INTEGRATION OF FOREST AND WILDLIFE MANAGEMENT IN EASTERN MANITOBA

By:

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"INTEGRATION OF FOREST AND WILDLIFE MANAGEMENT IN EASTERN MANITOBA."

A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of Master of Natural Resources Management.

By

Colin Graydon MacLeod

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SUMMARY

The integration of forestry and wildlife management in Manitoba was examined for the Abitibi-Price Ltd. Forest Management License using moose as the featured species. The forestry practices of Abitibi-Price Ltd. were examined through site visits in the FML and consultations with forest and wildlife managers across Canada. A literature review and further consultations evaluated forestry practices which will improve wildlife habitat.

A review of the literature revealed that moose require a diverse array of habitats. Riparian zones, protected calving sites, mature conifer and deciduous stands, and sites providing deciduous browse are all important habitat. Moose benefit from forest harvesting activities due to the early successional browse which invades cutovers. This benefit was counteracted by an increase in hunting pressure resulting from improved access by hunters on logging roads. The perception of forest and wildlife managers in Manitoba is that unlicensed hunting is a significant factor contributing to low moose populations in the FML.

The topography of the FML is rugged and contains few large continuous stands of merchantable trees. This results in a harvest pattern that consists of small, irregularly shaped clearcuts with varying degrees of residual cover and physical relief. These cutovers are generally good moose habitat.

Moose habitat is optimized by cutovers with no more than 200m between cover blocks, uneven edges, limited sight lines and a proximity of deciduous browse with mature conifer cover.

A number of forestry practices exist which will provide benefits to wildlife, but generally they increase costs to the forestry company. Guidelines for forest management for wildlife are supported by the literature and will result in increased populations if hunting can be controlled.

Integration of forest and wildlife management in Manitoba is progressing well. The Manitou Abi Model Forest is contributing to the development of new ideas, computer models, management systems, and planning processes. The Wildlife Guidelines for Forestry in Manitoba have been successfully implemented in the FML through co-operation between Manitoba Natural Resources and Abitibi-Price Ltd.

A co-management process is developing in the FML to build consensus among users of the moose resource. Future moose management plans will be based on recommendations from these users. Management of road access is a likely tool for mitigating hunting impacts.

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1.0 INTRODUCTION

1.1 Background

Manitoba's forests and wildlife are natural resources which have great value. In order to sustain and nurture these resources, under the many demands our society places upon them, considerable management effort is required. The interconnection between forests and wildlife adds to the complexity of balancing the needs of the forest industry with those of moose (Alces alces andersoni) and other wildlife. Herein lies one of the problems of incorporating wildlife concerns into forestry operations planning.

The conflict between forest management and moose and other wildlife management involves the need of the timber company to extract wood at reasonable cost, maintain a constant supply of wood to the mill and contribute to the local economy by providing jobs. One way of achieving these goals is to produce a uniform stand of conifer trees close to the processing plant and easily accessible by roads (Euler 1981). In contrast, the moose requires a diverse forest with shrubs, broad-leaved trees and conifers in a mosaic of age classes and species composition. Furthermore, logging roads may lead to increased hunting pressure.

Timber harvesting and reforestation activities have impacts on wildlife and habitat which are both beneficial and harmful (Thomas 1979), however, increasing public awareness of environmental issues tends to cause the forestry industry to be perceived in a poor light with respect to logging activities (Conway 1976). The forest has great value and meaning to Canadians (Canadian Forestry Association, 1991) based on the facts that it is:

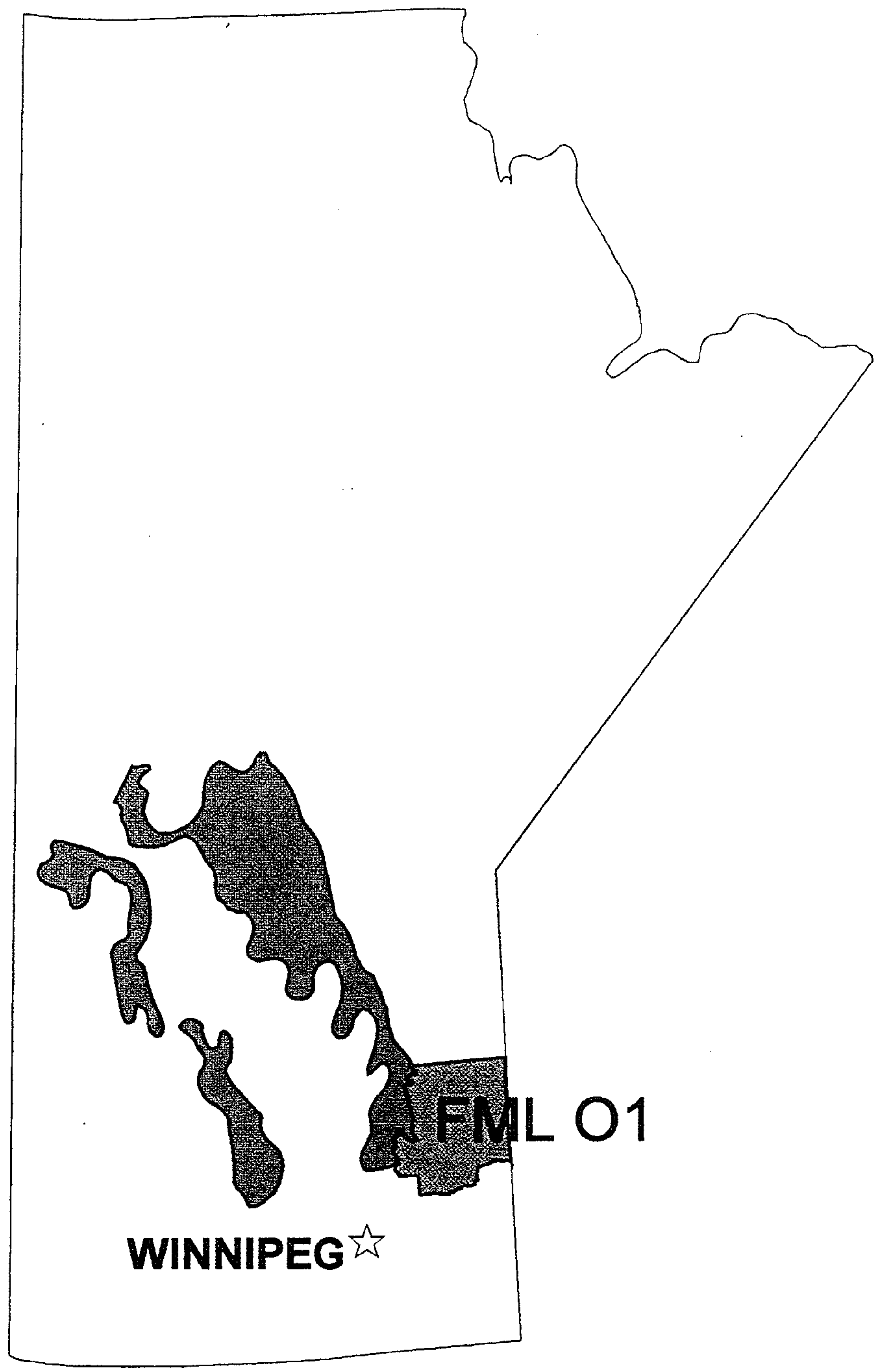
* Owned by the people
* The essence of the Canadian environment
* The cornerstone of the economy
* Rooted in Canadian history
* A recreation haven

Canadians have clearly stated that the forest has great importance to them. In a nation-wide survey conducted by Environics Research in 1991 (Forestry Canada, 1991) 71% of Canadians found the forest valuable as a means of protecting Canada's soil, water and air; 55% identified habitat for plant and animal life as a forest value, while only 38% mentioned it's value as a source of economic wealth and jobs. This same survey revealed that 49% of Canadians ranked clear-cutting, poor management, and inadequate reforestation as the greatest threat to Canadian forests. When comparing opinions of foresters with the public there was a wide disparity in views on old growth protection, clear-cutting, and the use of chemicals. The only survey item agreed on by both parties was that "there is a growing scarcity of timber in Canada today". The survey did not differentiate between accessibility to timber and resource depletion. The public does not appear to be happy with the status quo in forest management and values the forest for more than its significant role in the Canadian economy.

Faced with a shrinking forest land base, increasing demands for remaining forested land, and restrictions based on wildlife concerns and public perceptions, the forestry industry in Manitoba recognizes that there are benefits in integrating wildlife and forest management. Potential benefits include the maintenance of flexibility in forestry operations, continued access to current stands and key habitat areas, improved public perception of the timber industry, and clear expectations for habitat management. Wildlife managers will be more effective in maintaining and improving wildlife habitat if they work with foresters during the planning of management activities.

Moose are one of many species affected by forestry activities in the Abitibi-Price Ltd. Forest Management Licence (FML) (Figure 1). This ungulate receives considerable attention from natural resources managers due to its importance to the people of Manitoba. Moose are readily identifiable by the public and are a valued recreational resource. Moose are a primary game animal for subsistence hunters, tourists, and resident hunters and a high value is generated from these activities. In fact, the net value to Manitobans from moose hunting in 1984 was estimated at $3,656,000 by Ruhr and Crichton (1985). However, the forest ecosystem as a whole is very important and managing a forest solely for one species may lead to negative impacts on other species. Hence, the habitat requirements of other species and the impacts of forest and wildlife management on this habitat must be considered.

FIGURE 1
FOREST MANAGEMENT LICENCE



1.2 Issue Statement

Forest and wildlife management activities should be integrated so that the value of these resources may be maximized. One aspect of this integration is the evaluation of potential modifications to forest and wildlife management activities so that damage to wildlife and habitat is minimized and the benefits are maximized. The Abitibi-Price Ltd. FML area provides a suitable site in Manitoba for the investigation of this integration process.

1.3 Objectives

The main purpose of this practicum was to examine ways of increasing the integration of wildlife management and forest management activities. The specific objectives were as follows:

1) To identify the habitat characteristics of the FML and compare them to the habitat requirements of moose as they relate to specific forestry activities.

2) To document the current moose management activities in the FML.

3) To determine current timber harvesting and silvicultural activities in the FML with specific attention to cut block size, shape, timing and design, and renewal.

4) To document the impacts of timber harvesting and reforestation on moose.

5) To identify from the literature alternative cost-effective methods or modifications to current forest and wildlife management practices in the FML which will increase the net benefits to moose and Abitibi-Price Ltd.

6) To recommend an ways in which integrated resource management can better take place in the FML to improve moose habitat.

1.4 Delimitations

This project investigated the timber harvesting, reforestation practices, and wildlife management activities occurring in the FML with the intent of determining opportunities for enhancing moose habitat as cost-effectively as possible. The budget and time frame for the study limited the project to the investigation of high impact forestry activities and the identification of practices which might be implemented, or further tested. The recommendations were based on literature review, consultations, and inspections of the FML and the activities occurring therein.

The emphasis on moose is due to its importance as a game and recreation species, and its value as an indicator species. The needs of wildlife in general are too comprehensive to be included in any detail here, but have been briefly summarized to provide some frame of reference.

1.5 Importance of Research

There is a movement in forest management to consider all the values of the forest and not just timber. The intensity of forest management is increasing and is now combined with recognition of the concept of multiple use and integrated resource management Wildlife is one of the resources in the forest and the extent and success to which its management is integrated with that of forestry differs between regions. One of the objectives of this practicum is to research the practices used in other areas for consideration in Manitoba. The results will hopefully be useful as a guide for forest and wildlife managers in the implementation of forestry practices that will conserve and enhance wildlife habitat.

This study will be of value to forestry and wildlife managers in Manitoba in the public and private sectors. The study was oriented with cost effectiveness of the forestry activities as a high priority. If it is reasonable to ask the forest industry to help manage forests for wildlife as well as timber, then the associated costs must also be reasonable. It is important that the forest industry be committed to conserving habitat, and the best way to make this option more acceptable while maintaining a cooperative relationship is to look for cost-effective solutions.

With the advent of the model forest program across Canada and the Manitou Abi Model Forest which encompasses the Abitibi-Price FML in Manitoba, the information contained herein is timely. The need for integrating wildlife and forest management is one of the prime aspects of the model forest initiative.

The integration of forest and wildlife management is necessary if these two resources are to be maintained for future generations. The benefits of this study may include larger wildlife populations resulting in increased value generated from hunting and other recreational uses of wildlife. As well there is the potential for increasing forestry industry access to forests where wildlife concerns are paramount.

1.6 FML Description

The Abitibi-Price Ltd. Forest Management Licence area covers 866,000 ha in southeastern Manitoba (see Figure 1). The area is roughly bounded by Lake Winnipeg on the west, Atikaki Wilderness Park on the north, the Manitoba/Ontario border on the east, and the Winnipeg River on the south. Of the total area, 67% is considered productive, 21% is non-productive, 7% is non-forested, and the final 5% is covered by water. Approximately 85% of the total productive area is in softwoods.

The FML is within the boreal forest on the Precambrian Shield and has a rolling, hilly topography formed by glacial drift. Bedrock outcrops vary from prevalent on the east side to scattered on the west. The glacial striation of the area is typically northeast to southwest. The soils are generally classified as either luvisols, brunisols, gleysols or organic.

The area is typical Boreal Forest, containing many rock outcrops and bogs, and is interspersed with lakes and rivers. Cover includes black spruce bogs, upland conifer forests, and mixed-wood forests. The area is intensely glaciated with thin glacial soils. Bedrock exposure is common with many lakes and wetlands. There are some glacial tills near the Manitoba/Ontario border with a clayey and sometimes sandy consistency.

The predominant softwood species is jack pine [Pinus banksiana Lamb.] followed by black spruce [Picea mariana (Mill.) B.S.P.], tamarack [Larix laricina (Du Roi) K. Koch], white spruce [Picea glauca (Moench) Voss], and balsam fir [Abies balsamea]. The main hardwood species is trembling aspen [Populus tremuloides], followed by balsam poplar [Populus balsamifera L.] and white birch [Betula papyrifera Marsh.]. Harvesting is predominantly black spruce, white spruce, balsam fir and jack pine.

Jack pine grow predominantly on sand and rock ridges, while black spruce dominates in lowlands and swamps (Durocher, pers. commun., 1989). Very few large continuous stands exist within the FML. The varied topography and common bodies of water make for a diverse forest.

The FML serves as one of the wood supply areas for Abitibi-Price's paper mill in Pine Falls, and provides 27% of the mill requirements.

2.0 METHODS

This study involved a review of related research, consultation with concerned parties and professionals across Canada, site inspection, and analysis of potential alternative forestry and wildlife management practices.

2.1 Literature Review and Consultations

Beginning in January 1989 and continuing throughout the project, consultations and a literature review examined techniques being used in other areas, and determined possible applications to the study area. Emphasis was placed on regions of Canada in the boreal forest, although practices in the United States and Scandinavia were also examined. Consultations with personnel of the Wildlife and Forestry Branches took place to determine the activities and issues in the FML. As well consultation with forestry industry personnel (Abitibi-Price Ltd.) was necessary to identify current practices, to incorporate the needs of the private sector into the project. Communication with other agencies was by phone, mail and in person.

A comprehensive literature search included visits to libraries, Universities and government resources in Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia.

2.2 Site Inspection

Site inspections occurred from May 1989 to June 1990. The purpose of the site work was to inspect the activities taking place, observe impacts on habitat and to evaluate the feasibility of implementing various new practices.

Summer and winter visits included guided tours with Abitibi-Price Ltd. personnel to a variety of cutovers and harvesting operations throughout the FML. A broad spectrum of sites were visited from lowland black spruce sites, to jack pine ridges, both before and after harvesting. Feller buncher harvesting was observed in winter with skidder hauling to the roadside. Delimbing and cutting to length took place at the roadside, prior to truck transportation to the mill. The majority of the cutovers visited were less than 40 ha and contained a variety of residual growth, intermixed with numerous rock outcrops.

One week was spent at the Sandy River fire base camp during fire control activities in the summer of 1989. Aerial views of the area were experienced via helicopter. Numerous visits to the FML took place during this summer to conduct habitat surveys for Manitoba Natural Resources and to participate in a woodland caribou capture and radio collar study.

3.0 FOREST MANAGEMENT

Forest management consists of planning, silviculture, protection, harvesting, and research and development. Each of these phases results in varied impacts on wildlife habitat. The types of activities practiced by the forest industry and the manner in which they are implemented depend upon the goals determined for a particular area. These goals may relate to issues other than timber production, such as fish and wildlife habitat, recreation and aesthetics, etc. Ultimately, decision-making is governed by economic factors, environmental limitations and often requires government approval. This section will look at the current practices of Abitibi-Price Ltd. in the FML as a basis for assessing potential alternatives.

The forest management policy of Abitibi-Price Ltd. commits to using sound forest management to provide sufficient fibre and other tangible and aesthetic benefits to meet the short and long term needs of both the company and society. The company supports the principle of multiple use of forest lands and recognizes the importance of preserving the environment (Abitibi-Price Ltd., 1993). The forests of the FML are managed on a sustained yield basis by Abitibi-Price Ltd.

These principles are generally accepted as being sound and part of responsible forest management, however, the methods used to implement these principles have varying degrees of acceptance amongst forest and wildlife managers and the public. The planning process, silvicultural and harvesting practices of Abitibi-Price Ltd. will be examined with a description of the impacts from such activities on wildlife, particularly moose. In general, the harvesting and silvicultural practices are consistent throughout the FML (Robertson, pers. commun., 1989; Durocher, pers. commun., 1989).

It should be noted that the FML is currently part of a model forest established "to develop a working model of ecologically sustainable forest management and use, through partnerships of diverse interests and values". Partners involved include Forestry Canada, Manitoba Natural Resources, and Abitibi-Price Ltd., aboriginal groups, universities and other interest groups. The model forest will be harvested using new technologies that respect the present ecosystems, wildlife and fisheries, aboriginal and local community needs and the economic implications of forest management (Waldram, undated). Specific initiatives of this project will be discussed throughout this document in appropriate sections.

3.1 Forestry Requirements and Limitations

The forest industry approaches forests from an economic stand-point. If no profits can be generated from the management of a particular forest area then the company will shift its attention elsewhere. Thus, the focus is on producing merchantable timber over the short and long-term, on a sustained yield basis. The maintenance of the ecological integrity of forest land is a condition or constraint which must be met while attempting to achieve financial goals. When special management is required for wildlife it is generally assumed that costs will increase. Hence, cost is the major limitation on the forest industries ability to manage for wildlife. As Thomas (1986) remarked, the net present value of the forest is the main criterion for making decisions in forestry operations.

The forest industry is faced with meeting competitive world market demands while being constrained by the local needs of other forest resource user groups and managers. In some cases this means the removal of forest land base for parks, wilderness, and fish and wildlife habitat. Therefore, in order to meet increasing world demand for forest products more intensive management must be conducted to increase productivity (Opper, 1988). To remain profitable forest companies must be assured a long-term supply of wood, and provide wood at reasonable cost to the mill gate. The investment in forest management and in mill facilities is both long-term and capital intensive. Before a company can commit the resources needed for a successful operation it must have the assurance of long-term renewable tenure of the forest land base (Abitibi-Price Ltd., 1993).

The forest industry seeks reasonability and justification for undertaking wildlife management as part of the "cost of doing business". The forest industry is being asked to change the way they have been doing business (harvesting timber) for decades through the development of wildlife guidelines which aim to maintain and improve habitat. To the industry it appears that incorporating these guidelines involves additional costs in the harvesting and regeneration of forests. Whether the forest industry should bear these costs or society in general is a philosophical question with a political mechanism of determination. Regardless of the solution to this ongoing debate, the fact remains that these costs are currently being borne by industry with some subsidization by Governments. As such, industry has a high degree of self-interest in seeing that these costs are minimized and that the guidelines are based on rational, scientific, and reasonable knowledge of cause and effect respecting forest disturbance and wildlife response.

3.2 Planning

Abitibi-Price Ltd. manages the forests in its license area within a framework of legislative acts, regulatory processes and government agencies. The Forest Act, Forest Management License Agreement, Forest Management Guidelines for Wildlife in Manitoba, and Environment Act all provide some degree of regulation and control over the companies activities on Crown land. The Forest Act and FMLA spell out the general and specific conditions of the license including the requirement for annual, five year and twenty year operating plans. The guidelines provide acceptable forestry practices which are applicable under normal conditions. The Environment Act has been used recently to require an environmental impact assessment (EIA) for Abitibi-Price Ltd.'s five year operating plan.

The Department of Natural Resources has an Integrated Resource Management Team (IRMT) which evaluates plans submitted by Abitibi-Price Ltd. The IRMT consists of Forestry, Wildlife, Fisheries, Parks, and Lands

Branch personnel, including the Regional Director of Natural Resources (Robertson, pers. commun., 1993).

Currently one year, five year plan and twenty year plans are submitted by Abitibi-Price Ltd. for evaluation by the IRMT. Concerns identified by the IRMT are expressed to the company and solutions found to revise the plan. The most recent five year plan was required to go through an environtmental impact assessment. After evaluation by the IRMT the plan went to the Director of Forestry Branch, and hence to the Department of the Environment where it was posted in a public registry. Based on their evaluation and the response of the public, Manitoba Environment decided that public hearings and an environmental impact assesement were required. The cost of this process to Abitibi-Price Ltd. was estimated to be $750,000 (Keenan, pers. commun., 1993). Due to the length of the process the five year plan was extended to become an eight year plan at the request of Abitibi-Price Ltd.

Co-management is the integration of various levels of local and provincial management systems (Berkes et al., 1991). It involves the sharing of both power and responsibility between government and local resource users. It is essentially a form of public participation. The people of Manitoba have provided input to the management of Manitoba's forests through recent public participation sessions to develop a sustainable development land and water strategy. The meetings on forests examined wide ranging issues such as clear-cutting and global warming. Each five year plan is also available for public comment when placed in public registries in the province. This mild form of public participation is being strengthened by developments in the FML which are leading to a higher level of co-management. In the past co-management tended to be native peoples and government agencies working together to manage a resource such as moose. The Department of Natural Resources is planning to hold stakeholder meetings over the future management of moose in the model forest which include those parties which in the past the government represented, such as non-native hunters (Robertson, pers. commun., 1993). These workshops are planned for 1994. Recommendations from the workshops may form part of the moose management strategy for the Model Forest. The Model Forest also has developed input processes for both Metis and treaty Indians. Cross cultural workshops were held to amongst the native groups to develop a common ground, and representatives will now have a formal process for participating in Model Forest decision-making (Waldram, pers. commun., 1993).

Payne (pers. commun., 1993) stated the need for more local/native voice in the management of natural resources including moose. Berkes et al. (1991) emphasized this as well stating that self management is one of the key issues affecting the social and economic health of many native communities. Joint stewardship arrangements and co-management were mentioned as ways of improving moose populations (Payne, pers. commun., 1993). Although the attitudes are slowly changing, it was felt that a broader vision of forest management is required, which includes both wildlife and fibre.

In terms of public participation the Model Forest has also provided access through a number of committees which are looking at such issues as information systems, environmental protection and monitoring, advanced forest mangement practices, and public awareness. These committees involve a varitey of stakeholder groups as well as government and nforest industry personnel. The Board of Directors for the Model Forest also includes an array of interested publics and stakeholders.

The Integrated Resource Management and Policy Committee of the Model Forest is charged with developing management systems and guidelines which will preserve and sustain the multiple values of the region's forest resources. This group is currently researching conflict resolution and co-management models as they apply to situations within the model forest (Miller, pers. commun., 1993).

Manitoba Natural Resources has recently tendered a contract for the preparation of a strategic long-term integrated forest management plan. The plan is to use a timber supply modelling approach and incorporate a case study (Manitoba Natural Resources, 1993). The plan will incorporate all forest values, all uses and all users and be based on a full forest rotation time frame. The product developed will be extensive in its scope covering such areas as current forest and natural resources data and gaps, formulating a long term wood supply analysis, development of forest management objectives and a cost benefit analysis of proposed forest management strategies. Based on the terms of reference sent to prospective bidders the plan should propel the province in to a sophisticated system of integrated management.

3.3 Silviculture

Silviculture is the science and art of growing and tending forest crops by controlling the establishment, composition, distribution and representation of tree species, age, and/or size classes (Brown, 1985).

There are a number of variables which control the silviculture treatment used on a site to achieve a given objective.

i) Stand condition
ii) Size of area
iii) Scheduling - rotation age
iv) Arrangement of stands in time and space
v) Topography and site conditions
vi) Accessibility

The specific areas examined here are site preparation and regeneration as they relate to impacts on vegetation and how it pertains to moose habitat in the FML.

3.3.1 Site Preparation

Site preparation is any action taken in conjunction with a reforestation effort (natural or artificial) to create an environment which is favourable for survival of suitable trees during the first few growing seasons; this environment can be created by altering ground cover, soil or microsite conditions through the use of biological, mechanical, or manual clearing, prescribed burning application of herbicides, or a combination of methods (Brown, 1985). Site preparation has the following objectives:

* Reduce the amount of logging debris
* Improve soil conditions to encourage rooting and growth of seedlings
* Temporarily eliminate undesirable vegetation (Canadian Forestry Service, 1987).

Scarification is one means employed to prespare soil regeneration. It is a method of seedbed prepartation that consists of exposing patches of mineral soil through mechanical treatment with heavy equipment (Peterson and Peterson, 1992). Brown (1985) defined it as the process of breaking up or loosening compacted soil to assure better penetration of roolts of your seedlings. Thus assuring greater survival and faster growth for these trees; also, removal of competing vegetation by mechanical means. Scarification can also be viewed as an attempt to truncate the successional sequence following disturbance of a mixed wood site (McNicol and Gilbert, 1980).

Most conifer seeds need an exposed seed-bed of soil to successfully germinate. Unless the soil is disturbed by scarification or the organic litter burned away by fire, the seed root will be unable to reach the required moisture and nutrients. Since most of the harvesting in the FML takes place during the winter, the snow cover will have minimized soil disturbance except on skid trails. Scarification on jack pine sites should occur as soon as possible after harvesting (Kaczanowski, pers. commun., 1993), and certainly less than two years later, while the seeds remain within the closed pine cones. Scarification on White Spruce sites is generally needed to expose the topsoil for planting since limited natural seeding occurs. In summer forest operations the amount of ground disturbance from mechanized harvesting often serves to scarify the soil.

Generally, scarification is not used on lowland sites which are being regenerated naturally (Keenan, pers. commun., 1993), however, disk trenching is sometimes used to prepare jack pine sites for natural regeneration. Disk trenching creates parallel furrows in the soil with large disks attached to a tractor. The disk essentially tills the soil to expose the mineral rich seed bed. Seeds may be present on the ground at the time of scarification, or they may come in from adjacent stands. Drag-chaining was used during the 1980's on the FML as a means for scarifying sites, but has been replaced by trench scarification (Durocher, pers. commun. 1993). Drag chaining involves dragging heavy steel chains behind a skidder/tractor across the cutover to expose the soil, and to redistribute serotinous cones. Drag chaining may be used again in the future if conditions continue to be wet, hence reducing fire hazard (Keenan, pers. commun., 1993).

Abitibi-Price Ltd., Forestry Canada and Manitoba Natural Resources are investigating site preparation techniques which will have benefits for habitat and forestry (Robertson, pers. commun., 1993). Trials have been conducted in the Beaver Creek area using a Sepimore mulcher which mixes the soil with surface debris into a uniform till. This equipment provides a good seed bed, but maintains flexibility and manoeuvrability so that residual growth can be preserved.

Prescribed burning is the controlled application of fire to fuels in either their natural or modified state under such conditions of weather, fuel moisture, soil moisture, etc., as allow the fire to be confined to a predetermined area and at the same time to produce the intensity of heat and rate of spread required to further certain planned objectives of silviculture, wildlife management, grazing, fire-hazard reduction, etc. (Peterson and Peterson, 1992). Prescribed burning removes slash and logging debris from the cutover in an economical manner (Bunnell and Eastman, 1976). Prescribed burning can be used to reduce fire-hazards and to prepare the seed bed for planting. It allows entry to the site to planters and releases seeds, and moves nutrients into the soil. Controlled burns produce an excellent seedbed and good regeneration (Rannard, 1988).

Prescribed burning is not currently used on the FML by Abitibi-Price Ltd. (Durocher, pers. commun., 1993). It is currently being discussed in a working group of the Model Forest as a means of reducing fire hazards, particularly after spruce budworm salvage operations, however, the expertise simply doesn't reside within the company operations in Manitoba (Keenan, pers. commun., 1993).

3.3.2 Regeneration

Regeneration is the renewal of a tree crop by natural or artificial means (Peterson and Peterson, 1992). In Manitoba, 60% of harvested areas are regenerated naturally, with the remainder either planted or seeded (Forestry Canada, 1991). Within the FML approximately 2/3 of regeneration is natural, and the remainder is through planting (Keenan, pers. commun., 1993). Of the planted portion, white spruce, black spruce and jack pine make up 40%, 40% and 20% of the quantity respectively. Very little aerial seeding takes place in the FML. This occurs only after burns and on areas with no seed producing cones (Keenan, pers. commun., 1993).

Abitibi-Price Ltd. is required by regulation to produce a stand as good or better than before harvest (Kaczanowski, pers. commun., 1993). The funding for regeneration available to Abitibi-Price Ltd. is a function of pulpwood delivered to the mill. The company pays stumpage fees to the government of $18/cord delivered to the mill and receives 2/3 of this amount back for silvicultural activities.

In the FML lowland black spruce, and jack pine are being regenerated naturally (Keenan, pers. commun., 1993). On sites where there is a good seed source, suitable exposed soil and conditions which aid in seed propagation jack pine may regenerate naturally in dense pockets (Durocher, pers. commun., 1993). Jack pine have serotinous cones which require heat or fire to open the cone and release its seeds. The bulk of seeding of a typical jack pine site tends to be natural (Schultz Int. Ltd., 1976). Black spruce have a semi-serotinous cone and will regenerate naturally if seed sources and a good seed-bed are available. Typically black spruce are the only tree which will regenerate in a moist black spruce site (Schultz Int. Ltd., 1976), although tamarack are also well suited to bogs and wetlands (Oswald and Nokes, 1988) and may successfully regenerate on these sites as well (Kaczanowski, pers. commun., 1993). Good natural regeneration takes place with edge cuts on black spruce stands due to the proximity of a seed source (Rannard, 1988). White spruce are not suited to natural regeneration in clearcuts (Schultz Int. Ltd., 1976). Mixedwoods, as well, can't be naturally regenerated because of hardwood domination of cutovers (Keenan, pers. commun., 1990). According to DePape and Collins (1977) natural regeneration has been consistently achieved only through the use of scarification.

Typically, planting is used to regenerate stands on upland spruce sites and mixed-wood sites. The decision of whether to planting will also be determined by the surrounding stands and their seed bearing ability, as well as the presence of insect infestations and/or disease Approximately 75% of seedlings planted are surviving to maturity. While Abitibi-Price Ltd. plants 1.8 trees for every tree harvested, this figure includes those trees harvested on sites which are to be naturally regenerated. This means that for each tree harvested on a site where planting is to occur, there will be 6 seedlings planted. Approximately 1000 ha/year are planted in the FML. (Keenan, pers. commun., 1993).

Natural regeneration is a highly variable process which depends on site conditions and weather. In 1993 the FML experienced hot, sunny weather which served to activate serotinous cones, and was followed by sufficient precipitation to encourage germination and seedling growth (Durocher, pers. commun., 1993). Under hot conditions without sufficient precipitation new growth may die off, or without adequate heat or stimulation the jack pine cones may not open.

Cutovers in the boreal forest will tend to naturally regenerate to a mixture of shrubs including mountain maple (Acer pensylvanicum), beaked hazel (Corylus cornuta), white birch, trembling aspen, mountain ash (Sorbus americana), green alder (Alnus crispa), balsam poplar, balsam fir, pin cherry (Prunus pensylvanicum), and willows (Salix spp.) (Thompson and Euler, 1984). In the past, hardwood stands in the FML were shear-bladed and then planted to softwoods, but this practice has been discontinued. Silvicultural prescriptions tend to based on the accessibility, productivity and expected natural regeneration capability on a site (Durocher, pers. commun., 1993). Cutovers which are not easily accessible, or have low productivity will often be naturally regenerated, where site conditions permit. More valuable sites may receive the additional investment of planting and herbiciding. Stands which are naturally regenerated will tend to have a higher composition of hardwoods, while in planted sites softwoods will predominate. Overall a balance between softwood stands and mixed-wood stands is maintained (Robertson, pers. commun., 1989; East, pers. commun., 1989).

Herbicides are used on cutovers to control successional deciduous vegetation and thereby enable softwood regeneration. In the FML a government issued license is required for ground or aerial spraying of herbicides. Vision is occasionally sprayed aerially and routinely applied on the ground. 100-200 ha/year are sprayed on the ground as a site preparation tool before planting, while an equal amount is aerially sprayed after planting for release (Keenan, pers. commun., 1993). Naturally regenerating areas are rarely treated. The release treatment gives the seedling a 2-3 year start on hardwood competitors. Robertson (pers. commun., 1989) suggests application from the ground would provide better results for both seedling growth and moose browse than would broadcast applications. He has also observed a decrease in the use of herbicides between 1988 and 1993 (Robertson, pers. commun., 1993). Abitibi-Price Ltd. is looking at means of becoming more site specific in its use of herbicides. Better prediction of competition on regenerating sites will allow a move towards more ground spraying before planting and less use of chemicals (Keenan, pers. commun., 1993).

Aerially spraying has been used to speed successional processes within the FML. Aerial surveys were conducted to identify sites with non-commercial aspen components and a minimum of 45% stocking of spruce. These sites were then aerially sprayed to kill off the aspen and move the stand forward (Keenan, pers. commun., 1993).

Thinning is the removal of selected trees from a stand for the purpose of improving the growth and value of the remaining crop trees (Peterson and Peterson, 1992). Thinning is used sparingly in the FML due to the high cost and debate over the return on investment. Approximately 200 ha/year are thinned in the FML , and this generally when there is some form of federal/provincial funding in place (Keenan, pers. commun., 1993). Manual thinning may cost up to $500/ha (Keenan, pers. commun., 1990). A study by the Forest Engineering Research Institute (FERIC, 1988) estimates the costs of plantation tending are equal to those incurred in growing the seedlings, preparing the sites and planting the stock combined. Tending may take the form of removal of overmature aspen to speed the succession of spruce undergrowth.

3.4 Timber Harvesting

3.4.1 Philosophy

The management philosophy of Abitibi-Price Ltd. is to harvest on a sustainable yield basis. The philosophy includes a commitment to reforestation that has seen 1.8 seedlings planted for each tree harvested (Durocher, pers. commun., 1993). By applying the principles of forest management they aim to maintain a long-term supply of timber, while recognizing the importance of preserving the environment and the multiple use concept. Working with the province to develop plans and accomplish goals is part of this process. Between 1979 and 1988 Abitibi-Price Ltd. harvested 45% of the annual allowable cut for all species on the FML (Abitibi-Price Ltd., 1989). During this period 99% of the allocation for spruce and balsam fir, and 29% of the jack pine were harvested. Between 1984 and 1988 roughly 95% of the harvest was for pulpwood, the remainder for lumber and fuelwood.

The Forest Management Plan (1979-1998) for the FML aims to completely utilize all commercially viable species at sustained yield levels. Forest Management Unit 31 is the largest unit in the FML and had full commitment of its annual allowable cut for Balsam Fir, White Spruce and Black Spruce, and 50% utilization of Jack Pine, with an expected increase to 75% by the year 2000 (Manitoba Natural Resources, 1988(a)).

3.4.2 Cutting Practices

A number of established cutting methods exist for harvesting in different situations or to achieve different goals. These include clear-cutting, shelterwood cutting, seed tree systems, single and selection cuts which are defined as:

Clearcutting "is the harvesting, in one operation, of all trees in a stand or on an area, with the expectation that a new even-aged stand will become established" (New Brunswick Department of Natural Resources, 1991). This is the most common form of harvesting practiced by Abitibi-Price Ltd.

The seed-tree system "requires leaving a few good seed producing trees per hectare when the mature stand is logged. These trees provide the seed that is needed to regenerate a new even-aged stand. The seed trees are usually harvested after the crop of new young trees has become established".

The shelterwood system is a series of partial cuts over a number of years in mature stands. Early cuts improve vigour and seed production of the remaining trees and prepare the site for new seedlings. The trees that are retained produce seed and also shelter for the seedlings. Subsequent cuts harvest the shelterwood trees and allow regeneration to develop as an even aged stand (Canadian Forestry Association, 1991). The original stand must have a high density of healthy and vigorous trees to provide the needed seeds and to protect young trees from insects and competition (Ontario Natural Resources, 1991, in Forestry on the Hill).

The single tree system creates and maintains an uneven-aged stand. Each tree in the stand is evaluated on its own merits and harvested as they mature. This system favours species that thrive in low light(Canadian Forestry Association, 1991).

Group selection involves harvesting trees in small groups, in what might be considered miniature clearcuts. Thinning of the stand is accomplished at the same time as harvesting. Stands managed in this way are uneven-aged as a whole.

Harvesting in the FML occurs year round (Cameron and Kaczanowski, 1989), however, the majority of activity is in the winter when access to wet areas is improved (Durocher, pers. commun., 1989). Before the Forest Management Guidelines for Wildlife in Manitoba (Manitoba Natural Resources, 1988) came out Abitibi-Price Ltd. was generally harvesting in the manner they best saw fit, excluding those areas where the Province required special management due to wildlife, parks or other concerns (Robertson, pers. commun., 1989).

Clearcutting is the preferred method for economic considerations, and to promote natural regeneration. Large clear-cuts are rare due to a lack of continuous stands and good planning. Clearcutting simulates the even-aged stand that naturally results from disturbance in the boreal forest (Kaczanowski, pers. commun., 1993) In the FML, cut block areas tend not to be greater than 40 ha (Keenan, pers. commun., 1990). Cutover size frequency distribution (Table 1) shows that nearly all the clearcuts in the FML were less than 40 ha in size, and average cutover size was 14 ha.

Table 1: Cutover Size Frequency Distribution (1991)

Size of Cut (ha)	Number of Cuts
0-20	92
21-40	8
41-80	6
81-120	1
121-160	1
Total	108

Source: Abitibi-Price Ltd.

The supply of jack pine on the FML outstrips demand, but the reverse is true of black spruce. Black spruce swamps are one of the main sources of timber within the FML. Traditional cuts in black spruce stands have been around the edges to take only the merchantable timber. Occasionally where the whole stand is merchantable it will all be harvested in a clear-cut. Typical harvesting will cut around the stand moving towards the centre until a minimum diameter is reached. The mill requires a minimum thickness of 3.5 inches. On ridge stands of jack pine a similar cutting pattern may occur. Larger trees tend to grow on the edges of these stands, downslope where better nutrients exist. Thus harvesting the larger trees will concentrate activity on the edges of stands (Durocher, pers. commun., 1989). To regenerate jack pine successfully they must be clear-cut. As a fire origin species they need the sunlight present in a clearcut to open the cones (Keenan, pers. commun., 1993). Harvesting is a random and somewhat selective process and trees are taken wherever they can be found. The shape of cutovers is largely dictated by topography.

Shelterwood treatments in black spruce and white spruce stands have been successful in the FML where scarification occurred on the lee side of good seed tree residual stands. The natural seed source and scarification allowed softwoods to establish themselves against competing hardwoods (Rannard, 1988).

Exercises in strip shear-blading within hardwood stands for the purpose of establishing merchantable timber stands have proven difficult with white spruce. Eighteen to twenty-four foot wide strips were bulldozed into Aspen stands and then intensively planted. Heavy browsing, in selective areas, by rabbit (Oryctolagus cuniculus) and white-tailed deer (Odocoileus virginianus) on the seedlings was observed. (Durocher, pers. commun., 1993; Rannard, 1988).

In general there is little strip or shelterwood cutting, or selective cutting as it is strictly defined (Durocher, pers. commun., 1989). Some selective cutting does occur in mixed-wood sites to remove the hardwoods and allow planting to restock the area to spruce (Keenan, pers. commun., 1993). In Jack Pine stands some selective harvesting occurs and larger materials are used both as sawlogs and hydro-poles. Top quality birch and aspen are taken for lumber as well, where hauling distance makes it economical (Rannard, 1988).

Typically, timber is cut and delimbed in the bush and then hauled to the road where it is cut into 8 ft. sections before going to the mill. Often, however, the logs are hauled to the mill in tree length sections. Delimbing in the bush is now required as a means of improving seed dispersal and nutrient cycling. In the past up to 14% of the wood was barged down the Winnipeg River to Pine Falls, where it was stored in the river until needed. This practice is no longer allowed by government due to concerns over water quality. Now all timber is trucked to the mill, where a larger storage yard is being built (Durocher, pers. commun., 1993; Kaczanowski, pers. commun., 1993).

Abitibi-Price Ltd. is working with some new Timberjack harvesting equipment which will improve protection of advance regeneration and minimize impacts on the site. The snipper on the unit has a 20 m reach and is attached to a cab that can rotate 180 degrees. It runs on tracks with high flotation tires. The snipper reaches out and cuts and fells the tree, and then feeds it into a delimber, and then cuts it to 8 foot lengths and leaves it for skidding. The unit is economical up to 4000 feet from the roadside which is four times the previous limit. This in turn will lead to less road construction (Keenan, pers. commun., 1993).

One watershed close to Pine Falls has been managed to convert a portion of hardwood residuals after a softwood harvest from within a mixed-wood. Removal of aspen, followed by planting of black spruce and herbiciding has had mixed results. Poor seedling quality was found to be one of the reasons for poor performance on these difficult sites (Rannard, 1988). This practice of stand conversion has been discontinued by Abitibi-Price Ltd. (Durocher, pers. commun., 1993).

3.4.3 Road Infrastructure

Roads are one of the major costs of harvesting in the FML (Kaczanowski, pers. commun., 1993). Logging roads can cost up to $30,000/km for an all season 28 foot wide road. This cost increases in hilly or rocky terrain (Durocher, pers. commun., 1993). Wepruk (pers. commun., 1989) reported haul roads costing up to $100,000/km in Ontario.

In 1976, Schultz International reported significant increased costs for the forest industry to make road modifications for wildlife. Costs for major roads increased by 40% and by up to 300% for minor roads. The modifications were to introduce short curves to restrict line of sight, avoidance of sensitive areas, and maintenance of roadside reserves 300-600 feet wide.

3.4.4 Equipment

Abitibi-Price Ltd. harvests 20% of its wood supply through company operations, with the remainder subcontracted to local operators. The trend within the companies operations is towards machine harvesting and away from men in the bush with chain saws and skidders. Particularly in stands where hardwood components are not significant, the trend in equipment is to fully mechanized operations to reduce costs and increase productivity. The tracked or wheeled feller-buncher uses shears or saw blades to cut the tree near the ground, and may be able to hold several trees in the cutting head at one time. The trees are left bunched and are delimbed in the bush. Grapple skidders then move them to the roadside where they are cut to length for transport. One operator and a machine snipper will replace 5-10 men and the required skidders. With current equipment cutovers can be kept small in size (Durocher, pers. commun., 1993).

Within the subcontracted operations cutting tends to take place much more with chain saws. The high cost of investment in more productive equipment has precluded more automated harvesting systems (Durocher, pers. commun., 1993). Conventional hand-falling methods leave most of the hardwoods standing. This has the advantage of minimizing competition and damage to advance conifer regeneration. The disadvantage is high felling and skidding cost, and difficulty in mechanically preparing the site (Schneider, 1988).

Abitibi-Price Ltd. had the following woodlands equipment as of 1992 (Giles and Bohning, 1992):

18 - Clark skidders
3 - Caterpillar crawlers
2 - One-man slashers
2 - Single stroke delimbers
1 - Koehring feller buncher

3.5 Forestry Impacts on Wildlife

Forestry operation activities have a wide array of impacts on wildlife, largely through their effect on habitat. No matter what disturbance and change occur in the forest there will be groups of wildlife which benefit and those that are disadvantaged (Kimmins, 1991). As Armson (1984) states,

> "In the Canadian scene two facts emerge clearly. The first is that management of our wildlife for the most part involves some form of manipulation of forest cover. The second is that the only user-group with either the interest in or the capability for such manipulation on any significant scale is the forest industry".

The timing, size, shape of cuts and adjacent and regional stand composition and age will affect the degree to which impacts are felt by wildlife

(Kimmins, 1991). Peek et al. (1976) stated that their studies in Northeast Minnesota and others throughout the world had shown moose to respond positively to forest operations. It should be noted also that habitat is only one factor affecting populations, predation and disease, hunting pressure all take their toll on moose (Ontario Natural Resources, 1985).

When a forest is managed for timber the life cycle of the forest is shortened to the rotation age. In this situation early successional species of wildlife thrive due to the increased percentage of the forest in early development, compared to climax species dependent upon old growth which will decrease in abundance (Schultz Int. Ltd., 1976).

The impacts from forestry on furbearers was summarized by Thompson (1988) in the table below.

Table 2: Forestry Impacts on Furbearers

Impact	Species
Positive -	lynx, red fox
Negative -	marten, ermine
Potentially positive with directed management -	beaver, and secondarily otter
No impact -	muskrat, mink, otter

The impact of forestry activities on woodland caribou (Rangifer tarandus caribou) was well documented by Hristienko (1985), and generally found to be negative. Woodland caribou inhabit lichen rich mature forests, and also browse on a variety of green plants in the spring and summer. They are solitary animals preferring to avoid human activity. Forest disturbance will destroy the mature habitats which they require for wintering, and lichen food sources. Heavy equipment will tend to also destroy lichen and moss formations. The increased access of hunters to logging areas has a negative impact on caribou populations, as they are easily hunted. Increasing numbers of moose and deer in cutovers will also tend to draw more predators to an area which may have been traditional caribou habitat. As migratory animals, caribou may be disrupted from their normal patterns by new forest operations.

The remainder of this section will examine specific forestry activities and how they affect moose and their habitat.

3.5.1 Silvicultural Impacts

Silviculture affects vegetation on a site. It is one of the factors determining what will grow there, the rate of growth, nutrient cycling, diversity, cover attributes etc. These factors and the ways in which they combine/compliment each over the course of a year and a rotation are important in determining moose habitat selection and carrying capacity.

Monoculture forestry and quickened stand establishment mean less browse, diversity and duration of available forage (Eastman, 1977). The regeneration of monocultures in large areas will have a negative impact on moose (Ontario Natural Resources, 1988). The concept of diversity in all aspects of habitat structure and age class seems to be a recurring theme relating to the needs and preferences of moose. Where softwoods are promoted over hardwoods through conversion or hardwood regeneration suppression, there will be decreased diversity within the forest, and less browse available to moose. It should be noted that jack pine and black spruce usually exist naturally as monocultures in the boreal forest, and it is the overall variability of stands which is as important as within stand diversity.

Scarification was found to increase the browse available to moose in the years following treatment (Young et al., 1967). It was believed that this was due to the increased exposure of the mineral soil, hence facilitating new growth. Scaife (1980) found that poplars, in particular, tend to regenerate quickly, providing good browse on a scarified site (Stelfox et al. 1976; Scaife, 1980). In contrast, Stelfox et al. (1976) showed that browse production on scarified sites was lower than that of undisturbed cutovers for up to 17 years following cutting.

Mechanical site preparation encourages establishment of deciduous and herbaceous plants, except on infertile soils. Unfortunately, mechanical preparation tends to remove residual growth which has habitat value as a food source and as hiding cover. The importance of residuals is proportional to the size of the clearcut. The experience in NE Minnesota has been that site preparation and the use of herbicides diversify browse through suppression of dominant competitors and extends the period in which it is available to moose (i.e. height less than 2.75 m). This is only true, however, to the point at which browse density falls below some browsing efficiency level at which moose will prefer other sites (Jordan et al., 1988). McNicol and Gilbert (1980) found that for 3-20 years after disturbance regeneration generally provides good habitat for moose, but that scarification and planting will shorten this period of hardwood domination.

Scarification can remove organic layers which may contain most of the nutrients (BC Forests and Lands, 1987). Unintentional removal of this topsoil will have negative effects on the production of all vegetation (Jordan et al, 1988). Compaction which results from heavy equipment can reduce productivity for up to 30 years.

Research by Stelfox (1984) revealed that forest diversity increased in tooth-blade scarified sites for the first 6 years after harvesting White Spruce in the foothills of Alberta and lead to increased summer use by ungulates. However, big-game use of cutovers was 2.7 times greater on unscarified sites over the first 26 years due to the presence of cover. Scarified sites lagged 5-10 years behind the unscarified sites in terms of providing cover requirements for ungulates. Twenty-six years after harvesting, all clear-cuts were found to be adequately stocked with conifers, although in spruce and mixedwood sites the growth was greater in the unscarified areas than in scarified ones. This trend reversed itself on lodgepole pine sites, where scarification appeared to improve regeneration performance.

Slash is the residue consisting of bark, branches, tops and other debris from harvesting which is left on the ground (Peterson and Peterson, 1992). It may be burned, left to rot or hauled away. Slash can have both a positive and a negative impact on usage of a site by moose. Slash may be an important winter food source for ungulates where deciduous growth is left on the ground within reach. Slash also contributes to the habitat of other wildlife such as small mammals (Foster, 1988) and provides for a slow release of nutrients onto the site thereby increasing the fertility of the soil for regeneration. Slash may also act as cover where it reduces sight lines for hunters and predators. However, in some cases where slash is heavy it may impede access and movement in a site, and even reduce the space available for regeneration (Foster, 1988). Sites studied 46 years after cutting in a Black Spruce swamp near Iroquois Falls, Ontario showed that those in which slash was piled in rows approximately 25 feet wide and 20 feet apart resulted in better regeneration than sites which used circular piles for slash, or spread slash evenly over the cutover, or piled and burned the slash (Moore, 1973).

Where slash is burned it was observed that moose prefer these locations to unburned areas during the first five years after burning (Eastman, 1977). This is likely due to the increased browse resulting from a nutrient flush in to the soil. In some cases burning may reduce the residual growth in a cutover. However, British Columbia Forests and Lands (1987) warns that slashburning has been found to decrease soil fertility by burning off the duff layer and slash which is rich in nutrients. Low intensity fires and avoiding burns in areas with thin soils are methods of minimizing this impact.

Prescribed burning actually extends the successional stage increasing the duration of browse availability (Bunnell and Eastman, 1976). Ungulates utilize post-fire areas due to an increase in quantity and quality of browse caused by increased nutrients returning to the soil (Taber, 1973; Stenlund, 1971; Randall, 1966; Cumming, 1972). Krefting (1972) found the improved browse for moose extended for a period of 15 years following treatment. As long as residual stands are allowed to survive, prescribed burning will tend to improve moose habitat (McNicol and Timmerman, 1980).

In northeast Minnesota in typical Canadian Shield boreal forest studies were conducted into the effects of the herbicides Glyphosate and 2,4-D on browse production (Kennedy, 1986, and Jordan, 1985). On sites 3-7 years after site preparation it was found that herbicided areas produced 56 lb/ha versus 89 lb/a for non-treated areas. Browsing by moose was measured at 18 lb/a and 27 lb/a respectively. A rough rule for comparing browse production on these sites was to use the ratio 50:100:200 lb/a for glyphosate, 2,4-D and untreated areas respectively. The reason for the lower biomass production in the glyphosate treated areas is due to the root-kill which occurred, compared to 2,4-D which only killed the tops allowing regrowth in 3-5 years. The experience of Abitibi-Price Ltd. with 2,4-D is that it results in increased grass growth in areas where it is applied. With Glyphosate they found that it affects only vegetation it is applied to, and is less toxic than 2,4-D and biodegrades in the soil (Durocher, pers. commun., 1993). Studies conducted by Manitoba Environment concluded that Vision biodegrades quickly and that natural plant species re-invade the site within 1-2 years. Impacts on birds were studied and although the species were found to change on herbicided sites, the populations of species present were stable (Keenan, pers. commun., 1993). Studies of glyphosate impacts on bird populations in Nova Scotia corroborated these findings (Mackinnon and Freedman, 1993). In these trials aerial spraying resulted in large decreases in vegetation for up to four years. Bird populations substantially recovered by year four, but many of the species had changed relative to a non-herbicided reference plot. The treatment was found to have permanently altered the successional state of the site, and placed it on a different successional trajectory than untreated plots.

Connor and McMillan (1990) studied the use of cutovers sprayed with Glyphosate in Ontario and found that the use of untreated sites was greater for the first three years after cutting when compared with treated sites during the winter. The browse production was four times greater on untreated sites and the browse utilized was 32 times greater than treated sites. McNicol and Gilbert (1980) argue that white birch and pin cherry are killed by herbicides and do not sucker back. These being two of the five most preferred species in winter, herbiciding should have negative consequences for moose. The FML, however, is home to very little birch and cherry according to Durocher (pers. commun., 1993). Species such as dogwood (Cornus spp.), and Manitoba maple (Acer negundo L.) which are plentiful are more able to survive herbicide application.

In contrast a number of studies in the U.S. have shown that moose use of cutovers treated with herbicides returns to normal after just one year (Krefting and Hansen, 1969; Beasom and Scifres, 1977; Tanner et al., 1978). Barker and Malone (1972) found that moose in the White River area showed no differentiation for treated or untreated sites 3-4 years after cutting.

The use of herbicides in forestry are controversial but Armson (1986) defended the use of chemicals in our forests, stating that the risks are generally exaggerated and unsubstantiated. In terms of risk assessment one must look at the risks of not using chemicals in terms of lost value due to disease and choked seedlings. The frequency of use in forestry is also low when compared with practices in agriculture. According to Abitibi-Price Ltd. the forest industry is responsible for only 1% of the chemicals applied in Canada (Durocher, pers. commun., 1993).

Experts have suggested thinning as a prescription for combining forestry and wildlife. Doer and Sandburg (1986) found that thinned stands of sitka spruce and western hemlock produced 17-50 times greater browse quantities compared with unthinned stands in Alaska. Thinning allows understory growth which is vital to moose (Bunnell, 1974; Depape and Collins 1977; Schultz Int. Ltd., 1976; Kimmins, 1991. Downed material is also available in the short-term (Bunnell, 1974). Reductions in crown closure must be relatively large to achieve significant response in forage biomass.

3.5.2 Harvesting

Timber harvesting can have a variety of effects on habitat as it pertains to moose, depending on the state of the stand and method of harvesting. Harvesting will generally enhance the diversity of a stand when mature conifers dominate the site. Opening the canopy allows shade intolerant species such as trembling aspen and white birch to grow. Remnant mature hardwoods and advanced conifer regeneration can provide diversity and escape cover (McNicol and Timmerman, 1980). In general, harvesting will result in an increase in the moose population (Scaife, 1980, Crichton, 1981).

The literature is quite definite about the increased production of browse following harvesting. In New Brunswick, Telfer (1972) found that available winter browse increased from 205 kg/ha 2 years after cutting to 9,000 kg/ha 10-12 years after cutting. In Alberta's Sand River area Usher (1977) observed browse yields of up to 242 kg/ha, whereas mature forests produced a top value of 11 kg/ha. Stelfox et al. (1976) found that initially browse was more prevalent in the mature forest after one year, but that this reversed significantly after five years. According to Crichton (1981) habitat created by fire and logging activity begins to decrease in value after 10-12 years.

Moose will often stay in and around a cutting operation to take advantage of browse and cuttings that have been felled into available feeding range (Robertson, pers. commun., 1989). Woodland caribou, on the other hand shun disturbance and will avoid harvesting operations. The key factor affecting impact from forestry activities is the size and timing of harvesting operations, as well as stand conversion from mixedwood stands to softwood (Robertson, pers. commun., 1989).

In British Columbia Eastman (1977) found that harvesting in winter areas resulted in little soil disturbance except on trails due to the protective snow cover and frost. Skid trails were found to contain greater quantities of browse than surrounding areas and were subsequently used more by moose. Winter site visits in the FML found little soil disturbance except on trails as well.

Wildfires and logging have generally improved moose habitat by providing large areas of early successional growth in which populations have grown (Cumming, 1972; Krefting, 1951; Peterson 1955; Peek, 1971). Fires have decreased over time as improved controls have come into use, while logging has increased as a factor in moose population change. This trend should not, however, overshadow the fact that in the 1980's fire affected six times the forest area in the FML that harvesting operations did. Natures impact on habitat continues to outweigh that of man.

The impact of clearcutting is largely dependent upon how it is practised. When practised properly clearcutting is sustainable (Kimmins, 1991). In many cases clearcutting is simply the best system for harvesting and regenerating in the boreal forest (Thompson and Welsh, 1993). Cuts which are excessive in size, however, will create a severe environment which is too cold in the winter and will be underutilized due to reluctance on the part of moose to move too far from cover (Foster, 1988; Vogel, 1979). Clearcutting will tend to restrict the spread of diseases such as mistletoe. A clearcut will also create diversity between stands whereas selection systems maintain a continuous cover. Shelterwood cuts will result in approximately the same conditions as a clearcut once the second pass has been completed (Macmillan Bloedel, 1991).

Following cutting there is a nutrient flush due to decomposing slash and a lack of uptake from vegetation. This has positive benefits for vegetation. Shrubs in the short term will flourish and trees over the next 15-20 years will perform better than average (Kimmins, 1991). However, clearcutting may have detrimental effects on vegetation due to soil erosion, soil compaction, and destruction of the soil layers (Foster, 1988). There are a number of issues surrounding the long term effect on nutrients in the soil due to leaching and impacts from whole tree harvesting which are subject to ongoing research. These will not be discussed in this paper.

3.5.3 Road Access and Hunting Issues

Roads are an inevitable development when logging operations are undertaken. They may include highways, secondary roads, and logging roads (OMNR, 1988). Roads do not inhibit moose movement, and their elimination of habitat is minimal when located with consideration for prime habitat. The main impact is use of roads by licensed and treaty hunters to access moose and other wildlife populations (Scaife, 1980; Crichton, 1981; OMNR, 1988; Robertson, pers. commun., 1989).

The vulnerability of moose to hunting is directly related to the amount of access for hunters and inversely related to the amount of cover for moose. Hence, in areas of recent logging activity and road building overharvesting will occur (Eason, 1989). Visibility increases following logging as does the frequency of moose utilization of the new cutover. This has been shown to increase mortality from hunting in the first year (Flemming and Koski, 1976; Timmerman and Gollat, 1982; and Eason, 1985; Cameron, per. commun., 1993).

Road access to a cutover and subsequent human activity tended to reduce the use of those cutovers affected (Stelfox, 1984). Many moose are killed along roads and may even use them as travel corridors making them vulnerable (Hildebrand and Imrie, 1975). Scaife (1980) corroborated this in Manitoba, where hunter kills were directly correlated with roads and forestry cuts. Where possible logging roads and trails should not go through the centre of the cut. Elliot (1990) agreed that road retirements will have a beneficial effect on moose populations.

Abitibi-Price Ltd. has limited authority over road closures in the FML. The company can close roads only when road integrity may be compromised by traffic during wet conditions, or when a hazard is apparent due to forest fires (Durocher, pers. commun., 1993). Even then they must do so with approval from the province. Under the FML Agreement roads must be left open for use by Manitobans. Manitoba Natural Resources does direct some roads to be abandoned or retired, one example being Happy Lake Road (Kaczanowski, pers. commun., 1993).

Increased access by hunters to new sites may lead to local pressures on moose populations and other wildlife but in the broader scope it may lead to a more even distribution of pressures over a larger area (OMNR, 1988). Where local overharvest occurs, it may be balanced by underharvest in other areas, or it may be managed through hunting quota restrictions. In any case, roads should be laid out to avoid special sites such as: mineral licks, calving sites, and winter concentration areas, where such sites have been identified.

The link between hunting, roads and moose populations was further explored by Ferguson et al. (1989) in Newfoundland. They found that moose closer to roads were in better condition due to the lower population density which resulted from hunting pressure. This meant that browse was more abundant and of higher quality, giving rise to healthier moose. Moose greater than 5 km from roads were in poorer condition due to lower intensity hunting pressure, and subsequent higher populations, resulting in less abundant browse.

Population surveys conducted in 1986 for Game Hunting Area 26 in Manitoba estimated the moose population at 850 with a bull:cow ratio of 55:100, and calf:cow ratio of 58:100 (Manitoba Natural Resources, 1986). Moose densities varied from 1.6 moose/sq. km in the Black River Block, to 0.07 in poorer areas. Many areas with good moose habitat were reported to be below their potential in moose population. This was especially evident along major all-weather access roads. One of the subsequent recommendations for moose management was for a refuge system along all-weather access roads. Aerial surveys flown in December 1992 and January 1993 resulted in a population estimate in the model forest of 2,911$\pm$30% animals (Robertson, pers. commun., 1993). The FML falls within the model forest and is approximately 13.4% smaller. Since 1985 the moose population in the area has been stable but is below its potential. Predation by wolves and bears, human hunting, and disease are keeping the population suppressed.

The moose population in Manitoba declined from 28,000 animals in 1981 to 21,500 in 1986 due to habitat loss, predation, poaching and hunting (Manitoba Natural Resources, 1987). Poaching has had a significant impact with an estimated 500 moose killed illegally each year from 1982-86 in

Manitoba, of which 70-75% were cows or calves. Licensed hunting accounted for 1,800 moose in 1986 with 7,226 licenses issued. Additionally 4000-7000 Treaty Indians hunted moose annually during these years in Manitoba and harvested 50-60% cows and calves, compared with 92% bulls harvest by licensed hunters in 1986 (Manitoba Natural Resources, 1987). New roads into formerly inaccessible areas have contributed to population declines due to increased hunting pressure.

The uncontrolled access to the moose resource by Treaty Indians was a key factor cited by Crichton (1988) and Robertson (pers. commun., 1993) affecting moose populations. Power (1990) felt that native hunting must be curtailed if moose are to thrive. Jack lighting and all night hunting take their toll and the limits of the moose population must be realized by all users. Licensed hunters are controllable, but native hunting and poaching are not. It is reasonable to ask whether the forest industry should be forced to improve habitat when other factors are limiting the moose population (Durocher, pers. commun., 1989; East, pers. commun., 1989; Robertson, pers. commun., 1989).

Conversations with Payne (1993) revealed a different attitude. He believed that licensed hunting, forestry practices, and predation had as much to do with suppressed moose populations as did native hunting. The basis or data to support the general belief that native hunting was the major factor in moose population decline was disputed. The anti-Indian bias that exists within the established forest and wildlife management community has not served wildlife well.

A resource road management plan is currently being prepared through the Model Forest. Consultants are in the process of completing a three stage plan. The first stage is to develop a classification system for roads in the model forest based on life expectancy, and other characteristics. The second phase will entail an inventory of existing roads and their attributes. Finally, a use strategy will be developed which will assist in decision-making on the uses of existing and future roads (Ardron, pers. commun., 1993). This strategy will address the issue of historical use patterns and means of modifying these patterns.

4.0 WILDLIFE MANAGEMENT

Wildlife management can be described as the "art of making land produce valuable populations of wildlife" (Bailey, 1984). Since it is the land which produces wildlife, we must determine what type of "land" moose require. It is then possible to apply the science and art of forest and wildlife management to try and create these habitats. This section will identify the habitat needs of moose and other species and describe current wildlife managment practices in the FML.

4.1 Moose Habitat Requirements

The requirements of moose can be categorized as energy, nutrients, water, climatic shelter, escape cover, and space (Eastman 1977, Bunnell, 1974). Habitat selection can be viewed as an attempt to acquire these resources. Different needs arise in different seasons so a variety of habitats are used in the course of a year. Van Ballenberghe and Peek (1971), Peek et al.(1976) and Oldemeyer et al. (1977) found that moose habitat preferences change from year to year depending on the weather, food supply and energy requirements. Liebig's Law of the Minimum states that the limiting habitat factor establishes the carrying capacity of the habitat (Watts, undated). The limiting factor will change in different areas and establishing what is limiting wildlife populations in a specific area is a major challenge to those managing the forest with wildlife population goals in mind. Crete (1987) looked at moose population froms the viewpoint of limiting factors. The major factors by which populations are regulated include forage availability year round, hunting, and predation. He found that in most cases in Quebec and Ontario there was ample habitat available and that populations were generally limited by hunting and predation. Robertson (pers. commun., 1993) also found this to be the case in the FML. There is good moose habitat which is not being utilized. Therefore, one of the other factors is limiting population growth.

Utilization of habitat depends on the factors of snow depth, accessibility (slash presence), migration patterns, predation, water, shade, human activity, space, and browse (Foster, 1988). If the needs for shelter, food, and cover are met, then the moose population will have greater resiliency to pressures from disease, predation, and hunting.

Predation can have a significant effect on moose populations. Wolves, bears and humans are the predators which hunt moose. A study of predation on the Kenai Peninsula in Alaska found that black bears took 81% of all calves taken by predators. Although predators were found to be significant, habitat quantity and quality were more important factors in determining moose populations (Schwartz and Franzmann, 1989). Moose are a prime prey species of wolves and calves in particular are vulnerable to black bears (Robertson, pers. commun., 1993). Although there has been no measure of impacts from these predators in the FML it is believed that they are one of the factors limiting moose populations. Studies in SE British Columbia (Seip, 1992) agreed that moose are one of the prime prey species of wolves, and that they frequented similar habitats. Woodland caribou tended to use higher elevations during the winter compared with the valley bottoms used by moose and wolves. As a result caribou minimized predation by wolves. During the summer wolves were found to be a major factor limiting caribou populations, with mortality of 29% in one site. Similarly, wolves were a major factor contributing to declining moose populations. Wolves were also found to be a limiting condition of ungulates in general in Alberta (Gunson, 1992). When wolf populations were high they suppressed populations, but did not have a sigificant impact during populations lows. A survey of North American studies on bear and wolf predation on moose by Ballard (1992) concluded that singly or in combination these species can significantly limit annual recruitment of moose.

Another factor affecting moose populations is a parasite known as brainworm (Parelaphostrongylus tenuis Dougherty). When white tailed deer and moose share the same habitat the parasite is transmitted to moose. Deer act as a host to this nematode and are unharmed, but moose will eventually succumb to it. Anecdotal evidence suggests that white tailed deer have been making a progressive movement northward in the boreal forest and now exist throughout the FML (Robertson, pers. commun., 1993). Management efforts to mitigate the impact of brainworm on moose have entailed increasing the hunting season and bag limits on deer in the region. No harvest results have been reported since these measures went in to effect, however the area is reasonably remote and difficult to hunt. White tailed deer are early successional feeders and follow forest harvesting in to areas where previously mature forest existed. Deer will yard in conifer swamps, or mixed-woods with heavy cover (Taylor, 1956), and hence tend to utilize similar habitats as moose.

Moose habitat needs fit within the context of their home range. Studies in the Chapleau Crown Game Preserve revealed a local population of 260 animals moving from cutover areas to an adjacent 200 square kilometre tract of uncut timber (Welsch et al. 1980). Addison (1980) noted summer ranges of 90 sq. km for an adult male and 32 sq. km. for a yearling in northwestern Ontario. Hoover and Willis (1987) reported similar findings with Shiras moose in Wyoming which had an annual range consisting of 15 square kilometres but with some animals cruising distances of up to 18 kilometres during a year. LaResche (1974) reported findings from a number of studies which showed annual movements of moose of up to 40 km were not uncommon. Van Ballenberghe and Peek (1971) found Ontario moose to travel shorter distances annually, in the range of 2-6 kilometres. Moose in southern Norway were found to migrate on average 11 km (Histol and Hjelford, 1993). Moose populations consisted of migrating and non-migrating animals. Those that migrated were moving to winter habitat in January (triggered by snow depth), and returning in April. The moose tended to winter in the same habitat year after year. Goddard (1970), Van Ballenberghe and Peek (1971), and Phillips et al. (1973) agreed that moose have relatively small annual movements, but are especially stationary in winter. Movements of bull moose in New York's Adirondack area had mean movements of 0.4 km/day and 0.2 km/day in summer and winter respectively (Garner and Porter, 1990). Movements in the fall increased tenfold over summer values which were in turn much larger than movements in winter. The large range of some moose make management on a micro-scale unfeasible. Management plans for harvesting should consider habitat availability within an area of several hundred square kilometres (Thompson and Euler, 1984). The range and density of moose populations in Manitoba is shown in Figure 2.

Cover can be defined as vegetation that provides concealment from view, lateral protection from wind, as well as overhead protection from precipitation and sun (Timmerman and McNicol, 1988). Security cover provides a visual barrier that minimizes opportunities for hunters and predators. Cover is a habitat that serves many purposes for moose. It may be for climate moderation, reproduction, resting, or escape from predators/hunters. The loss of escape cover may not affect populations where hunting pressure is minimal, however other forms of cover are essential (Bunnell, 1974).

What critical habitat consists of for moose has been given much attention in the literature. It is accepted that moose are well suited to inhabit the boreal forest where important early stage successional vegetation is available (Krefting, 1974). Peek et al. (1976) felt that the open cutovers used in early summer and late fall is the key habitat. The key habitat for moose, according to Robertson (pers. commun., 1989) are hardwood and mixedwood forests, and riparian areas. Crichton (1981) agreed that moose will generally be found within mixed-woods. The early seral stage of plant

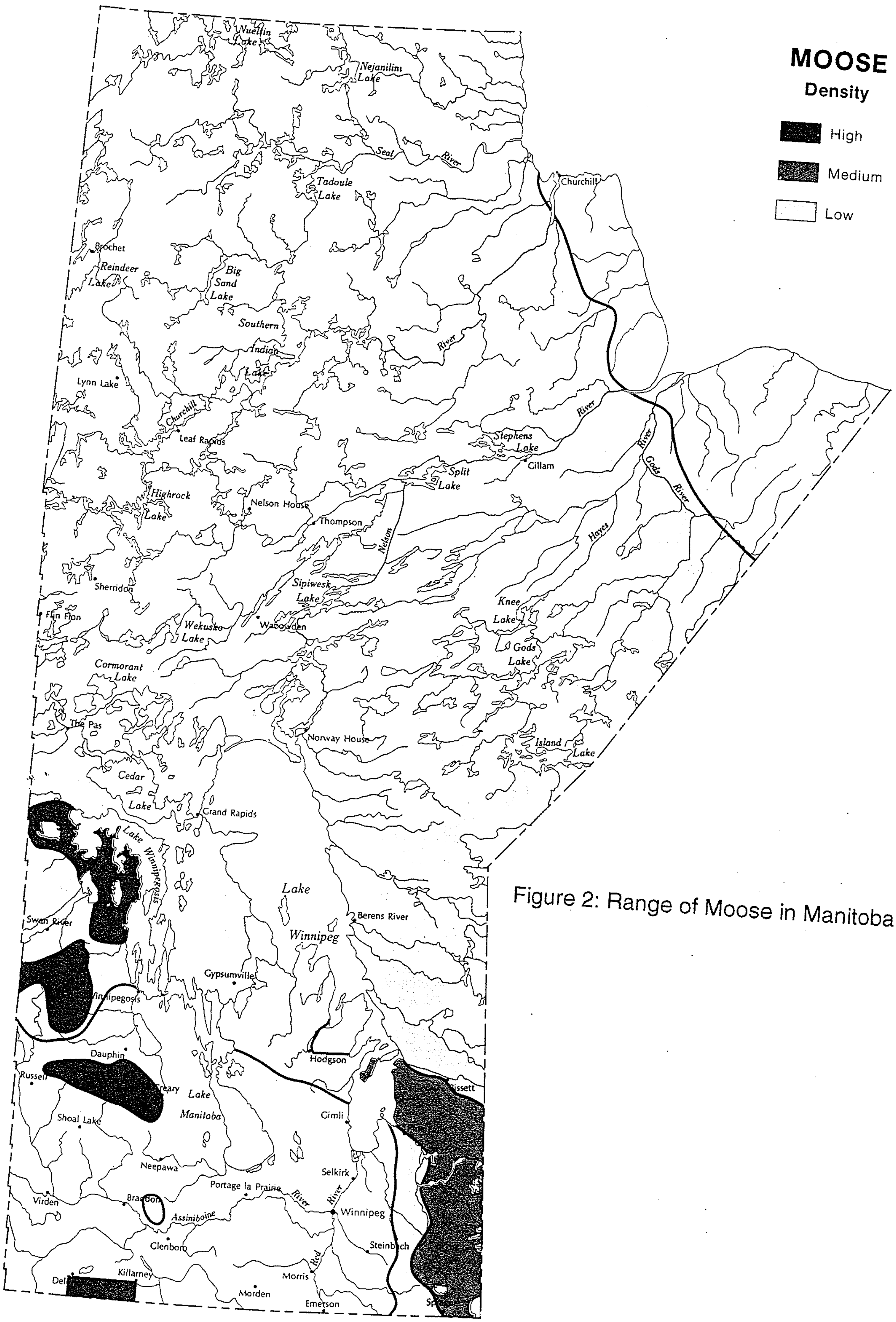


Figure 2: Range of Moose in Manitoba

succession was viewed as one of the important habitat types for moose (Peterson, 1955; Krefting, 1974)

Some experts have theorized that ideal moose habitat approximates conditions created by a medium intensity forest fire. Such an event leaves the forest with irregularly shaped cuts, scattered shelter patches, high diversity of age-class and species composition (Pimlott, 1953; Peterson, 1955; Dodds, 1974, Ontario Natural Resources, 1985). The Sandy River fire in Manitoba in the summer of 1989 was viewed from a helicopter and revealed a patchwork of burned areas mixed with unburned areas which often consisted of low lying stands of black spruce. The early forest succession following disturbances (up to 20 years) such as fire, insect damage, blowdown or logging has been widely reported as key habitat for moose (Krefting, 1974; Peek et al., 1976; Davis and Franzmann, 1979; Cummings, 1980; Bangs and Bailey, 1985).

Moose are early successional feeders adapted to disturbance, similar to deer, and in contrast to climax species such as woodland caribou with their low reproductive potential (Bunnell, 1974). Moose are more likely to be limited by the quality of browse than the quantity. For example, moose generally undergo a protein deficiency during the winter when they are limited to the low nutrient value of twigs compared to buds and leaves available at other times of the year.

Scaife (1980) stated that habitat utilization by moose in northern Manitoba is limited by the availability of cover. Moose prefer ecotone areas where clearings and mature forests meet due to the availability of food and the proximity of cover. Scaife also found that this preference for cover manifested itself as increased usage of cutover areas which were 10 years old or more. These findings confirm the observations of Eastman (1977), La Resche et al. (1974), Telfer (1967), (1978), and Markgren (1974) which reported high densities of moose populations in partially cut stands throughout the year. The greater diversity and edge effect in these forests was a desirable moose habitat attribute. In the case of the 1947 Kenai burn in Alaska, as reported by LeResche et al. (1974), densities of up to 12 moose/sq. km. were observed in an area of high vegetative diversity and edge. Telfer (1984) states that in general, moose densities rarely exceed 0.5 to 1.5/sq. km. Densities on the Chapleau Crown Game Preserve were observed to be 0.3 to 0.35 moose per sq. km., roughly double the populations in surrounding forests. This Preserve has been subjected to active forest operations, but has not been exposed to hunting for 60 years (Thompson and Euler, 1984). Moose reproductive abilities are adapted to maintain low densities (< 0.2/sq.km) but allow for rapid expansion into newly disturbed areas (1/sq.km) followed by a slow decline as the area matures (Cowan et al., 1950,; Geist 1974).

Two examples of areas which were known to have a high density of moose are the Kenai burn in Alaska, and NE Minnesota. The Kenai burn covered an area of 260,000 ha and studies on prime moose range in this area revealed that 46% was covered in remnant stands of mature coniferous and deciduous forest (Le Resche et al., 1974). In a 254 ha area there were 411 different stands which provided a high degree of diversity and edge, and moose populations responded positively to these features. In Minnesota the areas with the highest moose population potential were quantified as having 40-50% of the area in early succession (<20 years), 5-15% in mature coniferous spruce-fir stands, and 35-55% covered with water and aspen-white birch stands (Peek et al. 1976).

Moose are easily heat stressed, and the literature suggests that this may be a factor in habitat selection throughout the year (Renecker and Hudson, 1986). Observations found moose respiration began to increase above 14 degrees C, and open-mouthed panting occurred at 20 degrees C. At the other end of the spectrum moose are extremely tolerant of cold temperatures and even conditions of -30 degrees C did not stimulate metabolic rates in moose. Schwab and Pitt (1991) found similar results with their study of moose in the sub-boreal spruce forests near Prince George, B.C. In summer moose were found to avoid any site where temperatures reached 30 degrees C, but also found moose to become heat stressed in winter at temperatures above 8 degrees C. Above 8 degrees C they observed moose which were panting to dissipate heat. They concluded that avoiding heat stress was a major factor in determining habitat use year round, and that forage availability and snow depth were secondary determinants.

Although food preferences vary, moose feed primarily on deciduous browse year round (Eastman, 1977). A worldwide review of literature on moose by Morrow (1976) revealed that several hundred different plant species are consumed by moose, although locally there may be 25-30 preferred species. Moose prefer the crown twigs of shrubs and mature trees (felled). They will knock down suitable saplings and shrubs to gain access to crown twigs even if other browse is available within reach (Telfer and Cairns, 1978; Grizmek, 1975). Shrubs are generally more prevalent as a food source than downed trees (Cameron, pers. commun., 1993). Moose will generally not browse on desired softwood species such as spruce and jack-pine, and may in fact aid in silviculture. In areas of heavy browsing on Isle Royale, the height of broad-leafed perennials has been suppressed below 2 m. This will have benefits for regenerating softwoods (Jordan et al, 1988; Krefting, 1974).

The specific habitat needs in each season vary and are described in the following sections.

4.1.1 Spring/Summer

Calving sites are important habitat during the spring. Moose cows seek secluded areas such as islands, peninsulas, shorelands, and isolated thickets of alder, spruce, fir and willow usually near water presumably to avoid predators such as black bear and wolf (Hoover and Willis, 1987; Mech 1966; Peterson, 1977). Studies by Addison et al. (1990) found that moose use a variety of habitats for calving. No correlation was observed between calving sites and abundance of food or water, shelter from the elements, or proximity of water or cover for escape from predators. They hypothesized that selection was based on avoidance of predators, as most sites were on hills. Of 145 islands checked during the spring, 44 were found to be calving sites.

Moose prefer aquatic vegetation (emergent and submergent) in the spring and early summer and hence frequent riparian zones during this period (Cumming, 1972; Kearny and Gilbert, 1976; Joyal and Scherrer, 1978; Brusnyk and Gilbert, 1983, OMNR, 1988). The extensive feeding on aquatic vegetation and the use of mineral licks at this time of year supply needed nutrients which are not available from other food sources (Jordan et al., 1973, Fraser and Reardon, 1980). Aquatic macrophytes may contain between 50-400 times more sodium (Jordan et al., 1973) and 2-200 times more iron than woody browse (Aho, 1978). Fraser and Hristienko (1983) found moose in Sibley Provincial Park to consume up to 50% of the annual growth of aquatics in areas of heavy feeding. Cummings (1972) concurred and found that by late summer moose begin browsing on hardwoods in early successional plant communities. Favourite lakes may exist due to preferred vegetation available as a result of mineral soil substrates in the lakes. Where aquatics are not available, salt licks may provide an alternative source of sodium (Green and Salter, 1987). In particular, mineral licks are used during the early spring before the aquatic plants are out to provide sodium (Faser et al, 1980). Use of these licks declines after July.

During summer months moose are vulnerable to extended periods of high temperatures. Cool moist lowland habitats are often preferred in the summer as a means of keeping body temperature down. Moose may even bed down in shallow water on hot days as observed by Timmerman and McNicol (1988).

Belovsky and Jordan (1978) studied moose on Isle Royale and found them to consume forage that consisted of 69% leaves, 24% aquatic vegetation, and 7% herbaceous plants during the spring and summer. In Northeastern Minnesota moose were found to concentrate on aquatics and aspen during the spring, and shift towards a variety of species including willows, mountain maple, white birch and cherry during the summer (Peek et al. 1976). The summer diet of moose in Denali National Park, Alaska was 85% willow (Salix spp.) (Van Ballenberghe et al., 1989). Aspen, saskatoon, red-osier dogwood, choke cherry and pin cherry are other species of prime moose browse (Green and Salter, 1987).

Rounds (1975) studied moose in Riding Mountain National Park and found low habitat selectivity and preference for any vegetation type. A strong rejection was afforded only to jack pine forests. Addison et al. (1980) also recorded heavy use of deciduous uplands and burns during the summer. This shows the diversity of habitats that moose utilize during this part of the year.

4.1.2 Fall

Throughout the fall and winter moose continue to browse, with preferred species being mountain ash [Sorbus decora], dogwood [Cornus sp.], willow, aspen and birch. Cummings further states that although moose prefer these species, the major food source in north-western Ontario is hazel [Corylus sp.]. The Ontario Ministry of Natural Resources (1988) states that moose require successional growth of willow, aspen and birch in the late summer and early winter. Krefting (1974) added balsam fir as a key species to this list, while Peek (1976) found red osier dogwood (Cornus stolonifera michx.) to be appetizing to moose at this time of year.

4.1.3 Winter

Winter is the hardest season for moose to survive. Although well adapted to the cold, mortality is generally highest during the winter. The availability of food sources is severely reduced over the winter. One of the effects of this is that moose metabolism decreases as does movement in winter to conserve energy (OMNR, 1985). Moose store energy in the form of fat during the summer and fall and use this energy during the winter months (Schwartz, 1992). Forage quality is lower during the winter, and moose eat less during this time of year.

Moose must balance the need for food with the need for shelter from the elements and predators. Shelter or cover during the winter is usually in the form of mature stands of conifers, with sufficient crown closure and density to mitigate winds and snow depth. Cameron stated that moose in the FML are also able to winter in mixed wood and hardwood stands which provide suitable cover (pers. commun., 1993). Escape and thermal cover are more important factors affecting cutover use than browse abundance (Stelfox, 1984). A stand must have 50% crown closure before it will be used year round by moose.

Moose have large rumen (stomachs) which allow them to eat large quantities of food with only partial chewing. They can then retreat to a secure location where cud chewing processes the food. Adult moose feeding in winter have been observed to average 5-6 feeding periods every 24 hours each of an average duration of 1.13 hours (Risenhoover, 1986; Franzmann et al. 1976). Moose bed close to conifer cover to reduce wind chill (McNicol and Gilbert, 1978). This frequent movement back and forth between cover and forage sites further indicates the importance of proximity between these habitat types.

In a study of habitat selection by moose during the winter in the sub-boreal forests of north-central British Columbia, Eastmann (1977) found that moose used partial cutovers and burns more than the surrounding coniferous forest. Deciduous forests and recent clearcuts were the least preferred habitats. Use of cut blocks was nonexistent immediately following cutting and increased to a peak between 10 and 25 years later. Usage then declined until a mature forest stage was reached at which point the populations increased slightly and stabilized. Elliot (1990) felt that moose usage of a cutover reaches a peak after 15 years.

Moose will often concentrate in winter in areas where exposure to the sun is maximized (Stelfox and Taber 1969; Brassard et al. 1974; Prescott 1974; Telfer 1984). South facing slopes provide better thermal cover for animals (Brown, 1985).

In early winter when snow depth is not great moose will continue to utilize cutovers and other browsing sites. Moose tend to concentrate in areas that typically consist of mature or overmature, open canopy, mixed wood stands with low stocking (<60%) with a proximity to burns and cutovers in the 5-20 year age range (OMNR, 1988). Early winter concentration areas tend to be small areas (2-10 sq. km) used by large numbers of moose (up to 10 moose/sq. km) in the November to January period (Thompson and Euler, 1984). These areas are generally upland open sites with abundant browse. Moose prefer young deciduous stands and openings in milder weather (Phillips et al.,1973; Peek et al.,1976; Telfer, 1970; Des Meules, 1965).

Cows with calves are particularly restricted by snow even in easy winters and generally will not wander more than 60 metres from cover (Thompson and Vukelich, 1981). This population cohort used sites that were most often lowlands with an average cutover size of 64 ha. The best early winter habitat also had residual stands of mixed or coniferous trees and a maximum distance to cover of 250 m in an 18 year old cutover.

Winter habitat is the most critical component of moose habitat (Des Meules, 1964; Schultz Int. Ltd. 1976; Poliquin et al. 1977; Welsh et al. 1980; Thompson and Vukelich, 1981). During the late winter moose are forced to minimize movements and seek thermal cover (Thompson and Euler, 1984). Winter severity is a function of snow depth and is an important factor affecting habitat selection by moose (Eastman, 1977; OMNR, 1988). As snow depth increases moose move into areas with forest cover to bed down and seek shelter from the wind. A snow depth of 80 cm and sometimes even less was found to be sufficient to limit use of an area (Des Meules 1964, Telfer 1970, Phillips et al. 1973, Coady 1974; Dodds, 1974). Moose in SE Alaska avoided snow that was greater than 80 cm deep and used coniferous and mixed stands more in winters with deep snow (Hundertmark et al. 1990). Moose in Fundy National Park, New Brunswick also were found to be severely restricted by snow depths of 70 cm or more (Kelsall and Prescott, 1971).

Harsh winter weather may result in a yarding behaviour as moose density increases in suitable stands (Bunnell, 1974). Moose may still use cutovers but many abandon them completely, particularly in March. Residual stands in cutovers are also used much less during this time of year (Hamilton et al. 1980). In general, mature conifer forest were found to have higher humidity, less wind, higher temperatures and 50% less snow depth than surrounding openings (Eastman, 1977). Late winter cover is more limiting than that of early winter, and Hamilton et al. (1980) recorded 95% of all winter browsing by moose in Northern Ontario in cutovers was within 80 m of coniferous cover when snow cover was crusted and deep.

Addison et al. (1980) reported late winter ranges in black spruce swamps for 2 yearlings and an adult male and a rolling upland area with tall aspen growing above a stand of balsam fir for an adult female. Areas of late winter use by cows with calves had an average cutover size of 16 ha with a maximum distance to edge of 370 metres, generally in lowland sites (Thompson and Vukelich 1981).

Phillips et al. (1973), Peek et al. (1976), Telfer, (1970), and Des Meules (1965) found that moose inhabited mature mixed and coniferous forests when winter conditions were severe. The Ontario Ministry of Natural Resources (1988) views mature stands of conifers as the preferred moose habitat for protection from predators and winter weather. These stands will generally have greater than 70% stocking and complete crown closure. Mature conifer stands provide warmer microclimates and lower snow depth, thus decreasing the depletion of energy reserves (Telfer 1970, 1978; Kelsall and Prescott 1971; Peek 1971; Peterson and Allen 1974). Tree species typically providing cover for moose include jack pine, black spruce, balsam fir, white cedar (Thuja occidentalis L.), and white spruce. Mature conifer stands must be at least 100m wide to provide winter thermal cover and security cover (Stelfox, 1984).

Conifer cover, residuals and shoreline reserves improve site usage in winter when snow is deep or crusted and may impede movement (McNicol and Gilbert, 1980; Thompson and Vukelich, 1981; Brusnyk and Gilbert, 1983; Hamilton et al. 1980). Brusnyk (1981) found that uncut shoreline reserves had a greater diversity of species than surrounding natural and cut areas. This proximity of cover and browse resulted in higher utilization by moose than in surrounding areas. McNichol's surveys near Thunder Bay (1976) found that cutovers with scattered residual stands of mature or semi-mature conifers and deciduous trees accounted for 72% of moose utilization of cutovers during the winter. The proximity to both food and cover during the winter months is crucial (Eastman, 1977; OMNR 1985). Hundertmark et al. (1990) also recommended that management of moose should provide for proximity of cutovers to mature stands. Studies of moose near Thunder Bay during winter (Jan./Feb.) found that moose showed little preference between scattered residual stands of either conifer or deciduous trees (McNicol and Gilbert, 1980).

Winter pellet sampling and analysis from 23 sites across Canada over a five year period revealed that Betula spp. (mostly B. papyrifera) comprised 85% (by weight) of the fibre fragments found within the pellets (Thomas, 1990). Surveys of moose browse near Thunder Bay, Ontario found white birch, mountain ash, and willow to be the most commonly browsed species during the winter (McNichol, 1976).

4.1.4 Cut Block Design

The size, shape and residual vegetation of cut-blocks have a significant effect on moose use of a site. Clear cuts that are over 400 metres wide will not be fully utilized by moose, since they generally do not travel more than 200 metres from cover (Males and Stabb, 1988). Eastman recommended a cut size of no greater than 32 ha with an area/circumference ratio of less than 0.8. Telfer (1974) suggested a maximum cutblock area of 1.3 sq. km presumably on the assumption that moose will move 600 metres from cover. Peek et al. (1976) suggested an 80 ha block size based on their observations of high density moose habitat in NE Minnesota. Eastman (1974) felt square cuts should not exceed 1.08 km on edge or exceed 115 ha, while Hamilton and Drysdale (1975) argued for a maximum width of cut not exceeding 200 m to maintain use by moose (Hamilton and Drysdale, 1975). Usher (1978) stated that cuts should be even narrower, less than 100m wide, less than 400 m long and less than 5 ha in total area. In Saskatchewan, it was recommended that clearcuts be less than 40 ha (Schultz Int. Ltd., 1976), and in Alberta the area was 32-40 ha (DePape and Collins, 1977). Telfer (1970) felt that 60-80% of any given operating area should be 35 years or older. Foraging areas should be irregular in shape and 2-5 ha in size. Under low levels of harassment they may be as large as 32 ha (Green and Salter, 1987). Perala (1977) recommended a cutover area of less than 80 ha for moose.

Markgren (1974) found that patch cuts of 2-25 ha over a ten year period resulted in increased usage by moose in Sweden. Clear-cut patches of up to 200 acres or more have potential for supporting a large moose population for 10-25 years, after which time canopy closure shades browse out (Jordan et al., 1988).

An advocate of "new forestry", Franklin (1989) found that small patch cuts (8-15 ha) changed the conditions surrounding uncut stands, as did DePape and Collins (1977). Wind, temperature and humidity are altered up to 3 tree lengths from the edge of the stand. Franklin suggested placing new cuts next to existing cutovers to retain the original conditions in residual cover. Seed or shelter trees would have to be left within the cutovers to provide some cover until the next rotation.

Cut blocks should be small and separated by regeneration areas at least five years old (Vogel, 1979). An irregular shape will maximize edge, and larger blocks should contain corridors for wildlife movement. Generally a mixture of age classes and openings in the forest will optimize habitat for wildlife. In North-Central Manitoba it was observed during the summer that moose were able to utilize large irregular shaped cutovers, as well as smaller but geometrically oriented areas (Scaife, 1980). No decrease in browsing was noted as distance from the edge of the cutover increased due to the presence of residual cover on these sites. The cutovers used most tended to be greater than 6 years of age.

Moose studied in the Porcupine forest of Saskatchewan tended to stay close to cover when browsing in cutovers (MacLennan, 1975; Hunt, 1976).

Telfer (1974) found that cuts larger than 1.3 sq. km (130 ha) were not used until 15 years after harvesting due to lack of cover. Moose in Alberta stayed out of strip cuts in winter even after 17 years of post-harvest growth (Stelfox, 1962). Cutovers that were 9-10 years old were found to be preferred by moose in winter by Hunt (1976) in Saskatchewan. Whereas Usher (1978) found cutovers to be optimal for moose 12-15 years after clearing due to a combination of browse and cover (see Figures 3 and 4). However, moose will use cutovers at a younger age if cover is available. After 30 years the value of the site becomes marginal due to the increasing canopy and decreasing browse diversity, quantity, and quality.

There is a consensus within the literature that residual stands or cover within a cutover will increase utilization by moose. Residual cover in cutovers enables moose to utilize the entire cut, even when it is less than 4 years old and other cover is minimal (Scaife, 1980). Irregularly shaped cuts allow moose to use bigger cuts than those with uniform edges. Zigzag clearcut strips 50-90 ft wide were found to be the most practical method for increasing browse growth, and hence use by moose (Morton and Sedam, 1938). McNicol et al. (1980) suggested that moose prefer cutovers that have a residual component equal to about 2.5 sq. m/ha of both hardwoods and softwoods. Unharvested mixed-woods stands are the recommended composition.

Residual stands of conifers such as balsam fir are important for the use of a cutover by moose (McNicol and Gilbert, 1980). Dense cover blocks 1 ha in

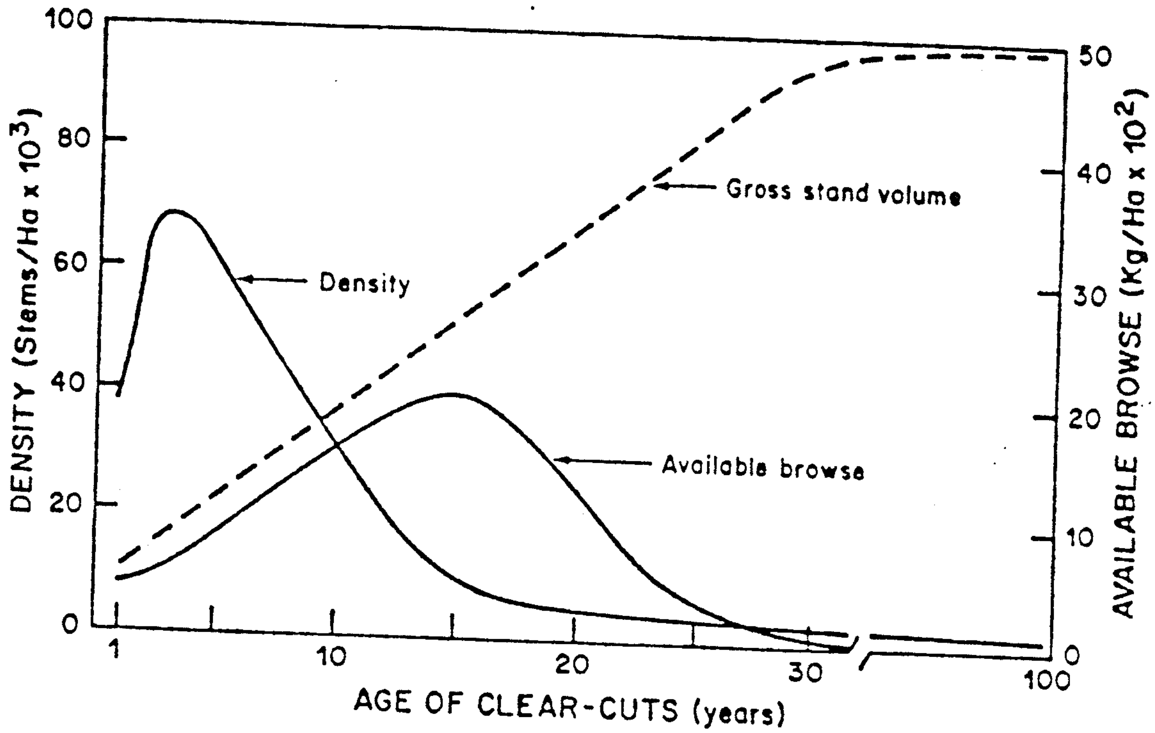


Figure 3. *Browse production in clear-cuts ranging from 1 to 30 years.*

Source: Usher (1978).

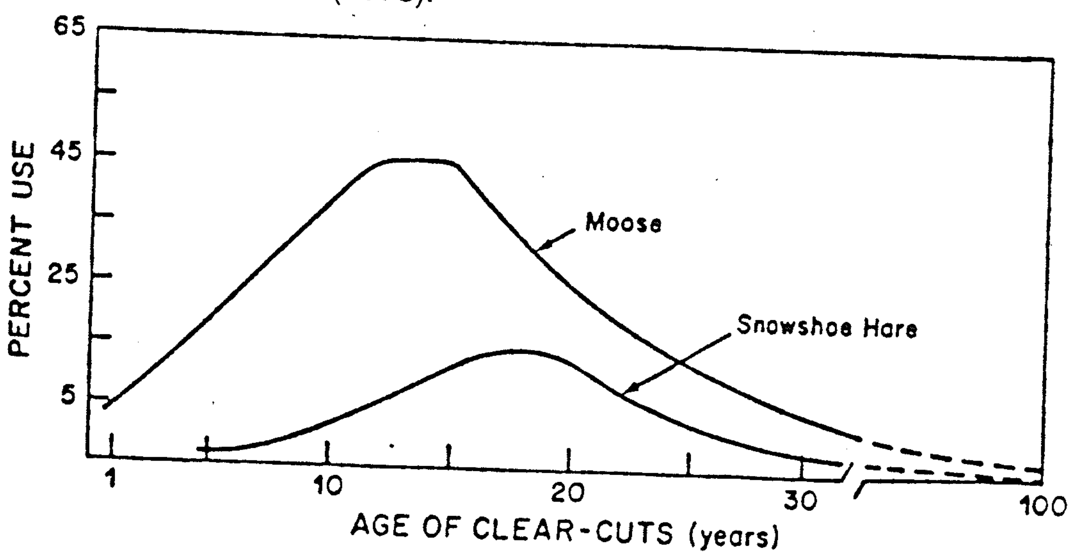


Figure 4. *Browse use by moose and snowshoe hare in clear-cuts, ranging from 1 to 30 years.*

Source: Usher (1978).

size should also be available (Green and Salter, 1987). Sufficient space should be left in between cut blocks to provide hiding cover and shelter (Brown, 1985). Clearcut blocks require an ample supply of cover patches and snags to maximize utilization by moose and other wildlife (Jordan et al., 1988). Cutting plans should allow for moose to be within 200 m of shelter patches which are at least 6m high and 3 ha in area. Hence clearcuts greater than 100 ha should contain scattered shelter patches.

Residual stands should contain at least 1/3 conifers, be 3-5 ha in size, 300-400 metres apart, and at least 6 metres high, with a basal area of 11 sq. m/ha (OMNR, 1988). The stocking densities for immature and mature residual stands at this basal area should be 70% and 40% respectively. Where the residuals are intended for winter cover they should be stocked to at least 70% with conifers and have a basal area greater than 11 sq. m/ha. Where these stands are greater than 8 ha in size they will better resist blowdown, and have potential for future harvests. In terms of landscaping woodlands for wildlife in general, a 200 ft. buffer around wetlands greater than one acre, and 100 ft. for smaller wetlands was recommended by Henderson (1988).

4.2 <u>Other Wildlife Habitat Requirements</u>

There is certainly a variety of wildlife within the FML with differing values to different user groups. This section will attempt to briefly outline the general habitat needs of some of these species.

Many of the furbearers have similar habitat needs as moose. As such moose are a good indicator species for furbearer populations (Robertson, pers. commun., 1989). Hare and moose forage on similar species (Telfer, 1974). Habitat which is good for moose will also be used by small herbivores, upland game birds, song birds, snowshoe hare and beaver (Green and Salter, 1987). The maintenance of a variety of aspen stands intermixed with conifer stands will provide habitat for moose, ruffed grouse, snowshoe hare, and beaver (Peterson and Peterson, 1992). Perala (1977) recommended a cutover area of 2-5 ha for hares, while Gullion (1986) suggested a similar small cut-block size for grouse. Snowshoe hare require a combination of dense forests and small clearings (Grzimek, 1975). Ferron and Ouellet (1992) found that hares prefer areas with dense understory and ecotones. Mature conifer and areas with sparse understory were poorly utilized.

Stelfox (1984) studied wildlife use of clear-cuts in Alberta which converted stands of lodgepole pine, white spruce and mixed-woods to open herb-dwarf shrub communities over a 26 year period. During years 17-25 black bears were found to heavily utilize the cutovers which were producing an abundance of insect food and berries. As well there was adequate growth on the sites to provide cover and cool conditions in the summer. Furbearing animals were depleted on the sites and began to recover only by year 17. The abundance of red squirrel, weasel, lynx, coyote and wolf were17 times greater in mature blocks than in scarified blocks, and 3 times greater than in unscarified blocks. Of the grouse observed over the 26 years, 75% were sighted in years 16 to 26. The majority (59%) of the observations were in mixed-wood sites. Ruffed grouse represented 72% of these observations. Cavity dwelling species such as marten, flying squirrels, woodpeckers, and other birds were much more common in the unscarified sites due to the maintenance of snags in the cutover. The table below summarizes the habitat needs of a number of species.

Table 3: Summary of Habitat Needs

SPECIES	POPULATION IN FML*	HABITAT
White Tailed Deer	Low-med	Aspen forests, edges, openings
Woodland Caribou	Low	Mature conifers, old growth, islands, wetlands
Beaver	High	Lakes and slow-flowing steams with aspen, willow, alder and white birch
Lynx	Med	Prime prey is hare which require successional areas, also use mature conifer stands
Coyote	Low-med	Openings, successional areas
Marten	Low	Mature conifer stands (>70% crown closure), in winter use deadfalls and debris
Mink	Med	Wetlands, lakes with stony shores
Muskrat	Med	Slow-flowing or standing aquatic habitat
Otter	Med	Stream and riverine habitat, marshes, swamps
Raccoon	Rare	Riparian zones, mixed wood forests
Red Fox	Med-low	Prey on successional species
Black bear	Med	Aspen forests, grass understory of forested wetlands, thickets of balsam fir, forest openings
Gray Wolf	Med	lowland conifer and bogs
Snowshoe hare	NA	15-30 year old cutovers
Grouse	NA	Aspens forests, downed logs
Canada Goose	NA	Riparian habitats
Bald Eagle	NA	Rivers, lakes, large open branched trees
Great Gray Owl	NA	Snags, lowland conifer bogs
Osprey	NA	Snags, wetlands

* Source: Manitoba Natural Resources, 1985. Five Year Report to the Legislature on Wildlife. Populations are relative to the rest of the province.

A diversity of habitat is needed to benefit a broad spectrum (Brown, 1985). When using even-aged management diverse stands are created, but which lack structural diversity within the stand. With uneven-aged management there is a higher structural diversity within each stand, but not much diversity between stands. Both types of management are needed to optimize diversity. Diversity within the forest has benefits for both wildlife and forest resilience (Nova Scotia Department of Lands and Forests, 1988). Varied habitat means more wildlife and stable populations as well as reduced risk.

Biodiversity has been defined as the total variety of genetic strains, species and ecosystems (IUCN/UNEP/WWF, 1991). It refers to the structure, function, and composition at three different levels (genes, species, and systems) (Noss, 1990). Genetic diversity is the "raw material for evolution" (Kimmins, 1992) which all organisms possess. Species or alpha diversity refers to the variety of different species in an ecosystem. Systems or beta diversity is a measure of the differences between local ecosystems. Real biodiversity must be measured at the landscape level. It is a function of the groups of ecosystems and the stages of development of those systems, over a sufficiently large area to support viable populations in all biota (Thompson and Welsh, 1993). Unfortunately, forest management has not been focused on reproducing ecosystem pathways which lead to a diverse forest structure at young stages. Silviculture results in simplified habitat structure through planting, tending, thinning, and herbiciding.

The public has focused on biodiversity as one of the key concerns over forest management in Canada (Kimmins, 1992) and is expected to be one of the major challenges to forestry over the next decade. Many people express concern about the conservation of biodiversity yet only about 1% of Canadians have more than a rudimentary understanding of the concept (Watson, 1992). There is a need to identify biodiversity goals for the forest in terms of the different types of biodiversity. Biodiversity may mean different things to different people, and effective management requires clear expectations. The forest is a dynamic system built around regular disturbance, and hence the preservation of forests does not necessarily mean that biodiversity is being conserved.

4.3 Wildlife Management in the FML

Precise knowledge of wildlife populations in the FML is unavailable due to a lack of funds for surveys. However, the management emphasis is on preserving key habitat (Robertson, pers. commun., 1989). Moose and woodland caribou are the priority species from a management perspective due to their value to the public and due the fact that caribou are on the protected species list (Robertson, 1989). Populations of moose tend to increase with distance from Lake Winnipeg due to better habitat in more well drained areas (Robertson, pers. commun., 1989). Woodland caribou number approximately 300 in the FML and appear to be stable. Due to their dissimilar habitat needs, moose and caribou cannot both be managed for in the same area (Palidwor, pers. commun., 1993).

Strategies in Manitoba for maintaining the moose population have included bulls only hunting restrictions in critical areas and road refuges along access roads (Manitoba Natural Resources, 1986). In Manitoba between 1982 and 1986, 6000 sq. km. were closed to hunters (Manitoba Natural Resources, 1987). Co-operative agreements were signed with Indian bands in G.H.A.'s 8 (The Pas) and 20 (Waterhen) for the management of moose populations. Key management objectives for maintaining moose populations are to reduce uncontrolled hunting, reduce and direct the licensed hunt, and alter the age and sex patterns of the native harvest. As well, predator control programs are an option to allow herds to recover in specific areas.

Game Hunting Area 17A was surveyed in the winter of 1985 and resulted in sightings of 119 moose, 40% females, 30% males, and 30% calves (Schindler, 1985). Approximately 75 moose were taken by hunters (subsistence -60%, poaching - 7%, sport - 33%) from this area in 1984.

The Manitoba Forestry Wildlife Project has the goal of sustaining the richness and diversity of our forest resources. The partners in this project are Wildlife Habitat Canada, Manitoba Natural Resources, Abitibi-Price Ltd., Repap Manitoba, The Manitoba Habitat Heritage Corporation, and Canada-Manitoba Partnership Agreement in Forestry. In conjunction with the Model Forest program computer models are planned for development to predict the impact of forest management practices on the supply and quality of habitats for resident wildlife. Twenty wildlife species have been identified as indicator species which are representative of a wide range of wildlife based on their shared environment (Manitoba Forestry Wildlife Project, 1993). Models for moose and woodland caribou are currently being developed by consultants. The basis for the moose model is data acquired from aerial surveys conducted in the winter of 1992/93. Moose are more properly described as an emphasis species rather than an indicator species. They use a variety of habitat and so are not habitat type specific, but they have an economic significance to the province which is cause for their "emphasis" (Kearny, pers. commun., 1993). Woodland caribou tend to be traditional in their use of habitat and are a better indicator species (Palidwor, pers. commun., 1993).

Currently consultants are evaluating the data which exists and determining what more is needed by the model for accuracy (Robertson, pers. commun., 1993). Once the model(s) are validated they will be utilized in the early harvest planning stages to gain an understanding of forestry impacts on wildlife habitats. This will allow managers to become proactive in managing forest and wildlife resources (Kearny, pers. commun., 1993). The model will also allow planning to take place on the landscape level. This fits well with the Forest Management Guidelines for Wildlife in Manitoba which are used on a more site specific basis, and can be viewed as constraint based management. The model should be viewed as decision support system, and not a decision maker. There are many other factors affecting wildlife populations besides harvesting activities, such as hunting, predation, and road access. One of the significant implications of this project is that the forest companies will in a sense be "off the hook" for wildlife populations which may not respond due to other factors. If Abitibi-Price Ltd. harvests in accordance with model supported targets for habitat, then they have done all they can. Management of these other factors is largely the responsibility of Manitoba Natural Resources. This model is scheduled for completion in March 1995.

5.0 INTEGRATED MANAGEMENT

5.1 The Integration Process

The historical conflict between forest and wildlife managers stems from a traditional view that land can be managed effectively for only one of the many forest resources. Multiple uses of the forest are often compatible in time and space, but some may require sequential slotting which excludes other uses (Rannard, 1990) Not all areas can be managed for coincidence of timber and wildlife production. Multiple use will lead to conflicts particularly with differing consumptive uses (Wagner, 1990). However, the forest is habitat for wildlife regardless of the state it is in, whether managed or not. What is in question is: to which species does a forest provide suitable habitat and for which species is it being managed, if at all (Thomas, 1986).

Integrated resource management can be defined as considering and planning for all resources in the same area at the same time, using an interdisciplinary approach (Holtrop, 1987). Thompson and Welsh (1993) defined it as a planning process that directs harvesting in a manner consistent with the production of wood products and the conservation goal of maintenance of biodiversity.

Since this practicum is attempting to increase the integration of forest and wildlife management the necessary prerequisites for this process should be examined. The views of forestry and wildlife managers are often similar on these requirements.

Innes (1984) states that the requirements for integration are commitment, communication, policy formulation and acceptance, and planning. Forest and wildlife managers must be committed at all levels to manage forests for wildlife and there must be a policy upon which this commitment is based. Both groups must also be willing to take the time to become familiar with the problems and needs of the other. This communication is necessary to avoid the mistrust which is created by a lack of understanding. Finally, he says that planning must be undertaken to avoid conflicts, but that this may be more difficult for the biologists due to the relatively poor data from which they work.

Salwasser (1984) mentions four things required for integration of wildlife concerns into multiple-use forest management:

"1) the right attitude, 2) a process for systematic resource coordination, 3) models that relate forest conditions to wildlife outputs, and 4) effective monitoring to support an adaptive management strategy. These four things reflect that resource managers must first want to make forestry-wildlife coordination work, that they need a mechanism for doing it, that they need habitat criteria for meeting wildlife goals, and that we only know enough at this time to get pointed in the right direction".

For integrated resource management to be successful each resource must have a champion, and the public must participate. Specific objectives must be set for each resource within an interdisciplinary setting for true integrated management to occur. In Wisconsin, units of land of 2000 ha or more are selected as "opportunity areas" upon which integrated resource management is carried out. Specific objectives are identified which will lead to a desired future vision of the site. Objectives are translated into operational plans, scheduled, budgeted and executed. These plans are developed by the USDA Forest Service with input from State biologists (Holtrop, 1987). Integrated resource management places emphasis on all resources and on preventing adverse effects rather than mitigating them (Marita, 1988).

Wildlife objectives need to be clearly stated and considered as a co-product of wood fibre, and not a constraint, even though it is unlikely that timber and wildlife can both be maximized in any given area (Thomas, 1986). Ideally, explicit goals should be set at the initial planning stages to sustain all resources. Wildlife management plans and species priorities need to be established on a FML wide basis. This should include population goals on a provincial, regional and special areas basis. An inventory system must be available upon which to base decisions in similar scale to that available for forest managers. The various inventories of resources should be integrated by multidisciplinary teams, and inventories broken down into forest management unit levels. Population objectives then need to be translated into operational plans throughout the rotation (Dancik et al. 1990).

Gayle (1984) proposes that forest companies must be given long term management rights, and with this the responsibility and accountability for managing the forest for multiple uses. McTaggart-Cowan (1984) states that long term funding of basic and intensive management must be in place so that enhancement of the forest environment is possible and that these expenses should be looked at as operating costs to be borne by the government.

The desire for rational, science based forest management guidelines for wildlife has been around for as long as there have been conflicts in the management of these resources. Eastman (1973) expressed this need almost twenty years ago and it is slowly beginning to be addressed. The financial constraints on the wildlife management community have limited the extent of the required research. The forestry community with more resources, has gradually begun to assume more responsibility for this basic research. Local examples of this are the Abitibi-Price Ltd. participation in the Model Forest Program, and studies on Woodland caribou in the FML. Recently a joint study by Natural Resources and Abitibi-Price Ltd. was completed which looked at movements of caribou in the FML using radio collars. The company's involvement was direct funding, in kind support, and staff time (Robertson, pers. commun., 1993).

5.2 Guidelines

Guidelines have been established in many areas of North America to aid foresters in their efforts to practice forest management with consideration for wildlife. A variety of these guidelines are presented here with attention to those relating to moose management and habitat.

The following table outlines some of the key forest management guidelines for moose and other wildlife across Canada.

Table 4: Summary of Guidelines

Guideline	Alta.	Sask.	Man.	Ont.	N.S.
Cut block size (ha)	24-60	40-60	-	80-130	<50
Maximum line of sight in cutover (m)	400	-	400	-	-
Maximum distance to cover (m)	200	-	200	200	-
Buffers along					
a) roads	no	yes	yes	no	no
b) riparian zones	yes	yes	yes	yes	yes
Road closure policy	yes	yes	yes	yes	no
Leave snags	yes	yes	yes	yes	yes
Travel corridors	yes	no	no	yes	yes

Manitoba's Forest Management Guidelines for Wildlife also included the following direction (Manitoba Natural Resources, 1988(b)):

1. Line of sight along roads is not to exceed one km
2. Cutblocks must incorporate irregular edges
3. A minimum of 20% cover will be maintained in any operating area
4. Where less than 50% cover is maintained, then an adjacent leave area of equal size must maintained
5. Where less than 50% cover is maintained the operating area must not exceed 5 sq. km
6. Natural regeneration should be allowed wherever possible to maximize diversity
7. Softwood reforestation should be limited to original stocking
8. A minimum of 50% cover will be maintained in any operating area on critical winter range

These guidelines have been reviewed in 1993 by Natural Resources and Abitibi-Price Ltd., but as yet no revisions have been made.

Earlier "Rules of Thumb" published by Manitoba Wildlife Branch (Teillet, 1984) included:

1. Retain buffer strips along streams and highways
2. Keep clearcuts to 130 ha or less with irregular edges
3. Leave residual stands of 3-5 ha within cutovers
4. Reclaim abandoned roads
5. Utilize strip cuts where possible

The Forest Management Guidelines for Wildlife in Manitoba will lead to new ways of operating for companies such as Abitibi-Price Ltd. Since they are "guidelines" they possess an inherent flexibility, but the end result should be a greater consideration for wildlife habitat in the planning and operational stages. The participation of wildlife managers in the planning stages will identify these wildlife concerns. The guidelines are open to interpretation for each site but provide the basic principles to be used.

Some of the effects of bringing these guidelines into use are viewed unfavourably by foresters. As cutblock size decreases the ratio of road length to area cut increases, as does the road maintenance cost. Flexibility in road location is also a problem with decreasing cutblock size. This can result in greater costs due to greater road lengths to avoid steep or wet areas and poorer available stream crossings (Manitoba Forestry Branch, 1988). Skid trails will follow the same pattern. There will be more of them and they may be less than optimal in their location.

In addition, other costs will rise due to increased mobilization time for equipment moving between the greater number of cutovers, and increased planning and field layout in response to greater perimeter to area cut, irregular boundaries, increased roads, etc. Costs from implementing wildlife guidelines are generally due to increased road requirements per unit of area, lost timber due to reserves and restricted areas, and lost productivity due to constraints upon method of harvest (Opper, 1988).

Another implication of the guidelines is hunter access. A two cut system will lead to longer road life due to the need to re-enter an operating area to harvest leave areas when regeneration has reached three meters in height. A greater road system will also be necessary to reach the stands necessary to meet demand. This will result in increased access by hunters (Manitoba Forestry Branch, 1988).

The guidelines call for natural regeneration where possible. This is appropriate in some circumstances but may lead to poor regeneration of softwoods due to competition. Seedling planting is the most effective way to ensure proper stocking and future fibre availability. The use of herbicides is the most cost effective and sometimes only method for ensuring the investment in reforestation is allowed to reach maturity (Manitoba Forestry Branch, 1988).

Forest harvest design, planning and regeneration have implications for future rotations. A two pass system will diversify the age class of an operating area making future harvesting even more difficult (Manitoba Forestry Branch, 1988).

The forest industry response to the Forest Management Guidelines in Manitoba raised a number of concerns (Keenan, pers. commun., 1990). It was estimated in 1990 that the new requirements for timber harvesting would approximately double costs, however no analysis has been done since guideline implementation to determine the exact cost (Keenan, pers. commun., 1993). A greater number of roads will be required, line of sight requirements may limit cutovers to 16 ha, from a current estimated maximum of 40 ha. When strip-cutting the need for curving the strip to meet line of sight requirements will mean an increased cost from subcontractors. The 200 m buffer on riparian zones could mean a significant loss of merchantable stands. The forest industry believes the real reason behind declining wildlife populations is nonlicensed hunting, and that the guidelines will not lead to an improvement in the wildlife situation.

Implementation of these guidelines has been fairly smooth and the relationship between Abitibi-Price Ltd. and the IRMT has been co-operative (Robertson, pers. commun., 1993; Keenan, pers. commun., 1993). The guidelines have resulted in better habitat being created for moose and are viewed as a step in the right direction (Robertson, pers. commun., 1993). The company benefits from only having to deal with one government body, the IRMT.

In Ontario the 50% two pass system is generally used along with the Timber Management Guidelines for the Provision of Moose Habitat. Cut-blocks are less than 130 ha in size, and oldest wood is taken first. Road systems in Ontario are fairly well established. The timber companies submit cutting plans and are responsible for reforestation. Regeneration of 2 m in cutovers is required before the leave blocks may be harvested (Wepruk, 1989). Moose are used here as the main indicator species and are believed to be representative of 70% of species in the forest. A 3 cycle cut is recommended by Kaufman (1989) for use in Ontario especially for maintenance of moose wintering grounds. The passes would harvest 50%, 25%, and 25% of the timber respectively.

Seed tree cuts should include snags in the residual growth. Snags are used by many species of wildlife as nesting and feeding sites. Other prescriptions for maintaining habitat for wildlife in general are to leave islands uncut since they are used by many different species. Streams and lakes should be protected from siltation through the use of buffer zones. Corridors should be in place to connect uncut areas. Some amount of felled debris should be left as a source of habitat. These measures all fall subject to the overriding need for edge and diversity (OMNR, 1985).

In Saskatchewan a two pass system was established in 1973 which limited cutover size to 40 ha, and allowed harvesting of only 50% of the timber on the first pass. The second pass was to take place only after regeneration had reached a height to meet Provincial standard (Schultz Int. Ltd., 1976). Strip cutting in Saskatchewan has been successful under this guideline for allowing natural regeneration in the cut areas. Strip cuts of 100-200 m will restock from seed sources in the adjacent uncut strips. However, on the second pass to harvest these uncut strips, planting may be required to generate adequate regrowth.

Saskatchewan updated its requirements in 1985 with changes to the FMLA of Prince Albert Pulpwood Company (Saskatchewan Wildlife Branch, 1985). These changes included the following:

1. Options for road reserves to protect wildlife
2. Harvesting reserves after reaching a height of 4 metres at 70% stocking
3. Reclaiming abandoned roads
4. Banning of stand conversion from deciduous to coniferous

5. Allowing use of herbicides upon approval
6. Maintaining the two pass 50% system with maximum block sizes of 40, 125, and 60 ha in softwood, hardwood, and mixed woods respectively
7. Requiring "No Hunting" signs within a 2 km radius of all active logging sites.
8. Requiring the routing closure and reclamation of all roads except main haul roads immediately following logging
9. Requiring "dog-legs" in roads to prevent views directly into logging sites

In Alberta the timber harvest guidelines (Alberta Forestry, Lands and Wildlife, 1989) specify a two pass system which takes approximately 50% of the merchantable volume from 50% of the merchantable area with the balance taken in the second pass. The second pass can take place once regeneration has reached a height of 2 m (approximately 20 years) in conifers and 3 m in deciduous stands. In areas where new stands have become merchantable a third pass may be appropriate. In spruce stands the blocks may be laid out in patches to a maximum of 24 ha, and strips to a maximum of 32 ha where no part of the cutover is further than 150 m from a seed source.

In pine stands the blocks can be up to 100 ha in size. Skid trails, landings and roads not required to access second cuts are to be permanently put to bed and reclaimed. Roads needed for the second pass will be temporarily put to bed by removing road stream-crossings. Operating plans for Weldwood, Alberta Newsprint Company, and Proctor and Gamble Cellulose all are consistent with these guidelines (Weldwood of Canada Ltd., 1988; Alberta Newsprint Company Ltd, 1989;Proctor and Gamble, 1989).

Alberta guidelines suggest a 15 year interval before returning for the second pass (Dancik, 1990). Earlier recommendations suggested a 20 year interval between the first and second pass or at least 6-8 ft. of regeneration, although 15-20 ft was optimal. In critical habitat this higher standard should apply (Environment Council of Alberta, 1979).

Nova Scotia also made the following recommendations (Nova Scotia Department of Lands and Forests, 1988):

1. 3-8% of the total area under management should be openings such as roadsides, landings, and pond edges
2. 3-8% should contain old growth
3. Corridors should be at least 50m wide and should be present in clearcuts greater than 50 ha
4. Second cuts can begin when adjacent regeneration is 2 m

Starting in 1992, New Brunswick will be including objectives for Crown land which include maintenance of specific quantities of whitetailed deer winter habitat, and mature softwood forest habitat (Miramichi Pulp and Paper Inc., 1992).

In Minnesota the Department of Natural Resources has the goal of maintaining 5% of upland habitat in openings as a general habitat prescription. The maintenance of snags and irregular edge are advocated for wildlife. Old growth forests (those that are 1.5 times the age of traditional forest harvesting) provide an abundance of hard and soft snags, fallen logs, nesting cavities. These features are beneficial to a variety of birds and furbearers, and in Minnesota's Chippewa National Forest 145 wildlife species make use of the old growth stands. This National Forest has a goal of maintaining 5% of the area in old growth. One of the benefits to forestry are the bird species which require old growth habitat and which feed on forest pests which are prone to outbreaks (Henderson, 1988).

Practices recommended in Oregon included:

1. A two pass system with 10 years between passes
2. Road closure wherever possible
3. Leave breaks in windrows
4. Use of prescribed burning
5. Good site preparation and prompt planting preferred to herbiciding, however herbiciding will diversify habitat when spread over time and area

An example was given for a harvesting plan that will maintain stable wildlife populations. In a 4000 ha FML and an expected 60 year rotation, the annual harvest of 65 ha was sustainable (Stone and Carleson, 1983).

5.3 Alternative Practices

The forestry industry is going through changes due to increasing public demands and a growing internal awareness of non-timber values of the forest. Looking at some of the management practices outside Manitoba can be insightful in suggesting new ways of producing a sustainable harvest.

The Canadian Forestry Association and the National Round Table Forestry Dialogue have both endorsed the concept of zoning public forest land for multiple use, dominant use, and protected areas. This approach will lead to diverse mosaic of forests types and ages across Canada which serves the needs of the public in terms of timber production, wildlife populations, wilderness and parks, tourism, hunting, and preservation (Blouin, 1992). Thompson and Welsh (1993) proposed a similar concept which called for planning at the landscape level. This would allow the wise designation of areas to left as reserves, zones of sustainable development, and forests earmarked for intensive management. They also suggested that planning horizons of 100-200 years would be needed to properly manage the forest resource at this macro-level.

As simplified even-aged stands replace natural stands, between stand diversity must be increased to offset losses in within stand diversity. In order for this mosaic of stands to work for wildlife, decisions of timing, size, shape, and location must be viewed in a broader scale (Harris and Marion, 1981). If the average home range of moose in Manitoba is assumed to be 20-40 sq. km as suggested by work done by Phillips et al. (1973), Addison et al. (1980), Crete (1988), and Lynch and Morgantini (1984) then ideally forest management would provide for the provision of all critical habitats within any given 30 sq. km area (Crete, 1987).

Weldwood in Alberta has a biologist on staff who is working on integrated resource management on their 10,000 sq. km Forest Management Area. The Province and Weldwood have established a Integrated Resource Management Steering Committee (IRMSC) comprised of one forester and one biologist from each of Weldwood and Alberta Forestry Lands and Wildlife. The IRMSC was to develop population goals for 35 wildlife and 2 fish species within the FMA. This has entailed renegotiating the Alberta Timber Harvest Planning and Operating Ground Rules to incorporate specific concerns. This has been done through a zoning process to identify sites within the FMA which have specific wildlife and forestry issues that would not be adequately addressed by the Ground Rules. Examples include maintaining increased stands of old growth for caribou, or restricting guideline requirements for elk thermal cover to key elk winter range. Habitat supply modelling will be done for each of the selected species under various forest management scenarios to determine if minimum sustainable populations are predicted. Goals for each species will be set in time and space somewhere between minimum sustainable populations and the maximum carrying capacity. This means that habitat and population inventories and mapping must be done to integrate them with forest data-sets. Weldwood is to manage habitat through modifications to their operations, while the province will accomplish this through regulation of hunters and access (Bonar, 1989).

Habitat Supply Analysis (HSA) is a means for determining the habitat requirements in time and space necessary to meet a wildlife population target for a given management unit, and lays out the habitat-population relationship in explicit terms. HSA is being used by the U.S. in forest management and places non-timber values on even footing in the management process. It requires the establishment of explicit goals for an area in terms of timber and wildlife production (Ontario Federation of Anglers and Hunters, 1989). Specific habitat objectives should be determined for any region under management (Brown, 1985).

In Saskatchewan a five year project to integrate habitat and forest management is now in its third year. The Saskatchewan Forest Habitat Project is a partnership between Forestry Canada, Weyerhaeuser, Saskatchewan Natural Resources, Saskatchewan Wildlife Federation, Wildlife Habitat Canada, the Federation of Saskatchewan Indian Nations, and the Canadian Parks Service. The pilot project is a 10,000 ha forest near Candle Lake, north of Prince Albert. Six indicator species have been selected which represent the major habitat types in the forest - moose, woodland caribou, pileated woodpecker (Dryocopus pileatus), ovenbird (Seiurus aurocapillus), beaver (Castor fiber), and snowshoe hare (Lepus americanus). Using computer-based tools and other means the partners are trying to manage the forest for both timber production and habitat values. (Forestry Canada, 1992).

The use of habitat capability assessments as a tool for providing wildlife management input to forest harvest plans is an area where much effort has been placed over the past 20 years. Efforts to correlate moose population to data such as soil and drainage classification, topography, stand type, moisture, and soil nutrients have been used with varying results (Houser, 1972; Welsh et al. 1980; Jones et al. 1983). The continuing improvement in computer and GIS technology makes this area one of good potential for making the most of the limited resources available to wildlife managers in providing input to forestry operations. Modelling and geographic information systems (GIS) are useful tools for matching forest information with other environmental characteristics, constraints and classifications (Kimmins, 1991).

The "New Forestry" developed out of Washington and Oregon has the aim of developing forest management systems that incorporate ecological values as well as timber production goals. New forestry calls for:

1. Large rather than small and dispersed cut blocks which tend to fragment the forest
2. Partial retention logging or "sloppy" clear-cuts with a number of standing green trees, snags, dead and downed logs and coarse woody debris
3. Unlogged strips of timber along stream banks
4. Planting mixed, rather than single species, including some deciduous trees
5. Longer crop rotations
6. Protection of the below-ground ecosystem
7. Creating ecological reserves of timber, while recognizing that preservation alone will not sufficiently protect biodiversity (MacMillan Bloedel, 1991).

The New Forestry advocates conducting timber harvesting such that water, energy, and nutrient cycles are preserved and enhanced. Maintain debris on the cutovers to properly cycle nutrients, and leave dead trees and snags for cavity dwellers. The disadvantages of this approach are that more roads are needed, safety problems arise due to snags, and larger forests are needed to support the same level of harvest (B.C. Forest Resources Commission, 1991).

While research for these concepts has been based in coastal forests, it is likely that there is something of value in its progressive perspective. This approach begins to move forest management to a new level of complexity that requires a good understanding of the ecological principles and systems within the forest. Better understanding of the forest environment should lead to benefits for society in the long-run, but dealing with this complexity may have short-term impacts on the efficiency of timber harvesting. A challenge exists in determining how these concepts might be applied within Manitoba.

5.3.1 Silviculture

The importance of silviculture as a tool for managing forests for wildlife is felt by some to be high. Shaw (1970) expressed the view that 90% of habitat management can be accomplished through planned silviculture. Generally, however, silviculture is practiced with a primary focus on regeneration of a tree crop, and benefits accruing to wildlife are incidental.

The use of herbicides has been hotly debated due to the perception that toxic chemicals are used and will enter the environment, water systems and food chain. Generally, herbicides such as Vision have short-term negative impacts on browse availability within cutovers. Moose utilize deciduous flora which is typically the target of herbicides. Mitigation of this impact on moose best be achieved by avoiding aerial spraying, and instead treating sites on the ground. The use of less herbicides and more targeted application will minimize impacts on browse availability while still serving the needs of forest managers. Abitibi-Price Ltd.'s attempts to move herbicide treatments to the pre-planting stage is an example of this in practice.

Natural regeneration systems will improve the diversity of species within the cutover and increase browse production, over planted sites. This should result in a larger moose population and better habitat for a wider number of species. One company experimenting with natural regeneration systems is Domtar Inc. They have implemented strip clearcutting in black spruce stands near Sault St. Marie, Ontario with the intention of letting them regenerate naturally. These upland sites are often poor sites for regeneration due to shallow soils, exposed rock, high winds, and hot, dry microclimates (Smith, 1988). Domtar has chosen to use its planting resources on better sites and leave these sites to take their natural course following scarification. They have found that in wet lowlands where strip cutting is practiced, a wider strip may be used than on drier uplands. The higher moisture level in the lowlands aids in germination and means that less shelter is required by leave strips. Sphagnum moss in the lowlands is a good seed-bed and requires no preparation. Eighty metre strips yielded more than 60% stocking and more than 7500 seedlings per hectare with a four year leave period.

The benefits from this type of regeneration have a price, however. An economic analysis conducted by the Great Lakes Forestry Centre estimated that twice as much forest must be accessed in the first round of cutting compared with clearcutting. Hence, there is an increased need for road building, and secondary and tertiary roads must be maintained over a longer period. Much of this added road cost must be carried by the company as it falls outside the Forest Management Agreement program. Blowdown also increased in the residual strips. Black Spruce in shallow soils have an intertwined root network that provides stability. When this network is disturbed they become vulnerable to blowdown. However, the study concluded that this type of strip-cutting when followed by natural regeneration is less costly than clearcutting followed by planting, but more costly than clearcutting followed by seeding. The savings from not having to plant the cutovers were found to be greater than the increased costs for road-building and losses from blowdown.

In B.C. a pre-harvest silvicultural prescription must be prepared and approved before an area is harvested (B.C. Forest Resources Commission, 1991). A similar request has been made by the government of Manitoba pertaining to the Repap Manitoba forest management licence area Five year operating plan (1990-1994). This process requires better planning by the forest company and greater consideration for the factors affecting the regeneration aspect of forest management.

Studies by Froning (1980) showed that careful logging can protect conifer understory. In an area near Hudson Bay, Saskatchewan, 56% of spruce undergrowth was damaged during harvesting of mature Aspen when no guidance was provided. By surveying the sight beforehand and identifying areas of good conifer growth, they were able to layout skid trails to take advantage of sparse areas. Good planning reduced the damage to only 12% of spruce understory. Peterson and Peterson (1992) related the experience of Pelican Spruce Mill Ltd. in Edson, Alberta who are protecting understory through a harvest system much like the Timberjack harvesting done by Abitibi-Price Ltd (described by Keenan (1993) in section 3.4.2). The Pelican Spruce Mill Ltd. system uses a mechanical harvester that cuts parallel swaths into the stand, and harvests on both sides of the swath as it enters. Trees are placed in the trail behind the harvester, where they are skidded to the roadside. Although the trail is disturbed there will be little damage in the strips between the parallel trails. These systems have the advantage of maintaining advance regeneration, which may mean that less scarification, planting and herbiciding will be needed. This will provide better habitat for moose and reduce costs for silviculture.

Alternatives to herbiciding have been tried which involve scarification before planting to control hardwood regeneration. Double disking in the boreal forests of Alberta was found to control aspen regeneration for up to five years (Ehrentraut and Branter, 1990). Marttiini plow scarification was used to control suckering to 1/3 of normal density on moist sites, while ripper plows have been successful on wet sites. Another method used in Alberta was mowing. On regenerating cutovers where deciduous stems had reached an average height of 2 m, a mower cut the stems above the height of conifer regeneration and significantly reduced the number of stems per hectare (Holmsen, 1989). These types of treatments will hae an impact on deciduous growth which is equal to herbiciding.

In Finland there is pressure on the forest industry from conservationists to practice more natural regeneration, and less planting (Appelroth, 1982). Foresters there view natural regeneration as an activity with numerous constraints which require a more intensive management. Slightly more than half of the forest area regenerated in Finland has been by natural means, however any more than this is viewed as a threat to wood production due to inferior yields when compared with artificial regeneration. Natural regeneration of Norway spruce requires seed or shelter trees to provide the seed sources for the new stand. Good seed crops are very irregular with this species and generally requires scarification the year prior to these seeds being available. Subsequent to stand establishment the seed or shelter trees are removed, and thinning takes place, all at additional cost. Finally the benefits of tree-breeding cannot be brought in to play when natural regeneration is used. It appears that in the Finnish forest economics is just as important as in Manitoba, however with their intensive management systems, natural regeneration was viewed as being more costly than planting.

In Finland the use of prescribed burning is increasing as a means of site preparation, in place of scarification (Appelroth, 1982). In many cases, however, burning is not sufficient by itself to prepare the site for planting must be followed by scarification. Although it reduces planting costs prescribed burning is still viewed as an additional cost.

Forest management in Finland is similar to that in the FML, in that over half of the forests are naturally regenerated. For stands of Norway spruce this generally requires a good seed crop and preparation of the seed bed the year before the seed crop is expected. Mineral soil must be exposed for the seeds to germinate. Removal of seed or shelter trees, while protecting the young stand has been found to be difficult and expensive (Appelroth, 1982).

A number of recent operations in Canada have been designed for handling hardwoods, particularly trembling aspen. Technology has provided the opportunity to utilize this resource for products such as pulp, panelboards, and other value added products (Peterson and Peterson, 1992) Aspen have the advantage of good natural regeneration capabilities and natural thinning. Within the FML there is a large volume of poplar available under the annual allowable cut (Abitibi-Price Ltd, 1989) which is nearly equal to the AAC for spruce and balsam. In the future it is conceivable that hardwoods could become a merchantable species in the FML. This could have benefits for wildlife since the establishment of softwood stands is less desirable for wildlife than if mixedwoods are created (Cameron, pers. commun., 1993). In mixed-woods it is possible to double the yields per hectare when harvesting both hardwoods and softwoods (Denney, 1988). The costs of harvesting and renewal are then spread over a greater volume of extracted timber.

Mixed-wood stands have a 20-60% lower volume of conifers than would pure conifer stands on the same site (Revel, 1983). Hence, while conifers are the primary fibre source, attempts to control hardwood growth will continue through manual treatments and herbicides. I should also be noted that mixed-woods tend to regenerate on the best sites, while pure stands exist on poorer sites such as lowlands, or ridges. This explains the higher productivity of mixed-woods but also means that stand composition is often not so much a management decision as a function of site conditions (Atkinson, pers. commun., 1993).

5.3.2 Harvesting

A number of case studies were documented by Payne et al. (1988) which detailed the efforts of Ontario forest and wildlife managers to work together to implement modified cutting with the intent of maintaining and improving moose habitat. A number of cutting patterns which will contribute to improved moose habitat and natural regeneration of cutovers were listed and included group seed tree areas, alternate block cuts, alternate strip cuts, and linear (waterway) reserves. The common element amongst these methods is the quantity, and more importantly, distribution of uncut timber within the harvest area. In these cases the amount of edge left within the harvest area correlated positively with subsequent moose populations.

The first case study was a site at Three Island Lake roughly 145 km northwest of Thunder Bay, Ontario. Forest cover consisted of mature to over-mature jack pine and upland black spruce, interspersed with lowland black spruce bogs, lakes and rivers. Surveys of the area revealed an above average moose population prior to harvesting, and maintenance of this population was the post-harvest objective from a wildlife management standpoint. A 50% cut and leave pattern was requested by the Ministry of Natural Resources for areas around a number of the lakes. The company was given the flexibility to develop/modify the layout in the most efficient manner.

Cutting was performed in 1980 over a 1357 ha area, with aerial surveys conducted in 1976, 1979, 1984, 1985, and 1987. These surveys revealed that the moose populations had doubled in the area since the harvesting took place. In one 340 ha section 33% was left in residual cover. This was 65% more than other modified cut areas and produced 38% more edge than these areas as well. Moose appear to have responded to this management, as densities in this area were at least twice what they were in the rest of the harvest area. A 817 ha section of clearcut forest had the lowest density of moose post-harvest.

The increase in moose populations may have been affected by other factors as well. Hunting was largely restricted in the area after cutting, and a large uncut block of forest existed to the east of the site which may have acted as cover habitat for the moose.

Table 5 outlines the cutting volumes and costs for this alternate block cutting plan. Additional costs averaged $.32/cubic metre of wood harvested for both the first and second cut. Road and layout costs for the first cut were higher than they should have been due to poor coordination between the forestry company and the Ontario Ministry of Natural Resources. Many roads had already been constructed before the decision was made to implement a modified cut. Forestry companies need long lead times on modifications to plans if they are to minimize their costs.

Table 5. Cut and Leave Volumes and Costs (1987$) at Three Island Lake

First Cut		
	yield 320 ha at 175 cu. m/ha	56,000 cu. m
	left 122 ha at 175 cu. m/ha	21,350 cu. m
	increased road and layout costs	$9,800.00
	additional cost/harvested cord	$0.17
Second Cut (projected)		
	road reconstruction and layout costs (seed tree plots)	$14,200.00
	volume to be harvested	19,250 cu. m
	additional cost/harvested cord	$0.74
Blowdown Losses		
	1750 cu. m (8%)	
	$7000 in stumpage fees lost to the Crown	

A second case study was reviewed from the Bragg Township which is 56 km northeast of Cochrane, Ontario. The site consisted of conifers such as spruce, balsam and jack pine, and mixed wood stands. The area was subdivided into a control zone (3954 ha) and an experimental zone (3868 ha). The control zone was clearcut in the usual manner, while in the experimental zone linear reserves, leave blocks (4 ha) and alternate strip cuts (in spruce lowlands) were used.

Moose densities before the cut ranged from 0.08 to 0.37 moose/sq. km based on aerial surveys between 1960 and 1979. Surveys flown during the harvest (1982-86) revealed that the experimental area averaged three times (0.12 moose/sq. km) the moose population that was found in the control area (0.04 moose/sq. km). Interestingly the amount of residual cover in both areas was approximately equal (5% more in experimental area), but the amount of edge created in the experimental area was greater due to the use of leave blocks and greater dispersion.

Again as in the first case study a number of other factors may have had some effect on the results. In this instance the follow-up surveys were conducted during the harvest so adjacent uncut blocks may have had some impact on moose preference. The area was also aerially sprayed with herbicides following cutting to encourage natural regeneration, thus reducing browse potential.

A total of 2118 ha of forest was harvested in the experimental area at an additional cost of $34,977. Assuming a productivity of 175 cubic metres/ha this gives a cost of $0.09/cubic metre for modifying the cutting operation for the first cut only. This compares with $0.17/cubic metre for the first cut in the Three Island Lake example.

These examples would tend to indicate that the improved habitat which results from implementing modified cutting practices are balanced by an increase in cost of harvesting and regeneration. These cost can be attributed to increased road construction, block layout and movement of men and equipment, blowdown of residual stands, and higher regeneration costs for smaller areas. Natural regeneration is improved by the presence of seed trees in cutovers, but intensive regeneration is more costly. The process of returning for a second cut to harvest leave blocks and bypassed timber has significant costs. The cost of the second cut increases with the interim time period due to road degradation and overmaturing of timber in residual stands.

Another case study of integrated planning was documented by Eastman (1973) and illustrates the management practices which have been in effect for the last 20 years. Approximately 48 km NNW of Prince George, British Columbia, a harvesting license was granted for 47 square kilometres within the subboreal spruce zone, consisting of lodgepole pine, and white spruce as the dominant commercial species.

The management goal for this area was to maintain moose habitat while maximizing economic and social benefits. To meet these goals the recommended forest management practices called for upland clearcuts of less than 65 ha with area circumference ratios of 0.8 or less. No road restrictions were placed on the upland areas, but corridors were required for wildlife moving between the till plain and valley. On the higher value lowland, which acted as a wintering area for moose, clearcuts were not to exceed 80 acres with the same area circumference ratio. No roads were allowed in the area, and logging had to stop by February 15th to minimize harassment of moose during the late winter. The process for developing this plan involved early participation by wildlife and forest managers to look at the needs and concerns from both perspectives.

An optimal cutting pattern for ungulates was described as a ten square kilometre operating area divided into four segments, and logged on a 100 year cutting cycle, where each segment is harvested sequentially over a 25 year period using small clearcuts of 8-15 ha. In terms of the impact on forestry operations this plan will increase road construction and maintenance costs, and increase the area of forest committed.

Schubert (1974) made recommendations for forestry practices which would minimize damage to residual stands in areas where partial cutting was taking place. Some of these recommendations appear useful to the situation in the FML, such as:

1) Layout spur roads and skid roads to take advantage of existing openings

2) When skidding trees to the roadside avoid using residual trees as pivot points for turning logs

3) Keep landings small and take advantage of natural openings

4) Use the smallest skidders possible

These simple suggestions would minimize the impacts of logging operations on remaining stands and vegetation.

The Expert Panel on Forest Management in Alberta looked at the issue of harvesting methods. They stated that the type of system used must depend on the specifics of the site involved. A two pass system is the traditional method of harvesting, but they noted that an initial pass rarely removed more than 30% of the timber from an operating area, when residual cover, seed trees, shelterwoods, reserves, and unmerchantable timber were accounted for. Thus the two pass system was in effect a three pass system. The two pass system was generally an acceptable manner of harvesting respecting wildlife and ecological concerns, but that three or more passes might be appropriate in critical areas such as wintering or calving areas. The road building aspects of moving to a three pass system are substantial. It was estimated that the amount of roads required to service a three pass system that would have to be built in the next twenty years in Alberta, would be the equivalent of 80 years of road building in a two pass system. The cost of this would be immense as would be the increased access by hunters (Dancik, 1990). In priority timber production areas, industry should be allowed to determine its cut block size and layout, within the guidelines set out by government (Dancik et al., 1990).

The experience of Sweden is of use in assessing the effects of various management practices on moose populations. The national moose herd in Sweden had declined to as few as 300 animals in the 1830's due to overhunting, but has since grown to a peak of 315,000 in the early 1980's. This compares with a Manitoba herd that is less than 1/10th this size in an area approximately 45% larger. The main reasons for this increase in population were an increase in the number of clearcuts, and hunting restrictions which created a long open season with protection for cows and an increase in the calf harvest. The percentage of young forests in Sweden has tripled in this century, providing abundant habitat for moose. Ironically, the population had grown too large by 1980 and the incidence of road accidents and forest damage increased to such an extent that the population has since been reduced (Lavsund and Sandegren, 1989). The moose herd in Sweden also has factors in its favour which differ in the Manitoba situation. Predation by wolves and bears, as well as uncontrolled Treaty Indian hunting are much less prevalent in Sweden. The winter climate is also less severe than in Manitoba.

The natural process for establishing succession, species composition, and age structure has largely been through fire (Eastman, 1977). Where possible, therefore, fires should be allowed to burn, i.e. where timber values are not high. Since this is generally not the case in the FML other options must be considered. Forest management which can successfully mimic fires through clearcutting and slash burning is one of these options.

Clearcutting which mimics the pattern of openings created by wildfires and used in conjunction with selection cuts and 2, 3 or 4 pass systems was recommended by Neave (1991) as a means of improving wildlife habitat (Neave, 1991). Mimicking nature is one way of dealing with uncertainty in forest management. The lack of knowledge about the complex relationships within the forest ecosystem make decision-making problematic for all resource managers. If actions can be designed to follow the well trod path of mother nature, perhaps, the same results can be achieved. One of the things mother nature does well is maintain biodiversity. Thompson and Welsh (1993) made the following recommendations for the mimicking of natural disturbance to maintain diversity:

1. Utilization of three pass systems over extended periods
2. Increased use of shelterwood cutting
3. Maintenance of leave blocks of various sizes
4. Keeping clearcut size small on average, but mixing in the occasional large cutover
5. Maintenance of firm, standing dead trees
6. Increased delimbing at the stump
7. Maintenance of seed trees within the cutover

The Mead Corporation owns 280,000 ha of forest in Michigan which supplies much of their wood fiber. They have adopted a policy to manage forest resources to balance commodity production with the provision of other forest values (Ticknor, 1993). Using what they call a Total Ecosystem Management Strategy (TEMS) they have selected a 10,000 ha study area to try and develop a better understanding of basic ecosystem function. The program is looking at such issues as mammal habitat utilization, water quality and biodiversity, bird population inventories and habitat use, as well as the role of local ponds within the ecosystem. This attempt to better understand the ecosystem is beginning to translate in to greater consideration for site conditions during road planning, and harvest plans which consider the relationship of cutovers with the adjacent uncut stands and the implications this has for wildlife.

A study by Shultz Int. Ltd. in Saskatchewan recommended special or critical moose habitat sites should be identified where possible and removed from the annual allowable cut. These sites might include wintering areas, calving sites, mineral licks, or aquatic habitats. Concentration areas should be subjected to a modified harvesting regime which minimizes impacts. This regime would restrict cuts to 400 m in width with equal uncut areas adjacent to the site. At least 120 m of reserve should be left around special sites. If proposed cuts do not exceed 100 ha the moose concerns are only special sites. Maintaining 15% of a cutover in the mature state will ensure adequate conifer cover for game species. Bunnell (1974) suggests a method for harvesting around critical winter habitat which would enhance availability of browse in close proximity to cover. This method involves strip clear-cutting in a circular fashion around the yarding area in a manner that reaches its point of origin as the area first cut has reached a point where it is providing cover.

Moose will more fully utilize stands which are in the early successional stage or in a mature state. In order to maximize utilization of stands by moose, the time spent in the intermediate stages of forest development should be minimized. Intermediate cuts or thinning will move stands forward to maturity faster, as well as opening the understory for early successional growth. This type of uneven-aged management may be useful for extracting timber from sensitive and riparian areas (Patch and Stocek, 1983).

5.3.3 Hunter Management

As previously discussed clearcuts and forestry roads can have a serious impact on local moose populations through improving the access and sight lines of hunters. The licensed hunter can be controlled by imposing limits and restrictions on the hunt, and through road closure. Unlicensed hunters can be managed by road closure and through co-management programs such as the one being developed in the Model Forest. Historically, natives have been good resource managers and with the trend towards increasing public participation in the management of our environment, co-management appears to be the best alternative. In terms of long-term success, the users of the resource, both native and non-native must be involved and feel some sense of stewardship towards the resource.

The control of road access by hunters was recommended by Hildebrand and Imrie (1975), and Brown (1985). They suggested closing spur roads after logging ceases, and designating routes to be used for travel to minimize hunter access. Abitibi-Price Ltd. also suggested road closures as the easiest and quickest means of aiding wildlife (Keenan, pers. commun., 1990). The example of Saskatchewan was used, citing a doubling of the moose population in five years through road closures and restrictions.

Saskatchewan has been very aggressive in the area of "road management". Faced with similar over-access problems as Manitoba, they have undertaken a program of planned road closures. Using gates, earthberms and moats, over 1500 roads were closed during the 1980's (Barber, 1989). Support for this initiative was achieved through an advertising campaign to inform the public. Consultation with the native community was able to garner further support.

6.0 CONCLUSIONS

1. The FML lies within the boreal forest and has the habitat potential to support a moose population in excess of current numbers.

2. Moose require and are able to adapt to a diverse mix of habitat, including riparian zones, mineral licks, edges or openings with deciduous browse, and mature stands which provide cover.

3. Proximity to both mature stands and deciduous browse (typically found in cutovers) is an important habitat characteristic affecting moose utilization of an area. In a logged site this cover may be provided by adjacent uncut forests, as well as by residual stands within the cutover.

4. Moose habitat is generally improved by forest operations, and from Abitibi-Price Ltd.'s activities specifically in the FML. The caveat to this conclusion is the significant negative impact on moose and other wildlife populations which results from increased hunting activity. This activity results from the increased access afforded by logging roads built in to new areas.

5. Moose habitat will improve from implementing the forest management guidelines for wildlife.

6. The general belief among forest and wildlife managers is that native hunting is a major factor suppressing moose populations in the FML. The literature suggests that predators and disease may also have significant effects on moose populations, however, little information is available on predation in the FML.

7. Altering forest management practices to benefit wildlife tends to result in increased operating costs for Abitibi-Price Ltd. This is due to increased road building, planning, and layout activities, and higher harvesting costs for repeat entries for second and third passes.

8. Cut block size, shape and cover characteristics in the FML are generally good due to the diverse features of the region. The natural terrain in the FML limits the size of clearcuts, obstructs sight lines, and tends to promote the maintenance of residual stands. Cutovers are generally small in size and irregularly shaped. A variety of unmerchantable timber

and topographic relief break up the site and provide hiding cover and to a lesser degree climatic cover within a typical cutover.

9. Abitibi-Price Ltd. harvests the majority of their timber using a clear-cut method with blocks usually less that 40 ha.

10. Harvested sites within the FML are regenerated by both natural and artificial means. Roughly 1/3 of the sites are planted with seedlings, and the other 2/3 regenerated naturally.

11. Integration of forest and wildlife management within the FML is progressing quickly. Numerous initiatives are under way which will result in improved planning, harvesting, regeneration, and greater recognition of the varied forest values. The Model Forest program has acted as a catalyst for examining innovative ideas and undertaking research into new and existing concepts..

12. Computer models being developed through the Manitoba Forestry Wildlife Project have great potential for improving moose populations through better understanding of the effects of forestry on habitat. Although information on wildlife resources is not as complete as forest databases, these models produce outputs in terms of habitat. This means that they promote decision-making that is science based yet do not require data gaps to be completely filled.

13. Many of the numerous forestry practices discussed in the paper will have benefits for wildlife, and moose in particular. Generally, they result in increased costs to the forest company.

14. Co-management of the moose resource in the FML seems to be one of steps necessary to improve moose populations in the FML. A successful management plan would likely include some type of road closure or use strategy.

15. Canadians are concerned about the state of their forests and perceive that they are not being properly managed. They are concerned about practices such as clear-cutting and feel that Canada's forest are being depleted. In general, the public has a relatively poor knowledge of the complexity of the forest ecosystem and the factors which come into play in forest and wildlife management decision-making.

7.0 RECOMMENDATIONS

1. The current relationship of Manitoba Natural Resources to Abitibi-Price Ltd. is reactive. The company plans activities and the IRMT reacts to these plans with their concerns and requests modifications. Greater involvement by the IRMT in the early planning stages to identify concerns would improve this process. The models being developed by the Manitoba Forestry Wildlife Project will need to be integrated in to the early planning processes as well.

2. The Resource Road Management Plan which is now being developed should be integrated with the co-management process which is also in the development stage. Dealing with road access in the FML should be a significant issue to both endeavours.

3. The long term sustainability of the forest is dependent on maintenance of sufficient nutrients within the forest ecosystem. A large body of information and ongoing research on this topic exists and should be reviewed to assess the sustainability of current harvesting methods. The move by Abitibi-Price Ltd. to delimbing at the stump will reduce the removal of nutrients from the forest, but a large bundle of nutrients leaves with the logs.

4. The forest industry and government need to educate the public about the realities of logging practices in the FML and the improved habitat that results for moose. The Model Forest has the mandate to improve public awareness and is a good vehicle for doing so. It has a cross-section of participants which should add to its credibility, and objectivity. Public participation is an increasing trend in the management of natural resources and this process is much more successful when the public is informed on the concepts, and realities, as well as the high profile issues.

5. Biodiversity and ecosystem management are popular themes in discussions of forest management today. The Manitoba Forestry Wildlife Project is planning to use indicator species to model ecosystem responses to forestry practices. Twenty species will be used to represent the habitat needs of the over 200 wildlife species in Manitoba's forests. What is not clear is how this information will be used to determine priority species and tradeoffs that will be necessary. An overall plan is needed to look at habitat and populations across the landscape and set goals for both for each species. Some form of public

input may be a wise undertaking to give this goal setting some basis in public desires.

6. Work should continue in the areas of improving silviculture and harvesting techniques which can improve habitat, and minimize costs. Some investigation in these areas is happening in the FML and should be expanded.

7. Some investigation in to the factors suppressing the moose population might be useful. How the moose population is affected by factors such as predation by bears and/or wolves, native hunting, non-native hunting, brainworm, and habitat is important for moose management.

Forestry is an industry which has a long planning horizon. Each generation of trees may take up to 80 years to mature from its beginning as a seedling in a nursery or a cone in the forest. In the early days of forestry in Canada little consideration was given to the long term impacts of harvesting or of future availability of timber. The supply seemed endless and the industry has experienced continued growth in North America.

The use of wood began as a fuel source, moved to implements, construction material and then paper. In North America the main use of wood is for paper production. In Canada, 52% of the forest industry's exports in 1991 were from pulp and paper. Forest industry exports to the United States accounted for 66% of total forest exports, while 53% of the forest industry revenues were generated within Canada. Manitoba earned $165 million from forest industry exports in 1991, 36% from wrapping paper and 14% from newsprint. The vast majority of these exports (93%) were to the United States (Forestry Canada, 1993).

The changes in the North American forest industry have been dramatic. The reliance on manpower, axes and horses has changed to feller-bunchers, chainsaws, and skidders. Multiple use has meant that environmental concerns, and recreational and subsistence users have more input into how the forest is managed and where harvesting can take place. The rate of change in forestry has been proportional to the rate of industrial change in society. Canadians experienced the great changes brought on by the internal combustion engine, telecommunications and the computer. We have experienced dramatic change in a very short 20th century. It is hard to envision how our society will change in the next 10 to 20 years.

So what does this mean for forestry? It means simply that determining what the demands will be on the forest resource in 80 years is an exercise filled with uncertainty. Even our best guesses may well be meaningless when future managers are faced with a very different reality. Perhaps society will have truly moved to a paperless existence. Newspapers, printed material, mail, banking and other traditional paper consuming activities will all be done electronically. Possibly new plantations and forests will be maturing in twenty years due to improvements in tree science. Alternative materials may have replaced many of the uses of wood fibre, or alternatively the demands on the resource may completely outstrip supply. Harvesting techniques may be of a type that are impossible to imagine.

This high level of uncertainty means that decisions we make today may retain little of their value 80 years from now. Should we weight our management decisions heavily to the needs of today, and discount perceived needs of users 80 years in the future? Wildlife habitat needs have a much higher probability of stability over time than do the needs of the forest industry. A good example is the switch to aspen pulping processes in various mills across the world, which is a remarkable innovation. Possibly then, the bias in decision-making should be towards wildlife since we know what their needs are, and since society will reap benefits immediately from increased wildlife populations.

This concept is in contrast to some of the trends in forestry and in alignment with others. Certainly there is a strong movement to give greater consideration to the values of non-timber resources in the forest. However, there is also a trend to increasing investment in reforestation and renewal in an attempt to ensure a sustained yield for future generations. Only time will tell which answers are the right ones.

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