Forest Management Guidelines for the Conservation of Woodland Caribou: A Landscape Approach

For use in northwestern Ontario

Version 1.0

Final Draft

January, 1999

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Summary

This document provides direction for landscape planning at regional and local levels in forest-dwelling woodland caribou (*Rangifer tarandus caribou*) range. The objective is to ensure a suitable and sustainable landscape containing year-round caribou habitat, and to achieve this primarily through forest management and land use planning. Conservation of forest-dwelling woodland caribou means maintaining caribou range occupancy within a managed forest landscape.

This document consists of a brief account of woodland caribou biology, direction for regional land use planning, special considerations for applying the *Forest Management Guidelines for the Emulation of Fire Patterns* in caribou range, management recommendations for site-specific habitat values and instructions for completing spatial and aspatial habitat supply analysis.

Direction in this document will be followed where woodland caribou habitat management is recognized as a priority, either through designation of caribou as a featured species or through designated zoning recommended through regional land use planning. It is to be applied in concert with the *Forest Management Guidelines for the Emulation of Fire Patterns*. Ecological variation across the northern Ontario landscape requires a flexible approach to forest management. The recommendations in this document must be interpreted to fit local situations based on local knowledge and the professional judgment of experienced practitioners. These guidelines focus on the northwestern Ontario situation and make specific reference to experience, knowledge and understanding of the northwestern Ontario landscape.

Recommended Forest Management Guidelines

To meet the current and future habitat needs of forest-dwelling woodland caribou within their range in boreal Ontario, the following practices are recommended:

Regional Considerations

- Caribou should be managed on a very large spatial and temporal scale, spanning more than one Forest Management Unit over 80 years or more.
- Protecting selected winter habitat areas should be a priority during land use planning.
- Protection of strategic calving areas should be a priority during land use planning.
- Plan primary roads and road corridors to avoid traditional winter habitat tracts, and landforms and soils with high capability to support winter habitat.

Bridging Regional and Forest Management Unit Level Planning of Caribou Landscapes

- The objective for planning caribou landscapes is to maintain a continuous supply of suitable, mature, year-round habitat distributed both geographically and temporally across the landscape in such a manner as to ensure permanent range occupancy.
- Plan a series of disturbance events (potential harvest areas) on the landscape following the *Forest Management Guidelines for the Emulation of Fire Patterns* in such a manner as to i) maintain a current supply and ii) ensure a continuous supply of large areas (> 10,000 ha) containing current winter or summer habitat, and iii) account for existing distribution of caribou, and alternate and future habitat.

Forest Management Unit Considerations

- Areas with high potential to provide current or future winter habitat should be managed for winter habitat by prescribing disturbance events in the order of 10,000 ha or greater, or maintaining them as part of 10,000 ha or greater tracts of older forest.
- Maintain or allocate potential winter habitat tracts based on relative habitat supply and local ecological context. Assess relative habitat supply on an area approximately 700,000 ha in size.
- Manage the winter habitat tract to a future forest condition that provides for winter habitat value and refuge from predators and human disturbance.
- Apply a 1000 m Area of Concern to all calving areas and develop and appropriate prescription for this AOC.
- Forest management activities in snow-free season habitat should i) discourage conversion to hardwoods, ii) avoid fragmentation and iii) promote no net change in forest composition or structure at the regional and local landscape level compared to pre-disturbance conditions or best estimates of what a fire-driven ecosystem would maintain.
- The preferred approach to maintaining the connection between summer and winter habitat is by placing disturbance events under the *Forest Management Guidelines for the Emulation of Fire Patterns* to maintain connectivity between large habitat tracts.
- Where the landscape does not facilitate connectivity between large habitat tracts and travel routes are known, priority should be given to maintaining the integrity of the vegetation along these routes, through harvest scheduling and building upon riparian reserves.
- Where isolated habitat tracts are located near the southern boundary of the zone of continuous distribution, a two kilometer wide (approximate) corridor of relatively mature to mature timber should be maintained to connect with nearest neighbor mature habitat tracts.

Site-Specific Recommendations

- Harvested areas should be regenerated to restore the composition and structure (at maturity) of the previous forest as required by the *Crown Forest Sustainability Act* (Statutes of Ontario 1994), or to meet sub-regional forest composition objectives.

- Documented mineral licks should be identified by a minimum 120 m AOC and should preferably be incorporated within a mature forest habitat tract.
- Forest access roads should be of a temporary nature when constructed in significant winter or snow-free season habitat tracts. These roads should be made impassable by ditching, culvert removal or site preparation and regeneration as soon as possible following completion of timber management operations.

Other Human Activities

- Where possible, mineral exploration activities should recognize caribou habitat values and address them through modified line cutting and scheduling.
- Remote tourism operators on caribou calving lakes should mitigate human disturbance by discouraging campsites, shore lunch locations and boat caches in close proximity to calving sites.
- Major winter recreational developments such as snowmobile routes should avoid current and potential winter habitat tracts.

Habitat Supply

- Habitat management decisions shall support maintenance of a sustainable supply of year-round habitat. These decisions shall be supported by both an aspatial and a spatial habitat analysis.

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Using the Guidelines

This document provides guidance to help resource planners and managers conserve forest-dwelling caribou in boreal northwestern Ontario. Information in this document may also provide insight relevant to conserving woodland caribou elsewhere in Ontario, under different, less well understood systems. Applying these guidelines in northwestern Ontario will require planners and managers to assemble and use the best information available about the forested landscape, caribou use of that landscape, and the relationship between caribou biology and expected impacts of resource management activities, while recognizing that such knowledge is often imperfect or incomplete. Application should take advantage of unique limitations or opportunities within each management unit. Habitat planning must be flexible enough to allow for modification and improvement as new knowledge about the resource is obtained through inventory efforts, research or monitoring. Above all, resource managers are urged to apply the precautionary principle and err on the side of reasonable caution when necessary. These guidelines are to be applied within the context of a broader caribou management strategy for the Northwest Region.

Section 2 describes current understanding of caribou biology, habitat and status. Resource managers should integrate this understanding with local knowledge of caribou biology and management impacts. *Section 3* describes the implications of forest management activities on caribou. *Section 4* contains regional, Forest Management Unit and local guidance for managing caribou habitat and explains how this guidance is applied under the *Forest Management Guidelines for the Emulation of Fire Patterns*. *Section 5* describes how these guidelines are applied when developing forest management plans. *Section 6* provides suggestions relating to generating improved knowledge of caribou biology and management impacts, and discusses how this knowledge may be used to revise and improve these guidelines. *Appendix I* provides direction for regional land use planning. *Appendices II* and *III* describe basic habitat supply estimation procedures used to estimate relative habitat supply and availability, for consideration in regional land use planning and when applying the *Forest Management Guidelines for the Emulation of Fire Patterns*. *Appendix IV* provides direction on how to assemble and map land-base and caribou habitat information to support assessment of habitat capability or broad habitat values.

Relationship to Other Guidelines

These guidelines are part of a broad ecosystem-based approach to management, and feature both landscape and site-specific direction. The *Forest Management Guidelines for the Emulation of Fire Patterns* (see *Appendix V*) should be applied along with sub-regional forest composition guidance to set the ecological context for the management unit. The intent of the *Forest Management Guidelines for the Provision of Marten Habitat* (Watt *et al*. 1996) may be largely satisfied through the thoughtful application of these caribou guidelines. Snag management components of the fire pattern and marten (*Martes americana*) guidelines are expected to be applied in occupied caribou range.

Development of the Guidelines

This document evolved from interim direction on caribou habitat management for the Northwest Region (OMNR 1994) and previous draft caribou habitat guidelines. It has been revised in accordance with the Crown Forest Sustainability Act and requirements of the Decision of the Environmental Assessment Board. Suggestions for additional improvements came from many sources including recommendations from *Toward a Strategy for Caribou Habitat Management in Northwestern Ontario* (Greig and Duinker 1996), meetings with special interest groups, forest management plan public information sessions and other public consultation sessions. Biological background to support this document is found *in Woodland Caribou in Ontario. Background to a Policy* (Darby *et al.* 1989). A chronology of the political, social and economic issues is documented in Racey and Armstrong (1996) and Racey *et al.* (1991).

This document replaces the previous mosaic-based planning process used in the Northwest Region. Greater flexibility was achieved by using the mosaic as a landscape assessment and analysis tool that provides a framework for application of the *Forest Management Guidelines for the Emulation of Fire Patterns.* The scheduling of harvest in these new guidelines is driven more by relative habitat supply than by the mosaic.

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Forest Management Guidelines for the Conservation of Woodland Caribou : A Landscape Approach

1.0 INTRODUCTION

There is conservation concern about the status of forest-dwelling woodland caribou (*Rangifer tarandus caribou*) in the boreal forests of northern Ontario. Range recession since the late 1800s and expansion of forest harvest and other management activities has contributed to this concern (Darby *et al.* 1989, Cumming and Beange 1993, Racey and Armstrong in preparation). The Ontario Ministry of Natural Resources (OMNR) is committed to sustaining the ecological systems of which woodland caribou are a part. Managing forest use to sustain these systems requires planning of both regional and local landscapes. This document is intended to provide direction on caribou habitat management at several planning levels including regional land use planning, Forest Management Planning and site-specific habitat value identification.

1.1 Evolving Management Philosophy

Historically, the OMNR attempted to ensure habitat for some featured game species, and those species whose long term survival was of concern (i.e. vulnerable, threatened and endangered species) (Baker and Euler 1989). In recent years, appreciation of the connections among components of natural systems, and the recognition of the intrinsic value of all species has grown (OMNR 1991). Thus, the current focus of forest management planning is to maintain entire ecological systems and their associated biological diversity. This perspective does not preclude managing habitat of individual species such as woodland caribou, but this management should not threaten the long term well being of other species, or the functioning of the overall biological system. Consequently, these guidelines have been developed so that the needs of caribou are considered in the context of broader ecosystem-based management principles.

This evolution in thinking about resource management has been reflected in, and encouraged by, a number of government policy initiatives. For example, *Ontario's Policy Framework for Sustainable Forests* (Ontario Forest Policy Panel 1993) and the *Crown Forest Sustainability Act* (Government of Ontario 1994) promote the sustainability and long term health of forest ecosystems. This direction is being implemented through individual forest management plans, as directed by the *Forest Management Planning Manual* (OMNR 1996). At the national level, Ontario has indicated support for the provisions of the *1995 Canadian Biodiversity Strategy*

(Anonymous 1995). Caribou are sensitive to changes in the forest landscape related to logging, and could be considered an indicator of long term forest health.

The *Crown Forest Sustainability Act* requires forest management to be conducted in a manner that emulates natural disturbance within silvicultural constraints. To comply with this requirement and to also meet the terms of the *Class Environmental Assessment for Timber Management in Ontario*, OMNR is developing *Forest Management Guidelines for the Emulation of Fire Patterns* for cut size, shape and distribution across the landscape (*Appendix V*). These guidelines attempt to emulate the natural patterns produced by fire, based upon the natural fire patterns observed since 1920 across the boreal forest. These guidelines will form a broad landscape "umbrella" under which species-specific management guidelines will be implemented.

Ontario promotes the sustainable use of forest resources (OMNR 1994). **Sustaining or conserving forest-dwelling woodland caribou means maintaining caribou range occupancy within a managed forest landscape**. Management strategies for conserving caribou in the forested portion of boreal Ontario are consistent with three guiding principles:

i) provide for the maintenance of caribou range,
ii) provide for the maintenance of viable forest-based industries, and
iii) comply with accepted principles of sustainability, conservation and forest health.

These guidelines exist because we practice forest management. The OMNR is committed to maintaining viable forest-based industries while pursuing its' mission of ecological sustainability. Sustainability is defined as the maintenance of all forest components and ecological functions which compels the OMNR to maintain caribou range. The ecological capital and management actions required to sustain these components determine the limits to wood availability for commercial use. Shutting down all forest-based industries or implementing widespread predator control are not viable solutions to the challenge of conserving caribou.

An adaptive management approach to caribou conservation is endorsed (*Section 6*).

2.0 WOODLAND CARIBOU AND THEIR ENVIRONMENT

2.1 General Description and Distribution

Caribou or reindeer (*Rangifer tarandus*) are members of the deer family (Order Artiodactyla, Family Cervidae). They are widespread in the circumboreal region, inhabiting tundra, boreal coniferous forest and mountains. Caribou formerly ranged from Norway to Siberia, and across North America from Alaska to Newfoundland and south to the northern United States (Banfield 1974). Wild reindeer are no longer present in much of their former European range, although herds

in Russia have recently reoccupied much of their historic range. In North America, the southern edge of caribou range has generally receded northward. Caribou have been extirpated from the New England and Great Lakes states and the maritime provinces (Kelsall 1984). Populations of woodland caribou from western Canada (including Ontario) are considered "vulnerable" by the Committee on the Status of Endangered Wildlife in Canada (Kelsall 1984).

Woodland caribou bull.

Five subspecies are or were native to North America (Banfield 1974). Peary caribou *(R. t. pearyi*) is a small, pale subspecies inhabiting northwest Greenland and the Queen Elizabeth Islands in the Canadian Arctic. The Queen Charlotte Islands subspecies (*R. t. dawsoni*) is extinct. Barren ground caribou (*R. t. groenlandicus* and *R. t. granti*) inhabit tundra and northern boreal forest from Alaska to northern Manitoba. Woodland caribou (*R. t. caribou*), the largest subspecies, are found in boreal forests from Newfoundland to the Yukon.

In Ontario, caribou are mainly found north of approximately 50^{o}N (Figure 1). They formerly ranged as far south as Lake Nipissing and Minnesota (Darby *et al*. 1989). Isolated relic populations are found along Lake Superior at Neys and Pukaskwa parks, Pic Island, the Slate Islands and southeast of Geraldton (Darby *et al*. 1989). An introduced population resides on Michipicoten Island at the east end of Lake Superior (Bergerud and Mercer 1989). Some caribou in the Hudson Bay Lowlands, including the large Pen Island herd, summer in the open coastal tundra, and migrate inland for the winter.

Ontario caribou belong to the woodland subspecies (*R. t. caribou*), although caribou from the Pen Islands herd share behavioral characteristics with the barren ground subspecies (*R .t. groenlanicus*), and may be a mixture of these subspecies (Abraham and Thompson 1998).

"Ecotypes" are useful for describing caribou populations for conservation and management purposes (Bergerud 1988, Edmonds 1988, Kelsall 1984, Mallory and Hillis 1998, Thomas 1992, Williams and Heard 1986). Ecotypes classify caribou by their habitat use and seasonal migratory

behaviour. The Pen Islands herd and some other herds along the Hudson Bay coast are the migratory forest-tundra caribou ecotype. The remainder of Ontario's caribou, including boreal forest animals and some Hudson Bay Lowlands animals, are migratory or sedentary and are collectively referred to as forest-dwelling ecotypes.

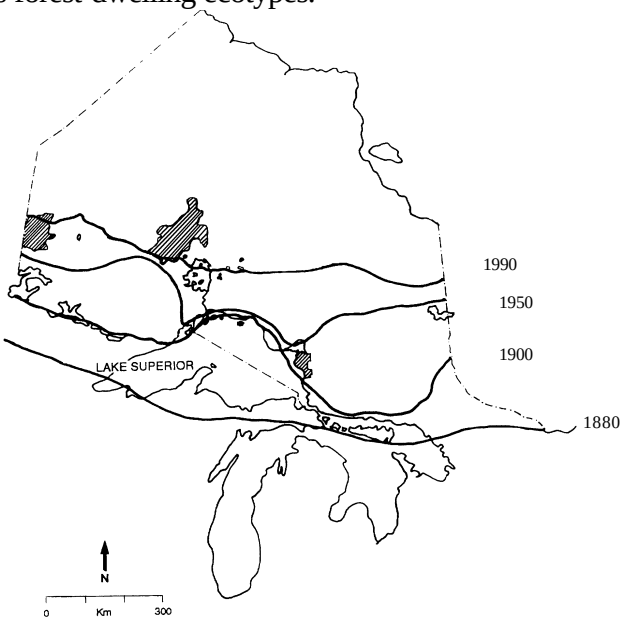


Figure 1. Range recession on woodland caribou in boreal Ontario (adapted from Darby *et al*. 1989).

2.2 Life History and Development

Caribou are well adapted for life in boreal regions. They have a well-furred muzzle, thick fur made up of hollow hairs, and large crescent-shaped hooves to support them on snow. They are able to dig through snow to reach ground lichens. Lichen feeding permits caribou to persist where other ungulates cannot (Thomas 1992).

Caribou have lower reproductive potential than most other ungulates (Banfield 1974). Cows typically first breed at 2 1/2 years and almost always bear only a single calf. This compares with moose (*Alces alces*) and white-tailed deer (*Odocoileus virginianus*) which breed at 1 1/2 to 2 1/2 years and commonly bear twins and occasionally triplets. Pregnancy rates have been estimated at 63 to 75 percent for cows 1 1/2 years old or older (Darby *et al.* 1989). Calf recruitment by late winter averaged 12.8 percent of the population in Ontario herds (Darby *et al.* 1989). Average natural mortality rate of forest-dwelling caribou when predators are present has been estimated at 50 to 70 percent per year for calves and 7 to 30 percent per year for adults (Thomas 1992).

Maintenance of calf survival rates and subsequent recruitment into the breeding population are considered essential for population maintenance.

2.3 Population Density and Home Range

Ontario's caribou population has been estimated at approximately 20,000 animals (Cumming1998). This minimum estimate was generated from expert opinion of OMNR personnel and is based on aerial surveys, ground surveys and other accumulated observations and knowledge. No confidence intervals are available. The population estimate is broken down into approximately 10,800 in the Pen Islands herd, 6,700 elsewhere in the Hudson Bay Lowlands, and 2,700 in the boreal forest. Cumming estimates that approximately 1,800 caribou inhabit the commercial and potentially commercial forest.

Forest-dwelling caribou have developed life-history strategies to exist at low densities on the landscape, probably to reduce predation risk (Bergerud 1996). In combination with their low productivity, this makes them vulnerable to shifts in predator-prey numbers, hunting and changes in habitat (Bergerud and Page 1987). Estimates of population densities derived from winter aerial surveys range from 0.006 to 0.042 caribou per km^2 with a modal value of approximately 0.02 caribou per km^2 (Darby *et al.* 1989).

Winter range size of seven herds in Ontario averaged 390 km^2 in a single winter (Cumming and Beange 1987). This size would increase when the range over several winters is considered (Cumming 1992). Summer ranges are smaller, typically in the range of 25 km^2 (Cumming 1992). Forest-dwelling caribou group size range from 1.2 in late spring to 6.2 in winter (Darby and Pruitt 1984, Bergerud and Page 1987).

2.4 Habitat Relationships

Woodland caribou use habitat differently in various parts of their range. Seasonal differences in habitat use often occurs. Their range usually includes some habitat that supplies abundant arboreal or terrestrial lichens. Lichens are a readily available source of carbohydrate and an important winter food in much of caribou range (Schaefer and Pruitt 1991). Mature coniferous forest, alpine meadows, tundra and peatlands are used in various parts of Canada (Kelsall 1984).

Habitat selection by caribou is influenced by the need to space themselves from populations of alternate ungulate prey, thereby reducing the risk of predation (Bergerud 1985, Cumming *et al.* 1996), while still providing essential resources for caribou survival.

Caribou habitat in the boreal forest has been shaped primarily by fire. Fire size in the boreal forest is variable, with fires ranging in size from less than 0.1 ha to more than 1,000,000 ha. Typically there are many small fires and relatively few large fires, but the majority of the forest landscape is shaped by fires in the size range of 10,000 ha or greater. In northwestern Ontario, large wildfires are common, with Red Lake, Sioux Lookout and Nipigon districts averaging at least one fire per year greater than 100 km^2 since 1976. Caribou life history strategies in the boreal forest are adapted to large scale disturbances.

The amount and distribution of caribou habitat within currently occupied range is a result of the cumulative effects of historic and recent natural disturbance, modified by timber harvesting and other human activities. This disturbance regime has resulted in large areas of recent fire disturbance and large areas with little or no recent fire disturbance. Maintaining woodland caribou range occupancy will require maintenance of these landscape mosaic patterns and ecological processes in light of the challenges of human activities and climate change.

2.4.1 Winter Habitat

Caribou winter range typically includes open coniferous forest with abundant ground cover of reindeer lichens (*Cladina* spp.). Arboreal lichens are generally a secondary food source, but may be locally important (Schaefer and Pruitt 1991, Darby and Pruitt 1984). Preferred arboreal lichens are *Bryoria* spp., *Usnea* spp. and *Evernia* spp. (Schaefer and Pruitt 1991, Rominger *et al.* 1996). Forest with abundant ground lichens are often found on dry soils, sandy outwash deposits, eskers, sand dunes, or very shallow soils with exposed bedrock. These habitat types often exist in a matrix of other habitats, including various feathermoss-dominated conifer forest types, mixedwoods and hardwood-dominated forest. Peatlands, consisting of sparsely treed bog and fen, are used extensively in the Hudson Bay Lowlands (Thompson and Abraham 1994), and locally or seasonally in portions of the boreal forest (Gollat pers. comm.). Pen Islands caribou and some other populations inhabiting the Hudson Bay Lowlands winter in the Sub-Arctic Lichen Belt, eating lichens in raised bogs (Darby *et al.* 1989).

Caribou are most common in areas where alternate prey and wolf (*Canis lupus*) densities tend to be low (Seip 1992, Cumming 1992, Cumming *et al.* 1996). These are typically large areas dominated by mature coniferous forest and sometimes open peatland complexes where deciduous browse and edge habitat are minimal. This habitat apparently provides an escape advantage for caribou, and refugia within a broader landscape with generally higher predator numbers.

Habitat selection is influenced by snow conditions (depth and crusting). Early winter habitat may consist of sparsely-treed peatlands where caribou eat arboreal lichens (Darby and Pruitt 1984). As snow accumulates, animals move to wind-swept ridges with partial canopy closure and less snow accumulation. Varied topography, offering a variety of snow conditions, may be an important habitat component (Darby *et al.* 1989). Winter habitat typically includes frozen lakes and rivers.

Caribou often congregate in these open areas where they can see approaching predators and move quickly on crusted snow, particularly in late winter (Darby *et al.* 1989).

Winter habitat is most often associated with deep, dry, sandy sites (left), or very shallow soil, bedrock-dominated sites (right) with abundant terrestrial lichens.

Young successional forests, including cutovers, are not generally used during the winter, possibly due to increased predation risk, reduced food availability or unfavourable snow conditions (Cumming and Beange 1993). *Cladina* lichen cover tends to be low in younger fire-origin stands, gradually building to approach pre-disturbance levels by a minimum age of approximately 40 years (Schaefer and Pruitt 1991, Harris 1996), although in many stands lichen cover may continue to accumulate to 60 to 80 years. Although suitable lichen abundance may exist by 40 years, young stands often have dense stems and numerous lower branches, impeding movement by caribou and impairing their ability to detect predators (Schaefer and Pruitt 1991). These stands therefore have limited habitat value until they have undergone self-thinning and self-pruning. Moose and white-tailed deer tend to be more abundant in young forests associated with higher browse production. These areas tend to support higher densities of wolves due to the increased prey availability. Browse availability may be greater after logging than after fire due to increased hardwood regeneration. Deep, crusted snow in open cutovers and burns may impair movement and cratering for food (Schaefer and Pruitt 1991).

The winter habitat value of older stands may decline when the lichen crop declines as gaps in the canopy close in with understory trees (often spruce and fir) and *Cladina* is replaced by feathermosses (Schaefer and Pruitt 1991). This process typically begins when the stand reaches approximately 100 years, but varies with soil and site conditions, and overstory composition.

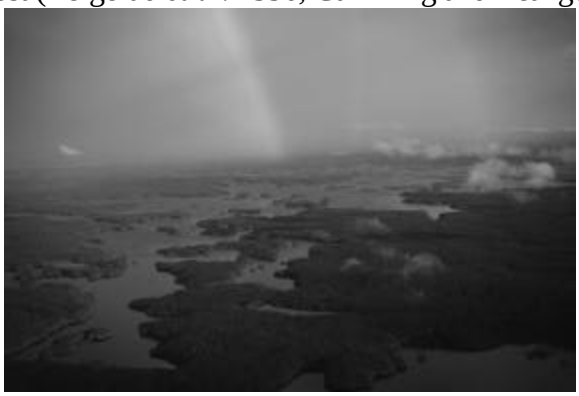
Caribou show some affinity for traditional wintering areas, returning year after year to the same range, while bypassing similar forest habitat (Cumming and Beange 1987). However, natural disturbances such as wildfire and blowdown in traditional wintering areas force shifts to alternate wintering areas.

2.4.2 Snow-free Season Habitat

Spring, summer and fall habitat is generally not as well understood or documented as winter habitat. In this snow-free period, caribou distribute themselves across the landscape, and group size tends to be smaller than in winter. Habitat during the snow-free season may include mixed and hardwood stands, but caribou continue to be associated with mature coniferous forest which may largely overlap winter habitat (Darby *et al.* 1989). The summer diet is more diverse than the winter diet and consists of forbs, deciduous leaves, lichens, fungi, grasses and sedges.

Cows tend to have traditional calving areas, which are used year after year. Calving areas are chosen primarily to minimize the risk of predation. A variety of strategies are used to reduce encounters with predators and ensure escape opportunities when predators are encountered.

Caribou often disperse into areas where wolves and alternative prey species such as moose as well as other caribou, are scarce (Bergerud and Page 1987). At Pukaskwa National Park, calving takes place on islands and along the coast where there are lower concentrations of wolves and lynx (*Felis lynx*) (Bergerud 1985). An on-going telemetry study in northern Ontario suggests peatland complexes are used as calving habitat (Darby *et al.* 1989, Gerrish, pers. comm.). These complexes may offer a similar advantage for predator avoidance. Forest-dwelling caribou often calve on islands and peninsulas which are relatively predator-free and offer escape opportunities associated with access to water. At Lake Nipigon, caribou leave the islands when ice forms in early winter and the escape advantage is lost (Bergerud *et al.* 1990, Cumming and Beange 1987).



Landscapes with abundant water, islands and irregular shorelines tend to provide refuge from predators during the calving period and may be good calving areas.

2.4.3 Rutting Habitat

Caribou often select open habitats, including open peatlands, tundra or alpine tundra, for the autumn rut (Banfield 1974). They may be exceptionally vulnerable to predation at this time of year (Cumming 1992). In southeastern Manitoba, rutting takes place in open and semi-open bogs

(Darby and Pruitt 1984). No description of rutting habitat is available for the forested portion of Ontario.

2.5 Predation

Predation by wolves is usually considered the major cause of mortality and an important limiting factor in most caribou populations (Seip 1992, Thomas 1992, Bergerud 1996). Caribou generally occur at higher densities without wolves (Thomas 1992). Predation by black bears (*Ursus americanus*) (Ballard 1994) and lynx (Bergerud 1971) can be important locally.

Caribou densities are lowest where wolves and alternate ungulate prey, especially moose and deer, inhabit the same range (Seip 1992, Thomas 1992). Where wolves and alternate prey are common, caribou will only persist if there are features of the landscape that allow them to avoid or escape from predators, particularly when the calves are vulnerable (Bergerud 1985). Bergerud (1996) has proposed that caribou populations exposed to wolf densities greater than 6.5 wolves/1000 km^2 will decline.

Changes in the habitat such as fragmentation of the forest and shift to generally younger successional stages and increased browse production can inadvertently tip the predator-prey balance in a manner which elevates the risk of predation to caribou. For example, fragmentation of large areas of mature forest into small patches of mature forest interspersed with patches of younger forest and abundant edge and browse, can lead to increased densities of alternate prey resulting in higher densities of predators.

2.6 Disease and Parasites

Caribou are subject to many parasites including warble flies (*Oedemagena tarandi*) and internal parasites. The most significant parasite in Ontario may be brainworm (*Parelaphostrongylus tenuis*) which is transmitted from white-tailed deer. This parasite has been implicated in the decline of several caribou herds where deer and caribou overlap (Racey and Armstrong in prep.). Increases in deer population or expansion of deer range may be associated with logging, wildfires and favorable climatic conditions. The extent to which brainworm contributed to the decline of caribou in northwestern Ontario is difficult to determine due to the number and complexity of simultaneous change agents. The failure of several caribou re-introduction attempts has been attributed to brainworm (Bergerud and Mercer 1989).

2.7 Disturbance by Other Human Activities

Caribou may modify their behaviour or range occupancy patterns to avoid human activity. Woodland caribou in Newfoundland, especially females, were displaced from areas undergoing

active clearcutting, but not all animals responded this way (Chubbs *et al*. 1993). Vehicle activity can also disrupt caribou movements and use of winter habitats. In northwestern Ontario, caribou were displaced within a traditional wintering area when a logging road was ploughed and used for short-term, high frequency log hauling, compared to years when the road was unploughed (Cumming and Hyer 1998). Animals may become habituated to traffic and other noise, and eventually resume use of their former range.

Road and train kills have been documented in Ontario and British Columbia (Cumming 1992). One train accident killed 12 caribou from a herd of 20. Such events can be an important cause of mortality for individual small herds, but generally do not have much impact at the population level.

There is no open hunting season for caribou in Ontario. Caribou are used as subsistence food by First Nations people. Poaching or hunting accidents have been known to occur when access roads penetrate caribou range. Historically (pre-1929), hunting contributed to the decline of caribou in Ontario (Racey and Armstrong in prep., Voigt *et. al* in prep.).

2.8 Movements, Space and Scale

Caribou inhabiting open tundra areas move substantial distances between summer and winter ranges. The Pen Islands herd moves over 400 km between the coastal tundra and forested wintering areas (Abraham and Thompson 1998). Forest-dwelling caribou are less mobile. Movements of up to 80 km between calving and wintering areas occur, but some caribou are essentially sedentary or non-migratory (Cumming 1992, T. Hillis pers. comm.). Traditional migration routes are sometimes used (Cumming 1992). Migration routes tend to avoid dense, young coniferous forest and areas with extensive blown down trees which may impede movement (Schaefer and Pruitt 1991).

Large areas of relatively mature to old conifer forest are an important part of woodland caribou range .

Caribou require large areas to maintain spacing from predators and supply adequate mature forest habitat in a landscape subject to large fires. Home ranges are frequently 40 to 50 km across, covering many types of terrain including rivers, lakes, uplands, and lowlands and forests of various ages. Some forest-dwelling caribou tend to migrate directly between winter and summer or calving range, while others tend to follow a less structured "wandering" behavior. Preliminary results from ongoing telemetry studies (T. Hillis pers. comm.) tend to confirm the large spatial scale of caribou range utilization in northwestern Ontario (Table 1).

Table 1. Preliminary estimates of extent of caribou movements and range utilization in northwestern Ontario, based on ten cows and two bulls.

Habitat Attribute	**Median Size or Distance**	**Range of Observations**
Core winter range (km^2)	53	26-282
Early winter range (km^2)	83	53-282
Summer range (km^2)	42	20-114
Occupied (home) range (km^2)	322	$100\text{-}10{,}000^+$
Centre to centre distance between winter and summer range (km)	38	10-70

These data are consistent with earlier estimates by Simkin (1965) and provide evidence of the size of winter and summer range to be retained and/or created for future use by caribou. They also demonstrate that caribou conservation strategies must consider changes in predator densities and other disturbances across broad areas on the landscape.

2.9 Current Caribou-Occupied Landscapes

Caribou currently occupy site regions 2W, 3W, 3S and 4S (Figure 2). Landscapes in these regions were historically shaped by wildfires ranging in size and frequency from many small fires to a few landscape-shaping fires exceeding 10, 000 ha.(Figure 2). Occasional fires 40,000 to 60,000 ha or larger occur every few years, and may cross previous burns and cutovers. Although most fires are in the smaller size classes, the large fires greater than 10,000 ha account for the largest proportion of the area disturbed in 2W and 3S, and frequently “erase” smaller disturbances within their boundaries. Site regions 3W and 4S also have the greatest amount of area disturbed by fires greater than 10,000 ha but also have a greater amount of area disturbed by forest harvesting. The actual distribution, within these site regions, of fire and cutovers by size and frequency are documented in the *Forest Management Guidelines for the Emulation of Fire Patterns* (*Appendix V*). The basis for these caribou guidelines is the assumption that caribou have evolved with and adapted to landscape patterns associated with these natural disturbance regimes.

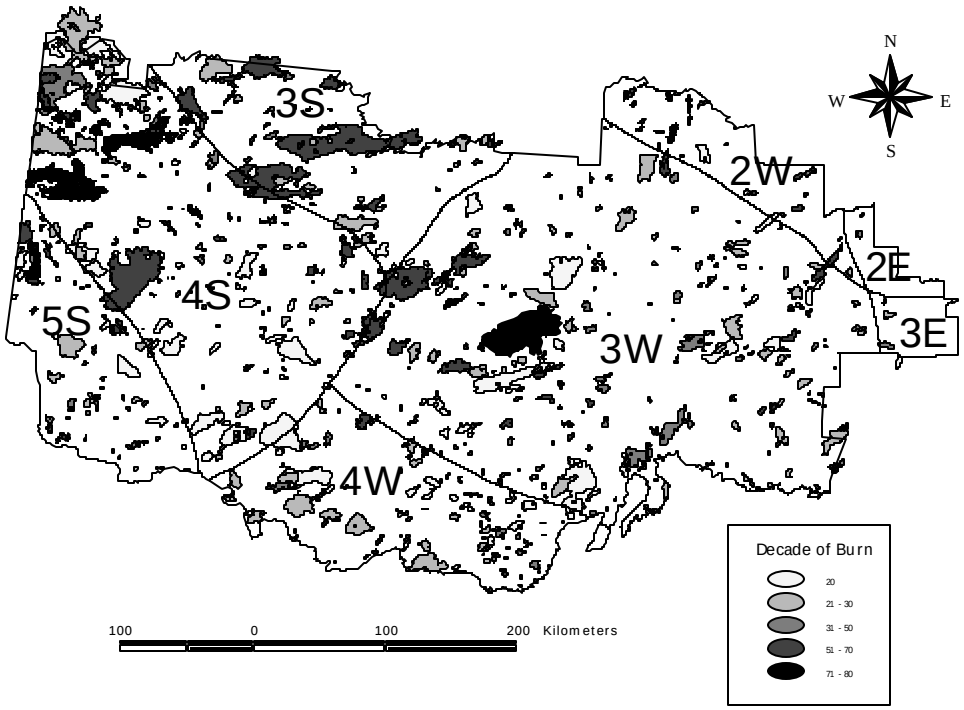


Figure 1. Site regions in the commercial forest of northwestern Ontario and fires greater than 200 ha in size that occurred in each decade between 1920 and 1980.

3.0 IMPLICATIONS OF FOREST MANAGEMENT ACTIVITIES

There has been a gradual recession in caribou range over the long term (Racey and Armstrong in prep.) and local extirpation coincident with the expansion of forest harvesting since 1950. It is likely that many variables have contributed to this decline. Those variables associated with forest management activities likely include changes in forest composition and structure, increased access attributed to the proliferation of access roads and elimination of large contiguous patches of older forest adjacent to occupied caribou range. It is not known to what degree each of these factors has contributed to the decline either individually or cumulatively. Until these factors and their impacts are better understood, future forest management should be conducted in a manner which decreases the likelihood of these factors causing future declines. This is the premise under which the first steps toward an adaptive approach are taken.

Forest Planning Horizons

Caribou occupy conifer-dominated landscapes composed of large, old and relatively even-aged forest tracts. Harvesting these landscapes without careful planning that considers long term habitat supply and renewal could lead to habitat losses over large areas and long time periods. Traditional modeling practices to maximize fibre production and plan over relatively short, 20-year planning periods make it difficult to maintain large areas of older forest on the landscape for caribou habitat. Without careful and thoughtful planning, the cumulative effect of wildfire and forest harvesting in areas currently occupied by caribou could make large areas unsuitable as caribou habitat for long periods of time.

Managing Forest Composition and Structure

Forest management activities can modify forest composition and structure. Caribou forage for their primary winter food, terrestrial lichens, in forest stands with structural attributes conducive to lichen growth. These stand conditions regenerate readily after fire, and the technology is available to regenerate these stand conditions through forest management. Harvesting and renewing these areas without careful attention to recreating these structural characteristics could result in the long-term depletion of suitable caribou habitat. Forest management in a manner that promotes hardwood growth, enhances soil nutrient levels or produces more young forest than would be represented under a natural disturbance regime may reduce the suitability of these sites for lichen regeneration, and could result in long term habitat depletion. Similarly, fragmentation of the old forest component into small, disconnected blocks of habitat may diminish the ability of the forest to provide refuge from predators because of a more uniform distribution of predators across the landscape. Brainworm and predator increases associated with range expansion of white-tailed deer and moose may also contribute to reduced caribou calf and adult survival.

Calving areas are an important component of caribou range. Cows tend to return to traditional calving areas where they were raised and which offer escape from predators. These areas are often on the shores and islands of large lakes, but also include small lakes, systems of small lakes and large wetland complexes with bedrock or bog islands. Forest management in the vicinity of these calving areas may increase human disturbance through increased access, or alter predator numbers or activity patterns in areas traditionally used by the vulnerable cow-calf group. Disrupting cow-calf groups, increasing predator activity near calving areas and isolating calving areas from contiguous range may be detrimental to calf survival.

Silviculture plays a critical role in developing a future forest condition that is conducive to supporting woodland caribou food production, refuge and connectivity. Forest management practices that access, harvest, regenerate and tend the forest such that landscape patterns and ecological processes are maintained in a state similar to that produced under natural disturbance regimes should have reduced impacts on woodland caribou and their habitat.

Access

Dry, sandy landforms associated with many winter caribou habitats and with highly desirable well-spaced jack pine forests are often preferred locations for road construction. Long-term, year-round access in all significant caribou habitats, is a concern in that it increases risk of both human disturbance and predator-related mortality. In addition, maintained access roads within winter and summer habitats may encourage year-round access, contributing to increased predator movements along snowmobile trails and ploughed roads in the winter, and potential human disturbance impacts throughout the year. Managing access is required to avoid long-term impacts on winter habitat and to minimize the number of maintained roads in regenerating winter habitat and other critical habitats.

4.0 RECOMMENDED FOREST MANAGEMENT GUIDELINES

Given the size of the landscapes that caribou use and the preferred habitat and site conditions within these landscapes, it is necessary to structure these guidelines according to several spatial and temporal scales. Recommendations applicable to these scales will be applied at the regional and sub-regional, Forest Management Unit (FMU), and stand levels of planning.

Caribou habitat management issues are complex and are not well suited to rule-based prescriptions. Many of the recommended guidelines that follow provide general guidance intended to support caribou conservation by maintaining range occupancy through time, while recognizing the dynamic nature of boreal landscapes. Prescriptions developed from these guidelines must be based on consideration of regional and local ecological context, knowledge of caribou use in specific areas and expected cumulative stresses on caribou populations.

4.1 Regional Considerations

Caribou should be managed on a very large spatial and temporal scale, spanning more than one Forest Management Unit over 80 years or more. Caribou habitat can not be managed sustainably on any single FMU in isolation. Variation in ecoregional landscape pattern, forest succession and habitat utilization can be accommodated at this spatial scale. This time scale (80+ years) would be the minimum required to allocate and harvest a forest tract, regenerate it and grow it to the point where it could once again be suitable for use as caribou habitat. In addition, there must be the intent to allow reasonable time for use by caribou before re-harvest. Both planning and managing long term habitat supply for caribou will require regional coordination among FMUs and/or districts. Regional coordination and planning is required to develop an approach to maintaining broad landscape pattern and forest composition and to address, at a strategic level, three landscape features; 1) winter habitat, 2) calving habitat, and 3) location of primary access roads. This Section describes, in general terms, the main regional scale decisions required for these three components. Specific direction for Regional Land Use Planning is described in *Appendix 1*.

4.1.1 Regional Forest Structure and Composition

Regional forest composition and structure provides the ecological context for planning at the FMU level. General site-regional direction for defining future forest structure is identified in the *Forest Management Guidelines for the Emulation of Fire Patterns*, which are based upon historical stand-replacing natural disturbance events, their size distribution and how they are distributed across the landscape. Site-regional disturbance plans, coordinated among FMUs will provide general direction, on a site-regional basis, for disturbance event size and distance between disturbance events of designated size classes.

For the purpose of linking site-regional planning of forest pattern to development of a forest management plan, a clearcut is defined as an area which is planned to be harvested under the clearcut silvicultural system. A clearcut boundary is the stand boundary or stand boundaries that are allocated to be cut under that system. Once harvesting has occurred within those boundaries, it becomes a disturbance "event" and may contain area left uncut (Figure 3). The uncut portions are referred to as residual patches. The *Forest Management Guidelines for the Emulation of Fire Patterns* will recommend criteria for the size and patterns of these residual patches.

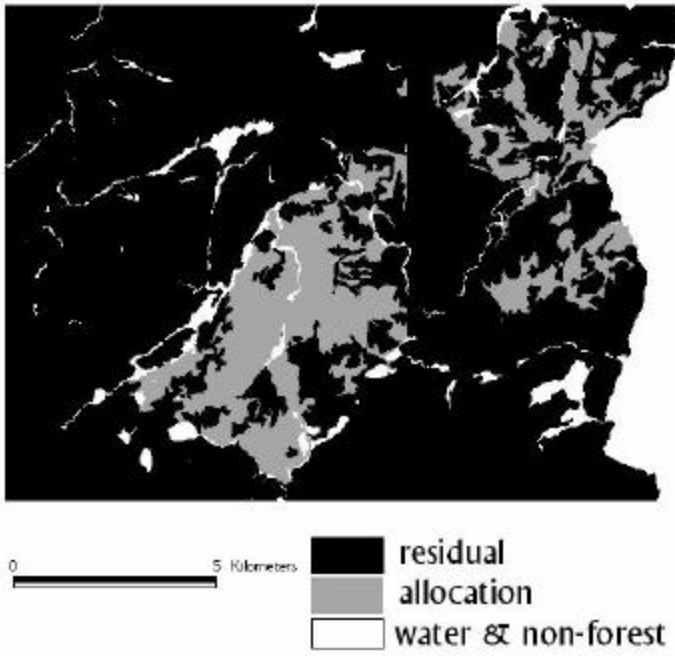


Figure 3. Example of expected residual in two large harvest events. Residual within a planned harvest area is a result of differential merchantability and operability. A clearcut is defined as an area which is planned to be harvested under the clearcut silvicultural system. The residual within boundaries of the allocated area

includes stands that are not harvested and individual trees within the harvested areas.

The *Forest Management Guidelines for the Emulation of Fire Patterns* should largely supplant the need for the range management aspects of other guidelines featuring specific wildlife species. It is not the intent of *the Forest Management Guidelines for the Emulation of Fire Patterns* to provide guidance on how to replicate the ecological processes resulting from fires. These guidelines deal solely with attempts to emulate the patterns of natural fire disturbances at the landscape and stand levels. They do this by describing the range of disturbances in various size classes across each of Hills' site regions, as well as certain characteristics of fire events such as residuals and edge.

The *Forest Management Guidelines for the Emulation of Fire Patterns* describe a frequency distribution of disturbance events within the size range considered acceptable under contemporary operational and social constraints (*Appendix V*). The disturbance history of northwestern Ontario naturally includes many larger disturbances to which caribou have adapted. Caribou habitat conservation will require special consideration of the larger disturbance events within the landscape.

4.1.2 Regional Consideration of Winter Habitat

Protecting selected winter habitat areas should be a priority during land use planning. Managing caribou winter habitat involves ensuring a continuous supply of mature coniferous forest featuring winter habitat attributes in large (in the order of 10,000 ha or greater) tracts. This protection may include long term deferral of harvest, and both stand and access management. These tracts include winter habitat tracts where long term deferrals are considered necessary for maintaining caribou occupancy in the area, or to prevent further northward recession of caribou range. Thus, identification of these sites will be especially important near the southern limit of occupied caribou range.

4.1.3 Regional Consideration of Calving Areas

Protecting strategic calving areas should be a priority during land use planning. All calving areas are significant because they play an important role in ensuring recruitment into the caribou population. Calving areas can be considered strategic if they meet one or more of the following criteria:

- are located near the southern edge of caribou range,
- are used by many caribou,
- offer proximity to year-round habitat,
- are used by a declining or vulnerable herd, or
- offer a calving location for a large geographical range.

The most important of these known calving areas in northwestern Ontario have been identified (Table I - 1, *Appendix I*).

Appropriate protection of calving lakes may include up to a 1000 m reserve of standing timber, restrictions on road access, restricted development or use of tourism facilities, and/or modified forest management activities compatible with maintaining caribou calving values and survival of the cow-calf group(s). Assigning compatible land uses such as remote tourism or roadless/wilderness designations in the vicinity of calving lakes may supplement other measures for conserving calving values. Managing human activity patterns to make them compatible with caribou calving values is also appropriate.

Calving areas of less strategic importance, or those that can not be addressed through regional land use planning may be identified and protected through the application of Areas of Concern (AOCs) during the forest management planning process (*Section 4.3.2*).

4.1.4 Regional, Long-term Planning of Primary Access Roads

Plan primary roads and road corridors to avoid traditional winter habitat tracts, and landforms and soils with high capability to support winter habitat. These areas include dry sandy outwash deposits, esker complexes, dunes and shallow soil complexes with abundant bedrock outcrops. As these sites are often preferred for building roads, careful planning is necessary to avoid compromising present or future caribou habitat values. Where roads must cross these landforms or landform complexes, they should follow the edges, rather than transecting them. Strategic primary access road corridors should be identified for the remainder of the commercial forest, including north of 51^{o}.

4.2 Bridging Regional and Forest Management Unit Level Planning of Caribou Landscapes

The objective for planning caribou landscapes is to maintain a continuous supply of suitable, mature, year-round habitat distributed both geographically and temporally across the landscape in such a manner as to ensure permanent range occupancy. This section provides general direction on how to apply the *Forest Management Guidelines for the Emulation of Fire Patterns* to conserve landscape values required for conserving forest-dwelling woodland caribou habitat.

4.2.1 Caribou Landscapes and Habitat Assumptions

A landscape is considered suitable for woodland caribou if it has: i) patches of habitat currently used by woodland caribou, ii) available calving areas where there is a high probability of calf survival, and iii) a mechanism for replacing winter habitat lost through natural or other disturbances. The primary role of habitat is to allow caribou to distance themselves from predators and minimize loss of animals to predation, while still providing essential resources of food and cover.

A landscape managed for caribou habitat has a supply of currently used winter habitat and access to calving areas. The majority of winter habitat should occur as part of relatively mature (40 to 100 years) or old (80 to140 years), even-aged (within a 20 (+ / -) year age range) tracts greater than 100 km^2 in area. Other land capable of producing winter habitat, and much land that is not capable of producing winter habitat, should be managed in an attempt to produce future habitat of various ages (young to old) within large, relatively even-aged tracts of land. If these conditions are satisfied, caribou requirements for snow-free season habitat will generally also be addressed.

Winter habitat quality changes with age. Habitat starts to become available in the 40 to 60 years age range. Habitat tracts in the 60 to 80 year range can be counted on to provide winter habitat and tracts greater than 80 years of age can be considered as prime habitat.

Specific areas of documented, repeat winter use (e.g. used two or three years out of five) should be considered traditional winter habitat. Alternate winter habitat can be considered available when adjacent to the harvested tract or nearby. In most cases alternate winter habitat should be within 40 km, depending on the specific landscape and traditional caribou use patterns.

4.2.2 Integrating Caribou Landscapes and Habitat with the *Forest Management Guidelines for the Emulation of Fire Patterns*

Plan a series of disturbance events (potential harvest areas) on the landscape following the *Forest Management Guidelines for the Emulation of Fire Patterns* in such a manner as to i) maintain a current supply and ii) ensure a continuous supply of large areas (> 10,000 ha) containing current winter or summer habitat, and iii) account for existing distribution of caribou, and alternate and future habitat. The landscape pattern should contain a variety of large habitat patches of various ages interspersed with large operating areas where forest management is taking place. Some of these large operating areas will be planned to renew caribou winter habitat, and others will renew snow-free habitat. The largest disturbance events are allocated first. Smaller disturbance events are allocated in such a way as to minimize fragmentation of large contiguous tracts. Decision rules for allocating smaller disturbances events should be compatible with maintaining a sustainable supply of large disturbance events and large areas of older forest, and will most likely be associated with access roads corridors. This procedure will result in a regional mosaic (Appendix IV) that will facilitate implementation of both the *Forest Management Guidelines for the Emulation of Fire Patterns* and the *Forest Management Guidelines for the Conservation of Woodland Caribou: A Landscape Approach*.

Planned disturbance events supported by the *Forest Management Guidelines for the Emulation of Fire Patterns* may be amalgamated, with Regional Director approval, into larger harvest areas that more closely reflect those often associated with natural caribou range. In the portion of site regions 2W, 3W, 3S and 4S occupied by caribou, allocating harvest effort (hectares harvested) to size classes of harvest tracts will generally be consistent with natural disturbance regimes (Table 2,

Figure 4), and should result in no net change in forest composition or structure at the site-regional or local landscape level. The combined contribution of fire and harvest disturbance in a landscape managed for caribou is expected to approach this natural disturbance pattern. These large disturbance events are created, where necessary, by allocating one or more large disturbance events created under the Forest Management Guidelines for the Emulation of Fire Patterns within a 20 year period. Amalgamation of harvest blocks, if required, should be in the context of a specific landscape to renew large tracts of caribou habitat, maintain landscape diversity at levels associated with the pre-harvest conditions, or to integrate caribou habitat conservation with forest management activities within a broader ecosystem-based management approach.

Table 2. Proportion of burned area in each ecoregion, over a 30 year period, belonging to >5000 ha or >10,000 ha fire size classes.

Fire Size Class (ha)	**Percent of Area Burned by Fire Size Class**			
	Ecoregion 2W	**Ecoregion 3W**	**Ecoregion 3S**	**Ecoregion 4S**
>5,000	78%	68%	74%	82%
>10,000	63%	52%	56%	73%

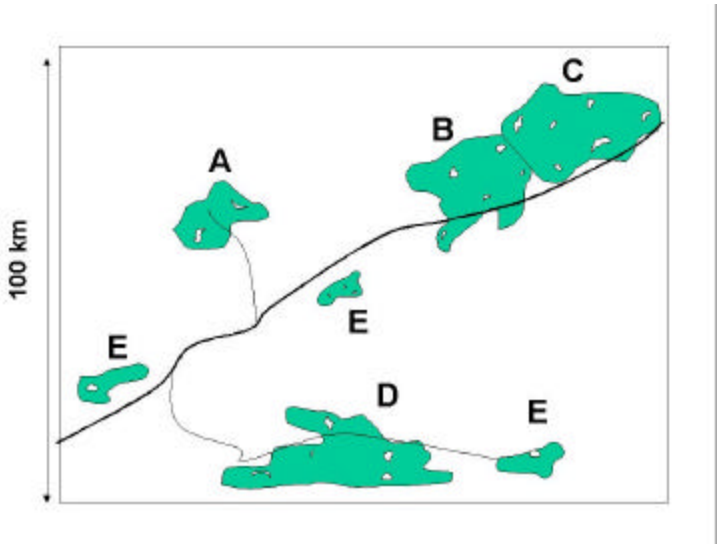


Figure 4. Schematic example illustrating ten years allocation of the largest disturbance events (5,000 to 10,000 ha) under the Forest Management Guidelines for the Emulation of Fire Patterns. Events **A** and **D** are large disturbance events under the Forest Management Guidelines for the Emulation of Fire Patterns. Events **B** and **C** are amalgamated within a 20 year period to create an event greater than 10,000 ha for caribou management reasons. Smaller events (**E**) will also occur on the landscape as recommended under the Forest Management Guidelines for the Emulation of Fire Patterns.

4.3 Planning for Long Term Caribou Habitat Supply on the Forest Management Unit

This section provides guidance used in developing a forest management plan for a specific Forest Management Unit, where the ecological context and broad landscape pattern and composition objectives have already been defined in accordance with the *Forest Management Guidelines for the Emulation of Fire Patterns*. It defines:

i) a set of criteria for placing disturbance events on the landscape to conserve the value of calving and snow-free habitat, protect winter habitat tracts, ensure connectivity between calving, summer and winter habitat, and ensure that all habitat needs are met in the future;
ii) site-specific recommendations for mineral licks and silviculture; and
iii) recommendations on managing human activities to maintain the value of habitat created and maintained through forest management.

Applying the direction presented in this section requires that planners understand and consider traditional caribou habitat use in the area, access issues, wood quality, vulnerability of the forest stands, and FMU history.

4.3.1 Winter Habitat

Areas with high potential to provide current or future winter habitat should be managed for winter habitat by prescribing disturbance events in the order of 10,000 ha or greater, or maintaining them as part of 10,000 ha or greater tracts of older forest. Winter habitat tracts are allocated for harvest or maintained in a thoughtful, strategic process that will ensure a sustainable supply of caribou winter habitat through time, consistent with the *Forest Management Guidelines for the Emulation of Fire Patterns.*

Significant areas with a high potential to produce future caribou winter habitat should be identified through mosaic development early in the planning process and across the Management Unit landscape (*Appendix IV*). Habitat potential (species composition, substrate), habitat use (density and duration), habitat age (current or future supply) and relative habitat supply should be considered. These areas include landforms with repetitive, very shallow soils (mineral soil depth less than 20 cm), bedrock outcrops, deep coarse-textured soils or sand dunes complexes, areas where moisture availability is limiting or where nutrient status is very low, whether or not the vegetative attributes of winter habitat are present. These areas are considered candidates for maintaining current winter habitat or for developing future winter habitat, and should be included as part of proposed future habitat tracts for the purpose of landscape planning.

Maintain or allocate potential winter habitat tracts based on relative habitat supply and local ecological context. Figure 5 and Table 3 indicate how priorities are set for retaining or allocating habitat tracts as part of a disturbance event at the local landscape level. The guidance presented here may be constrained or modified in response to age class distribution of the forest,

past disturbance history, and social and economic values. However, care must be taken not to compromise the caribou habitat values across the management unit. Generally, it is a priority to allocate older, unused habitat, or forest that is older and declining in habitat value, to fill future shortages in habitat supply. It is a priority to retain habitat that is high quality and is being used by caribou, (particularly in the southern portion of the range), and younger forest that will provide habitat in the near future (20 to 30 years).

Assess relative habitat supply on an area approximately 700,000 ha in size. A suitable assessment area for determining relative habitat supply (proportions of management unit; Table 3) is approximately 700 000 ha, centred on the FMU for those units entirely within caribou range, and centred on the occupied portion of the FMU for those management units that are not entirely within caribou range. The actual size and perimeter of this assessment area is to be agreed upon by the Sustainable Forestry License holder and the Crown. Such a large assessment area will require consideration of capable and suitable habitat in neighboring FMUs and parks, and will require generation or sharing of inventory information and caribou habitat mosaics. Portions of the area not included in the zone of continuous distribution of caribou should not be included in this analysis. These provisions are provided for general guidance and professional interpretation should be applied.

Extensive areas of mature spruce and jack pine that exhibit the vegetative attributes of winter habitat but have no record of use by woodland caribou in the winter, may be considered candidates for alternative winter habitat, particularly if these stands exist on landforms with very shallow soils, bedrock outcrops, deep coarse-textured soils or sand dunes complexes, or areas where moisture availability is limiting or where nutrient status is very low.

In the Northwest Region, stands with winter habitat attributes are most closely described by Northwestern Ontario Forest Ecosystem Classification (NWO FEC) vegetation types V30 and V29. These are jack pine and black spruce stands with abundant lichen in the understory (Sims *et al.* 1989, Morash and Racey 1990). These stands are often associated with large tracts of V32, V28, V20, and V18 and are older than 40 years for jack pine and older than 60 years for black spruce. NWO FEC soil types S1, S2 and SS1 to SS5 (Sims *et al.* 1989) typically support these stand conditions. Habitat quality increases with the abundance and availability of terrestrial lichens. Components of these winter habitat tracts often include lowland stands described as V23, V34, V36, V37 and V38, particularly on shallow-soil dominated landforms. These wetland complexes may be more important winter habitat in some parts of northwestern Ontario than others.

Manage the winter habitat tract to a future forest condition that provides for winter habitat value and refuge from predators and human disturbance. Primary roads should avoid traditional and potential high quality winter habitat. After regeneration and ground tending treatments are complete, other roads within the winter habitat tract should be regenerated where

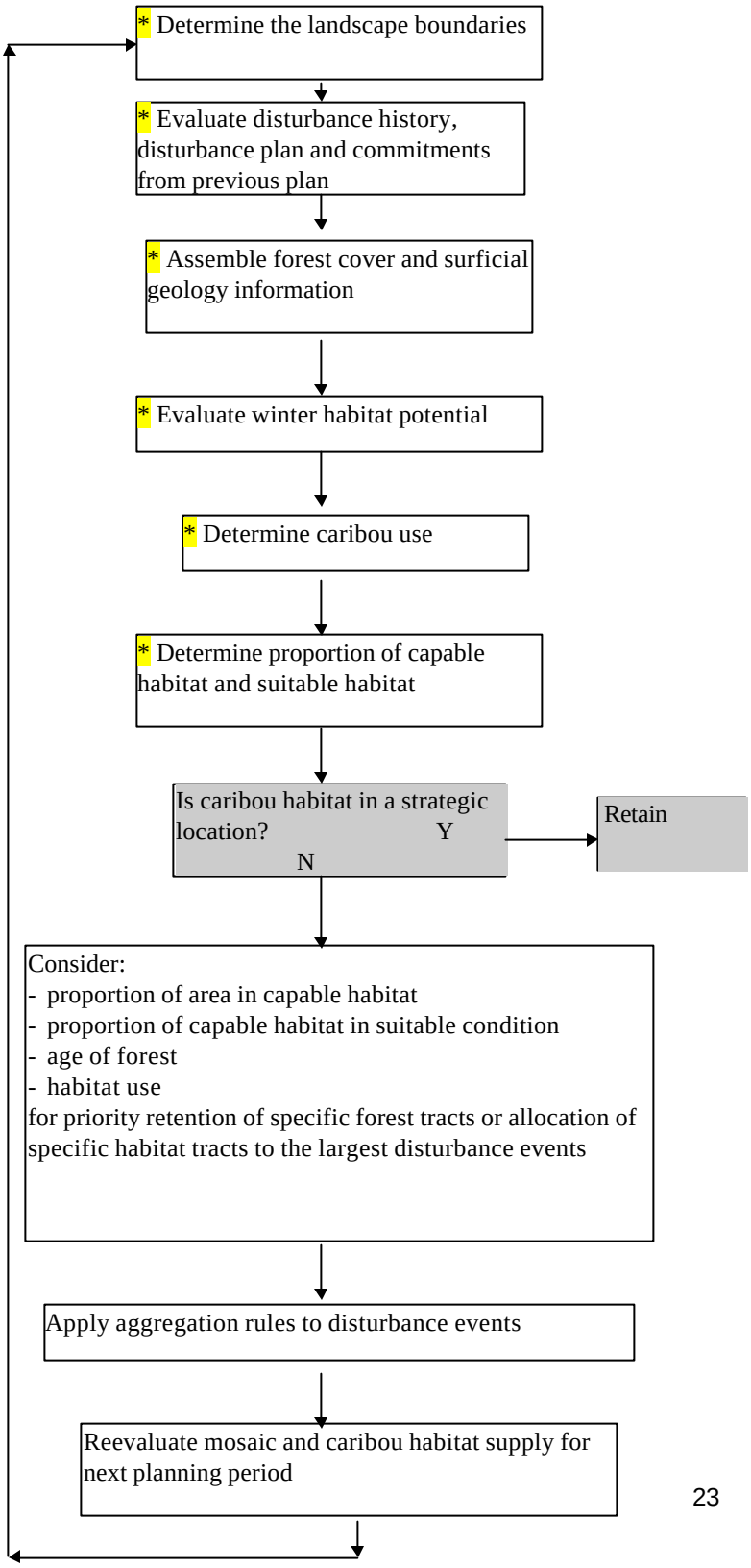
silviculturally possible or made impassable physically or administratively to allow for natural regeneration to trees or lichen communities. After the end of the planned harvest period, no further harvest should occur within winter habitat tracts until it is rescheduled for allocation in the next rotation as required for application of the *Forest Management Guidelines for the Emulation of Fire Patterns*. Maximum wood utilization from a harvest block is encouraged. Merchantable, unmerchantable or undesirable wood may need to be harvested or left to meet the requirements for residual vegetation and snags, consistent with an ecosystem-based approach and application of the *Forest Management Guidelines for the Emulation of Fire Patterns*. Residual wood would not be available for allocation until the following rotation.

4.3.2 Calving Areas

Calving sites and their associated summer habitat are significant components of caribou range. Typical calving areas include large lakes with islands, complexes of smaller lakes surrounded by mature or over-mature coniferous or mixedwood forest, and open peatlands with treed islands. Calving habitat should provide the necessary space for cow-calf groups to avoid predators during the critical post-calving period. Areas that provide calving opportunities, or are regularly used by cows and calves during the snow-free season are considered to be calving areas. Opportunities to escape predators, security cover, foraging opportunities and human disturbance should be considered in developing a meaningful prescription to protect the integrity of calving areas.

Apply a 1000 m Area of Concern to all calving areas and develop and appropriate prescription for this AOC. Prescriptions will be developed on a case-by-case basis. For portions of the AOC considered critical for maintaining the integrity of calving habitat, the prescription will be a reserve. Where evaluation of calving activity, summer use and physical attributes of the area indicate that portions of the AOC are not essential, a modified prescription may be considered. Modifications could include harvesting all or a portion of the AOC, restricting timing of operations, restricting road locations, prescribing specific renewal and maintenance techniques or a combination of the above. It is necessary to consider security cover, availability of food, distance to refuge (often water), and proximity to other habitat values when deciding on an appropriate prescription for the AOC.

Figure 5. Flowchart for conserving caribou habitat when applying the Forest Management Guidelines for the Emulation of Fire Patterns.



Notes *application or interpretation of habitat mosaic

Refer to long-term habitat commitments from previous plan

Application of environmental guidelines must consider size and number of existing disturbances

Consider information from FRI, NOEGTS and existing habitat mosaics. See *Appendix IV*

See *Section 4.3.1*

Refer to *Section 2.0* Timmermann 1998a and 1998b, and available telemetry data.

Low, medium or high abundance – see *Appendix II*

Prioritize to retain all areas of great strategic importance - see *Appendix I*

Apply Table 3

See *Sections 4.1.1* and *Section 4.2.2*, Table 2, and Figure 4.

Recognize that this is an iterative process that must be repeated and gradually improved, carrying forward long term commitments into the next planning period and ensuring that long-term integrity of caribou range is maintained.

Table 3. Decision guidance matrix for placement of large disturbance and retention tracts for conserving woodland caribou when applying the *Forest Management Guidelines for the Emulation of Fire Patterns*. This table may be applied after habitat tracts are mapped and assessed (*Appendix IV*), and relative habitat supply is determined (*Appendices II* and *III*).

Proportion of land base that is capable habitat	**Proportion of capable habitat in suitable condition**	**Low capability**	**Capable: 0 - 39 yr.**	**Suitable: Not used 40 - 99 yr.**	**Suitable : Not used > 100 yr.**	**Used: 40 - 59 yr.**	**Used: 60 - 99 yr.**	**Used: > 100 yr.**	**Used: any age, strategic location**
Low <= 15%	Low	A/R	R2	R3	R	R1	R1	R1	R1
	High	A/R	A/R	R3	A	R1	R1	A	R1
Medium 16-35%	Low	A/R	A/R	R3	A/R	R1	R1	A/R	R1
	High	A/R	A/R	A/R	A	R1	R1	A/R	R1
High >= 36%	Low	A/R	A/R	R3	A/R	R1	R2	R2	R1
	High	A/R	A/R	A/R	A	R1	A/R*	A	R1

*apply *Forest Management Guidelines for the Emulation of Fire Patterns* if adjacent to used habitat < 100 years old; otherwise retain

A/R: allocate or retain following the *Forest Management Guidelines for the Emulation of Fire Patterns*, based on disturbance event size or distance between disturbance events
A: priority for allocation (cutting in planning period)
R: priority for retention (no cutting in planning period): very high retention priority (R1), high retention priority (R2), moderately high retention priority (R3)

Definitions

Capable habitat has physical and spatial attributes likely to supply caribou winter habitat now or in the future. It consists primarily of ecosites capable of producing suitable habitat (see Appendix II). The proportion of capable habitat is that part of the land base that has the potential to produce caribou winter habitat, irrespective of the present suitability.

Suitable habitat is capable winter habitat where the current forest age (typically greater than 40 years for jack pine dominated habitat tracts and greater than 60 years for black spruce dominated habitat tracts) provides suitable conditions for caribou. Although caribou winter habitat begins to be available at approximately 40 years of age it may not be prime habitat until 80 to 100 years of age. Absolute habitat quality may vary with age.

Used habitat has documented, repeated winter use by caribou. It does not include areas where occupation by caribou is transient or irregular. A strictly quantitative definition is not desirable because survey effort and timing is variable, but use by caribou in two or three of the last five years is a possible criterion if annual surveys have been completed.

Strategic location includes winter or snow-free season habitat critical to maintaining caribou in a local landscape, typically within 30 km of the southern edge of caribou range.

Calving areas in large lakes and archipelagos may require reserves on adjacent shorelines to provide for mainland foraging and security cover by cows and calves. Location and size of no-cut areas should be based on proximity of calving islands and peninsulas to shorelines, relative availability of forage, traditional travel routes, location of long term deferrals under the *Forest Management Guidelines for the Emulation of Fire Patterns,* degree of use by caribou and whether or not the calving area is in a strategic location.

Calving areas in groups of small lakes or dispersed small wetlands may not benefit from individual AOC no-cut prescriptions. These prescriptions may fragment the landscape in such a way as to encourage an increase in alternate prey and predators. These areas should be managed as a single habitat tract in a dynamic forest landscape. As such, these entire tracts may be retained or allocated depending upon relative habitat supply. Avoidance of large scale fragmentation is likely more important than specific value protection in such areas.

Isolated (single)small lakes or wetland complexes that are used for calving may benefit from a no-cut reserve prescribed within the AOC. Refuge, security cover and foraging opportunities must all be met in relatively small areas under these circumstances.

Calving areas are sometimes dispersed in large peatland complexes which have a combination of both treed and open wetland conditions. A 1000 m AOC may be applied around the edge of the open wetland condition where this would be beneficial to the maintenance of calving value. Treed portions of these complexes may be large enough that the AOC may not need a no-cut prescription. Large treed wetland complexes should be considered part of a habitat tract for the purposes of planning and allocated or retained depending on relative habitat supply. These complexes may have very high quality calving, summer and winter habitat value and should be addressed on a case-by-case basis.

4.3.3 Snow-free Season Habitat

Forest management activities in snow-free season habitat should i) discourage conversion to hardwoods, ii) avoid fragmentation and iii) promote no net change in forest composition or structure at the regional and local landscape level compared to pre-disturbance conditions or best estimates of what a fire-driven ecosystem would maintain. Caribou are most dispersed in the spring and summer and tend to occur in smaller groups. However, survival of all population components is as much a concern in the snow-free habitat as it is in winter and calving habitat.

Snow-free season habitat includes areas used during spring, summer and fall, other than calving habitat. As caribou are much more dispersed at this time, and more difficult to locate, identifying and managing specific habitat tracts is not normally practical. Therefore, a sound, ecosystem-based approach to managing the intervening landscape is necessary to provide for snow-free season habitat. Specific habitat requirements during the snow-free season are not well documented, but snow-free season habitat often overlaps with winter habitat. If snow-free season habitat is thought to be limiting and requirements are not met by winter habitat tracts, the

same principles should be applied as those applied to winter habitat (minimize habitat fragmentation, maintain large tracts of mature forest habitat, maintain connectivity with calving areas, and avoid placing roads through critical locations).

Where the soil, landform, vegetation and physiographic features of the landscape are not conducive to producing caribou winter habitat, and the local area is not used for calving, there is still potential the area to be used by caribou during the snow free season. The management objective should be to avoid excessive forest fragmentation, increases in forest diversity or inadvertently tipping the predator-prey balance in a manner which elevates the risk of predation on caribou. As a forest tract within a managed landscape, these areas may be better suited to the location of primary roads, more intensive silviculture to reduce hardwood regeneration and hardwood conversion, and encouragement of shorter rotation, conifer forest. Harvest areas should be as large as the *Forest Management Guidelines for the Emulation of Fire Patterns* permit, although smaller disturbance events should be allocated to these areas when necessary. Excessive forest fragmentation should be discouraged. Regeneration strategies should initialize and maintain a successional trajectory that would renew forest structure and composition similar to that existing prior to harvest, and be consistent with sub-regional targets for forest composition.

4.3.4 Habitat Connectivity

Connectivity between winter and summer or calving habitats is an important landscape attribute. Winter and calving habitats may be close to one another or separated by many kilometers. Known or suspected travel routes linking winter habitats (used or potential) and calving areas (used or potential) should be given special consideration in landscape planning.

The preferred approach to maintaining the connection between summer and winter habitat is by placing disturbance events under the *Forest Management Guidelines for the Emulation of Fire Patterns* to maintain connectivity between large, mature habitat tracts. In many cases, maintaining connectivity will result in older (>40 years) forest along one or both sides of traditional travel routes that follow lake and river chains, or aligned along the landscape features that facilitate caribou movement. Managers should avoid creating situations along these travel routes that may interfere with traditional movement patterns, such as forest conditions that encourage predators or impede movement (i.e. tangled blowdown, excessive slash), or areas expected to have high levels of human activity or disturbance. The most effective way of achieving this objective is by identifying and scheduling habitat tracts across the landscape such that they provide older forest "bridges" between winter and calving habitats.

Where the landscape does not facilitate connectivity between large habitat tracts and travel routes are known, priority should be given to maintaining the integrity of the vegetation along these routes, through harvest scheduling and building upon riparian reserves. Migration corridors supporting rapid directional movement by caribou typically follow natural relief features such as rivers, lake chains, eskers or ridges. These travel routes are assigned a two km AOC, centered on the traditional travel route with a minimum 120 m reserve

consisting of relatively mature to mature forest. Corridors should be wide enough to provide a buffer to avoid predators, offer a sense of security and provide feeding opportunities en route. If the corridor covers a long distance, patches of relatively mature to mature forest two km wide should be placed every five to ten km along the route. Older forest is preferred and may be required where mixedwood forest communities dominate the travel corridor.

Where isolated habitat tracts are located near the southern boundary of the zone of continuous distribution, a two kilometer wide (nominal) corridor of relatively mature to mature timber should be maintained to connect with nearest neighbor mature habitat tracts. Areas with very dense young forest or blowdown may impede the movement of caribou and should not be considered a valuable contribution to the corridor.

Active roads may, under some circumstances, compromise connectivity. Road impacts may be reduced by avoiding main caribou travel routes, minimizing habitat disturbance or minimizing human activity during periods when caribou are most likely to be traveling. Roads should cross known traditional caribou movement areas perpendicularly, with minimal road corridor widths in those areas.

4.4 Site-Specific Recommendations

4.4.1 Silvicultural Objectives

Harvested areas should be regenerated to restore the composition and structure (at maturity) of the previous forest as required by the *Crown Forest Sustainability Act* (Statutes of Ontario 1994), or to meet sub-regional forest composition objectives. These objectives are met through silvicultural prescriptions that may include harvest methods, site preparation, seeding or planting, residual management and tending, consistent with the development of Silvicultural Ground Rules (SGRs) following the *Silviculture Guide to Managing for Black Spruce, Jack Pine, and Aspen on Boreal Forest Ecosites in Ontario* (OMNR 1997). The regeneration strategy should try to initiate and maintain a successional trajectory that would renew forest structure and composition similar to that existing prior to harvest, except where the current forest condition has been degraded due to past human activities. This is particularly important for stands contributing directly to winter habitat. Consideration of ecoregional forest composition standards is important to prevent a significant shift in forest composition that would alter landscape function such as the provision of year-round habitat and refuge. Restoration objectives may be required on some forest areas where the forest condition has shifted to balsam fir, aspen or mixedwood communities due to past management practices.

Intensive silviculture for conifer production could play an important role in the management strategy. It has the potential to ensure adequate conifer forest on the landscape, discourage conversion of conifer and conifer-dominated mixed stands to hardwoods and may also provide a means of reducing the age at which the forest becomes suitable caribou winter habitat. These

techniques may be used to help fill gaps in the future habitat supply. Shortened rotation ages and reduced time to reach minimum operability standards normally associated with intensive silviculture may be a benefit if the projected landscape level habitat supply is sufficient. However, maintained road networks associated with some intensive forest management techniques such as commercial thinning, may be detrimental to the welfare of caribou in important habitat tracts. Road construction and retention should be considered a source of impact when considering the merits of silvicultural treatments.

Harvest or silviculture treatments such as pre-commercial thinning, commercial thinning and fire salvage may be applied where short and long term caribou interests will not be compromised. They must also contribute to desirable future forest condition for caribou within the context of the *Forest Management Guidelines for the Emulation of Fire Patterns* and sub-regional forest composition requirements. Impacts on caribou habitat values of many of these treatments are uncertain and caution is advised. Limited experimental application of these treatments in caribou range is endorsed with appropriate monitoring, analysis and reporting.

For sites that have potential to produce winter habitat (i.e. soil types S1, S2, SS1-SS4) the regeneration objective should be to re-establish stands with the attributes of V30, V29 and V32 (Sims *et al.* 1989), or ecosites ES12 and ES13 (Racey *et al.* 1996). Silvicultural practices that encourage an abundant lichen understory will improve the quality of future winter habitat.

4.4.2 Mineral Licks

Documented mineral licks should be identified by a minimum 120 m AOC and should preferably be incorporated within a mature forest habitat tract. Where feasible, these sites should be incorporated as part of the boundary between allocated and unallocated habitat tracts. Adjacency to a large tract of older forest will be an advantage to caribou and other forest-dwelling species. A site-specific prescription should be developed considering the location within the landscape, the surrounding physical and biotic habitat context and caribou use patterns.

4.4.3 Road Construction

Roads may compromise caribou habitat because they can facilitate movement of predators, encourage poaching and cause caribou behavioral changes through noise associated with human activity. **Forest access roads should be of a temporary nature when constructed in significant winter or snow-free season habitat tracts**. **These roads should be made impassable by ditching, culvert removal or site preparation and regeneration as soon as possible following completion of timber management operations**. Roads should be incorporated back into the productive forest land base where appropriate. In some cases retaining portions of the intact road base on deep sandy soils may encourage lichen regeneration in the new forest. Roads with a planned life expectancy of more than five years should avoid important (current and potential) habitat tracts where possible. Short-term road maintenance to support silvicultural activities following harvest is permitted.

4.5 Other Human Activities

This section deals with land management issues involving human activity other than forest management. These issues are not addressed in the *Forest Management Guidelines for the Emulation of Fire Patterns.*

4.5.1 Mineral Exploration

Where possible, mineral exploration activities should recognize caribou habitat values and address them through modified line cutting and scheduling. Mineral exploration in and around caribou winter habitat should recognize the importance of minimizing habitat alteration that would encourage mixedwoods, habitat fragmentation, or predator access. Major exploration activities should avoid traditional winter habitats during the winter (November to April) period. Activity in calving habitat should minimize disturbance to cow-calf groups during the calving season (May to September).

4.5.2 Remote Tourism

Remote tourism operators on caribou calving lakes should mitigate human disturbance by discouraging campsites, shore lunch locations and boat caches in close proximity to calving sites. Many remote tourism lakes are also calving lakes. Remote tourism activities on calving lakes, including boat cache locations, shore lunch sites and campsites in close proximity to caribou calving sites should be avoided. Effort should be made to minimize disturbance of cow-calf groups. Outfitters should advise clients to view caribou discretely and avoid undue disturbance.

Consistent with concern for woodland caribou calving success, there should be no new land use or boat cache permits issued for islands or shoreline areas with a documented history of caribou calving or high snow-free season use.

4.5.3 Snowmobile Trails

Major winter recreational developments such as snowmobile routes should avoid current and potential winter habitat tracts.

4.5.4 Fire Management

Fire is a driving ecological factor in the boreal forests of Ontario. Fire management plans and priorities should reflect the need to manage the forest landscape in a manner consistent with ecological sustainability. Fire suppression for current winter habitat tracts should be enhanced and encouraged where caribou habitat is in short supply, especially near the southern limit of continuous caribou range. High priority for protection should be assigned to habitat tracts that have been identified for retention.

Fire should be managed in a manner consistent with the renewal of winter habitat, when winter habitat is in abundant supply and is not about to be renewed through timber management. Fire

management priorities should reflect the importance of caribou habitat in operational plans. Suppression priorities should focus on identified, existing critical habitat features such as wintering areas, calving areas and travel routes.

4.5.5 Wood Flow and Wood Management

Institutional factors such as the regulatory framework and wood flow should be adjusted by all parties involved in timber management to maximize the amount of merchantable wood removed from the cut blocks. This will in turn minimize volume reductions associated with applying these guidelines. This is to be done while still meeting the requirements of an ecosystem-based approach that provides for residual management, maintenance of snags, old growth and a desired future age class structure and species composition. These guidelines provide for shorter rotations on non-winter habitat tracts, but may require more intensive silviculture to provide them.

Partial mitigation of wood supply impacts can be achieved by thoughtful habitat tract delineation (*Appendix IV*), placement of small disturbance events under the *Forest Management Guidelines for the Emulation of Fire Patterns*, and scheduling stands in a harvest tract to best provide for volume and quality of product.

4.6 Limitations

There are several limitations on conserving caribou habitat when applying the *Forest Management Guidelines for the Emulation of Fire Patterns*. Logging activity can only approximate fire patterns on the landscape. Sincere effort should be applied by forest managers to create forest conditions that are as ecologically similar as possible to those created by nature. This will require much insight and training on the development of harvest and regeneration strategies and silvicultural prescriptions that address essential elements of an ecosystem-based approach, including integration of regional and local landscape objectives and residual management. Recognition of human and ecological impacts beyond the boundaries of the management unit will be important in understanding the ecoregional context of management activities.

Regional guidance and direction applied in *Section 4.3.1* is required to ensure that an appropriate landscape pattern is sustained.

5.0 APPLYING THE GUIDELINES

These guidelines are to be applied in the boreal forest wherever forest-dwelling woodland caribou habitat conservation is a concern. Appropriate planning at regional and FMU levels is necessary to apply these guidelines. Caribou conservation issues usually relate to more than one scale and more than one planning process; for each scale there is an appropriate planning process (Figure 6). Caribou home ranges consist of large landscapes which often cross administrative (district, Wildlife Management Unit and Forest Management Unit) boundaries.

Managing caribou habitat involves examining the landscape and developing management actions at various scales through regional and sub-regional land use planning, development of a forest management plan and development of specific prescriptions for silviculture or human activity.

Figure 5. The caribou guidelines planning environment crosses several scales and includes regional land use planning (landscape assessment and protecting strategic habitats), sub-regional planning (developing a disturbance plan and harmonizing caribou habitat needs across management units), and forest management planning (applying the *Forest Management Guidelines for the Emulation of Fire Patterns*, identifying AOCs , and modifying human activity). Additional management actions to influence land use and human impacts are included as a separate component.

Forest management planning on Crown lands in Ontario is governed by *the Crown Forest Sustainability Act* and directed by the *Forest Management Planning* Manual (OMNR 1996). The planning process is comprised of three interrelated levels which describe forest operations in varying levels of detail. Public input on operational concerns with applying these guidelines is solicited in public information sessions associated with the Forest Management Planning Process.

In a forest management plan (FMP), forest operations are described in terms of broad objectives and strategies for a 20 year term. Specific operations for the first five years are identified on an individual FMU. Caribou habitat on neighboring management units, sub-regional disturbance plans developed under the Forest *Management Guidelines for the Emulation of Fire Patterns* and general proximity to the southern boundary of caribou range should be considered to successfully implement these guidelines. It is also at this level where the application of disturbance events using the *Forest Management Guidelines for the Emulation*

of Fire Patterns are planned among and within FMUs in order to achieve landscape patterns appropriate to the ecological conditions. AOCs around calving areas and mineral licks, and silvicultural ground rules and silvicultural treatment packages to produce desirable future forest conditions are also identified in the FMP.

Areas are selected for operations and included in an annual work schedule (AWS) during each of the five years of the FMP. A forest operations prescription (FOP) is prepared for each operation that is outlined in the AWS. The FOP verifies actual site conditions and identifies the treatment package that will be used on that site. At this level of planning, the FOP should be appropriate for creating future caribou habitat conditions. For example, operations in high potential future winter habitat should include provisions for maintaining the appropriate tree species composition and density for future use.

Operational design (on-site planning), which is conducted at the field level, is not specifically prescribed in the FMP manual. At this level detailed operational decisions are made, such as the individual trees to be harvested or retained (i.e. quantity and quality of residual).

These caribou guidelines should be applied with consideration of caribou habitat requirements at multiple scales which include regional, FMU, and stand levels. In considering those requirements, the following steps should be followed in developing the Forest Management Plan:

Step 1. Organize Background Information

Many types of information and knowledge are needed to support landscape planning to conserve caribou habitat. Managers must understand caribou ecology and landscape processes, and have information about caribou habitat utilization, landform distribution and forest cover in an area.

Caribou Information

- existing caribou habitat maps for each FMU
- documented calving areas, significant snow-free season habitat, wintering areas, travel routes
- habitat analysis outputs (*Appendices II* and *III*)
- map of occupied caribou range and the southern limit of continuous distribution.

Landscape Information

- forest pattern and land cover data
- landform inventory
- fire frequency distribution data
- fire residual analysis
- site-regional forest composition data
- targets for forest composition and structure (FMU and ecoregional level)
- 1:100,000 or 1:250,000 caribou habitat values and capability maps (Appendix IV)

Planning teams should consult with the local wildlife manager, regional wildlife staff and/or the Regional Caribou Task Team in Northwest Region to evaluate where caribou habitat should be managed. Their advice should be based on the above information, regional and FMU application of the *Forest Management Guidelines for the Emulation of Fire Patterns*, and direction from the most current land use plans. These evaluations should follow the flow chart in Figure 5 along with the decision guidance contained in Table 3.

After these evaluations, the planning team should be advised as to where potential forest harvesting allocations are best suited to be consistent with long term conservation of caribou habitat and the direction from the *Forest Management Guidelines for the Emulation of Fire Patterns*. The caribou mosaic (*Appendix IV*) will be updated and revised based on these evaluations.

Step 2. Determine Management Direction
After the evaluations are completed the preferred alternative for forest management in terms of caribou habitat and other forest management objectives is selected from an analysis of forest management alternatives. Spatial and aspatial habitat supply analysis using the Strategic Forest Management Model (Davis 1997) and spatial analysis (*Appendix III*) are used to help select among alternatives.

Step 3. Select Areas for Operation
Areas are selected for operations on the basis of a set of selection criteria. These selection criteria may include criteria which address caribou habitat needs as described in these guidelines and as a result of the evaluation process in Step 1 above.

Step 4. Determine Prescriptions for Areas of Operations
For most areas of operations the silvicultural ground rules, developed in accordance with OMNR's silvicultural guide (OMNR 1997), will prescribe management operations, such as the forest harvest system to be employed. Production of future critical caribou habitat should be considered in silvicultural prescriptions. Critical caribou winter habitat may be deferred from operations for long time periods until other areas that are judged capable of providing winter habitat become suitable. Strategically important calving areas should be identified as AOCs in the forest management plan and specific operational prescriptions produced.

6.0 FUTURE DIRECTIONS

6.1 Adaptive Management

Habitat management recommendations in this document are based on the best scientific information available. However, there is uncertainty about the long-term effectiveness of these guidelines for both caribou and the forest industry. An adaptive management process should be used to reduce this uncertainty. Adaptive management addresses the uncertainty of natural resource policies and guidelines by treating management as an experiment. Through this

process, knowledge is obtained to continually improve policies and guidelines. In the case of these guidelines, a rigorous adaptive management design would evaluate their effectiveness through the outcome for both caribou and the forest industry over both the short and long term.

The uncertainty associated with these caribou habitat management guidelines is a function of the complexities regarding the dynamics of caribou populations, both in density and distribution, over large spatial scales and over long time periods in relation to habitat disturbance. Past habitat disturbance has included both fire and forest harvesting. Both historical patterns of human activity and habitat disturbance have contributed to the decline of caribou range occupancy in northwestern Ontario (Racey and Armstrong in prep.). Consequently, a change in traditional forest management practices is justified. However, there is little direct knowledge of how caribou populations and distribution have changed in relation to specific habitat disturbances which can be used to understand future impacts.

A sincere effort to monitor the effectiveness of proposed management actions is encouraged to provide a basis for future improvements to the guidelines. This process should include: 1) identification of landscape and habitat values, 2) a statement of rationale for applying the guidelines in each specific area, 3) documentation of anticipated short and long-term response of caribou and the forest industry, and 4) establishment of a rigorous design for data collection and analysis to accelerate learning about why the guidelines are either effective or ineffective.

Although the distribution of caribou has receded northward in concert with the expansion of forest harvesting activities, it has also coincided with the expansion of other forms of development including permanent road access and increased human contact with caribou. An adaptive management process should address both habitat and non-habitat related constraints on caribou populations.

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APPENDIX I. Direction For Regional and Sub-Regional Land Use Planning.

Regional and sub-regional land use planning (RLUP) establishes natural resources objectives and allocate land and natural resources among competing uses. Caribou habitat management requires consideration of values on land areas larger than a Forest Management Unit (*Section 4.1*), and therefore has a place in RLUP. Caribou conservation is served well by addressing long term strategic direction for forestry activities, long term habitat conservation measures associated with strategic calving areas, and establishment of strategic primary road access corridors or road planning standards.

This Appendix is intended for regional planning staff and RLUP participants.
It provides the ecological rationale for managing caribou habitat at the regional landscape level, and describes appropriate land use considerations for regionally significant habitats.

I - 1.0 Preparation for Decision Making

RLUP participants will need substantial information, knowledge and skills to be able to make wise decisions pertaining to conservation of forest-dwelling woodland caribou within the managed forest. Information requirements are demanding but are essential to supporting decision making.

I - 1.1 Information Requirements

Caribou information required to support RLUP decisions include:

- woodland caribou range occupancy maps,
- inventory of major documented calving areas,
- inventory of major documented winter activity areas,
- inventory of known travel corridors, and
- caribou habitat mosaic and associated habitat supply maps produced by district staff (1990 to present) to provide the spatial and temporal context of the value of a particular area. These mosaics can be used to show areas of strategic importance to maintaining caribou in a given landscape.

Landscape information required to support RLUP decisions include:

- fire history and fire pattern information from the *Forest Management Guidelines for the Emulation of Fire Patterns* (*Appendix V*),
- forest composition and condition estimates including age class structure and broad ranges of species composition (under development, expected early 1999), and
- landscape features contributing to high winter habitat potential, including 1:250,000 scale woodland caribou habitat capability maps.

I - 1.2 Skills and Knowledge Requirements

Planners and RLUP participants will need to have an in-depth appreciation of caribou biology, habitat needs and a thorough understanding of the ecology of boreal landscapes.

I - 2.0 Where to Apply Caribou Habitat Management

Conservation of forest-dwelling woodland caribou is a concern wherever caribou exist. A regional map of caribou range occupancy describes the southern boundary of the zone of continuous distribution of woodland caribou. Range occupancy is determined using a variety of sources including caribou surveys, incidental sightings during moose surveys, substantiated observations by the public and expert opinion of district biologists, foresters and other OMNR staff. Updated copies of this map may be obtained from the Northwest Regional office of the OMNR.

I - 3.0 Caribou Habitat Management

RLUP will identify and afford appropriate consideration to the conservation and protection of habitat values of extraordinary or strategic importance to woodland caribou within the zone of continuous distribution. This section provides general direction for land use planning and timber management planning with respect to long term management decisions which fall beyond the scope of a Forest Management Plan or where habitats are expected to have considerable strategic importance to the conservation of caribou.

I - 3.1 Winter Habitat

Managing caribou winter habitat involves ensuring a continuous supply of mature coniferous forest featuring winter habitat attributes in large tracts, similar in magnitude to those maintained on the landscape under natural disturbance regimes (in the order of approximately 10,000 ha or greater). Forest management planning is expected to address most caribou winter habitat conservation and renewal needs, if executed well. However, RLUP decisions may allocate land to special uses compatible with maintaining caribou winter habitat values. Integrating compatible land use designations with selected winter habitat areas may be beneficial to the long term well-being of caribou. Some of these designations may include functionally roadless areas, natural heritage protection areas, remote tourism areas featuring compatible uses, access restrictions, old growth areas or specified long term deferral of harvest.

It is not the intent to have caribou habitat management at the forefront of RLUP, rather to consider the conservation of caribou habitat values as an important criterion in evaluating alternative land use designations. In addition, RLUP may recommend long term deferrals of strategic winter habitat tracts where these deferrals are considered necessary for maintaining caribou occupancy in the area, or to prevent further northward recession of caribou range. This

is an important link between RLUP, caribou habitat mosaic planning and forest management planning.

RLUP involvement in conserving winter habitat is primarily focused on strategic habitat tracts located near the southern limit of occupied caribou range. Designated retention periods may be assigned, usually 20 to 40 years, when the status of these areas will be re-examined. The majority of the other winter habitat areas and other seasonal habitats will be managed by applying the *Forest Management Guidelines for the Emulation of Fire Patterns* in conjunction with these guidelines during forest management planning (*Section 4.0*). Winter habitat is considered strategically important under the following four conditions:

- young forest (approximately 40 to 60 years old, with long potential life span), heavily-used (multiple animals most years), strategic location (within approximately 30 km of southern edge of caribou range), winter habitat is considered to be in limited supply;
- heavily-used (multiple animals most years), where calving habitat and winter habitat overlap or are adjacent, providing year-round caribou use;
- older forest (> 60 years old), used by caribou, strategic location (within approximately 30 km of the southern edge of caribou range), winter habitat is considered to be in limited supply; and
- high potential habitat (very shallow soils, dry, sandy soils and high conifer composition), young (< 40 years old), strategic location (within approximately 30 km of southern edge of caribou range), winter habitat is considered to be in limited supply.

I - 3.2 Calving Areas and Snow-free Season Habitat

Calving areas are an important component of year-round caribou range. Cows tend to return to traditional calving areas where they were raised, and which offer escape habitat from predators. These areas are often on the shores and islands of large lakes, but also include small lakes, systems of small lakes and large wetland complexes with bedrock or bog islands.

Some calving locations are of strategic importance and play a significant role in maintaining caribou in a given area. These calving areas (Table I-1) have strategic locations near the southern edge of caribou range, are used by many caribou, offer proximity to year-round habitat, are used by a declining or vulnerable herd, or offer a calving location for a large geographical range. Specific consideration of calving values on these lakes should be addressed when assigning land use designations in their vicinity.

Appropriate protection of calving areas in strategic locations may include reserves of standing timber (see *Section 4.3.2*), restrictions on road access, restricted development of tourism facilities, and/or modified forest management activities compatible with maintenance of caribou calving values and survival of the cow-calf group. Within these areas, compatible uses should be identified and management of human activity may be required to maintain value for caribou.

Table I-1. Regionally significant calving areas in Northwest Region requiring special consideration during the RLUP process[1]. The top two rationale for including the areas are documented. Significant calving areas within parks are not included.

Calving Lake	District	Rationale
Birch Lake	Red Lake	2,3
Nungessor Lake	Red Lake	2,3
Sydney Lake	Red Lake	1,4
Trout Lake	Red Lake	2,5
Underbrush Lake System	Red Lake	1,4
Jeanette - Sesikinaga System	Red Lake	2,3
Oiseau Lake System	Kenora	1,4
Lake St. Joseph	Sioux Lookout	3,5
Savant Lake	Sioux Lookout	2,1
Lac Seul	Sioux Lookout & Red Lake	1,4
Seseganaga Lake	Dryden	1,4
Campbell Lake	Thunder Bay	1,3
Hollingsworth Lake	Thunder Bay	1,3
Vivid Lake	Thunder Bay	1,3
Whalen Lake	Thunder Bay	1,3
Ogoki Reservoir	Thunder Bay	2,5
Mojikit Lake	Thunder Bay	2,5
Whiteclay Lake	Thunder Bay	3,5
Bishop Lake Wetland	Thunder Bay	1,4
Esnagami Lake	Nipigon	2,3
Kagianagami Lake	Nipigon	2,3
Lake Nipigon	Nipigon	2,1
Onaman Lake	Nipigon	1,4

Rationale:
1 - strategic location near southern edge of caribou range
2 - high use
3 - proximity to year-round habitat
4 - vulnerable herd
5 - calving location for a large range

All calving sites are important for long-term survival and continued range occupancy. Sites not provided specific protection during RLUP will be identified and values protected during the forest management planning process.

I - 3.3 Long Term Planning of Primary Access Roads

Strategic access of Forest Management Units across the region has implications for the long term management of caribou habitat as well as other land management issues such as timber management, remote tourism, mining and recreation. RLUP should address long term planning

[1] Additional regionally significant calving areas are expected to exist, but have yet to be identified.

of primary access roads to avoid traditional winter habitat tracts, and landforms and soils with high potential for winter range. These include dry sandy outwash deposits, esker complexes, dunes, and shallow soil complexes with bedrock outcrops. As these sites often provide the best road building opportunities, careful planning is necessary to avoid compromising caribou habitat values. Where roads or road corridors must cross these landforms or landform complexes, they should follow the edges, rather than transecting them. Identification of strategic primary access road corridors should be established for the remainder of the current and potentially commercial forest.

I - 4.0 Other Guidelines and Policies

Other guidelines and policies will be considered during the RLUP process, including those pertaining to game species, furbearers and vulnerable, threatened and endangered species. Conserving caribou habitat by applying the *Forest Management Guidelines for the Emulation of Fire Patterns (Section 4*) will form the basis for integrating the caribou guidelines with other guidelines such as those for marten, moose, fish habitat and locally featured species. Moose habitat guidelines will not be applied in areas of high caribou habitat use or potential.

I - 5.0 Limitations

RLUP participants will have limited time, experience and knowledge of ecological processes. Planners will not be able to identify all caribou habitat values, nor will they be able to provide tactical instructions for resource management activities. However, long-term, coarse scale, strategic decisions can be made to offer protection to highly significant and strategic caribou habitat values. It is one of the few planning processes that can provide caribou habitat protection beyond 20 years. It is not the intention of this process to automatically remove areas from consideration for forest management activities, although that may be the outcome in some areas.

Appendix II. Aspatial Habitat Supply Analysis

Aspatial habitat supply analysis provides information on abundance of habitat components and future habitat supply. This appendix describes how aspatial habitat supply analysis may be accomplished and guide decision making at regional and local landscape levels. It provides the biological background and defines the habitat classes for the analysis, and provides general instructions on how to perform the analysis.

Aspatial habitat supply analysis can provide

i) graphical and tabular inventory of habitat components,
ii) trend-through-time showing change in amount of habitat components under given management alternatives, and
iii) comparison of supply of habitat components under alternate management scenarios. The analysis could be performed with data from a single FMU, a group of FMUs, or a sub-region.

This appendix is intended for use by OMNR and industry foresters, biologists, technicians and GIS technicians involved in developing FMPs and providing guidance to RLUP.

II - 1.0 What is the Role of the Aspatial Analysis?

The aspatial habitat supply analysis provides a basic index of the relative abundance of habitat components. It identifies those habitat components that may be in short supply and how the supply is expected to change in the future. This aspatial habitat supply analysis is similar to that now used in forest management planning and is described in *the Draft Forest Information Manual* (Section 8.6). The analysis is an extension to existing requirements which include analysis with the Strategic Forest Management Model (SFMM) (Watkins and Davis 1996) during development of a FMP.

II - 2.0 What is SFMM?

SFMM is a computer modeling tool that uses Forest Resource Inventory (FRI) data. It allows users to represent large forested areas at a strategic level for forest management planning. SFMM is used in developing a forest management plan by determining the wood supply and sustainable levels of harvest under different forest management alternatives. It is a sophisticated tool that uses a linear programming technique to find optimum solutions for harvest and renewal of pre-defined forest units. Wildlife habitat matrixes can be incorporated within SFMM to project a crude measure of forest habitat supply under various forest management scenarios.

II - 3.0 What is required to Use the Aspatial Habitat Supply Analysis?

The primary model used to execute the aspatial habitat supply model is the SFMM. Preferred data required to use SFMM is ecosite-annotated FRI data. When these data are not available, approximate ecosite groupings, generated from standard FRI data, are used. These groupings must be thoughtfully created to maintain as much of the integrity of the ecosite definitions as possible.

Skills and knowledge in understanding forest composition, ecosite attributes, generating inputs for SFMM and interpreting outputs of SFMM will be required to successfully apply the aspatial habitat supply analysis. In addition, a solid understanding of landscape processes and caribou ecology will be required for interpreting the results.

II - 4.0 Caribou Biology in Relation to Habitat Supply

An understanding of how the quantity of older conifer forest, lichen communities, late successional non-conifer forest and early succession forests change under differing forest management strategies will provide insight into future habitat quantity and quality. Habitat quality and habitat supply must be interpreted within the context of the current understanding of caribou and forest ecology.

Winter habitat for the woodland caribou typically consists of lichen-rich forest with low densities of predators such as wolves. Landscape features that permit an easy escape from predators also contribute to favorable winter habitat. Lichens are most abundant in forests that are dominated with jack pine and black spruce, and are roughly 40 to 100 years of age. Rock outcrops, sands and sparsely treed peatlands are usually associated with these forest types. Time at which lichen availability peaks varies with the type of site and nature of the preceding disturbance.

Wolf predation is the primary cause of mortality in most caribou populations. Caribou populations can persist only where wolf densities are less than approximately 6.5 wolves per 1000 km^2 or where caribou are able to escape wolves (Bergerud 1996). Wolf densities are low where biomass of ungulate prey, especially moose, is low. Moose densities tend to be lowest where there is little browse and minimal edge habitat. Mature coniferous forest with dry or nutrient-poor soil conditions have low browse productivity and tend to have lower moose and other alternate prey densities. A change in forest landscape pattern to one where the age structure is becoming more fragmented will result in increased moose browse which has the effect of providing more food for wolf populations, hence, a more vulnerable caribou herd.

Large forest tracts allow enough space for caribou to disperse, resulting in an increase in search time for wolves. These large areas also act as buffers, reducing contact with wolves from

surrounding areas. Decreases in the sizes of these large tracts of forest force caribou into smaller areas, making them more vulnerable to wolves. The result is declining caribou populations.

Caribou range consists of both young and mature forest. Caribou respond to loss of mature habitat by moving to alternate areas of maturing and older forest with suitable habitat conditions.

Habitats that provide little in terms of food, cover or other essentials for caribou directly are still valuable components of caribou range if they provide refuge or a buffer from predators and/or support low moose biomass. These areas can consist of lakes, large peatlands, large burns or cutovers with low browse availability, or extensive conifer/feathermoss stands. Treed bog and poor swamp rank high because they provide arboreal lichens and are poor habitat for alternate prey. Aspatial habitat supply analysis permits the examination and description of how habitat components change through time under proposed forest management strategies.

II - 5.0 How to do Aspatial Habitat Supply Analysis

SFMMTool (Watkins and Davis 1996) is a software package that works in Microsoft Access. It massages and converts raw forest inventory data into a format that is acceptable for SFMM. The fundamental landscape unit for an aspatial analysis is the "forest unit." A forest unit is a group of forest stand types whose successional pathways, rotation ages, values and management strategies are the same. In an aspatial habitat supply analysis of caribou habitat, it is important to carefully define forest units that approximate habitat components. This is essential for a meaningful model.

It is particularly important to pay attention to the assumptions for forest growth, successional pathways and fire return cycles on the benchmark runs of SFMM. These assumptions will play a significant role in determining shortage or abundance of habitat supply. It is also important that these assumptions be compatible with assumptions used to calculate wood supply, and selected silvicultural practices as these will influence estimated changes in habitat supply through time.

The woodland caribou habitat matrix was developed using ecosites as habitat units. It may be necessary to develop a new set of habitat units to approximate specific groupings of ecosites to run the SFMM analysis. Developing algorithms to perform this task requires detailed knowledge of the FRI, ecosites and their related attributes. Individual algorithms for each analysis are necessary because management units have inventories that differ in quality. Landform and vegetation relationships differ among management units as well.

Table II-1. Woodland caribou habitat suitability matrix for northwestern Ontario.

Ecosite			Winter Habitat Suitability					Caribou Habitat Suitability				
			Successional Stage					Successional Stage				
Ecosite	**Soil**	**Vegetation**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
ES7	Very Shallow Soil	Rock Barren		1	2	2	2	1	1	2	2	2
ES11	v. shallow	Pr-Pw-Pj										
ES12	v. shallow	Sb-Pj		1	2	2	2	1	2	2	2	2
ES13	Dry – Mod. Fresh Sandy	Pj-Conifer			1	2	2	1	2	2	2	2
ES14		Pine-Spr. Mxwd			1	2	2		1	2	2	2
ES15		Pr-Pw										
ES16		Hdwd-Fir-Spr. Mxwd								1	1	1
ES17	Variable	Ce										
ES18	Fresh Sandy, Coarse Loamy	Pr-Pw										
ES19		Hdwd-Fir-Spr. Mxwd										
ES20		Spr-Pine/Fmoss				1	1		1	2	2	2
ES21		Fir-Spr. Mxwd									1	1
ES22	Moist Sandy, C. Loamy	Spr-Pine/Ledum				1	1			2	2	2
ES23		Hdwd-Fir-Spr. Mxwd									1	1
ES24	Fresh, Fine Loamy – Clayey	Pr-Pw									1	1
ES25		Pine-Spr./Fmoss								1	1	1
ES26		Spr-Pine/Fmoss								1	1	1
ES27		Fir-Spr. Mxwd									1	
ES28		Hdwd.-Fir-Spr. Mxwd										
ES29		Hdwd.-Fir-Spr. Mxwd										
ES30		Ab-Hdwd										
ES31	Moist, Fine Loamy – Clayey	Spr-Pine/Fmoss				1	1			2	2	2
ES32		Fir-Spr. Mxwd									1	1
ES33		Hdwd.-Fir-Spr. Mxwd										
ES34	Wet, Organic	Treed Bog	1	1	1	2	2	2	2	2	2	2
ES35		Poor Swamp Sb			1	1	2	2	2	2	2	2
ES36		Int. Swamp Sb				1	1	1	1	2	2	2
ES37		Rich Swamp Ce										
ES38		Rich Swamp Ab										
ES39		Open Bog	1	1	1	1	1	2	2	2	2	2
ES40		Treed Fen	1	1	1	1	1	2	2	2	2	2
ES41		Open Poor Fen						2	2	2	2	2
ES42		Open Mod. Rich Fen						2	2	2	2	2

ES43		Open Ext. Rich Fen						2	2	2	2	2

II - 5.1 Caribou Habitat Matrix

The caribou habitat matrix (Table II-1) describes the value of forest habitat components using ecosites as the habitat unit. *Winter Habitat Suitability* describes the value of an ecosite as caribou winter habitat. *Caribou Habitat Suitability* describes the value of an ecosite in the broader context of caribou range. It incorporates habitat value for caribou as well as value as refuge (areas unlikely to support large numbers of alternate prey species), or value in supporting a predator avoidance strategy. The matrix defines caribou habitat value for each ecosite at five seral stages.

Age ranges are approximate and vary between species and site conditions. The five seral stages are:

1. Young forest, clearcut, early regeneration, pre-closure; (< 20 years)
2. Sapling / pole, pre-self thinning; (approx. 20 to 39 years)
3. Pole / mature, self thinning; (approx. 40 to 60 years)
4. Mature; (approx. 60 to 100 years)
5. Old growth; (>100 years)

Values were assigned to the matrix cells based upon the potential of the ecosite to produce caribou food (*Cladina* and arboreal lichens), capability to provide habitat for alternate prey species, and forest structural characteristics. Discussion of the ecological principles are discussed in *Section II - 4.0*. The values in the cells represent the following:

1. Used when encountered, or when in proximity to preferred or highest value habitat,
2. Preferred, sought out, or highest value habitat, and
3. Empty cells represent ecosites of limited or unknown value.

II - 5.2 Interpreting the Results

Habitat availability will fluctuate over time even without logging or other human influences. SFMM analysis can be used to establish a benchmark "no management" scenario. It describes changes in forest composition resulting from natural succession and disturbance. This will be useful for determining the natural fluctuations in habitat supply in the absence of logging and establish the "moving target" against which to judge success or failure of caribou habitat management.

Compare alternative forest management strategies and evaluate for i) relative availability of habitat components, ii) changes in habitat component availability through time, and iii) magnitude and timing of constrictions in habitat component supply. The outputs are inspected for significant changes in habitat component availability.

- When are the habitat components in maximum supply?
- When are habitat components in short supply?

- Do habitat trends indicate increasing or decreasing supply over the next 20 years and over the full forest rotation?

Decide on appropriate changes to management strategies that will help mitigate adverse impacts or changes to habitat supply. The proportion of capable habitat in suitable condition (Table 3) may be roughly approximated using this aspatial habitat supply analysis. The maximum and minimum availability of habitat under a "no-management with wildfire" scenario, can be considered natural bounds on habitat supply. If prime habitat components fall below the midpoint of abundance that would occur on a natural landscape, then habitat is considered in low supply. If prime habitat components exist above the midpoint of abundance that would occur on a natural landscape, then habitat is considered in high supply. A conservative approach to management would suggest that intermediate values associated with a general downward trend in habitat availability over the next 20 years be interpreted as low supply of habitat. Future sub-regional forest composition guidance may provide a better benchmark against which relative habitat supply can be determined.

It should be an objective to maintain a relatively stable and sustainable supply of both winter habitat, snow-free season habitat and refuge values on the landscape.

II - 6.0 Limitations

An aspatial habitat supply using SFMM can only provide a crude scanning mechanism to determine trends in relative abundance of habitat components. It does not reveal spatial configuration of those components, and thus may not represent real habitat value. As such, a short supply of caribou habitat using the aspatial habitat supply will indicate that habitat is in short supply. An abundance of habitat components **will not guarantee** that habitat is in abundant supply.

Appendix III. Spatial Habitat Analysis

Spatial habitat analysis provides quantitative information on distribution of habitat, relative scarcity/abundance of habitat, and connectivity of habitat tracts. This information is used to guide decision making at the regional and local landscape levels. *Appendix III* describes the biological background for the analysis, defines the habitat classes used in the analysis, and provides the technical details of how to perform the analysis. At present, only a very simple spatial description of habitat units and landscape attributes is accomplished. Caribou habitat maps described in Appendix IV provide a visual representation of habitat to supplement, and aid in the interpretation of a spatial habitat supply analysis.

This section is intended for use by OMNR and industry foresters, biologists, technicians and GIS technicians: policy makers and planning teams.

III - 1.0 Why Have a Spatial Habitat Analysis?

Ecosystem processes function at multiple temporal and spatial scales. Woodland caribou habitat, travel/connectivity and refuge each have relative spatial arrangements and distributions which contribute to the goodness of the habitat. Measuring and understanding the relationship of meaningful landscape attributes (i.e., mean patch size, patch density, edge, interior, isolation, interspersion/juxtaposition, etc.) will contribute to a valid spatial habitat analysis. Thoughtful objective-driven landscape pattern analyses will aid in determining the relative habitat values.

The concept of habitat is explicitly spatial. Elements of habitat typically include availability of food, cover and water, provision of opportunities for reproduction, and space. Space is always a critical element in that it includes the land base within which the first four elements are present. It may be used to describe minimum requirements for home range size, or even the area required to support minimum viable populations. It is important that habitat components are spatially arranged so that food can be found near shelter, animals can escape predation and young may be successfully recruited into the population.

The spatial configuration of habitat components is critical for woodland caribou conservation. Caribou habitat needs and forest management activities are spatially explicit. This appendix describes how habitat component configuration on the landscape can be described and compared using landscape pattern analysis tools.

Impacts of forest management are inherently spatial. Stands are allocated based on age, position on the landscape and accessibility in a given planning period. Historical age class structure, waterways, landforms and history of human development all alter the location and configuration of forest management activities and range occupancy by caribou. These activities influence patch size, edge, connectivity and composition of the forest.

III - 2.0 Tools for Landscape Pattern Analysis

Spatial analysis is now an important component of forest management planning in Ontario. Landscape pattern analysis tools are continually being developed and improved. Use provincially and regionally approved tools for all spatial caribou habitat analysis.

III - 2.1 How Should These Spatial Analysis Tools be Used in Developing a HSA?

Landscape description using landscape pattern analysis tools can be very complex, with many difficult to understand output variables. Evaluation of caribou habitat will require definition of a unique set of landscape classes which can be generated from FRI data. The objective at this time is to quantitatively describe the spatial configuration of those landscape classes and habitat units evaluated in the aspatial habitat analysis, and the change in these units as a consequence of management activities compared to no management. Key landscape attributes will be described and monitored through time to determine if the quantity and quality of caribou habitat is increasing or decreasing, and to determine the relative value of different forest management strategies. These landscape attributes can also be used as indices to compare differences in habitat value among forest management alternatives.

III - 2.2 Evolution of Spatial Habitat Supply Analysis

Spatial habitat supply analysis is still in an elementary phase and is evolving from a manual mapping exercise to a more automated process that can examine caribou habitat quality and wood supply concurrently under a strategy for allocating areas for harvest or retention given constraints of road access and operability. Present capabilities are limited, but the best technology available will be adopted as it is developed. Spatial habitat supply analysis will evolve through three phases:

Phase 1 (1991 to 1999).
Caribou habitat mosaic maps served as a manual habitat supply analysis since 1991. The mosaic is now used in combination with regionally approved landscape pattern analysis tools.

Phase 2 (1999 to approximately 2003)
An early prototype of the Strategic Forest Management Model (SFMM) with limited spatial analysis capabilities is being developed and should be available for incorporation into the spatial habitat supply analysis within the next five years.

Phase 3 (future)
Forest growth models integrated with harvest allocation and wood supply models will permit landscape level analysis, incorporating habitat supply, under various forest harvest and regeneration strategies. This type of model will provide a spatial projection of habitat availability

throughout the forest rotation. This is the stage that could truly be called a spatial habitat supply analysis.

III - 3.0 Landscape Attribute Measures

The following sections describe important landscape attributes and explain how they are relevant to woodland caribou habitat. These parameters are similar to those required for spatial indicators of sustainability in the forest management planning process.

III - 3.1 Patch Attributes

Mean patch size provides a basic index of patch size that can be used to interpret fire emulation and wildlife habitat components. A patch is defined as the basic element, such as a forest stand, that makes up the landscape.

III - 3.1.1 Mean Class Patch Size (Within a Class)

This is the average size of patches of a given class on the landscape. A class represents a theme of interest. For instance, if a landscape was classified into three classes, i.e. conifer, deciduous and mixedwood, a mean class patch size is calculated for each class and is usually reported in hectares.

When classes are defined in terms of species composition, they represent landscape units which have specific habitat or forest product values. Classes of interest when describing caribou habitat include the description of existing and potential caribou winter habitat tracts by age class. Habitat components important for caribou winter habitat have the greatest value when they are contained in larger patches. Likewise, areas of refuge have greater value when contained within larger tracts. Therefore, mean patch size is very important for describing woodland caribou habitat.

III - 3.1.2 Patch Density

Patch density is measure of the relative distribution of patches of a specific class on the landscape. Patch density is usually reported in number of patches per 100 hectares.

Patch density is a good index to detect change in the relative availability of discrete habitats or environments. A change in patch density without a change in the mean patch size suggests that there is a change in the total area described by that patch type. Conversely, a change in patch density below expected values without a change in total area may represent habitat fragmentation. This parameter is particularly useful for comparing different caribou ranges.

III - 3.2 Edge Density

Edge is an important ecological concept. Edge represents that area where two habitats (classes) meet and is represented as a linear measurement between two discrete patch types. It represents a gradient or “ecotone” between two ecosystems. The contribution of edge to

ecological functions such as animal movement, predator-prey relationships, food-shelter relationships, microclimate, and dispersal depends on the species affected and the composition and structure of the two habitats that contribute to the edge. The thickness of an edge which is significant depends on the ecological functions one wishes to examine.

Thoughtful class definition will allow edge density to be a valuable index of relative abundance of habitat edge. Edge will also be heavily dependent upon some of the physical attributes of the land base. A change in edge density is a good indicator of relative proximity of various habitat components. Edge is generally a good habitat component for a large number of species and the food chains they support. Ecologically, an increase in the relative amount of edge is an indicator of a shift in preferred habitats for species such as moose, snowshoe hare and many songbird species. Increases in edge and edge density may be detrimental to caribou and the predator-prey relationships within caribou range.

III - 3.3 Interior

Forest interior is measured by patch core area and represents the relative amount of area in a class that is not adjacent (interior distance user defined) to other patches. It is assumed that there is no outside influence on core areas from neighboring patches. The quality of this assumption is dependent upon the definition of edge, and the distance one expects to have an influence into the patch. This distance may vary from one biological phenomena to another. Core area is very sensitive to pixel size. Pixel sizes may have to vary from 200 to 500 m for a meaningful analysis.

III - 3.3.1 Total Core Area (Within a Class and Landscape)

Total core area is the sum of the core areas of each patch within a class, or the sum of all core areas among classes across a landscape. Core area is measured in hectares.

Total core area measures will provide an important index of "refugia" for edge-avoiding species. It is relevant for area sensitive species such as woodland caribou as well as management of core “old growth”. Edge distance settings for woodland caribou refugia and winter habitat tracts should be set at 200 and 500 m for separate runs. The larger edge distances are relevant for describing the amount of core area well removed from patch edge and which therefore provide for the greatest refuge value.

III - 3.3.2 Mean Area per Disjunct Core

Mean area per disjunct core is the average size of core area for each type of patch. The core area is measured in hectares.

Mean area per disjunct core provides a meaningful index of the size of core areas left on the landscape. Core area alone may have a high value but may only guarantee a lot of small fragments of core area. A stable mean area per disjunct core indicates that values associated with the core areas are likely being protected. The higher the mean value of disjunct core area

associated with caribou winter habitat attributes, the greater the degree of protection of caribou winter habitat values.

III - 3.4 Isolation

The important concept of isolation in biology relates primarily to reproduction and dispersion - major factors in population dynamics. The proximity of one habitat to another or one habitat component to another is a reflection of distance and is difficult to determine on a complex spatial database. Two of the more simple measures are mean nearest neighbor and mean proximity index.

III - 3.4.1 Mean Nearest Neighbor Distance

Mean nearest neighbor distance is an average measure of edge to edge distances of patches of the same class. It reflects how isolated certain patch types are from one another.

Mean nearest neighbor distance can be a good relative index of impediments to biological phenomena such as dispersion to similar habitats, travel, courtship and even genetic transfer. This parameter may vary dramatically from class to class, depending on rarity. The smaller the mean nearest neighbor distance between caribou habitat patches and refugia the higher the quality of the landscape.

III - 3.4.2 Mean Proximity Index

Mean proximity index reflects the occurrence and closeness of patches of a similar type within a specified search radius. The search radius is user-defined and will be represented by 1,000 and 10,000 m, respectively, for the class definitions selected below.

The interpretation of mean proximity index varies with the search radius and the patch definition criteria. A large search radius and a low index could mean greater difficulty for a wildlife species to gain access to neighboring habitats for reproduction, escape from predators or dispersal. A small search radius and a high index could mean a ready flow and exchange of genetic material from stand to stand in species where this may be a concern, such as white pine. For caribou, the search radius for proximity index should be between 10,000 to 40,000 m for winter habitat tracts. Such analysis may require consideration of FRI data from neighboring Forest Management Units.

III - 4.0 What You Need to do Spatial Habitat Analysis

III - 4.1 Data Requirements

The following data and information are required to support spatial habitat analysis:

- spatial FRI data (raster format: 200 m pixel size), and
- ecosites data associated with FRI, or approximated crudely from the FRI.

III - 4.2 Skill and Knowledge Requirements

The following skills and knowledge are required to perform and interpret the spatial habitat analysis:

- familiarity with ecosites and FRI data,
- familiarity with caribou habitat matrix (see aspatial habitat supply),
- skills in using landscape pattern analysis tools,
- skills interpreting landscape pattern analysis tools,
- familiarity with landscape ecology and management concepts, and
- understanding of caribou ecology and habitat use.

III - 5.0 How to do Spatial Habitat Analysis

There are a number of steps that must be followed to perform a meaningful landscape pattern analysis for the purpose of assessing habitat quality. Defining landscape classes is a primary task. Landscape classes should describe generalized units of land that represent different caribou habitat values. For some model runs there will be a requirement for analysis with a specific edge distance and a data base assembled at a larger pixel size (i.e. 500 m). There are six steps involved in describing and comparing landscape attributes for caribou.

Step 1. Identify and set spatial objectives for woodland caribou habitat consistent with the Forest Management Guidelines for the Conservation of Woodland Caribou: A Landscape Approach.

Step 2. Develop classification(s) based on FRI attributes such as age or species composition, that would be suitable for evaluating landscape structure or pattern variables (*Section III-5.1*) for woodland caribou.

Step 3. Prepare FRI data for the spatial analysis with selected raster size.

Step 4. Estimate landscape parameters based on a specific forest management alternative and a specific land base classification.

Step 5. Compare landscape parameters from specific forest management alternative against targets and landscape parameters from other forest management alternatives.

Step 6. Return to *Step 2* or *Step 3* for fine tuning analysis to better understand the impacts of forest management upon landscape parameters important for woodland caribou.

III - 5.1 Data Organization and Class Definition

Landscape pattern analysis input data used to examine caribou landscape attributes in the Northwest Region will most frequently be generated from spatial FRI data. Rasterized FRI data at 200 m pixel size will provide adequate resolution for most analyses. Habitat attributes specific to caribou can be described in may ways and act as indices for the quality and quantity of

caribou habitat. Examples of classifications and the process for conducting spatial analysis in forest management planning is described by the OMNR (1997). Classifications useful in evaluating caribou habitat include:

Classification #1: Class definition related to old and young forest conditions. The separation between old and young may be set at approximately 40 years to correspond to the minimum time period in which winter habitat begins to have value for caribou.

Classification #2: Class definition related to "prime" age classes for the production of winter habitat (greater than 50 to 60 years) combined with broad conifer composition categories such as boreal conifer (Sb + Pj > 70%), deciduous (Pot + Bw > 70%) or mixed forest conditions.

Classification #3: Class definition approximating aggregations of ecosites similar to the wildlife habitat units used in SFMM.

Classification #4: User-defined classes related to significant caribou habitat values of prime winter habitat suitability, supporting winter habitat suitability, and a concept called "caribou habitat suitability" (see *Appendix 2, Section 5.1*). These classes will help to link and interpret the results of both the spatial and aspatial analysis. These analyses do not take into account proximity to water bodies, terrain features or specific exposed bedrock outcrops.

Classification #5: User-defined classes related to significant caribou habitat values of prime winter habitat suitability, supporting winter habitat suitability, and a concept called caribou habitat suitability (see *Appendix 2, Section 5.1*). These classes may be assembled as aggregations of the habitat units defined for classification #4 but take into account the anti-predator value of water bodies, bedrock plateaus and wetland complexes.

III - 6.0 Inspection and Interpretation of the Outputs

Landscape pattern analyses can be a valuable tool in the hands of a knowledgeable and skilled individual. Interpreting caribou habitat value of a managed landscape will also require solid understanding of forest ecosystems, forest stand structure, caribou biology, biology of other common boreal wildlife species, caribou movement patterns and predator-prey relationships.

The landscape pattern analysis, when considered in context with aspatial habitat analysis, inventory information and landscape interpretation, provides a relative index of caribou habitat quality. Its primary value will be to objectively describe landscape attributes for a number of forest management alternatives. Later versions of the analysis will project landscape attributes into the future.

Generally changes in the landscape that increase edge or reduce patch size of prime winter habitat, core area of older forest, quantity of older conifer forest or prime winter habitat, will be considered detrimental to woodland caribou relative to current conditions or future management

alternatives. There will also be complex interactions to consider. Core areas of prime winter habitat should be located across the landscape within a certain distance from one another (i.e. proximity index).

Visual inspection of all mapped outputs of the landscape pattern analysis will be necessary to facilitate interpretation. These outputs will also be an essential resource in maintaining and developing a meaningful forest mosaic. This caribou habitat mosaic is still intended as an important component of a caribou habitat management strategy in the region.

Appendix IV. Instructions for Assessing and Mapping Caribou Habitat: Habitat Mosaic

Conserving woodland caribou through regional land use planning or by applying the *Forest Management Guidelines for the Emulation of Fire Patterns* requires identification and mapping of caribou habitat use, habitat capability and other information pertaining to present or expected future habitat use. These caribou values maps identify high value habitat, present and future habitat shortages, and connectivity between habitat components. From 1991 to 1997, such a map has formed the basis of the caribou habitat mosaic for application of an earlier version of the caribou habitat management guidelines (OMNR 1994). This appendix outlines the information, the process and special considerations for producing a useful map to support planning. In the previous version of the caribou guidelines, this map was used to identify areas of priority for retention or protection, placement of disturbance events on the landscape, identification of habitat tracts and harvest scheduling.

The caribou habitat mosaic is a valuable strategic planning tool and is required for effective application of these guidelines and for integration of these guidelines with the *Forest Management Guidelines for the Emulation of Fire Patterns* through mechanisms described in Figure 5 and Table 3. It serves as a caribou values map, a caribou habitat map, a crude habitat supply analysis and as a mechanism for tracking long term commitments for habitat tracts from one management plan to another. The caribou habitat mosaic is one of the most valuable pieces of information supporting the application of the *Forest Management Guidelines for the Conservation of Woodland Caribou: A Landscape Approach*.

IV - 1.0 Background Information

Many sources of information are required to develop a meaningful caribou habitat map or caribou habitat mosaic.

IV - 1.1 Caribou Information

- historical caribou observations
- moose and caribou observations from winter aerial surveys
- sighting reports: public and MNR staff
- Natural Heritage Information Centre data records
- calving/population inventory
- caribou satellite telemetry study data (range use and movement patterns)
- results of winter and summer caribou habitat inventories
- recent moose observations

- existing caribou habitat maps, where available (e.g. Brightsand, Caribou East and West, Domtar-Armstrong (Harris 1991); Trout, Red Lake Crown and the Lac Seul forests (C.M. Consulting 1992))
- a map illustrating current caribou range occupancy, including the southern limit of continuous range - the "caribou line".

IV - 1.2 Forest Condition Information

- forest disturbance maps (cutover, blowdown, fire, access)
- 1:100,000 or 1:250,000 scale maps for the entire forest and neighboring Management Units
- maps showing forest age, structure and composition on a broad management unit level such as FMP eligibility maps, GIS-derived maps (i.e. age class and working groups), land cover maps or, at minimum, FRI maps

IV - 1.3 Soil and Landform Information

- Northern Ontario Engineering Geology Terrain Study (NOEGTS) maps
- Ontario Land Inventory (OLI) maps
- Surficial Geology of Northern Ontario maps
- Existing FEC or ecosite plot information or maps

IV - 1.4 Other Values

- future forest harvest allocations
- existing road locations and planned or approved road corridors
- location of major forest values that will likely receive AOC prescriptions

IV - 2.0 Required Personnel

- area biologist and forester
- company foresters
- planning staff from adjacent forests

IV - 3.0 Mapping Process

The objective of this mapping exercise is to delimit blocks or tracts of land with similar soil, landform, forest age and species composition. These tracts should be in the order of 10,000 ha to approximate the size of the larger, planned disturbance events. These maps may be digital or hard copy at 1:100,000 scale. The following steps, conceptually outline the process to develop caribou values maps:

i. Plot caribou management line.
ii. Plot historical caribou sightings.

iii. Delineate the known key caribou habitat, such as winter habitat and calving lakes, travel corridors.

iv. Map the following physical values directly onto 1:100,000 series maps:
- management unit boundaries
- roads
- resource values such as tourism facilities, cultural values, nesting sites, parks, nature reserves, etc.
- areas of disturbance (blowdown, fire, cutover)

v. Identify areas of highest priority to retain presently used, high quality winter habitat and calving areas.

vi. On transparent film, or as a thematic layer, outline the areas of bedrock, shallow soils, outwash plains and eskers. On some Management Units these features may be presently utilized as winter habitat.

vii. Identify and assess younger stands of suitable working groups for the potential to become future high quality winter habitat.

viii. Use FMP eligibility maps or a GIS produced working group and age class map to stratify the land base into blocks or tracts of forest that have similar working group and age class structure. These blocks should be transferred to transparent film or thematic layer.

ix. Using a separate transparent overlay or thematic layers, delineate tentative habitat tracts. Start the process at logical access points or areas of disturbance.

x. Confer with adjacent districts to:
- ensure compatibility of the caribou values map across administrative boundaries;
- ensure a continuum of habitat is available across the landscape;
- adjust the priorities and habitat tract delineation as required.

IV - 4.0 Interpreting the Map

Attributes of good caribou habitat (current and future) are described in *Section 2, Table 2,* and *Appendices II and III*. Briefly, good caribou habitat consists of:
- mature coniferous forest in large blocks,
- landforms dominated by shallow sandy or dry soils,
- low moose densities,
- general low density of roads, and
- connectivity between winter and snow-free season habitat and present and future habitat is important.

Assessing habitat supply requires consideration of the Forest Management Unit and adjacent forests and/or parks.

IV - 5.0 Points To Consider in Mapping Habitat for Conservation of Woodland Caribou

- The primary reason for the mosaic/mapping approach to managing caribou habitat is to maintain large tracts of forest on the land base at all times and to maintain a sustainable supply of occupied caribou winter habitat.
- Be aware of the possible existence of resident (non-migratory) caribou populations.
- The discovery of new information regarding caribou presence and habitat preferences will be ongoing.
- Be aware of the need and importance of maintaining suitable, occupied winter habitat over time at the southern periphery of the range. Caribou must remain near the southern range line in order to re-populate areas that become suitable habitat.
- The preferred mosaic/values mapping process is to form a joint OMNR-company team to develop the initial or preliminary mosaic, and to continue to use this team to fine tune and make changes to the mosaic.
- In the absence or reduction of the occurrence of wild fire, the renewal mechanism for caribou habitat will, to a large degree, be forest harvesting.
- Let the biology drive the habitat mapping process, but be sensitive to FMP objectives, targets, issues and concerns
- Recognize that the result will be a first approximation of a habitat mosaic which represents a long-term commitment to caribou habitat sustainability. It will be reviewed regularly as part of the planning process and may be revised as necessary to ensure that new information is incorporated, and that it is still accomplishing its objectives and goals.

Appendix V. Abridged Rationale and Analysis Results Used for Formulation of "Forest Management Guidelines for the Emulation of Fire Patterns".

The *Forest Management Guidelines for the Emulation of Fire Disturbance Patterns* should provide guidance on clearcut size, distribution and configuration across the Boreal forest regions of Ontario. These guidelines are intended to assist forest managers in their attempts to emulate natural disturbance patterns at landscape and forest stand scales. Benchmark measures of landscape structure and composition are derived from current understanding of how forests look and function under a natural disturbance regime. These benchmarks guide the establishment of desired future forest condition in Forest Management Planning.

V - 1.0 Rationale for Forest Management Guidelines for the Emulation of Fire Patterns

Many forest researchers and managers realize that traditional management practices may not be maintaining the biological diversity of forests. Past practices have sometimes led to fragmentation of the forested landscape resulting in a changes in biological diversity. Forest Management Plans can no longer focus solely on their own forest objectives but must take into consideration objectives for forests at the site-regional level. Plans must shift from managing at the stand level to the landscape level.

The *Crown Timber Act*, which had been governing timber management since 1952 was replaced with the *Crown Forest Sustainability Act* (CFSA) in 1995. The basis of the new Act is Section 1(3)2. which states,

The long term health and vigor of Crown forest should be provided for by using forest practices that, within the limits of silvicultural requirements, emulate natural disturbances and landscape patterns while minimizing adverse effects on plant life, animal life, water, soil, air and social and economic values, including recreational values and heritage values.

Using the clearcut and shelterwood silvicultural methods to emulate stand replacing fire events will be contentious. The size of clearcuts will be one of the more contentious issues. The

Environmental Assessment Board made the following comments with respect to the clearcut issue in their rationale for Decision:

> *"We conclude that clearcuts should be made in a range of sizes to emulate natural disturbances, and that - although extremely large clearcuts would likely be rare for practical reasons - limiting clearcuts strictly to small sizes would make it impossible to regenerate the boreal forest to its natural pattern of large even-age stands.*
>
> *We accept that some large clearcuts are required and we rely on the judgment of foresters to make exceptions above the 260-hectare limit for biological and silvicultural reasons such as salvage operations, overmature stands and wildlife habitat requirements. The rationale for exceeding 260 hectares must be reported in the Plan. It is also important that 260 hectares not become the standard size clearcut, resulting in only a few clearcuts being larger or smaller. The evidence is clear to us in supporting a range of various sizes."*

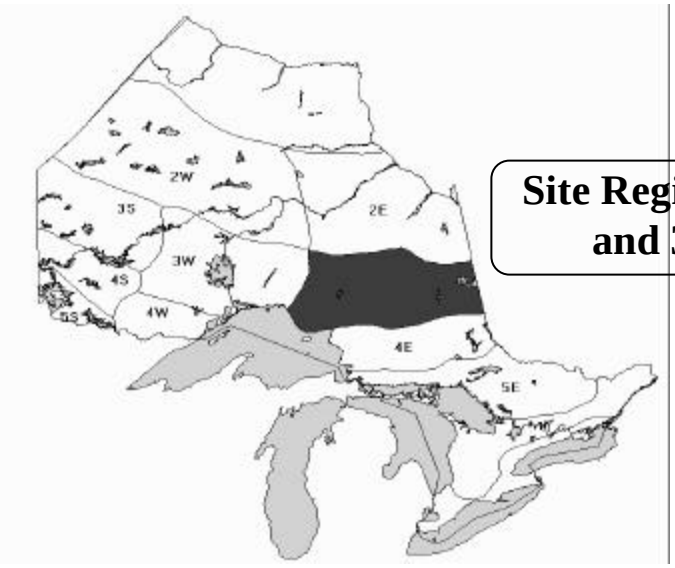
The *Forest Management Guidelines for the Emulation of Fire Patterns* will provide guidance to forest managers on emulating natural fire disturbance at various scales including landscapes. This guidance will be based on the following summary of analysis results of wild fire occurrences in Ontario from 1920 to 1950. The results presented here cover only the site regions in Ontario where woodland caribou occupy continuous range.

V - 2.0 'Natural' Template Description

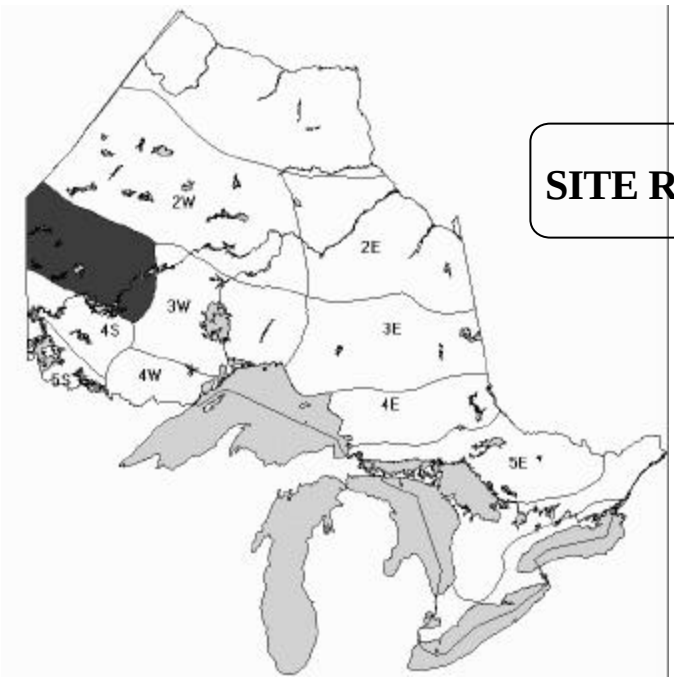
The period 1921 to 1950 was chosen to represent the natural disturbance regime. Analysis of fire was frequency and size was done site-region by site-region. Fire disturbances greater than 10,000 ha were not used in developing the natural template for practical reasons.

The disturbance template for a site region consists of observed fire frequencies by size classes. These data suggest a frequency and aggregate area for disturbances in a forest managed under the *Forest Management Guidelines for the Emulation of Fire Patterns.*

The natural fire disturbance frequency by size class generally is many small fires and fewer large disturbances. Most of the area disturbed by fire in total is the result of a few large fires. The *Forest Management Guidelines for the Emulation of Fire Patterns* recommend this general template to guide application of the clearcut silvicultural system in Boreal site regions. The size classes most practical for this emulation of natural disturbance range from 10 ha and 10,000 ha.

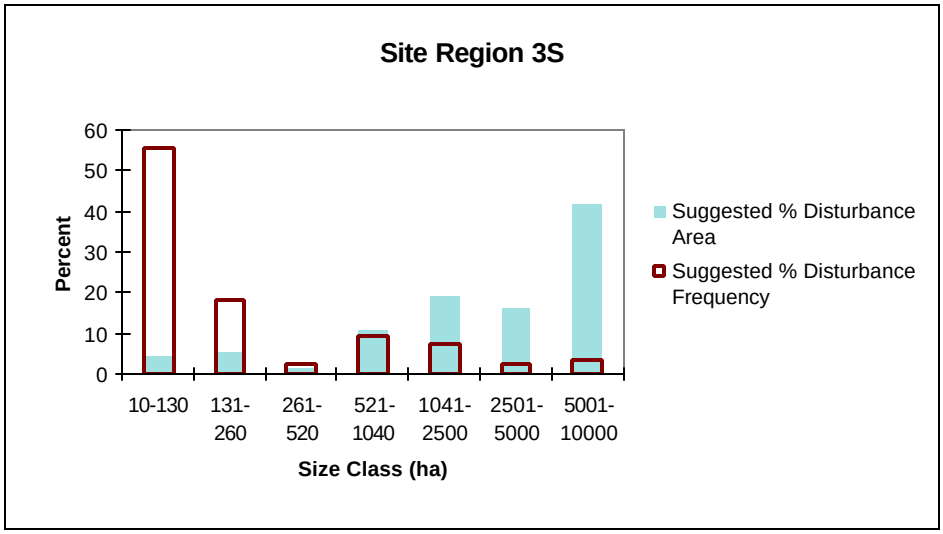


Size Class (ha)	Total # Fires	Total Area Burned (ha)	Annual Frequency	Annual Area Burned (ha)	Suggested % Disturbance Frequency	Suggested % Disturbance Area
10-130	46	1996	3	111	27	1
131-260	16	3085	1	171	10	2
261-520	52	19257	2	642	19	7
521-1040	50	36608	2	1220	18	13
1041-2500	41	69303	1	2310	15	24
2501-5000	24	79486	1	2650	9	28
5001-10000	10	72942	0.3	2431	4	25



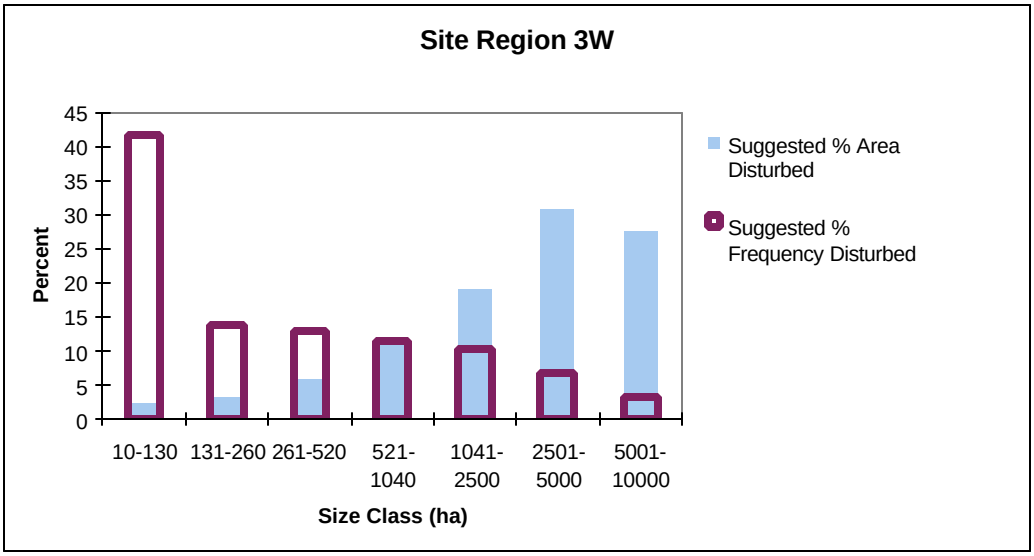
SITE REGION 3S

Size Class (ha)	Total # Fires	Total Area Burned (ha)	Annual Frequency	Annual Area Burned (ha)	Suggested % Disturbance Frequency	Suggested % Disturbance Area
10-130	84	3978	5	221	56	4
131-260	28	5374	2	299	18	6
261-520	7	2551	0.2	85	3	2
521-1040	24	17628	1	588	10	11
1041-2500	19	30648	1	1022	8	19
2501-5000	7	25714	0.2	857	3	16
5001-10000	9	65957	0.3	2199	4	42



SITE REGION 2W and 3W

Size Class (ha)	Total # Fires	Total Area Burned (ha)	Annual Frequency	Annual Area Burned (ha)	Suggested % Frequency Disturbed	Suggested % Area Disturbed
10-130	107	5046	6	280	42	2
131-260	35	6816	2	379	14	3
261-520	55	20445	2	682	13	6
521-1040	49	36663	2	1222	12	11
1041-2500	43	65963	1	2199	10	19
2501-5000	29	105444	1	3515	7	31
5001-10000	13	95299	0.4	3177	3	28



V - 3.0 Fire Pattern Emulation Issues

MNR's ability to emulate natural fire patterns will be constrained by a number of socio-economic factors in addition to the capability (and advisability) of managed forests accepting the full range of natural disturbance size classes. The size classes that are suggested in the "Fire Pattern Emulation Guidelines" are a reflection of some of the practical and socio-economic constraints that generally will affect our abilities to emulate natural disturbance patterns. In situations where biological or silvicultural considerations would support disturbances outside the suggested size classes, such as management of woodland caribou habitat, Regional Director approval will be required (this will be conferred at the time of plan approval). Planning of disturbance patterns at the subregional level will have to deal with these and other related issues as they affect individual FMUs in the development of the Subregional Disturbance Plans. At the stand level, retention of appropriate amounts of residual timber in harvested areas to emulate fire will be carried out by operators at time of harvest. Much of this area is likely to be composed of unmerchantable or inaccessible timber.

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