem management goals.

The design of an ecosystem management plan, its principles and objectives, could follow the steps outlined in Table 2.

Table 2: Possible Steps for Designing Ecosystem-Based Land Evaluation and Planning

Step	Explanation
1. Ecological Potentials	Describe the ecological potentials of the analysis area for meeting stated societal needs. Such descriptions must include the following items: a description of the range of conditions required to maintain long-term ecosystem sustainability, a description of current conditions, and a description of desired landscape conditions that achieve societal needs (i.e., complete vegetation surveys, determine sustainable AAC, conduct landscape analysis under different management scenarios, see Section 5.1.5).
2. Social Needs	Determine the desires and requirements of the people who will be influenced by the planning outcome (i.e., the local community meetings held by Alberta-Pacific at the initial stages of the project, see Sections 5.8 & 5.9).
3. Public Consultation	If desired landscape conditions fall outside the range of conditions that are required for long-term ecosystem sustainability, affected public needs to be informed of this fact. Public awareness of ecosystem potentials is critical to the development of achievable "desired future condition" strategies for land management (i.e., Forest Management Task Force, etc., see 5.8).
4. Implementation Design	Once a socially acceptable, sustainable vision of landscape conditions is achieved, it is then contrasted against available technology to determine if it can be implemented. Factors such as system design and equipment availability are considered to determine if it is technologically feasible to move the existing landscape to some desired set of conditions (i.e., harvest planning and scheduling, understorey protection, etc., see Sections 5.1 & 5.2).
5. Reality Check	Economic factors are also used to determine what parts of the stated human desires can be fulfilled. If resources (economic and technological) are not available to implement management of desired landscape conditions, affected public should be notified and alternative strategies developed. Avoid trading off long-term ecological and human values for short-term economic benefits.

4.1.3 MAINTAINING BIODIVERSITY

Biodiversity means, in its broadest sense, the variety among living organisms and the ecological complexes of which they are a part. This includes diversity within (genetic) and between species (number of species and structure of local ecosystem), and diversity of ecosystems across a landscape.

The biodiversity of all forest ecosystems changes over time (Kimmins 1991). A mature forest may change very slowly as individual trees die and create small gaps. Young, vigorously growing forests will change more quickly. Disturbances from forest fires, wind, and insect or disease, can cause rapid change, affecting small to extremely large forest areas. In the boreal forest, where these larger scale disturbances are common, species and ecosystem diversity undergo a continual change across the landscape.

The understanding and the approximation of natural disturbance processes (fire patterns, stand structure, succession) in forest management activities will act as a mechanism to conserve biodiversity. This approach to maintaining biodiversity suggests that by managing aggregates (e.g., communities, ecosystems and landscapes), the components (species, habitats) will be managed as well (Bourgeron and Jensen 1993). If a management strategy utilizes plant communities and natural disturbance processes at the landscape level, it is assumed that the associated species will be protected through time as a consequence of the persistence of plant communities, patterns and processes (Section 4.2).

Examining existing and past ecosystems will provide a means of assessing the historical range of variability of ecosystem characteristics. This will be useful as a baseline reference for assessing the present condition or health of existing ecosystems, and as a guide for implementing management practices that will maintain biodiversity.

4.1.4 SOCIETY'S NEEDS

People are an important part of forest ecosystems. They utilize and protect forests, influencing ecosystem processes in many ways. Society's values must play a dominant role in developing ecosystem management objectives. These values are diverse and often conflicting. They include industrial values in timber and access to oil and gas resources, wildlife, trapping, hunting, fishing, aesthetics, cultural, traditional use, spiritual, recreation, wilderness and other values. It is important to realize that sustaining these social values requires a management program that ensures the maintenance of biodiversity.

Ecosystem management, to properly reflect social values, requires the ongoing input and meaningful participation of concerned groups and individuals. Careful planning must be jointly undertaken to integrate and balance values across the whole of the landbase. Societal values can change in time and the planning process must be responsive to new needs.

4.2 COARSE FILTER APPROACH

Maintaining biodiversity is a primary goal in the implementation of ecosystem management on the FMA (Section 4.1.1). The basis for accomplishing this goal is a coarse filter approach to ecosystem management. This is a preventative approach to maintaining biodiversity (Hunter 1991). It assumes that maintaining vegetative communities and landscape patterns and processes (the coarse filter) within the limits of natural variability will result in the maintenance of the full complement of native plant and animal species (both seen and unseen, known and unknown). In a coarse filter approach, timber harvesting must be designed to regenerate the diversity of structure and vegetation within forest stands, and the patterns of forest stands on the landscape that could be found in natural (fire) disturbance regimes. Maintaining these critical features of the forest will provide the variety of habitats needed to support the diversity of living organisms found under the diversity of natural (fire) disturbance regimes.

The implementation of the coarse filter approach, however, is new. Although supported by research and current understanding of boreal forest ecosystems, there are many uncertainties with regard to our knowledge of biodiversity and natural disturbances, and how coarse filter harvesting strategies might affect biodiversity differently than natural disturbances. Therefore, the FMA Holder will implement a monitoring program (Section 7.0) that will focus on "indicator species" to identify species groups that may be adversely affected by harvesting strategies. This indicator species specific work (Fine Filter, Section 4.3) will supplement the coarse filter approach; providing a basis for possible modifications to harvesting strategies and improved management of sensitive species.

4.2.1 NATURAL PROCESSES

Many natural processes operate in the boreal forest. These processes include natural selection, nutrient exchange, decomposition, photosynthesis, and disturbance. Among disturbance processes, the effects of fire are probably the most significant. Fire has been the dominant natural disturbance in the boreal mixedwood ecosystem for the past several thousand years. Fire affects species composition, and processes such as snag production and decline, decay of coarse woody debris, short and long-term nutrient exchange and energy flow.

Plant succession is the companion process to fire. Succession is the natural process which initiates the development of structure, complexity, and diversity in stands. The entire process of stand removal and regeneration is highly dynamic. In many cases, successional changes that are initiated following logging appear to be similar to those that follow fire (Ehnes and Shay 1995).

4.2.2 PATTERNS AND STRUCTURE

Pattern at the landscape level (stand adjacency, juxtaposition, fragmentation, connectivity, etc.) is a key element of diversity. The boreal mixedwood forest maintains much of its complexity because of the pattern of stands created by fire. Pattern can exist at a variety of scales: at larger landscape levels, between stands (age, species and site differences); and at a smaller scale, within stands (species composition and structure).

Structure at the stand level is an important determinant of biodiversity. Stand structure is directly related to natural succession. Young stands, regenerating after a fire, will have extensive snags and a continuing supply of coarse woody debris. Mid-successional stands (older, immature) generally will have high canopy closure, low understorey production and a reduced number of snags. Late-successional stands (mature to overmature) contain openings in the canopy, greater understorey shrub and forb production, and increasing amounts of snags and coarse woody debris. These old age stands exhibit the greatest structure (lateral and vertical) because of more coarse woody material, standing dead material and gaps in the canopy.

4.2.3 DISTURBANCE REGIMES (FIRE)

Fire in the boreal mixedwood can be characterized by three factors: frequency of occurrence, severity or intensity, and variation in the size of the disturbance created. In respect to frequency, the return interval for fire in the boreal mixedwood forest is approximately 38–40 years (Murphy 1985); this varies with species composition and site characteristics. For instance, stands on north-facing slopes of large river valleys (such as along the Athabasca River) may burn less frequently (however, when they do burn it often creates larger fires due to higher fuel loads).

In terms of severity or intensity, most large fires are intense, stand-replacing fires. Partial burns (underburns) may occur on all sites, but are most likely to be prevalent in aspen and mixedwood forests. Nevertheless, all fires leave some residual material in the form of snags, live trees, and unburned patches. Stand structure is completely altered by stand-replacing fires.

The size of fire-origin stands range from less than one hectare to hundreds of thousands of hectares, with more small ones than large ones. Frequency distributions may differ with site conditions and species composition. Aspen and mixedwood stands may have a higher proportion of smaller fires. Xeric pine sites and black spruce sites may have larger disturbances due to low fuel moisture and the density and distribution of fuel loads.

4.2.4 BASELINE MEASURES OF NATURAL VARIABILITY

A key requirement for forest ecosystem management is to identify and measure the structure and pattern of vegetation cover within representative forest types that have been largely unaffected by man (with the exception of fire suppression). Ecological land classification and mapping provides a framework for evaluating the vegetative characteristics and potentials of land areas at different scales. Province-wide classification and mapping of ecological regions, subregions and districts should provide an initial framework for evaluating the range of natural variability in vegetative cover on the FMA (Alberta Environmental Protection 1994; Strong 1992). Additional landscape stratification within these broad provincial frameworks will be needed to provide baseline measures of sufficient reliability and geographic focus to guide forest harvest plans (Section 5.1.4).

FOREST ECOSYSTEM CLASSIFICATION FOR NORTHERN ALBERTA

Ecosystems are complex and evolving systems with the flow of energy and matter determined by the interaction of climate, landforms, topography, water, soils, vegetation and animals. Ecosystem classification allows the organization of current understanding about ecosystem function. This organization is achieved by grouping field research plot data into similar units that respond to disturbance in a predictable and similar manner.

Recent ecosystem classification work completed in northern Alberta provides both a regional and site-specific framework for making forestland management interpretations (Beckingham 1994). At the regional level, the province has been divided into Natural Regions and Subregions (Section 3.1). Over 80% of the FMA falls within the Central Mixedwood Subregion. At the site specific level, a handbook has recently been developed by Environmental Protection for field classifying plant community associations and ecological land types (Ecosites and Ecosite Phases), within the Natural Regions and Subregions of Alberta (Alberta Environmental Protection 1994). This site classification will be used for prescribing forest harvesting and silvicultural activities that are best suited to the character of a site.

ECOLOGICAL LAND SURVEY

The structure, function and diversity of landscape-level ecosystems are influenced, first and foremost, by regional climate and topography. Variations in the physical environment, limiting factors, and periodic disturbances (natural and manmade), will determine the spatial patterns and temporal changes observed in plant and animal communities through time.

Ecological land survey (ELS) provides a useful framework for classifying, mapping and evaluating ecosystems. Table 3 outlines a five-level spatial hierarchy of organization for ecological systems. This hierarchy provides a framework for evaluating the ecological characteristics and capabilities of land areas at different scales. This framework is useful for identifying socio-economic considerations and resource management objectives/issues.

ELS provides a means to identify landscape units that have distinct physical characteristics that affect plant and animal life. These land units are delineated on the basis of relatively enduring landscape features (e.g., landforms, aquatic features, soils, potential vegetation) that do not change appreciably in response to disturbances such as fire and commercial resource extraction. Such units provide a workable framework for evaluating more dynamic or changeable landscape features, including the following:

- pattern and diversity of vegetative cover;
- changes in the pattern of vegetation cover over time in response to disturbance (fire, logging, insects, disease, blowdown) and natural succession;
- fire regimes (size, intensity, severity, frequency and season);
- flood regimes; and
- habitat suitability/capability for various wildlife species.

Landscape units distinguish biophysical features, including patterns of vegetation that are significantly different from adjacent units. This variation is due to differences in physical factors such as landform, aspect, elevation, rainfall pattern, evapotranspiration and soil moisture, as well as natural disturbance regimes (wind, fire and insect outbreaks). Province-wide classification and mapping of ecological regions, subregions and districts provide a good initial framework for evaluating ranges of natural variability of regional landscapes in the FMA (Alberta Environmental Protection 1994; Strong 1992). Additional landscape stratification within these broad provincial frameworks will be needed to effectively sample and measure baseline indices of natural variability and develop meaningful ecologically based subdivisions for managing harvest and silviculture activities.

Table 3: A Multi-Level (hierarchical) Perspective for Ecosystem Management

Level of Organization	Map Scale	Land Unit Size	Ecological Perspective	Ecosystem Features	Resource Management Issues
PROVINCIAL (e.g., natural regions & subregions of Alberta)	1:1 000 000 to 1:2 500 000	> 2,500 km^2	coarse filter	▪ broad climate patterns ▪ major physiographic and topographic features ▪ soil zones ▪ faunal life zones ▪ potential natural vegetation ▪ landscape-level biodiversity	▪ provincial land use and economic development strategies/policies ▪ climate change ▪ sustainable resource use
REGIONAL (e.g., ecodistricts)	1:250 000 to 1:1 000 000	250 km^2 to 2,500 km^2	coarse filter	▪ regional climate and soils ▪ regional topographic and landform wetland features ▪ broad patterns of vegetation structure and form ▪ regional distribution of plant and animal communities ▪ major disturbances (e.g., fire)	▪ regional land use planning and development opportunities ▪ resource production potentials and limitations (sustainability) ▪ regional socio-economic needs and resource development objectives ▪ regional/widespread pollution
SUBREGIONAL (LANDSCAPE) (e.g., ecosections)	1:50 000 to 1:250 000	25 km^2 to 250 km^2	coarse and fine filter	▪ mesoclimate and subregional topography and landforms ▪ vegetation cover types/patterns ▪ distribution and abundance of larger vertebrate species ▪ aquatic systems; lakes and rivers ▪ community-level biodiversity	▪ current status/inventory of ecosystem components and selected biological resources ▪ integrated resource planning and allocation of resource use opportunities ▪ community level socio-economic needs and issues
LOCAL (LANDSCAPE) (e.g., ecosites)	1:5 000 to 1:50 000	1 km^2 to 50 km^2	coarse and fine filter	▪ species composition of plant and animal communities ▪ distribution, growth and productivity of individual plant and animal species ▪ population genotype biodiversity	▪ operational planning and management of resource use ▪ regulation of resource use at the population/stand level ▪ operating ground rules
SITE SPECIFIC (STAND) (e.g., ecotypes)	<1:5 000	<5 km^2	coarse and fine filter	▪ distribution, growth and productivity of local populations and individuals ▪ site productivity assessments	▪ enhanced species/population management ▪ silviculture ▪ wildlife habitat development

STAND AND LANDSCAPE MEASURES

Baseline measures will include a measure of different patches of vegetation types (i.e., forest stands) by size, shape and age (or height). These are features that can be readily managed for and influenced by forest harvesting practices. Measures comparing natural disturbances to various harvest systems are being made using the Fragstats model. Stand adjacency, connectivity and dispersion pattern (clumped vs. uniform) may be important measures that reflect arrangements of different habitat types required for certain types of wildlife. Currently, the Alberta Phase 3 Forest Inventory provides the information for this type of analysis. The FMA Holder is completing a new, more detailed inventory to Alberta Vegetation Inventory (AVI) standards that will enhance the ability to evaluate distribution of vegetation (Section 5.1.3).

Distributions of Phase 3 forest cover types by stand size and age within the FMA area are summarized in Figures 7 and 8. These distributions reflect a history of disturbances involving intense, stand-replacing fires of highly variable size and frequency.

Identification of patterns produced by historical disturbance regimes has focused on mesic aspen and mixedwood sites. Although this is the merchantable component of the ecosystem, the FMA area is composed of approximately 50% non-merchantable landbase. This area varies from large continuous wetland units to highly variable upland-wetland complexes. This non-merchantable variability undoubtedly contributes significantly to biodiversity and connectivity among ecological units (e.g., riparian corridors). Identification, measurement and clarification of the role of this portion of the landbase in maintaining biodiversity and landscape pattern will be an essential part of forest ecosystem management.

Research is a vital part of establishing baseline measures that can effectively guide ecosystem management on the FMA area. There is extensive research underway and plans that will provide further baseline measurements of natural diversity in plant and animal communities. Projects include studies of biodiversity in aspen stands, landscape level fire/vegetation modeling, stream surveys and studies of individual species. Section 6 describes the research program being undertaken on the FMA area.

Protected areas may provide baseline areas for ongoing research and comparison with managed areas through time. Protected area discussion and the evaluation of specific proposals are presented in Section 5.4.

Figure 7: Age Class Distribution in Productive Forest Types

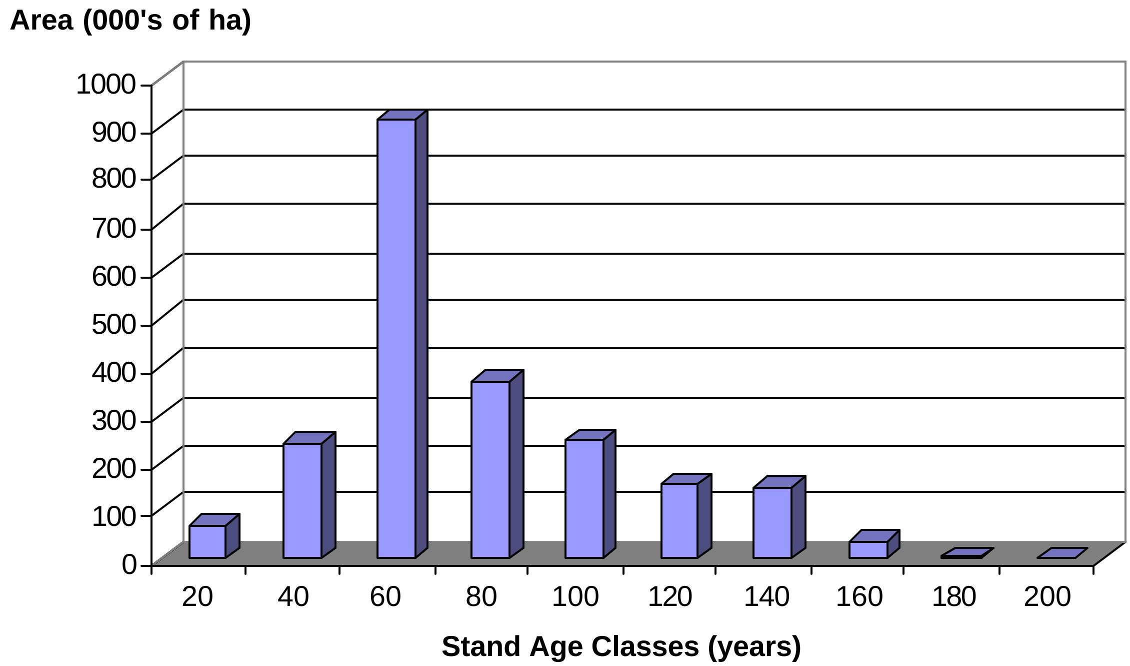
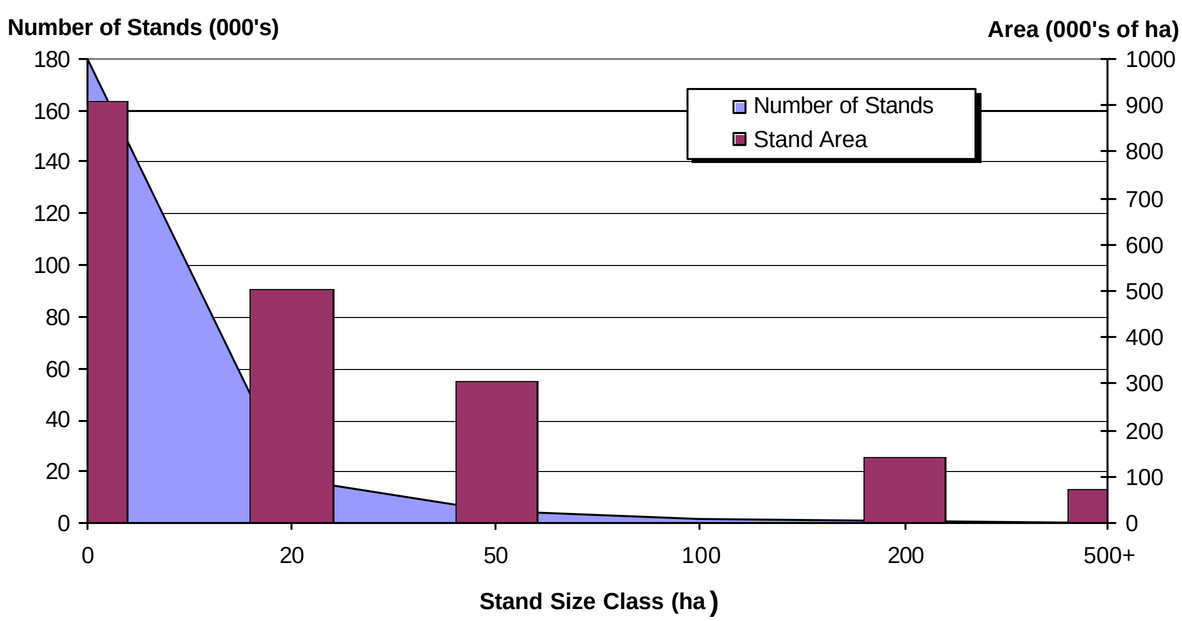


Figure 8 - Stand Size Distribution in Productive Forest Types



4.2.5 EFFECTS OF CONVENTIONAL FOREST HARVESTING

Forest harvesting often falls outside the range of disturbances naturally occurring in a forest, particularly in terms of the size and shape, severity, and frequency of disturbances. In Alberta, typically the required harvesting system, clearcut patches of similar size and shape, results in a landscape with a uniform quilt-like pattern of cut and uncut areas (see Section 1.3 for background). When this type of harvest regime is applied over large areas, it reduces the natural variability in landscape and vegetation patterns and has the potential to reduce the biodiversity of a region. Fragmentation of the natural forest matrix also reduces the availability of interior forest habitats, leading to an increase in abundance of those organisms associated with forest edges and a decrease in those requiring large intact tracts of interior forest habitat.

Current harvesting ground rules, utilization standards and safety regulations generally require that most standing live and dead trees be removed from the sites (although in mixedwood stands it was common for the deciduous trees to be left standing when there was no market for them). Silviculture standards and practices have the objective of regenerating these sites into stands that are relatively uniform in terms of tree species, age, size and spacing. Such stands do not have the range of diversity found in natural stands, where multi-layered canopies, diverse tree sizes, abundant snags and fallen trees are common. Biodiversity within stands therefore tends to be reduced by current practices.

Conventional forest management also attempts to maintain maximum fibre production from the available productive landbase. To accomplish this, all forest stands would be harvested before their average growth rate slows down. Eventually, after all stands are brought into rotation, there would be an absence of old (120+ years) stands in the productive landbase (with the exception of creek buffers and other reserve areas). This would have an adverse affect on species that require the greater structural diversity of older forest types.

4.2.6 ECOSYSTEM MANAGEMENT APPROACHES TO FOREST HARVEST

Harvesting, following an ecosystem management approach, should approximate the historical structure and pattern of vegetation at the regional, landscape and stand levels. Logging of aspen and coniferous timber is designed to create effects similar to those of natural fire, with respect to patch size, age, and stand structure, as well as landscape pattern. The coarse-filter approach (Section 4.2) assumes that biodiversity will be maintained if landscape and stand patterns, and processes are maintained. Patches are cut following natural stand boundaries and stand types, so that natural patch size, shape, and landscape patterns are perpetuated. Fragmentation will not be increased and, with patches of various sizes, interior habitat is kept intact. Constraints on cutblock size must be recognized (i.e., public perception of large cuts); however, there will be an increase in variation of patch size and shape that should approach the naturally existing variation on the landscape.

At the stand level, fine and coarse woody debris, residual conifers, shrubs, snags, layered components of aspen, individual trees and/or clumps of single species or mixed stands can be left within harvested blocks. This leave material emulates the gaps, skips, and standing dead trees that are left after fire passes through a stand. As harvested sites regenerate and grow through successional stages, the leave material on each site adds structure and complexity to the stand, and will ultimately produce natural gaps in the canopy (by residual trees aging and dying), prior to the next rotational cut. In addition, the leaving of conifer within harvested aspen stands will help the forest retain its natural mixedwood character, and not become a simplified, stratified landscape (understorey protection and alternative silviculture systems will be important in maintaining conifer; see Sections 5.2.3 and 6.2).

Several technical and social issues must be addressed when using ranges of natural variability as the basis for ecosystem management (Swanson et al., 1993). Such issues include: limits to our abilities to interpret past ecosystem variability; effects of management measures (such as fire suppression) on ranges of natural variability; and gaps between the state of naturally occurring ecosystems of the past and desired future conditions (i.e., large fires vs. socially acceptable limits to harvest areas, Table 3 in Section 4.2.4).

4.3 FINE FILTER SITE LEVEL ISSUES

Biological research and management have traditionally focused on individual species and their relationship to their habitat. The extension of this species level thinking to biodiversity and ecosystem management is called the fine filter approach. The application of this approach would involve collecting and using extensive knowledge of all the organisms in the affected ecosystems to design forest management activities that would maintain biodiversity. Realistically, it is not feasible to study and understand all of the species in our forests. The fine filter approach instead assumes that a smaller number of “indicator species” will represent the full spectrum of organisms present. Research, management and monitoring then focuses on this select group of species.

It is generally felt that ecosystem management based entirely on a fine filter approach is unlikely to succeed. A multitude of individual species and habitats would require detailed and costly scientific analysis. Then, even if all the necessary information could be collected, what decision criteria would be used to manage the conflicting and very complex needs of individual species? What species would be favoured and where? For these reasons, ecosystem management must follow a coarse filter approach (Section 4.2) augmented, where required, by fine filter strategies. Fine filter strategies will be utilized where there are species at risk (Section 5.3.2) and as part of an overall monitoring program (Section 7.0). From a social perspective it might be desirable to develop fine filter approaches for species not considered to be at risk, provided they are developed within the scope of an overall ecological management plan.

The following sections provide background information for species or species groups and identify some general species level concerns relevant to ecosystem implementation (Section 5.0).

4.3.1 MIXEDWOOD MANAGEMENT

The boreal mixedwood forests are characterized by deciduous and coniferous trees growing both in mixed and relatively pure stands. The wetter forest sites are dominated by coniferous stands, whereas the well-drained, productive (mesic) sites support “mixedwood” stands ranging from pure deciduous to pure coniferous, but usually containing varying mixtures of both tree types.

In mixedwood stands, frequent disturbances from fire or logging will favour deciduous trees because they are very successful at establishing themselves on disturbed sites. The coniferous component of mixedwood stands, white spruce and fir, more typically establishes itself under deciduous stands and grows up through the canopy as gaps develop. If the stand remains undisturbed, the deciduous component will be replaced by conifers and become a climax (self-replacing) stand of spruce or fir.

Harvesting mixedwood forests will encourage deciduous trees to predominate unless special attention is given to maintaining the coniferous component. Appendix C of the Forest Management Agreement and the Timber Management Regulation address this concern by:

- the division of the FMA area into landbases to be managed for either deciduous or coniferous production through the reforestation standards;
- requiring the FMA Holder replace, by reforestation, the coniferous growth potential of conifer timber harvested from the deciduous landbase (Section 5.2.3.3); and
- requiring that damage to coniferous understoreys during logging be minimized.

The landbases are designated by the forest cover classification of each stand and vary by Forest Management Unit (FMU) (see Appendix C of Agreement). Alberta's Phase 3 Forest Inventory was the initial basis for the designation. This is being replaced by the Alberta Vegetation Inventory as it becomes available (Section 5.1.3).

There is concern that managing mixedwood forests by landbase will in time "unmix the mixedwood" into deciduous and coniferous stands. Such a development would be undesirable as it would reduce biodiversity. Recent surveys of old cutblocks indicate that this unmixing is not taking place due to the dynamic nature of the forests and the extensive form of forest management being implemented (i.e., there is little in the way of weeding or stand tending). However, the FMA Holder in cooperation with Quota Holders is proposing:

- methods to encourage more mixedwood under the current system (Section 5.2.3);
- examination of alternative silviculture systems that encourage conifer and deciduous regeneration (Section 5.2.4.2); and
- to pursue alternatives to the divided landbase system in the future.

4.3.2 AQUATIC RESOURCES

The mixedwood boreal forest is characterized by low relief and a relatively arid climate. Lakes and streams in this region tend to be isolated due to the lack of flowing water, and complicated by the important role of groundwater. Water quality in the region is variable, but the tendency is towards eutrophic (nutrient rich) systems. Soils are relatively phosphorus-rich; and thus runoff and groundwater also tends to be rich in phosphorus. This situation is compounded by the fact that bottom sediments found in this area do not bind phosphorus.

All levels of the aquatic food chain can be influenced by the naturally high phosphorus content, including phytoplankton (where more phosphorus results in more potentially toxic cyanobacteria and in general, more photoplankton - lake greeners), aquatic weeds or macrophytes and aquatic invertebrate and vertebrate communities (species composition and structure). Increased nutrient content can also lead to summer and winter kill of vertebrates. Further, because many lakes have no permanent inflows or outflows the number of species of vertebrates and larger invertebrates (such as myseds and crayfish) is relatively small.

Presently there is little information on the effect of land use and clearing activities on aquatic ecosystems in the mixedwood boreal forest, and relatively little is known about aquatic communities in the region. Research is currently underway to look at new ways of managing aquatic systems (Section 6.1.1). There are two projects to increase our knowledge in this area:

1. Sandra Cooke, University of Alberta MSc (1996) quantified the effect of agriculture on nutrient loading (phosphorus, nitrogen and carbon) in small forested and cleared streams in the Baptiste Lake drainage basin; and

2. The Terrestrial and Riparian Organisms, Lakes and Streams (TROLS) study which involves a group of 12 researchers studying the effect of riparian buffer width (up to 800 m) on terrestrial and aquatic communities. This five-year program is focused on aspen dominated (>60%) stands surrounding 12 lakes and 12 streams (Section 6.1.1). TROLS will provide a basis for understanding the effect of logging on nutrients, water input and aquatic food chains, in aspen-dominated stands.

4.3.3 FOREST BIRDS

Birds constitute 72% of all vertebrate species in the FMA. Among vertebrates, birds generally exhibit the greatest degree of specialization relative to environmental diversity. The avifauna within any geographic area consists of species suited to the various niches presented by that environment. Because of its characteristically complex mosaic pattern of stand age, species composition, and structure, the boreal mixedwood (and its associated wetlands within the FMA) offers a diverse array of habitat niches that provide the breeding habitat for 190 species of birds (30 resident and 160 migratory). An additional 43 species (7 in winter and 36 in summer) use the area for foraging and staging during annual migration to and from arctic nesting grounds. Forty-eight of the breeding species are associated with lakes and wetlands, while the remaining bird species nest and forage in a wide variety of upland situations.

SOCIAL/ECONOMIC VALUES

Bird life in the western boreal forest is the richest north of Mexico (Robbin et al., 1986). This has been an important factor contributing to the attractiveness of the area for bird viewing. Outdoor recreational activities using birds as a focus are expected to increase substantially in the future. The regulated hunting of game birds provides highly valued recreational opportunities and contributes to local and regional economies. Subsistence hunting continues to contribute to the traditional lifestyles of Aboriginal communities in the area. There are about 22 species of geese, ducks and grouse that are hunted in the FMA area. The populations of grouse species (ruffed, spruce, sharptail) follow natural fluctuations and provide substantial hunting opportunity during years when numbers are high.

ECOLOGICAL SIGNIFICANCE

One of the most significant aspects of birds on the FMA is their migratory pattern. Breeding birds of the FMA fall into three groups: permanent residents, short-distance migrants, and long-distance migrants. Short-distance migrants winter mainly in the United States, many long-distance migrants winter in the neotropics.

A recent assessment of population trends from 1966 to 1992 in North American woodland bird species (Peterjohn and Sauer 1994) indicated that the portion of “increasing” species outnumbered “decreasing” species. However, since 1982 the portion of “decreasing” species has significantly increased. This trend was most apparent in the group of species termed neotropical migrants.

Populations of short-distance migrants appear to have fared reasonably well relative to influences on their wintering areas. However, there are declining population trends in long-distance neotropical migrants and these birds have been subjected to considerable research (Diamond 1986; Harris 1984; Lynch and Whigham 1984; Opdam 1991; Robbins 1979; Wilcove 1985; Whitcomb 1977). The studies suggest that declines are related to:

- loss of wintering habitat as a result of forest clearing in Latin American countries, especially in Central America; and
- loss and/or fragmentation of habitat on the breeding range as a result of agricultural and urban developments and logging in more northern forested areas.

Increased forest fragmentation may result in lower survival of many neoptropical migrant species by increasing exposure to and enhancing the efficiency of crows, magpies, and other predators. In addition, reproductive capacity of many neotropical migrants declines as a result of increased ability of brown-headed cowbirds to locate nests in fragmented forests and parasitize the clutch. Sustainable populations of area-sensitive, “forest interior” species may require the maintenance of relatively large, contiguous blocks of mature mixedwood forest that are interconnected to facilitate colonization of newly developing stands.

Neotropical migrants also include a number of species that cope with varying degrees of forest fragmentation. In addition, many short distance migrants as well as resident species have the same dichotomy of habitat selection.

Research on population trends of forest birds (Lynch and Whigham 1984; Whitcomb 1977; Aubrey 1990) indicates that a number of the negative effects of forest fragmentation on area-sensitive species can be partially offset by providing greater diversity in plant species and structure. For example, they found the presence or absence of sufficient snags and other structures after forest removal greatly influenced the resulting avifaunal diversity in developing forests.

A significant portion of North American birdlife depends on the mixedwood forest of the FMA for nesting habitat. The wide variety of habitat situations required to maintain this diversity of birdlife presents a challenge to forest managers. An effective bird monitoring program will, however, provide managers with a sensitive measure of forest health and vitality.

In order to maintain substantial bird species diversity within a logging regime, attention must be focused on the essential elements of habitat that each species requires. There are three important aspects to consider relative to maintaining bird habitat. These are: food type and abundance; nest site quality and availability; and habitat area sensitivity.

Of the various development stages of forests, the newly generating mixedwood forests and those that have reached or passed maturity, contain the most complex structure and therefore provide the greatest diversity of habitat niches for birds (Stelfox 1995). There is a direct relationship between complexity of vertical and horizontal structure within stands and the number of niches provided and hence the number of bird species supported. Structure in naturally occurring boreal forest stands largely results from the nature of the forest type that preceded the disturbance (usually wildfire) which began successional development, and the timing and intensity of the disturbance (again, usually fire). To provide the variety of internal forest stand structure required by the existing complement of birds, it is necessary in the design of harvesting to duplicate as closely as possible the structural diversity and pattern found in naturally occurring stands created by the natural wildfire regime.

To address the aspect of habitat area sensitivity, birds can be categorized relative to the forest growth types they occupy. Six categories are recognized in the FMA. They are: relatively contiguous mature/old age class forest (44 species, many of which are subjected to predation and nest parasitism from brown-headed cowbirds if their contiguous habitat becomes fragmented); relatively fragmented mature/old age class forest (36 species); young or immature forests (31 species); recent burns or clearcuts (15 species); aquatic areas (14 species); and other specialized habitats (8 species).

Within a traditional logging regime, utilizing small patch clearcuts and limiting the occurrence of older age classes, it would be difficult to provide the variety of forest types and stand sizes required to support existing bird diversity. To meet these requirements and retain the present degree of biodiversity in the FMA, it is desirable to implement a harvesting regime that provides a wide variety of cutblock sizes and shapes as well as residual material (live trees, snags, downed wood).

4.3.4 FURBEARERS

In the boreal mixedwood forest, trapping of furbearers is traditionally of economic and social value. Many of the 392 traplines found within the FMA provide the trapper with a supplementary income as well as a traditional lifestyle.

The 15 species of furbearers found throughout the FMA have very diverse habitat requirements and timber harvesting will influence different species to varying degrees.

Aquatic or riparian species such as beaver, otter, mink and muskrat likely will not be affected by logging under existing ground rules, as their habitat is protected by buffer zones.

Wolf, coyote, lynx, fox and weasel could all benefit from the young stands that develop as a result of logging. These benefits result from the increased abundance of their prey (i.e., snowshoe hare, ruffed grouse and mice), most of which are associated with young stands. The larger furbearers, especially wolf, may also benefit from the anticipated increased abundance of moose and deer browsing in young aspen stands.

Red squirrels are dependent on conifer cone crops and fungal fruiting bodies. Retention of conifer understorey will help maintain a future cone supply and retention of structure within the blocks should lead to a persistence of fungi.

Species such as fisher, marten and wolverine are of special concern because of their close association and apparent preference for structurally complex “old” stands and their susceptibility to over-harvest associated with incidental catches. Ongoing research is providing some answers on how habitat of these sensitive furbearers can be maintained or improved within cutblocks and over the landscape (distribution of cutblocks).

The preferred habitat of fisher is heavily forested areas with an extensive coniferous component. Fisher have a large home range of approximately 8-10 km^2 and fragmentation of habitat (i.e., coniferous stands surrounded by cutblocks) might have a negative influence on fisher populations. On the other hand, fisher are known to be quite adaptable and will inhabit a wide variety of habitat types if the food supply is adequate. Increased small mammal abundance in cutblocks, retention of snags and downed logs for hunting cover and denning sites might benefit fisher populations and could lead to utilization of structured cutblocks (Hessey and Racey 1989). Logging in dispersed patterns with cutblocks of varying sizes should aid in maintaining the fisher populations, as it will more closely approximate natural landscape patterns.

Marten are thought to be dependent on mature forests. Timber harvesting that reverts the forest to an earlier successional stage might reduce marten populations by altering their food supply and habitat, leading to decreased reproduction, increased home range size and increased dispersal (Hessey and Racey 1989). Like fisher, logging of aspen dominated stands will not directly change marten habitat, but will influence it due to fragmentation and edge effects. However, increased prey availability in the cutblocks, as well as retention of mature timber, downed logs, large diameter snags and small piles of tops and limbs should increase their utilization of cutblocks.

Wolverine are present in the FMA in stable but very low densities. Wolverine prefer remote areas as they are very sensitive to disturbance (Whitman et al., 1986). However, since less than 1% of the FMA is harvested per year, most of the FMA is left undisturbed and should easily support the naturally small population of wolverine.

Improved access may allow the trapper to work areas of the trapline previously untrapped. Trapper education and closure of temporary haul roads are both important components of furbearer management.

Research on the influence of logging on these sensitive furbearers, will continue to improve our understanding and provide answers on how to minimize the negative effects of timber harvesting on them.

4.3.5 UNGULATE SPECIES

The ungulates found within the FMA include moose, woodland caribou, white-tailed deer, mule deer, elk and bison. These animals attract special management attention for several reasons:

- they are among the most sought-after wildlife for viewing purposes;
- they are the primary focus for hunting, both subsistence and recreational;
- to a certain degree, large-bodied mammals can be indicators of important ecological conditions, such as habitat fragmentation at larger scales; and
- their populations are easier to monitor than many other wildlife species.

4.3.5.1 MOOSE

The primary factor determining moose population levels throughout North America is related to the quantity, quality, and availability of food, which consists largely of woody browse of a variety of plant species (Franzmann 1978; Gasaway and Coady 1974; Nowlin 1976). In northeastern Alberta moose are under significant influence from three additional limiting factors; predation by wolves and black bear, recreational and subsistence hunting, and periodic winter tick infestations.

Moose are a pioneer species well suited to sites where forest succession has been set back by fire or logging, creating luxuriant shrub production. They have therefore been relatively easy to accommodate within logging regimes (Stelfox et al., 1976; Usher 1978). Colonization rate and efficient use of burned or logged areas by moose is influenced by the time: since disturbance and the type, amount and proximity of thermal and security cover. The proximity of wetlands, riparian areas and topographic relief are important in providing seasonal food and thermal cover requirements. The optimal moose habitat occurs where sufficient forest cover has been retained to maintain connectivity among important habitat features (thermal and security cover, shrubland or newly generating forests, wetlands, and riparian zones) (Eastmann and Ritcey 1987; Franzmann 1978; Fuller and Keith 1980; Nowlin 1976; Telfer 1988).

Effects on moose populations from periodic tick infestations are not well documented (Glines and Samual 1989); however, investigations in Elk Island National Park, indicate that ticks have the potential to significantly suppress moose numbers (Glines and Samual 1989).

Several researchers have documented the direct loss of up to 50% of neonatal calves where the ranges of black bear and/or grizzly bear overlap with moose (Crete and Jolicoeur 1987; Franzmann 1980; Hauge and Keith 1981; Horjeski and Hornbeck 1987; Larsen 1989; Stewart et al., 1985). Most North American moose populations are influenced by wolf predation; however, the effect of this mortality factor as a control or limit to moose population growth is highly variable (Gauthier and Therberge 1987). Generally speaking, areas of better habitat will support higher moose densities. Franzmann (l978), concluded that moose occupying high quality habitat exhibited relatively high calf production and could readily absorb mortality caused by predation, disease, and severe weather. On the other hand, moose in low quality habitat exhibited relatively low calf production and were generally limited by those mortality factors. It is also possible for a moose population that has been "temporarily" reduced by some mortality factor (disease outbreak or bad weather) to be kept well below its potential because of continuing high mortality (usually some combination of predation and hunting). Hauge and Keith (1980), found that moose in northeastern Alberta were limited well below the food carrying capacity of their habitat by a combination of bear and wolf predation and hunting.

SOCIAL/ECONOMIC VALUES

Moose occur throughout the FMA. Their 1993-94 winter population was estimated to be near 11,000. Winter densities vary from $0.09/km^2$ in the conifer dominated areas to $0.45/km^2$ in the southern, more mesic mixedwood cover types.

Moose are likely the most valued wildlife species in the FMA. They are the most important focus of native subsistence hunting throughout the boreal forest, and provide a great deal in terms of meat and raw materials for clothing, crafts and other articles. This historic relationship is the basis for strong cultural and spiritual associations with moose.

Non-native people also place special value on moose. In practical terms, moose have high viewing value, and considerable value related to recreational hunting (including meat, hides, recreation, employment in the guiding, outfitting and retailing businesses).

Recreational hunters presently harvest about 550 moose per year (about 5% / year, primarily antlered males over most of the FMA; Alberta Natural Resources Service Hunter Harvest Questionnaire). Native subsistence harvest is poorly documented, but thought to be about 450 moose per year (Alberta Fish and Wildlife).

MOOSE POPULATION MANAGEMENT

Timber harvest will be managed on a sustainable basis, maintaining habitat that could support the density, distribution, and number of moose within the range of historic levels (approximately 1970 to present). Timber harvest that seeks to approximate natural patterns of stand age, stand structure, stand size and connectivity should accommodate moose quite favourably. Often forest companies in conjunction with wildlife agencies develop harvest plans to maximize moose habitat because of consumptive-user demand for moose hunting opportunities, and nonconsumptive-user demand for moose viewing opportunities. These harvest strategies often result in landscape patterns that can be quite different from natural landscape patterns. In most cases, timber harvest planning for moose results in a more fragmented forest and potentially more of the landscape in a younger age class. This type of landscape, though potentially beneficial for moose and other ungulates, may have adverse effects on other plant and animal species that prefer old age classes and large forest stands. Therefore, any harvest plans developed with the intent to maximize moose numbers will be carefully evaluated to ensure that consequences to other forest ecosystem values are recognized.

Management of moose populations and control of human-caused moose mortality is not the direct responsibility of forest managers. However, creation of young forest stands and increased human presence associated with logged areas present a number of opportunities for increasing moose numbers and managing hunter harvest of moose. In conjunction with Alberta Natural Resources Service (ANRS), local communities and stakeholders, specific local management plans may be developed to ensure hunting or viewing opportunities are available and that moose population objectives are met.

To evaluate response of moose to natural disturbance-based harvesting, moose numbers in specific areas throughout the FMA will be monitored. ANRS conducts periodic assessments of the status of moose in northern Alberta. With support from ANRS, the FMA Holder has initiated further research and inventory work which will provide some baseline data to evaluate moose response to timber harvest. In areas within the FMA where moose management is a priority, information from these research programs could be used to develop effective harvest plans directed at increasing moose numbers.

4.3.5.2 WOODLAND CARIBOU

Woodland caribou have disappeared from much of their former range in Canada due to various pressures. Sport hunting of caribou in Alberta ended in 1981 due to concerns about declining populations. Currently, they are listed under Alberta's Wildlife Act as an endangered species.

Among North American ungulates, woodland caribou appear to be least able to adapt to changing environments related to agricultural, urban, and industrial development. This is thought to be a result of their low productivity and dependence upon lichen-producing forest ecosystems which have declined in area and distribution.

In northeastern Alberta, woodland caribou are strongly associated with large peatland complexes containing significant areas of older, lichen-producing, forested bogs and fens. Such habitats can be characterized as:

- extremely slow to develop (because of the slowness of peat accumulation and the need for forests usually exceeding 120 years in age);
- stable over relatively long periods;
- susceptible to sudden destruction (typically by wildfire, under natural conditions); and
- exhibiting very low productivity.

Woodland caribou are adapted to their environment in the following ways:

- Caribou typically have low reproductive and recruitment rates, so their populations are often characterized by stability and slow response to improved conditions.
- Caribou calves are particularly susceptible to predation by wolves. Wolf predation is believed to be the most direct factor preventing the expansion of caribou populations above relatively low densities. Conversely, caribou avoid excessive predation by occupying large areas at such low densities that they cannot support high wolf numbers or attract significant hunting effort by wolves.
- Caribou are quite nomadic within their ranges and their movements appear quite random. This means that:
    - the location of a small group of caribou within a very large range is highly unpredictable, making searching by predators inefficient.

- only a small portion of the available food is consumed at any site at any one time. Cratering (winter foraging for ground lichens) by caribou hardens the snow for a significant area around the immediate feeding site, making it largely unavailable for further exploitation, and forcing caribou to disperse their feeding activities. This is important because the food is very slow-growing, and it means that the entire range will continue to be available as a food resource.
- when a particular area becomes unavailable for food production (e.g., through fire) caribou simply move to a different portion of the range.

Thus, while there usually appears to be an abundance of unused food and space, caribou probably require this kind of situation in order to achieve long-term stability. Caribou densities are typically low due to the complex interactions of habitat, predation and reproductive potential. Their progressive disappearance from southern portions of their distribution has been attributed primarily to:

- A decline in the amount of habitat available. The development of industrial-related infrastructure, agriculture and traditional forestry activities has greatly restricted the amount of habitat available for food and escape cover.
- Many of the same human influences have promoted the expansion of moose and deer populations in response to the creation of younger forests and much more forest "edge." This in turn has allowed wolf populations to expand. Higher wolf densities may lead to higher predation rates, even though caribou may be only incidental prey items.

The relatively low reproductive rates of woodland caribou are best suited to a stable environment. Smaller, less fragmented areas of habitat do not favour this species because of higher wolf numbers.

At extremely low densities, caribou may be more vulnerable to all types of limiting factors. Chance events such as extensive fires, extremely severe winters, or cold, wet conditions during calving could significantly reduce populations. Habitat removal, human-caused disturbance (e.g., through industrial activity), and increased mortality associated with expanded road access (e.g., subsistence hunting, vehicle collisions) can also become important at very low densities. It is possible that low populations would have poor dispersal, thereby reducing genetic exchange between sub-populations and the opportunity to bolster or recolonize depleted habitats.

Woodland caribou inhabit the FMA area primarily as semi-isolated sub-populations, each group occupying a relatively distinct area centred around large peatland complexes interspersed with upland sites. Densities are typically very low (0.02 to 0.07 caribou/km^2). Calf adult ratios suggest that populations are stable or declining slightly. Research data collected by Fuller and Keith (1981) and by Bradshaw (1994) indicate that these woodland caribou use terrestrial lichens extensively, use arboreal lichens in black spruce areas and avoid mesic upland sites. As such, there is very little direct overlap with timber harvest operations on mesic upland sites.

CARIBOU POPULATION MANAGEMENT

The management of caribou must consider a host of limiting factors and their individual and cumulative impacts. The strategy must recognize the relationship among wolves, moose and caribou; considering timber harvesting operations, moose harvest and habitat management strategies, wolf management and access planning. It is recognized that these caribou exist at very low densities in northeast Alberta, far below habitat carrying capacity. As such, they may be highly vulnerable to density independent factors such as weather, climate and cumulative human effects.

Where potentially good moose habitat overlaps or is adjacent to important caribou habitat, there is concern that logging may favour moose and deer, thereby supporting a larger wolf population which could put greater predation pressure on caribou. Where important caribou habitats have been identified within and adjacent to the FMA, management practices that avoid enhancing moose (and deer where appropriate) population may be considered; recognizing low caribou population levels and their high sensitivity to habitat change.

There are two main strategies to keeping moose numbers low in areas adjacent to caribou ranges: reduce habitat quality for moose; and directly reduce moose numbers. Habitat quality for moose can be reduced by making cutblocks large and circular, reducing the amount of edge habitat and cover. Buffers of mature forest can be left between harvested areas and caribou zones. Alternatively, moose numbers can be reduced by increasing harvest levels and/or increasing access (within a reasonable distance of caribou range, so as to promote moose but not caribou harvest). It is important that moose management plans take into account the requirements of caribou management and that specific prescriptions for different areas be developed, rather than following a blanket approach.

4.3.5.3 WHITE-TAILED AND MULE DEER

White-tailed deer have greatly expanded their distribution and density during the past 20 years. They are found primarily in the southern half of the FMA. Although they have significant human use values, they have become so common throughout most of their range, and their habitat requirements are so easily met, that they do not merit priority wildlife management attention in this area. Also, it must be noted that they are highly sensitive to severe winters. During the recent successive years of relatively mild winters, deer have increased greatly. One or two severe winters with exceptionally deep snow could severely decrease their population.

Mule deer are present within the FMA in relatively low numbers, and appear to be increasing in abundance and distribution. Generally, the coarse filter management approach will be applied to both mule and white-tailed deer.

4.3.5.4 ELK

Elk have been transplanted into the FMA on six different occasions between 1956 and 1988 in groups ranging from 5 to 91 individuals. Elk numbers are estimated near 200. Elk have not thrived in this area probably due to a lack of high quality foraging areas combined with a harsh winter climate. A prerequisite to any further elk transplants should be documentation of former historic range and a critical evaluation of suitable habitat.

4.3.5.5 BISON

Undetermined numbers of bison frequent two portions of the FMA (east of Winefred Lake and north of Fort McKay). It is not known whether they are wood bison (listed as an endangered species) or hybrids from the transplantation of plains bison stock during the 1920s. Their numbers and distribution may be slowly expanding, although they will not likely ever be abundant. Because of their small population and remote distribution there is very limited human use at present. There is no intent to enhance this population because of their uncertain genetic status and their capability of harbouring brucellosis and tuberculosis (significant threats to agricultural livestock) but the FMA Holder's timber harvesting activities may increase bison habitat.