

## Ecosystem management and the conservation of caribou habitat in British Columbia

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*Abstract:* Woodland caribou (*Rangifer tarandus caribou*) in British Columbia inhabit a wide variety of forest ecosystems. Numerous research projects have provided information that has been used to develop caribou habitat management recommendations for different areas. Recently, the province has implemented guidelines to protect biodiversity that are based on an ecosystem management strategy of mimicking natural forest conditions. There is a great deal of similarity between caribou management recommendations and biodiversity recommendations within different forest types. In mountain caribou habitat, both approaches recommend maintaining a landscape dominated by old and mature forests, uneven-aged management, small cutblocks, and maintaining mature forest connectivity. In northern caribou habitat, both approaches recommend maintaining some older stands on the landscape (but less than for mountain caribou), even-aged management, and a mosaic of large harvest units and leave areas. The ecosystem management recommendations provide a useful foundation for caribou habitat conservation. More detailed information on caribou and other management objectives can then be used to fine-tune those recommendations.

**Key words:** *Rangifer tarandus caribou*, habitat management, forestry, biodiversity.

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### Introduction

Woodland caribou (*Rangifer tarandus caribou*) conservation has been a high profile resource management issue in British Columbia (B.C.) for many years, primarily because of the conflict between forest harvesting and conservation of caribou habitat. That concern resulted in a large number of studies designed to provide information on how to integrate caribou habitat protection and forest harvesting. Those research results led to the development of numerous sets of guidelines and recommendations that have been implemented to various degrees throughout the province (e.g. Cichowski & Banner, 1993; Stevenson *et al.*, 1994). Forestry/wildlife guidelines have also been developed for various other high priority species in B.C. such as mule deer (*Odocoileus hemionus hemionus*) (Armleder *et al.*, 1986), and coastal black-tailed deer (*O. b. columbianus*) and Roosevelt elk (*Cervus elaphus roosevelti*) (Nyberg & Janz, 1990).

More recently there has been increased public

concern about the impacts of forest management practices on the full range of natural biodiversity. Forest managers must now attempt to manage forests in a way that will maintain all native species, including vertebrates, invertebrates, vascular and non-vascular plants, and micro-organisms. Given this complex task, relying on single species guidelines is no longer a feasible approach. The habitat requirements of many native species are unknown, and even if they were, it would be impossible to integrate the individual requirements of thousands of different species, many of which have habitat requirements that are incompatible with the requirements of others. Consequently, an ecosystem management approach has been adopted as a more appropriate strategy to conserve natural biodiversity within managed forests in B.C. Ecosystem management provides the framework for the British Columbia Forest Practices Code Biodiversity Guidebook (British Columbia Ministry of Forests, 1995).

## The British Columbia forest practices code biodiversity guidebook

The basic assumption of the Biodiversity Guidebook is that the more closely managed forests resemble natural forests, the greater the probability that all native species and ecological processes will be maintained. As natural ecosystems become increasingly modified by human activities, natural patterns of biodiversity become increasingly altered, and the risk of losing native species (including caribou) increases. Forest biodiversity is related to the age class distribution, patch size distribution (i.e. the size of contiguous, similar-aged areas of forest), and stand structure of the forest (Hunter, 1990). In natural forests, those factors were determined primarily by the frequency, scale and characteristics of natural disturbances such as fires, insects and disease. Thus, the Biodiversity Guidebook uses natural disturbance regimes as a model for forest management practices.

The degree to which natural biodiversity can be maintained within managed forests depends on how closely managed forests resemble natural forest conditions. As the forest age class distribution, patch size distribution, and stand structure become more like natural forests, the pattern of biodiversity will also approach more natural levels. However, moving along that continuum towards natural forest conditions usually has timber supply and economic consequences. Where we choose to be on that continuum becomes a social value judgement that considers the trade-off between biodiversity conservation and economic values. The Biodiversity Guidebook outlines three different options along that continuum, depending on whether biodiversity conservation has a high, intermediate, or low priority in a given area. The primary difference between those three options is the amount of old and mature forest retention. The High option maintains 75%, the Intermediate option maintains 50%, and the Low option maintains 25% of natural levels of old and mature forest in an area.

The Biodiversity Guidebook recommendations are intended to be applied at a landscape planning level. Forest Districts are subdivided into landscape units that are generally from 50 000 - 100 000 hectares in size. Landscape units must be quite large to represent the scale at which natural age classes and patch sizes were spatially distributed. The Biodiversity Guidebook provides recommended age class, patch size, and stand structure objectives for each landscape unit. Those recommendations vary

depending on the natural forest characteristics (i.e. biogeoclimatic subzones; Meidinger & Pojar, 1991) and the biodiversity emphasis option for each landscape unit. The biodiversity emphasis option for each landscape unit is determined using a combination of ecological criteria, government policy on allowable timber supply impacts, and public input from strategic land use planning processes.

## Ecosystem management and caribou habitat

Woodland caribou in B.C. live in a wide variety of ecosystems, but they can be broadly divided into a "mountain ecotype" and a "northern ecotype" (Fig. 1); (Stevenson & Hatler, 1985). Habitat management recommendations for the different caribou ecotypes have been developed based on specific information about caribou ecology in different areas. However, as will be discussed below, very similar recommendations would result from simply applying an ecosystem management strategy of trying to mimic the natural forest conditions in the areas where they live. The purpose of this paper is to discuss the value of an ecosystem management strategy for protecting caribou habitat.

## Mountain caribou

Mountain caribou live in the southeastern part of the province (Fig. 1). The habitat use of mountain caribou has been the subject of numerous studies including Simpson *et al.* (1987), Servheen & Lyon (1989), Seip (1990; 1992a), Terry (1994), and Apps & Kinley (this volume). Mountain caribou spend most of the year at high elevations (generally above 1500 m) in alpine areas and subalpine forests of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*). During the winter, snow depths are too great to allow cratering and the caribou feed almost exclusively on arboreal lichens. In some areas, caribou use lower elevation forests of western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) during early winter (November-December), but move to higher elevations as winter progresses.

These wet, mountainous landscapes had a very low frequency of stand destroying wildfires, and when fires did occur, most were relatively small in size. Thus, the landscape was naturally dominated by contiguous old forests, with early seral habitats relatively uncommon and small in size. Within

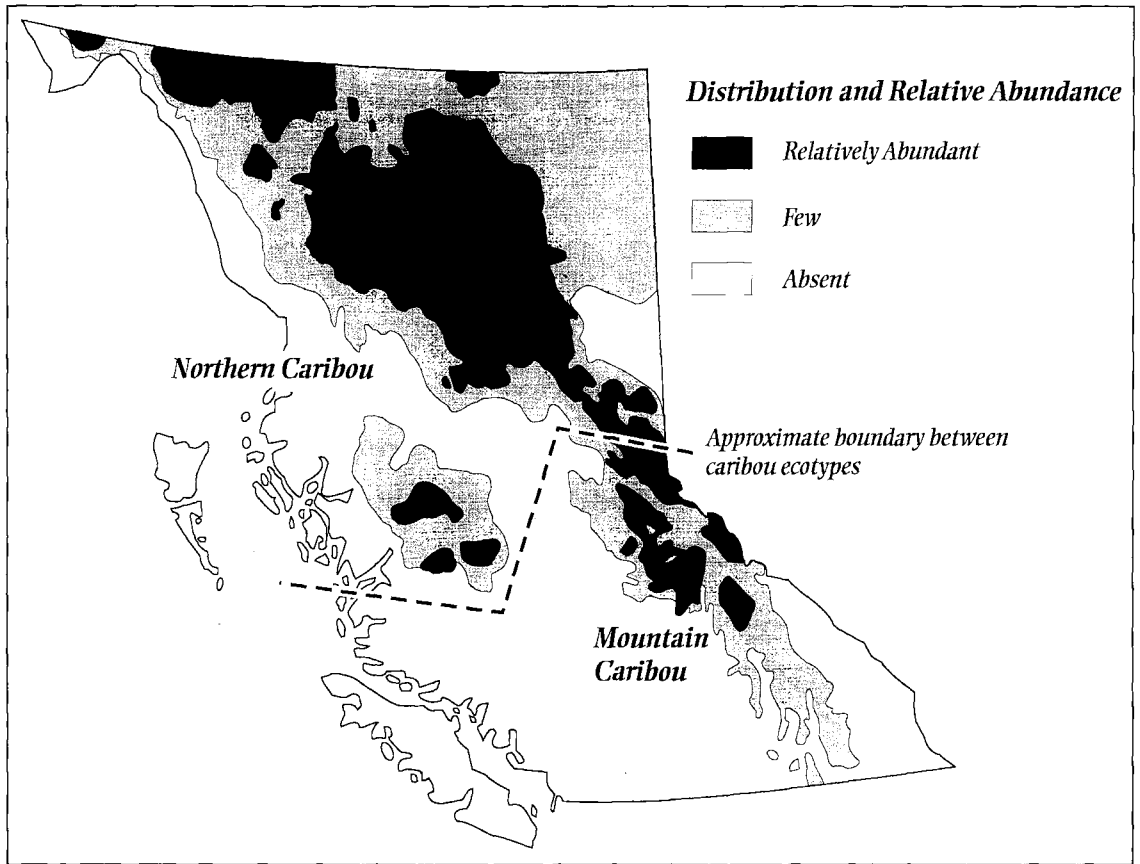


Fig. 1. The distribution and relative abundance of the mountain caribou ecotype, and the northern caribou ecotype, of woodland caribou in British Columbia (British Columbia Ministry of Environment, 1979; Stevenson & Hatler, 1985).

older stands, the death of individual trees or small groups of trees from small scale natural disturbances, such as insects or disease, created gaps in the forest canopy. Those gaps allowed trees to regenerate and grow in the understory resulting in the development of uneven-aged stands.

Arboreal lichens are most abundant in old forests (Antifeau, 1987) and are eliminated when those forests are clearcut or burned. Thus, maintaining old forests that provide arboreal lichen is an essential component of caribou habitat protection in these areas. Wolf (*Canis lupus*) predation is a major limiting factor of some mountain caribou populations, and caribou appear to be more vulnerable to predation when they live in close proximity to moose (*Alces alces*) because moose provide an alternative prey that sustains increased wolf numbers (Seip, 1992b). A similar situation probably occurs in the southern Selkirks and Monashee mountains where cougar (*Felis concolor*) predation is a major mortality

factor for woodland caribou, and cougar abundance is associated with deer numbers (Compton *et al.*, 1990; Simpson *et al.*, 1994).

Moose, deer and elk numbers usually increase in response to the creation of early serai habitats by clearcutting and fires. Increased ungulate numbers may sustain increased populations of predators. There is concern that fragmenting caribou habitat into a patchwork of mature and early seral forests will bring caribou and early seral ungulate species into close proximity, sustain increased predator populations in the area, and thereby lead to an increase in predation on the caribou (Seip, 1991; Stevenson *et al.*, 1994). Consequently, maintaining large, contiguous tracts of old forest is generally seen as preferable to maintaining fragmented patches of mature forest interspersed with clearcuts.

A variety of strategies have been implemented to maintain large contiguous areas of old forest for mountain caribou in southeastern B.C. Many exist-

ting parks, especially Wells Gray Provincial Park, provide habitat for a substantial number of mountain caribou. British Columbia is in the process of increasing the amount of parkland to 12% of the provincial area (Anonymous, 1993). Many of the new parks which are proposed for southeastern B.C. will provide additional protection of caribou habitat so that in the future, a substantial proportion of the total mountain caribou habitat will be protected by parks.

Caribou habitat is also being protected in areas outside of parks. In some forest districts, the highest quality caribou habitat has been identified and is unavailable for harvest. The areas have been removed from the timber harvesting landbase and the allowable annual cut has been reduced accordingly (e.g. Prince George Timber Supply Area, Robson Valley Timber Supply Area). Most of the highest quality caribou habitat is high elevation subalpine forest that has relatively low timber productivity so these areas can often be protected with relatively modest impacts on timber supply. In some other areas, forest age class constraints are applied to caribou habitat to ensure that a substantial proportion of the habitat is old enough to provide arboreal lichens. For example, within medium quality caribou habitat in the Robson Valley Timber Supply Area, no more than 1/3 of the commercial timber volume can be harvested every 80 years. If clearcutting is being used, the constraint will ensure that at least 1/3 of the forest is greater than 160 years of age. Alternatively, partial cutting systems could be used to remove 1/3 of the volume from the entire habitat area every 80 years so long as the silvicultural prescription maintains caribou habitat attributes. In some areas, if clearcutting is to be used in areas of caribou habitat, small cutblocks less than 15 hectares in size are recommended (Simpson *et al.*, 1994). Some Forest Districts also require that mature forest corridors be maintained across valleys to provide connectivity between upper elevation areas of caribou habitat.

Those caribou habitat management recommendations are very similar to the Biodiversity Guidebook recommendations for those forest types. If a landscape unit is to be managed with a "high emphasis" on conserving biological diversity, the Biodiversity Guidebook recommendations for these forests include:

I) At least 54% of the upper elevation forest should be >120 years of age (i.e. at least 75% of natural

levels). Lower elevation forest types that had a greater frequency of natural wildfires have a lower target for old and mature forest retention, but the target still represents 75% of natural levels.

II) No more than 17% of the upper elevation forest should be <40 years of age (i.e. no more than 1.5 times the natural level). More early serai habitat is allowed in lower elevation forests, but the target is still <1.5 times natural levels.

III) Partial cutting and uneven-aged silvicultural systems are preferred in the upper elevation forests to mimic the natural pattern of small disturbances within stands.

IV) If clearcutting is used, a range of cutblock sizes, up to 250 hectares in size, is recommended to mimic the size distribution of natural stand-destroying disturbances in these forests.

V) About 10% of the total area within each cutblock must be retained as mature forest remnants to mimic the structural features left behind by natural disturbances. Those remnants will provide habitat attributes, such as large diameter snags and arboreal lichens, within the regenerating stand.

VI) Mature forest corridors must be maintained to keep stands of mature and old forest connected into a contiguous "Forest Ecosystem Network".

These biodiversity recommendations are intended to maintain a relatively natural age class and patch size distribution within the landscape unit. The stand management recommendations are designed to maintain natural stand structure and habitat attributes such as snags and lichens. The "Forest Ecosystem Network" is intended to partially maintain the contiguous distribution of old and mature forests on the landscape.

By maintaining many of the characteristics of natural forests, it is assumed that relatively natural levels of biodiversity, and relatively natural population levels of all native species will be maintained. In relation to mountain caribou, implementation of these biodiversity recommendations would maintain a landscape dominated by contiguous old and mature forest that would provide arboreal lichens for winter food, and allow caribou to maintain spatial separation from early seral habitats and thereby reduce the risk of predation. Thus, the ecosystem

management recommendations provide a useful approach to conserving caribou habitat.

If a landscape unit is managed with an intermediate or low emphasis on biodiversity conservation, the mature and old forest requirement would be reduced (ie. 50% or 25% of natural levels respectively). Moving from high, to intermediate, to low emphasis biodiversity recommendations would increase the timber availability, but would result in a greater impact on natural biodiversity, and increase the threat to various native species such as caribou.

## Northern caribou

Northern caribou inhabit the northern and west-central areas of B.C. (Fig. 1). Historically the distribution was contiguous, but it became fractured during the past century due to the disappearance of caribou from portions of their range (Bergerud, 1978). Habitat studies of northern caribou are presented in Hatler (1986), Cichowski (1993), and Wood (1996). These caribou usually live in alpine habitats during the summer months but use lower elevation lodgepole pine (*Pinus contorta*) forests for at least part of the winter. During winter the caribou feed primarily by cratering for terrestrial lichens. The primary conflict with forest harvesting occurs on the low elevation winter ranges.

The low elevation forest types that provide caribou winter range experienced natural wildfires on average every 100-150 years. Those fires were often thousands of hectares in size. However, wildfires did not burn 100% of the area, but rather, left small, unburned remnants of mature forest that constituted 5-15% of the total burn area (Eberhart & Woodard, 1987; Delong & Tanner, 1996). Consequently, the natural landscape was a mosaic of large, even-aged stands of pine that regenerated following wildfires. Within those stands there were remnants of older forest that had survived the fires.

Terrestrial lichens were usually destroyed by fires, but recolonized disturbed sites and became abundant in mid-aged to mature stands (Brulisauer *et al.*, 1996; D. Coxson, pers. comm.). Xeric growing sites support abundant terrestrial lichens for hundreds of years (Brulisauer *et al.*, 1996). However, on more productive sites, terrestrial lichens may be abundant in mid-aged stands but are replaced by mosses in older stands and thus require periodic disturbance to be perpetuated (D. Coxson, pers. comm.). Very productive sites are usually dominated by vascular

plants and never produce substantial amounts of terrestrial lichens.

Habitat management strategies for these caribou must ensure that sufficient amounts of older forest are maintained to provide terrestrial lichens. However, on sites that naturally undergo a succession to moss cover, periodic disturbances of old stands are required to reestablish lichens. In addition, suitable foraging habitat should be maintained in large, unfragmented patches to keep the caribou spatially separated from early seral habitat where they would encounter increased exposure to moose and wolves.

Forest harvesting within the winter ranges of northern caribou in B.C. has been quite limited until now, but increased activity in those areas is anticipated. In response, a number of strategies have been implemented to protect winter habitat. Habitat for many northern caribou herds is contained within existing and proposed parks. There is an appreciation among Ministry of Parks biologists that maintenance of that habitat may require fire management plans that perpetuate natural wildfire regimes (D. Cichowski, pers. comm.). In areas outside of parks, forest age class constraints have been implemented in some Forest Districts to maintain old and mature forests that provide terrestrial lichens. For example, within caribou winter habitat in the Mackenzie Forest District, 25% of the forest must be older than 150 years. Similarly, in Ft. St. John Forest District 40% of the forest that provides low elevation caribou winter habitat must be older than 100 years. Those areas are available for harvesting, but on a rotation period that is long enough to provide terrestrial lichens for caribou. When harvesting is conducted, large harvest blocks of hundreds or thousands of hectares, offset with similar sized leave areas, are recommended to reduce habitat fragmentation (Cichowski & Banner, 1993).

Again, these caribou habitat recommendations are almost identical to the Biodiversity Guidebook recommendations which are based on mimicking the natural disturbance regime. Within landscape units that are managed with a "high emphasis" on conserving biodiversity, the Biodiversity Guidebook recommendations for the forest types that provide low elevation winter habitat for northern caribou vary (depending on the biogeoclimatic subzone and natural fire return interval) as follows:

1) At least 28-39% should be greater than 100 years of age (i.e. 75% of natural levels).

II) No more than 35-50% should be harvested within a 40 year period (i.e. 1.5 times the natural level).

III) Clearcutting with reserves is generally the preferred silvicultural system to mimic the stand structure produced by stand destroying wildfires that contained unburned mature forest remnants. Generally, about 10% of the total area within each cutblock should be retained as mature forest remnants, similar to the pattern of wildfires.

IV) A range of cutblock sizes is recommended, but the majority should be relatively large (i.e. 250-1000 hectares). This size distribution under-represents the frequency of much larger natural wildfires in these forest types, but the objective of mimicking natural patterns was balanced with public concern about large clearcuts.

By providing a relatively natural forest age class distribution, patch size distribution and stand structure, it is assumed that relatively natural levels of biodiversity will be maintained. For northern caribou, implementation of these guidelines would provide a perpetual supply of relatively large patches of mature forest that would provide terrestrial lichens for food, and some spatial separation from early seral habitats where predation risk is probably greater. If a landscape unit is managed with an intermediate or low emphasis on biodiversity conservation, the mature and old forest requirement would be reduced, and the risk to caribou and other native species associated with old forest would be greater.

## Roads and disturbance

In addition to the forest management issues discussed above, there are concerns regarding impacts of roads, linear corridors, and disturbance on caribou. Roads and linear corridors clearly provide improved access to caribou for hunters and poachers, but may also increase access for predators. Disturbances such as snowmobiles can displace caribou and force them into more rugged habitats where they probably face increased energy expenditures and mortality risk from avalanches (Simpson, 1987; own obs.). However, these impacts can be quite subtle and almost impossible to demonstrate conclusively with research and monitoring. Although the cumulative effects of small increases in poaching, energy expen-

ditures, vehicle collisions, avalanche deaths, and predation associated with increased disturbance may have a major impact on a caribou population over the years, it may be impossible to definitively show a direct cause and effect relationship. An ecosystem management strategy would assume that because roads, snowmobiles etc. are not part of the natural ecosystem, the more prevalent they become, the greater the probability that natural levels of biodiversity will be disrupted. Thus it would be prudent to minimize or prohibit roads and other disturbances in areas where maintaining natural levels of biodiversity, including caribou populations, is a priority, even if there is no conclusive research information that demonstrates a deleterious effect.

## Predator control

Predation is often a major limiting factor of caribou populations and predator control can significantly increase caribou survival (Bergerud & Elliot, 1986; Farnell & McDonald, 1988; Seip, 1992b). However, use of predator control to increase caribou or other ungulates to unnaturally high levels is a disruption of natural biodiversity. It may be appropriate to manage predators in areas where society has decided to enhance natural ungulate populations at the expense of natural biodiversity. Also, it may be desirable to manage predators in areas where past human practices have reduced caribou populations, and predator control is to be used to restore natural caribou numbers. However, predator control to increase caribou herds to unnaturally high levels is inappropriate in areas where there is a priority to maintain naturally functioning ecosystems and biodiversity.

## A general ecosystem management strategy

The following points outline the basic steps that are required to implement an ecosystem management strategy to conserve biodiversity in managed forests:

I) Delineate planning units that are large enough to allow landscape level planning objectives for age class and patch size to be applied. If the full range of forest age classes and patch sizes are to be maintained within a landscape planning unit it will have to be tens of thousands of hectares in size (B.C. Biodiversity Guidebook recommends 50 000 - 100 000 hectares).

II) Determine the management objectives for each landscape unit. If maintaining a high level of natural biodiversity, including caribou, is the priority, this will usually have a greater impact on timber production. Alternatively, an objective of maximizing timber production will have major impacts on natural biodiversity and caribou. An objective of enhancing early seral ungulates such as moose and elk may have negative consequences for some other components of natural biodiversity, including caribou.

III) Set forest age class and patch size objectives for each landscape unit. If there is a desire to maintain relatively natural levels of biodiversity within a landscape unit, the age class and patch size objectives should be as close to natural values as possible. Meeting other competing resource management priorities such as timber production or moose enhancement may require a significant departure from natural forest characteristics. That departure from natural forest conditions will result in significant changes in natural biodiversity, and an increased risk to caribou.

IV) Use silvicultural systems that mimic the dominant natural disturbances in the area, and retain stand attributes left by natural disturbances. For example, clearcuts with reserves can be used to mimic stand destroying wildfires that contained unburned mature forest remnants.

V) Minimize other habitat alterations which were not part of the natural landscape such as roads, other linear developments, and disturbance.

### **Fine-tuning ecosystem management guidelines for caribou**

Although a coarse-filter ecosystem management strategy should provide suitable habitat conditions to maintain most native species, some species may require additional, more specific management practices to ensure their survival. Similarly, it may be desirable to provide more detailed management practices for species such as caribou that are a high management priority. In either case, however, there is no need to develop a completely new set of management guidelines. Rather, the coarse-filter ecosystem management guidelines simply need to be "fine-tuned" to better meet the needs of those species of special concern.

In areas of caribou habitat, landscape unit age class objectives could be modified to provide more mature forest than is recommended for more general biodiversity conservation (e.g. maintain 100% of natural levels of mature forest rather than 25-75%). Also, the location of mature forest retention within a landscape unit may be targeted towards sites that have the greatest potential to provide caribou habitat. A somewhat larger patch size objective may also be required. As mentioned above, the B.C. Biodiversity Guidebook recommends patch sizes up to 1000 hectares in size within northern caribou habitat. That size may be adequate for most species that require larger patches of forest, but for caribou habitat, a 10 000 hectare patch size mosaic as proposed for northern Ontario (Racey & Armstrong, 1996) may be more appropriate. Similarly in mountain caribou habitat, in areas where partial cutting is not feasible, cutblocks at the upper end of the recommended size range (up to 250 hectares) may be preferred to reduce fragmentation effects and access concerns.

Earlier guidelines for northern caribou often recommended small clearcuts, which was inconsistent with the size of natural disturbances in those forests. Further research and understanding has supported a move to more natural sized disturbances to reduce predation risk. This is an example of why one should be cautious if habitat recommendations for a species are very different from the natural habitat pattern.

At the stand level, specialized site preparation guidelines may be appropriate in areas of caribou habitat. Natural wildfires often destroyed most of the terrestrial lichen groundcover whereas careful harvesting and site preparation methods have the potential to maintain much of the terrestrial lichen cover (Harris, 1996). Although an ecosystem management strategy would suggest that site preparation methods should mimic the natural pattern (i.e. broadcast burning), caribou management considerations may favour practices that retain the terrestrial lichen groundcover. Caution is required, however, because on sites where terrestrial lichens are replaced by mosses over time, periodic disturbances may be required to maintain lichens. On those sites, more aggressive site preparation techniques that reduce organic matter accumulations may be required to prevent succession by mosses from replacing lichens in the stand over time. Destroying lichens in the short-term may be necessary to maintain them in the long-term (Schaefer & Pruitt, 1991). This

situation is another example of why habitat management recommendations that greatly differ from natural patterns should be viewed cautiously. Diverging from natural patterns may have unanticipated, negative consequences that only become apparent after further study.

Naturally regenerating pine stands often had dense stocking which probably shaded out much of the lichen cover. It may be desirable to diverge from that natural pattern and use spacing to enhance lichen growth in regenerating stands.

### Summary of ecosystem management and caribou habitat

I) Ecosystem management recommendations to conserve biodiversity are based on the assumption that the more closely managed forests resemble natural forest conditions (ie. age class distribution, patch size distribution, stand structure), the greater the probability that relatively natural populations of all native species will be maintained.

II) Ecosystem management guidelines that have been designed to maintain the full range of native species in B.C. also provide many of the habitat requirements for caribou, and a strong foundation for the development of more detailed caribou habitat management guidelines.

III) When the impact of a certain habitat alteration is unknown (e.g. linear corridors), and difficult to resolve by research, the most prudent approach would be to assume that maintaining the habitat in a more natural condition is the best strategy to maintain all species.

IV) If habitat management recommendations for a species are very different from natural habitat characteristics, one should be cautious. Diverging from natural patterns may appear beneficial on the surface, but have unanticipated, negative consequences that only become apparent after we have a better understanding of habitat relationships (eg. patch size and predation risk).

V) Detailed understanding of the habitat requirements of individual species, such as caribou, need not be used to develop an entirely new set of "single species" habitat management recommendations, but rather can be used to "fine-tune" ecosystem management recommendations that have been

developed to maintain the full range of natural biodiversity.

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