Recruiting Caribou Habitat Using Silviculture Treatments

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Executive Summary

Integrating mountain caribou (*Rangifer tarandus caribou*) management and timber management is important in the Revelstoke area because a significant proportion of the allowable annual cut is harvested from old-growth forests, which are critical for caribou habitat. This has heightened the interest in applying forest management strategies that can maintain or simulate old-growth attributes on which the caribou rely.

Silviculture treatments applied to managed stands have the potential to accelerate the development of habitat attributes preferred by mountain caribou, including abundance of arboreal lichen and understory falsebox, and open stand structure with some large trees providing good sight lines and snow interception.

The Minister of Forests Advisory Committee (MAC) land use plan for the Revelstoke TSA requires 40% retention in mature and old-growth forests within areas with high value caribou habitat. In response to this requirement, the following goals and management objectives for caribou habitat recruitment using silviculture treatments are proposed:

Overall goals:

1. Maintain and supplement the 40% retention target for mature and old forests in caribou management areas (as laid out in the MAC plan) over time to ensure a sustainable supply of suitable habitat for the future.
2. Increase use of later seral stage (i.e., younger than mature) forests by mountain caribou for forage and cover in the Revelstoke TSA.

Management objectives:

1. Mimic attributes of mature and old-growth forests in later seral stage forests favorable to caribou using silviculture techniques (i.e., create open forests with large trees and complex structure).
2. Accelerate the development of suitable connective habitat for caribou in managed forests to facilitate movement between foraging habitats and predator avoidance.
3. Increase the amount of available lichen for caribou in later seral stage forests.

The purpose of this report is to provide guidance and ecological justification for managers and silviculture foresters to plan, prescribe, implement and monitor silviculture treatments, to meet caribou habitat requirements and timber harvesting objectives. The report specifically:

a) identifies desired attributes of caribou habitat;
b) proposes guidelines for ranking and priorizing stands for caribou habitat recruitment;
c) suggests specific silviculture treatments to recruit caribou habitat in young forests and maintain caribou habitat in old-growth forests; and
d) proposes using an adaptive management framework for monitoring, refining guidelines and improving prescriptions for recruiting caribou habitat.

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1.0 Introduction

1.1 Background

The mountain caribou (*Rangifer tarandus caribou*) herd that ranges through Mount Revelstoke and Glacier National Parks and the forests north of Revelstoke creates special challenges for management in this area. This has heightened the interest in applying forest management strategies that may simulate the desired old-growth structure that caribou rely on for survival. This area supports approximately 400 (Flaa and McLellan in press) of a total population of 2,400 mountain caribou (Simpson, et al. 1997). This has led to provincial, national and international interest in their maintenance. Caribou are considered an umbrella species; that is, the protection of caribou habitat will also serve to protect the habitat of many other species dependent on old-growth forests.

Recently the mountain caribou in the Revelstoke area have been provincially red listed, which means they are considered "endangered" by the Committee on the Status of Endangered Wildlife in Canada (http://www.cosewic.gc.ca/index.htm). It is expected that they will also be listed under the Federal *Species at Risk Act* (Bill C-5 in Parliament).

High use caribou habitat based on telemetry work was mapped and zoned as "Caribou Habitat" in the *Revelstoke and Area Land Use Planning Final Recommendations - Minister's Advisory Committee Plan* (MAC Plan 1999). Proposed guidelines are for retention of 40% Age Class 8 or greater (minimum 140 years old) in areas designated as caribou management areas. This recommendation recognizes that there is a "moderate risk" to the Revelstoke caribou herd due to habitat loss and fragmentation. (MAC Plan 1999) (Appendix B - Caribou habitat requirements.)

Much of the mapped caribou zone within the Revelstoke TSA is already fragmented by the pattern of large clearcut and leave areas (checkerboard pattern). Many of these cutblocks are reaching immature forest stages known to contribute to caribou decline in other areas. Retained old growth will soon be interspersed with very dense plantations, the result of intensive, successful planting programs and natural regeneration. Caribou avoid immature to mature stages of forest development. Silvicultural treatments have the potential to lessen the time that plantations are barriers to caribou movement, and accelerate stand development of habitat attributes used by mountain caribou including lichen biomass development, understory falsebox development and snow interception.

The purpose of this report is to provide guidance and ecological justification for managers and silviculture foresters to plan, prescribe, implement and monitor silviculture treatments to meet caribou habitat requirements and timber harvesting objectives. This information should be linked to higher level and land use plans and to any future Landscape Unit Plans. An adaptive management approach is suggested for implementation, including a plan for monitoring and a list of further research needs. More information is needed to develop decision support tools to help augment caribou habitat requirements and retain future options for management.

1.2 Objectives

The objectives of this report are to:

1. Identify attributes of preferred caribou habitat that can be modified or created in forests using silvicultural treatments. (Section 2)
2. Develop guidelines for choosing and ranking second growth stands for caribou habitat recruitment treatments in the Revelstoke Timber Supply Area (TSA). (Section 5)
3. Propose specific silviculture treatments for recruiting caribou habitat in second growth stands in the Revelstoke TSA. (Section 4)
4. Propose specific silvicultural treatments for maintaining caribou habitat within the old and mature timber types in the Engelmann Spruce Subalpine Fir (ESSF) biogeoclimatic subzone within the Revelstoke TSA. (Section 4.4)
5. Propose using an adaptive management framework for monitoring and refining guidelines and improving prescriptions for recruiting caribou habitat in second growth forests in the Revelstoke TSA. (Section 7)

1.3 Workshop

A workshop was held to disseminate the preliminary results of the proposed methodology to recruit caribou habitat using silviculture treatments. The purpose was to collect input from invited participants on the recommended guidelines and adaptive management framework. A list of participants, the agenda, and a list of questions that participants were asked are included in Appendix A. The B.C. Ministry of Environment, Lands and Parks, the Ministry of Forests, forest licensees, Parks Canada and consultants participated in this process. The results of the input have been incorporated into this report.

1.4 Location

The geographic area covered in this report is the Revelstoke portion of the Columbia Forest District, north of Revelstoke. See Figure 1.

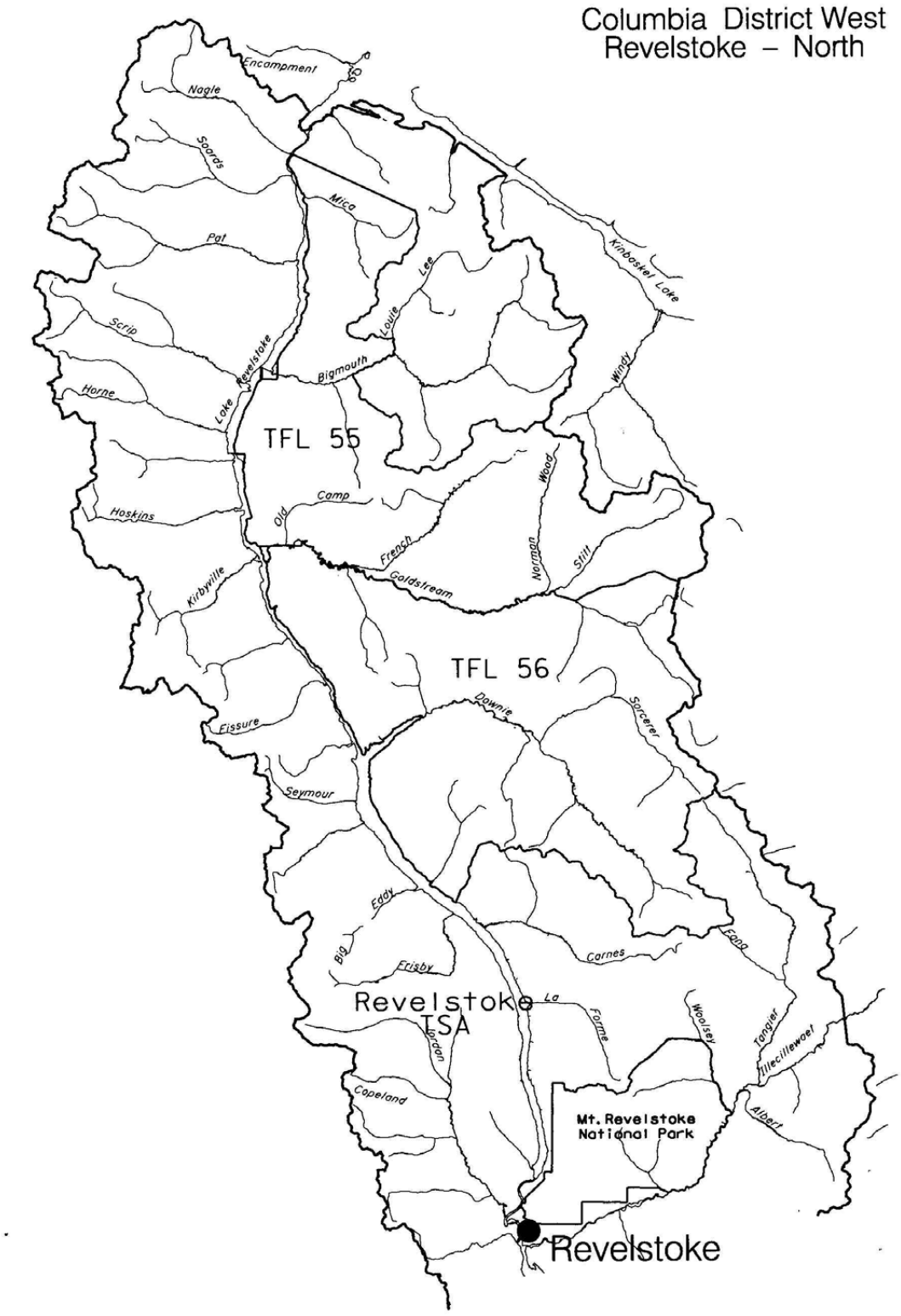

Figure 1. Location of Study Area: Revelstoke Timber Supply Area - North

The Revelstoke TSA is located within the Selkirk and Monashee Ranges of the Columbia Mountains (Fig 1). The topography is rugged with steep hillsides and narrow valleys. Elevations range from 475 m to 2700 m. Treeline is at approximately 2000 m. The lower slopes are within the Interior Cedar Hemlock biogeoclimatic subzones (ICHmw3,wk and vk) which extend from the valley bottom to approximately 1350 metres. These forests are dominated by western hemlock, western red cedar, with some Engelmann spruce and a minor amount of Douglas-fir, subalpine fir and white pine. On zonal sites the understorey shrub and herb layer is dominated by small amounts of falsebox, oval-leaved blueberry, oak fern, one-leaved foamflower and queens cup.

The Engelmann Spruce – Subalpine Fir (ESSF) biogeoclimatic (BEC) zone occurs above the ICH at elevations above 1350 m. Between 1350 to 1650 m elevation lies the "Very Wet, Cold Engelmann Spruce – Subalpine Fir subzone (ESSFvc). On zonal sites the forests are dominated by subalpine fir, Engelmann spruce and mountain hemlock. White flowered rhododendron, black huckleberry, oval-leaved blueberry and false azalea are the most common shrubs (Braumandl and Curran 1992).

Above the ESSFvc biogeoclimatic subzone lies the ESSFvv (very wet, very cold) (Braumandl 2001, personal communication). This subzone is characterized by long, cold winters with a high snow cover, and short, cool summers. However, the ESSFvv is not delineated due to mapping limitations. Above this subzone lies the Very Wet, Cold Parkland Engelmann Spruce – Subalpine Fir (ESSFvcp) subzone. This zone is above the operable forest land base.

2.0 Mountain Caribou Habitat

2.1 Attributes of preferred mountain caribou habitat

Mountain caribou make elevation movements in response to factors such as snow conditions, forage availability, and predation pressure. During the early winter the caribou use the ICH subzones and move up through the ESSF in the late winter to the upper ESSF and the ESSF parkland (See Figure 2). They consistently show a preference for old forests and an avoidance of young forests, especially during winter (Stevenson et al. 2001).

Suitable winter habitat for mountain caribou has characteristics of old forests (at least 140 years) including abundant arboreal lichens. Forests managed under any silvicultural system that eventually eliminates, or substantially reduces, the number of large, old, lichen-bearing trees will not provide winter habitat for caribou (Stevenson et al. 2001).

During the early winter, caribou show a preference on broad landscapes for low elevations in the ICH, and gentle terrain. On a finer scale they prefer old western hemlock leading stands, and high canopy closure for cover and snow interception. Arboreal lichens on standing and windthrown trees, lichen litterfall, and falsebox are important food sources for caribou during early winter (Terry et al. 2000).

During late winter, caribou prefer high elevations (ESSFvc, vv, vcp), old spruce and subalpine fir stands, low canopy closure (usually attributed to low site productivity), and gentle terrain. They prefer feeding on the arboreal lichen on subalpine fir to that of spruce and mountain hemlock (Apps et al. in press).

In the summer, caribou prefer higher elevations, old subalpine fir leading forest cover, and gentle terrain. In the spring, caribou are found in open avalanche paths, recent clear cuts and old forests at low elevations.

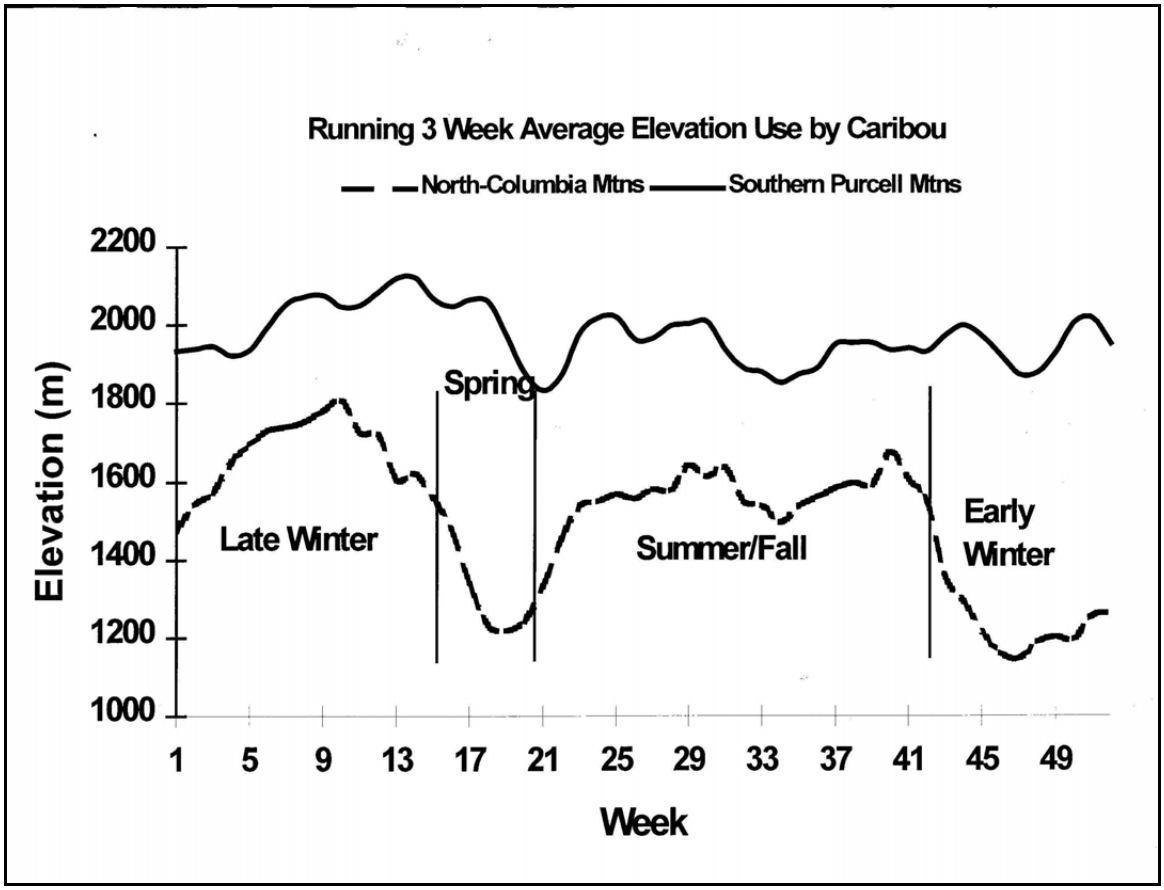

Figure 2. Seasonal Caribou Habitat Use by Elevation
(McLellan and Flaa unpublished)

2.1.1 Canopy Closure

As described in Armleder and Waterhouse (1994), old stands provide thermal benefits and superior snow interception due to their multi-layered structure and deep spreading crowns of older trees. They also provide lichen litter fall and pockets of available forage such as falsebox.

2.1.2 Lichen Availability

There are at least thirteen species of epiphytic arboreal hair lichen within the winter range of mountain caribou: ten species of *Bryoria*, two of *Nodobryoria* and one species of *Alectoria* (Goward 2001). During the winter, mountain caribou feed almost exclusively

on arboreal lichens, and chose *Bryoria* over *Alectoria* (Stevenson & Hatler 1985; Antifeau 1987; Rominger, Robbins & Evans 1996).

The distribution and abundance of arboreal lichens in forest stands is intimately connected with the structure of those stands. In the upper canopy, lichen receives more light, rain and snow, and greater ventilation, leading to rapid drying. Hence there is usually more *Bryoria* in the upper canopy. The lower canopy receives less light, and can stay wet for prolonged periods due to higher humidity and stiller air, resulting in more *Alectoria* lichen (Stevenson et al. 2001).

In the high elevation ESSF stands, Goward (2001) has recognized three vertical zones of *Bryoria* abundance in the canopies. Zone A is restricted to the basal portion of the trees, often extending 2 to 5 meters above the ground. Here, hair lichen loadings are negligible, probably as a result of prolonged wetting due to the heavy winter snow packs. Zone B is above Zone A, and supports negligible to heavy *Bryoria* loading. Zone C, which is above Zone B at the top of the tree, is the region of maximum *Bryoria* abundance, which benefit from exposure to high levels of ventilation. Heavy loadings within Zone B depend on copious litterfall from Zone C (Goward 2001). *Bryoria* abundance is significantly higher on the branches of trees growing in clumps than on isolated trees within the same stand (Campbell and Coxson, in press).

In the lower elevation ICH stands, the canopy is more closed, mature trees are taller, and the wind is generally more moderate than in the ESSF. Therefore, the zone of still air and higher humidity extends further into the canopy. In the lower canopy, *Alectoria* is often dominant.

Wind is the primary mode of dispersal for both *Alectoria* and *Bryoria*, and the tallest trees in a stand are especially important as dispersal sources. They support disproportionately high lichen biomass, and the distance that wind-borne thallus fragments travel increases with the height of its release point (Stevenson et al. 2001).

Many studies confirm that old-growth forests have more abundant, diverse and variable lichen communities than younger stands (Enns et al. 1999; Goward 1998; Stevenson 1998; Neitlich et al. 1997). Although lichen colonizes trees at early ages, it does not usually achieve appreciable biomass until much later. Goward (1998) proposes that the relationship between lichen abundance and the foliated versus unfoliated branches is very important. Wide crowns and large branches of open grown old-growth trees provide an inner drying cone and increased ventilation, allowing the development of very high lichen biomass. Observations indicate that *Bryoria* biomass is much heavier in the defoliated zone than in the foliated zone, probably due to prolonged wetting in the foliated zone.

2.1.3 Falsebox Availability

During the early winter, caribou consume evergreen shrubs such as falsebox (*Pachistima myrsinites*) along with arboreal lichen. Although Rominger et al. (2000) suggested falsebox is not a preferred forage item while arboreal lichens are available on

windthrown trees, McLellan and Terry's (in press) work indicate that falsebox is heavily used as an alternative food source.

Falsebox[1] is a shrub that occurs from British Columbia south into California and Mexico and east through the Rocky Mountains. In British Columbia it occurs between 500 and 1500 m elevation. It is a native, cool-season, evergreen shrub, whose stems can layer and root, and can be propagated easily through stem cuttings. Seeds are dispersed by gravity. Falsebox grows on dry to moist sites in shaded mountain areas. It occurs on well drained, shallow and a variety of soils; in BC it occurs on podzols and regosols. It is a climax shrub and can tolerate both sun and shade, but it usually indicates dry to moist, cool sites and well-drained soils.

Following fire, falsebox can sprout from buds on the taproot, or from the root crown. Some seedling establishment via short-term viability seed stored on site may also occur. (U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory 2001).

Within the Revelstoke TSA, falsebox is found with coverage of greater than 10% almost exclusively in the ICHwk-04, primarily on subxeric sites (but with a number of sites with submesic or xeric), often on warm aspects and with variable overstory canopy closure and stand age. There has been only one stand sampled in the ICHvk1-03 (submesic) and ICHwk-01 that had over 10% falsebox (Braumandl, T. personal communication). Falsebox is considered important forage for caribou as well as deer, elk, and moose. In general, production seems to increase in logged areas.

Rominger et al. (2000) studied the nutrient content of falsebox; their findings indicate that falsebox grown in the open (in young clearcuts) is not as digestible as that found underneath an old-growth canopy. This is due in part to higher levels of phenolics and tannins. Tannins have an inhibitory influence on both protein and dry matter digestibility in ruminants (Rominger et al. 2000). Also, foliar concentrations of nitrogen, phosphorous and potassium are generally higher when grown in lower light levels than in the open clear cuts, probably as a result of reduced carbon fixation (Van Horne et al. 1988). The combined effects of lower concentrations of nitrogen and higher concentrations of tannins result in an overall halving of the concentration of digestible protein in the leaves growing in clearcuts relative to those growing in the forests (Hanley et al. 1987).

2.2 Limitations of Early Seral Forests

Caribou prefer open stands that permit easy movement and good sight lines for predator avoidance. Silvicultural systems or treatments within or adjacent to caribou range should not enhance deer or moose habitat. The proximity of these early successional stands to retained old-growth caribou habitat can increase the vulnerability of caribou to predation. This increased risk of predation combined with low calf production can result in population declines.

[1] *Other common names are: boxwood, mountain box, myrtle bush, boxleaf, and Oregon boxwood.*

3.0 Caribou Habitat Recruitment

3.1 Stand Structural Variability in the Revelstoke TSA

Fifty six percent (56%) of the stands in the operable land base within the Revelstoke TSA are over 140 years old, while 23% are less than 20 years old; 15% are between 21 and 100 years; and just over 28% of the stands are older than 250 years (MOF - TSR, 1999). Timber harvesting will continue to reduce the amount of old growth and increase the quantity of young stands. Many of these stands are within the stand initiation or stem exclusion phase of structural development (See Figure 3). Timber management tends to simplify forests and reduce biodiversity (Carey et al. 1996).

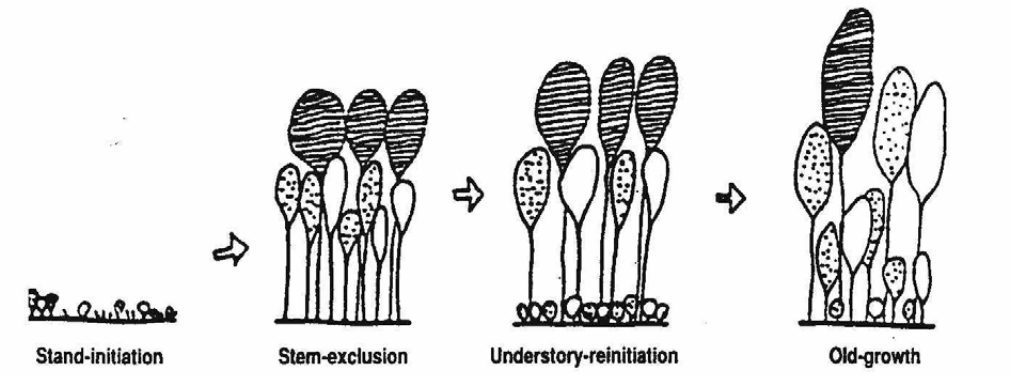

Figure 3: Changes in stand structure following disturbance (Oliver 1992)

The purpose of the silvicultural treatments to recruit caribou habitat is to place the stand on a trajectory towards developing old-growth characteristics sooner than without treatment. It is important to manage stands where a range of objectives can be met, including caribou habitat recruitment, timber production, and biodiversity.

3.2 Forest Planning Considerations

There must be a connection between forest management landscape level objectives and stand level silviculture objectives. A comprehensive forest management strategy is required to make rational choices of stand level treatments. Silvicultural regimes should foster densities and pattern of trees that maintain, enhance or recruit critical habitats (Guidelines for Stand Density Management Regimes 1999).

Studies by Oliver (1992) propose that maintaining populations of wildlife species by managing for each species individually is impossible. Rather, we manage for biodiversity by maintaining the habitat, forest structures and attributes where these species are found. The solution lies at the landscape level where diverse structures and patterns across the landscape can be maintained for a diversity of plants and animals. Biodiversity can only effectively be promoted in forest structure at the landscape level, where the balance of stands in diverse structures and patterns can be maintained for a diversity of plants and animals. Managed forests don't have the same stand structure that large areas of naturally forested areas have. Therefore, the most feasible method of

maintaining diversity in managed forests is to use silviculture treatments to maintain a target distribution of structures across a landscape at any given time.

3.3 Management Objectives for Habitat Recruitment

The Revelstoke and Area Land Use Planning Recommendations (MAC Plan 1999) states: "Within the ICH caribou habitat zone a minimum of 40% of the landbase (below 1994 operability line) will be in age class 8 or older (>140 years), with _ of this area having age class 9 (>250 years) forests. Within the ESSF caribou habitat zone, two options exist: 1) A minimum of 30% of the landbase must have forest in age class 8 or older, with at least 1/3 of this area having age class 9 forests and on an additional 20% of the landbase, partial cutting is acceptable so long as the removal of timber will not exceed 35%, with green-up defined as age class 7 or greater; or 2) A minimum of 40 % of the landbase must have forests in age class 8 or older, with at least one quarter of this having age class 9 forests". (See Appendix B).

As insurance to cover natural losses of older forests, it is necessary to augment this target retention. An objective to develop a certain amount of habitat per time period (i.e., per decade) needs to be defined. The amount of habitat should be based on historical losses, acceptable risk, ecological consideration, and an estimated success factor for recruitment treatments. A second objective for recruiting caribou habitat is to reduce the impacts of habitat fragmentation, by managing stands to encourage caribou movement, as well as growth and availability of lichen and falsebox.

Silviculture treatments may be able to increase the rate of stand development towards suitable caribou habitat, in conjunction with natural processes. Studies indicate that managed forests have the potential to provide the building blocks for a landscape with the capability of providing for the needs of late-succession dependent wildlife. They can provide the diversity, structure, and function that mimic, and suggest the capacity of, old-growth forests (Carey et al, 1996, Bailey, 1996). However, "no stand or density management treatment can possibly meet the needs of all wildlife species through all stages of stand development" (Guidelines for Stand Density Management Regimes, 1999).

Management cannot create "old growth". "We cannot produce old growth from second growth because old growth develops under unique ecological, climatic and disturbance regimes that we cannot hope to duplicate. It varies in age, geomorphic location, structure and organization. In other words, there is no single entity "old growth": old growth is a collection of various forest ecosystems that developed over periods of 200 –1,000 years from various biotic communities, under various climatic regimes, and in different physiographic provinces." *(Carey et al., 1996).* Using silviculture treatments to recruit caribou habitat should be attempted in recognition of this ecological limitation.

3.3.1 Defining Structural and Stocking Objectives for Caribou Habitat

Silviculture treatments can create a variety of desired stand structures. It is important to clearly define the specific objectives that the silviculture treatment is trying to achieve.

Appendix B lists general stand level management objectives and silvicultural strategies for caribou winter habitat taken from the MAC Plan (1999). These are intended to guide forest management operations and should be considered when developing silvicultural prescriptions within caribou habitat.

The attributes of caribou habitat described in Section 2.0 indicate that "old growthness" is important. However, defining the characteristics of that "old growthness" in a quantifiable manner is difficult. There has been little work to date on determining methods of assessing old-growth forests in the Biogeoclimatic subzones within the Revelstoke TSA (ICHwk, vk, mw3 or in the ESSFvc, vv). There has been some work done by Holt and Braumandl (1999), and Quesnel (1996) on the drier BEC subzones within the Nelson Forest Region. *Assessment and characterization of old-growth stands in the Nelson Forest Region* conducted by Quesnel (1996) indicates that within the wetter ICH (wk, vk) there needs to be a minimum of 60 stems/hectare greater than 50 cm dbh to meet "old-growth criteria". On zonal sites within the ICHwk there were approximately 20% snags (dead useless and dead potential), 50% suspect (includes stems with dead and broken tops, or scars, forks, crooks, conks) and 30% were healthy.

The following information lists the microhabitat characteristics found at caribou foraging areas north of Revelstoke. Refer to Appendix C for graphs of stems/ha by species (live and dead) and by diameter class, found at caribou foraging areas in the ICH and ESSF.

Table 1: Forest microhabitat characteristics found at caribou foraging areas stratified by biogeoclimatic zone. North Columbia Mountains, B.C. 1992-1999. (McLellan and Terry in press)

Variable	ICH	ESSFvc	ESSFvcp
Live tree density (stems/ha)[1]	503	557	415
Snag tree density (stems/ha)[1]	97	81	53
Total tree density (stems/ha)[1]	601	638	468
Live basal area (m^2/ha)	37	35	19
Snag basal area (m^2/ha)	5	5	1
Total basal area (m^2/ha)	42	40	20
% Western Hemlock	44	26	0.0
% Western Red Cedar	25	6	0.0
% Engelmann Spruce	6	23	8
% Subalpine fir	7	33	91
% Other	13	11	1
Average DBH (cm)	35	28	27
% Slope	35	32	21
Lichen abundance[2]	0.389	0.684	-
% *Bryoria*	27	66	-

Note: Data are from fixed area (0.01 ha) plots except basal area.
[1]Stems/ha is for stems over 7 cm dbh. [2]Number 10 g clumps.

Table 2. Microhabitat tree characteristics found at caribou foraging areas stratified by biogeoclimatic zone. North Columbia Mountains, B.C. 1992-1999. (McLellan and Terry in press)

BEC Subzone	Total Stems/ha		Live Stems/ha		Dead Stems/ha	
	Over 19 cm dbh	Over 50 cm dbh	Over 19 cm dbh	Over 50 cm dbh	Over 19 cm dbh	Over 50 cm dbh
ICH(mw3,wk,vk)	319 Hw5Cw2F08(Ba,Se,Pw)	102	272	83	47	19
ESSF(vc, vcp)	287 Bl6Hm1S1Hw1	47	252	37	35	10

A list of desired stand attributes was derived from the above information.

Desired stand attributes for caribou habitat include:

- Multi-storied canopy consisting of a range of tree species, ages and sizes.
- Diameter and species distribution similar to graphs in Appendix C.
- In the ICH and ESSF manage for approximately 300 sph at age 140 years +.
- Large-diameter standing snags and fallen logs: ICH - minimum 30 snags/ha, with 10/ha over 50 cm dbh; ESSF – minimum 25 snags/ha, with 5/ha over 50 cm dbh.
- Diverse understory including falsebox for caribou forage in the early winter, in ICH habitat.
- Heavy *Alectoria* and *Bryoria* lichen loads that are available to caribou, either by foraging directly on the tree, litterfall or wind blown trees.

4.0 Proposed Planning and Silvicultural Treatments to Recruit Caribou Habitat

Efforts to rehabilitate caribou habitat after clearcutting have met with limited success. Therefore, it is better to use partial cutting where feasible and retain caribou habitat features rather than clearcutting and attempting restoration. On areas recently clearcut, it may take many decades to establish even modest lichen-bearing habitat, and it may take more than a hundred years for enough lichen biomass to re-establish to be useful to caribou (Stevenson, et al. 2000).

Silvicultural treatments have the potential to reduce the amount of time that plantations are barriers to caribou movement. They may also accelerate stand development of habitat attributes used by mountain caribou including lichen biomass, falsebox understory and snow interception. Silvicultural systems need to maintain falsebox in the understory (McLellan and Terry in press) and maintain or increase the lichen abundance in caribou habitat. “Protecting gaps, hardwoods, wolf trees, and old-growth remnant trees during thinning or other partial cutting is likely to promote the majority of epiphytic macrolichens in young conifer forests.” (Neitlich and McCune 1997).

The proposed silvicultural treatments in this section will require a considerable amount of time for the stand to develop the desired attributes, and stands may need repeated entries to recruit preferred caribou habitat.

4.1 Assessment Process

It is important to determine which stands within the landscape need silviculture treatment to encourage growth and to put them on a trajectory towards old growth sooner than without treatment. Section 3.0 states the structural attributes that we need to manage for, Section 5.0 deals with the methodology for ranking stands for treatment, and this section proposes specific silviculture treatments.

Once the blocks have been field reviewed, a minimum of two (and preferably three) different types of treatments should be established, in addition to a control. The intention is to monitor these treatments for several decades to determine if they are meeting the management objectives. See Section 7.0 for details on adaptive management.

This section proposes silvicultural treatments for three broad categories of stand ages, with corresponding management objectives:

1) **Young Stands: Aged 20 – 50 years:** Improve sight lines, make the stand more open with large crowned trees and reduce potential habitat connectivity issues. Treatment should set the stand up for commercial thinning and/or future selection harvesting, while increasing development and value of caribou habitat.
2) **Older Stands: Aged 50 – 140 years:** Manage for and encourage late seral stand attributes to recruit caribou habitat sooner than without treatment, including recruitment of snags.
3) **Old Growth (140 yrs +):** Recommend silvicultural treatments including single tree selection, group selection and variable retention to maintain caribou habitat (Section 6.4). Snag recruitment should be increased.

The following is a summary of the methods to review and plan stands for caribou habitat recruitment:

Planning and Assessment Process for Caribou Habitat Recruitment (CHR) treatments:

1. Determine if the landscape and subunit area proposed for treatment is a high priority area for caribou habitat management.
2. Identify vertical and horizontal corridors spatially.
3. Identify planned harvesting in the area (Forest Development Plan maps).
4. Prepare a list of all openings within the identified corridors using the following criteria: *stands over 20 years old, with more than 3,500 total trees/ha*.
5. Identify other opportunities for treatment (i.e., older stands originating from a fire or other catastrophic events).
6. Evaluate stands using the ranking guide.
7. Conduct a field review to confirm priorities.
8. Prepare a plan for silviculture treatments within the drainage or subunit.
9. Within the high priority stands, rank for treatment over the next five years based on stand attributes and available funding.

10. Prepare Stand Management Prescriptions (SMPs) for spacing, pruning and other incremental activities.
11. Prepare Silviculture Prescriptions (SP) for commercial thinning and harvesting operations.
11. Conduct a Pre-Stand Tending Survey, or other appropriate field assessment for units planned for treatment, and implement.

4.2 Silviculture Treatments for Second Growth Stands

The following is a list of silvicultural treatments that may be appropriate for recruiting caribou habitat. For further information to prepare silviculture and stand management prescriptions, refer to the list of reference material in Appendix H.

Summary of Stand Management Strategies:

1. Conserve existing stand attributes at harvest related to caribou habitat, such as snags, large live trees and advanced regeneration.
2. Minimize site preparation, plant widely spaced trees (400-500/ha), and allow natural regeneration of western hemlock, western red cedar and deciduous species.
3. Create snags with branches to increase habitat for lichen development.
4. Use spacing to shorten the competitive exclusion stage. Early spacing is preferred (<40 yrs). This could speed up the development of large canopies and clumpy tree distribution.
5. Use a combination of spacing and commercial thinning.
6. Create heterogeneity with less uniform spacing (use a range of densities based on the landscape objectives).
7. Maintain shade tolerant advanced regeneration species.

4.2.1 Espacement and Species Selection

Plantation espacement in BC since 1940 has ranged from about 2 m (2500 trees/ha) to 4 m inter tree spacing (625 trees/ha) (*Guidelines for Developing Stand Density Management Regimes* 1999). Espacement affects site utilization and volume production for timber.

The desired clumpy and uneven tree distribution for caribou habitat may lead to reduced initial planting densities, and consequently reduced stocking at free growing. A range of initial planting densities and different patterns (clumps) should be considered. (There should not be an automatic conclusion that timber quantity will be affected. Modelling and analysis can be conducted to further explore the timber quality and quantity implications.)

Species preference for reforestation should consider the growing environment that the seedlings will encounter. In small patches, it is important to match the species to the range in light levels found in partial cuts or clumpy densities. It is also important to recognize that in the ICH caribou habitat, there is usually a high percentage of western hemlock followed by western red cedar. Therefore, it is important to ensure that these

species are included in the prescribed mix. In the ESSF, subalpine fir is a preferred species for lichen forage production. Therefore, it is important to encourage a percentage of subalpine fir in conjunction with spruce and mountain hemlock where appropriate.

4.2.2 Spacing

Stand treatments need to address stand succession over time, recognizing that younger stands are not expected to function as caribou habitat, but may provide more suitable opportunities for caribou habitat to develop. Objectives of initial spacing are to accelerate the development of old-growth characteristics. As described in Section 3.3, there is potential to mimic, and suggest the capacity of, old growth forests by managing for the diversity, structure and function needed by late-succession dependent wildlife (Carey et al 1996; Bailey 1996).

Spacing is an important tool in managing dense young stands to create or enhance diverse structures typical of older forests: larger trees growing faster, reduced mortality in small diameter classes, larger crowns on residual trees, and better opportunities for intermediate and understorey growth below the main canopy (Bailey 1996). Site specific and stand-age specific prescriptions with differing optimal spacing and stand attributes will vary across the district with elevation, topographic position, aspect and time.

Early spacing (<40 yrs) provides the best opportunity to maintain large crown ratios and rapid growth rates. Managers can create stand spatial heterogeneity with heavier and/or less uniform thinning. Thinnings to promote old-growth characteristics should favour shade tolerant advanced regeneration, given its potential to contribute to a multi-storied canopy (Bailey 1996). It is important to vary the intensity and arrangement of spacing to provide more old-growth habitat over time and across the landscape. See Figure 4.

The optimum early densities for recruiting caribou habitat to achieve eventual old-growth attributes are not known. Therefore, it is important to try a range of spacing densities and distribution and monitor over time for effectiveness. Multi-storied stands with gaps, and variable densities with wide, long crowns are desirable; therefore, relatively wide spacing and clumpy distribution is recommended. Spacing for caribou habitat recruitment should also address the following desired features:

Snags/ large live wildlife trees – Retain where feasible, it may be necessary to establish reserves around these for safety reasons. Recruit where possible, by girdling, inoculation, etc.

Vertical Structure of the Stand – The relative heights and varied canopy levels should be retained and encouraged to develop.

Horizontal Structure – Maintain a variety of stocking levels to provide forage opportunities and shelter. Wide, open spacing will encourage lichen growth. Dense thickets will reduce sight lines. Consider retaining clumps during spacing to achieve a diverse horizontal structure.

Forest Health – *Armillaria* is prevalent throughout the ICH. Where *Armillaria* is noted within a stand, take appropriate action for forest health purposes and recognize that this condition will help to create natural clumpiness.

Clumpy Spacing – "The goal of clumpy spacing is to use the growing space fully and obtain timber volumes similar to those achieved by standard spacing on similar sites. Clumpy spacing prescriptions can result in a wide range of post-treatment densities, which will vary according to pre-treatment stand structure, the prescription, and the contract specifications." (Armleder 1999). In Extension Note # 32 (Armleder 1999), there are recommendations for planning for clumpy spacing, and suggestions for contractual clauses to carry out the work in the field. It is important to monitor and compare clumpy spacing with the results of standard spacing.

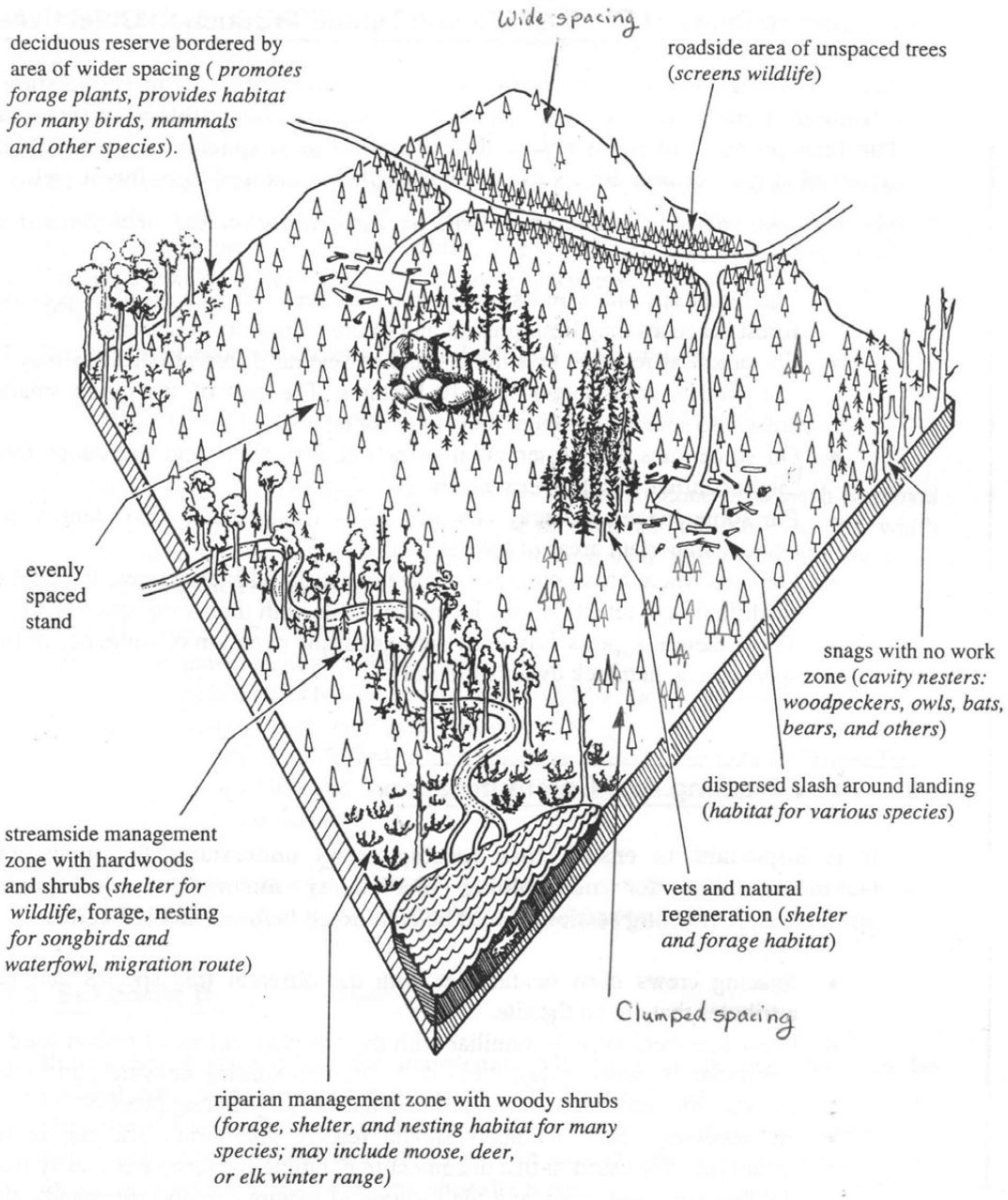

Figure 4. Perspective view of a spaced stand in which attributes that support biodiversity are maintained or enhanced (Taken from *Guidelines for Maintaining Biodiversity during Juvenile Spacing*, 1993)

For further information on spacing, refer to the *Forest Practices Code Guidebook for Spacing* (1995) as well as *Guidelines for Maintaining Biodiversity During Juvenile Spacing* (1993).

4.2.3 Pruning

Pruning improves stand and forest values by: reducing the size of knotty core and increasing clear wood production; improving wood quality; increasing log value; reducing stem taper; and reducing white pine blister rust. (*FPC Pruning Guidebook* 1995).

Pruning can also be used to reduce increase sight lines by pruning a percentage of the stems within a spaced stand. If the spacing regime includes leaving clumps of trees, pruning those trees on the edge of the clumps is suggested. Refer to the *FPC Pruning Guidebook* (1995) for further information.

Pruning must be included in the prescription where special management areas for caribou habitat recruitment include spacing densities that are at least 30% lower than the minimum stocking level specified in the *Establishment to Free Growing Guidebook.*

4.2.4 Commercial Thinning

Depending on tree size and thinning intensity, commercial thinning can create relatively large holes in the stand canopy that are reoccupied slowly by the crowns of the leave trees. In Europe it is common practice to conduct a series of frequent, light, low thinnings, intended to capture the wood that would be lost to mortality if untreated. *Developing Stand Density Management Regimes* (1999) states that commercial thinning is not likely to produce extra volume, unless a regime of frequent, light (5% removal) entries is implemented. It will provide an earlier interim harvest by removing wood sooner, but may also delay the final harvest.

Commercial thinning has the potential to move the stand towards developing more old-growth attributes by increasing the diameters, and possibly limbiness of the remaining trees. However, it will be important to either retain or possibly create snags through girdling to recruit caribou habitat. It will probably be necessary to extend the rotation age to 130 years or greater in order for these attributes to fully develop. Where long-term retention of caribou habitat is required, it may be necessary to move the stand towards uneven-aged management to retain mature forest cover on the site.

If commercial thinning is anticipated for a stand, it must be planned for, and a suitable number of stems left after spacing to allow for the interim harvest. For example, if 500 Douglas fir stems/ha would be left with no commercial thinning planned, 800 to 1100 stems/ha after spacing may be appropriate where a subsequent commercial thinning is planned.

4.3 Setting Standards for Establishment to Free Growing and for Second Growth Stands (Post-Free Growing)

The *Establishment to Free Growing Guidelines* recommend stocking standards by site series based on even-aged management of forests with standard stem distribution. When clumpy distributions are proposed, or when management objectives are for wildlife habitat, the District Manager can justifiably accept standards that differ from those recommended in the Guidebook.

Prescribing foresters are encouraged to provide a rationale when proposing standards that differ from the guidelines. In addition, local MoF and MELP staff should be consulted as the proposed standards are being developed, to further provide justification for the proposed standards.

There is often concern that if the proposed standards deviate from those recommended in the guidebooks, there would be a negative impact on timber supply. If this is a concern for the treatments proposed for caribou habitat recruitment, an analysis of timber supply impact should be conducted. The MoF Forest Practices Branch can provide additional guidance on the need for such an analysis, particularly if a Silviculture Strategy has not already considered the timber supply impact.

Maximum density may be an issue when managing for caribou habitat recruitment. The standard default maximum of 10,000 stems per hectare can be modified if the management objectives are for partial cutting, wildlife habitat, or succession management. The intent of the stand density policy is to encourage licensees to avoid creating undesirable high density stands through improper silviculture treatments.

For information on density management see:
http://www.for.gov.bc.ca/hfp/pubs/stand%5Fdensity%5Fmgt/maxchng2.htm

For a copy of the Chief Forester's policy on stand density management see:
http://www.for.gov.bc.ca/tasb/manuals/policy/resmngmt/rm2-24.htm

The following has been taken from the Chief Foresters Policy 2.24, as shown on the above website:

How to deal with density management practices on special areas:
There may be areas within a management unit that require analysis, evaluation, and selection of stand density management regimes that differ from the stand and forest level process outlined in the *Guidelines*.
Wildlife habitat - consider appropriate wildlife habitat guidance (e.g., guidelines for managing Goshawk, Woodpecker, Mule deer, Caribou, Elk, Grizzly Bear) to develop density management regimes. Any areas that are identified as Wildlife Habitat Areas or Special Management Zones may need to be separately evaluated to select a stand density management regime that adequately maintains or produces desired wildlife habitat conditions.
Partial cutting - for partial cutting in mixed species and all-aged stands, density management regimes should be developed using best available information and discussion with subject matter experts.
Landscape level forest succession - there may be opportunities to use stand density management to achieve old growth stand structure objectives. Where there are succession imbalances or limitations in the management unit, density management regimes may be developed that contribute to landscape level objectives.

Table 3. Stand densities for specific wildlife habitat for even-aged systems. ***Note: New Caribou Habitat guidelines are proposed below.*** **(FPC Spacing Guidebook 1995)**

Management Goals	Maximum Density (sph) (pre-thining, countable trees[e])	Target Stocking Standard (sph) (well spaced)	Maximum post spacing density (sph) (well spaced)	Minimum post-spacing density (sph) (well spaced)
Sawlogs – and Grizzly Bear Habitat (BC Coast)[a]	TSS[b]+ 100 sph	400 – 600[c]	TSS + 600 sph	TSS minus 100 sph
Sawlogs –deer and Elk – coast.[d]	600	500	600	400
Sawlog – Caribou habitat – Columbia Mountains[d]	TSS + 1000	500 – 1200	TSS + 200	400

[a, d] *Taken from the Forest Practices Code- Spacing Guidebook, (1995). Guideline 7.*

[b] *TSS = Target Stocking Standard (is usually 1200 sph depending on BEC site series)*

[c] *Precise target is dependent on the site series*

[d] ***Proposed standards for discussion purposes only (need to be verified).***

[e] *Whether a tree is countable or not is referenced to the median height of the well spaced preferred and acceptable trees. (For example, if the average well spaced tree height is 5 m+ , then the minimum height for a tree to be countable is 1 m; this height decreases with average stand height. For uneven-aged single tree selection systems, the minimum countable height is 1.3 m (Silviculture Surveys Guidebook 1995))*

Within caribou habitat recruitment areas, it is appropriate to carefully consider the preferred and acceptable trees that you use in either the Silviculture Prescription (SP) or Stand Management Prescription (SMP). Late seral species should be considered preferred, along with a mix of early seral species. Preferred and acceptable species are usually selected from the *Establishment to Free Growing Guidebook* list of primary, secondary and tertiary species, which are listed by site series.

4.4 Silviculture Treatments to Maintain Caribou Habitat in Old Growth

The predominate silvicultural system within the Revelstoke portion of the Columbia Forest District is clear-cutting. There are many biological and economic reasons to use this system. However, there may be opportunities within caribou habitat to modify treatments to retain some old-growth structural legacies within stands. This provides flexibility for future passes and retains wildlife habitat within the ESSF and ICH.

It is more appropriate to try to mimic natural processes as much as possible when conducting initial harvesting operations. By retaining some of the original stand structure, it will be cheaper and easier to work towards better managing for habitat in the future. This includes retaining wildlife tree patches, advanced regeneration and snags, and any non-merchantable (and sometimes merchantable material) where technically feasible.

A percentage of the new harvesting within caribou habitat should leave all residuals and poor quality stems (any diameter) to reduce the slash loading. Where feasible, leave stems that have little to no merchantable value (more appropriate in conventional ground-based harvest systems). These may serve as lichen inoculation, could provide some of

the desired diseased and damaged trees (i.e., to form future snags), may release and form future crop trees, and will provide existing and future vertical structure.

Within the ICH, commercial thinning and uneven-aged management has the potential to maintain caribou habitat while permitting some timber extraction. Unfortunately this is not formally recognized in the Land Use Plan. However, where there are appropriate stand ages and structures, using single-tree selection, group selection and commercial thinning to promote late seral stand structure is appropriate and should be encouraged.

4.4.1 Maintaining Caribou Habitat in the ESSF Old Growth

It is important to retain flexibility when planning silvicultural systems in the ESSF caribou habitat. As mentioned in Section 1.2, the ESSFvv occupies a narrow elevation band starting at approximately 1620-1650 in areas mapped as ESSFwc2 and ESSFvc. However, it is not delineated due to mapping limitations. The stocking standards for this subzone are less than that found in the ESSFvc (*Land Management Handbook Number 23* - see Appendix F).

The *Mountain Caribou in Managed Forests* program began in 1988 to question if forest stands can be managed, through silvicultural systems and habitat enhancement techniques, to sustain both timber harvest and caribou habitat in the long term. The program has yielded an excellent report, which is recommended reading for all land use managers in caribou habitat. *Mountain Caribou in Managed Forests: Recommendations for Managers – Second Edition* (Stevenson et al. 2001), presently in press, contains numerous suggestions for management. With the permission of the authors, a section of this report is reproduced in Appendix H, which summarizes recommendations for silvicultural systems for maintaining caribou habitat in ESSF old-growth forests.

In addition to this report, there have been innovative operational trials set up in Blue River by Weyerhauser in the Clearwater Forest District, which has timber types and terrain similar to the Revelstoke TSA. Some of the recommendations include:
High Elevation ESSF cluster planting – minimum inter-tree spacing should be reduced to 1 m to take advantage of raised microsites and to avoid overhead debris and brushy areas. Gaps up to 5 m between tree groupings will be permitted. Retention (depending on site conditions, varies from 40% to 20-80 sph) – these stems will be left scattered or in clumps through the block where operationally feasible to provide thermal cover and a source of lichen recruitment for caribou. These trees will also function as perching and nesting trees and a source for future snags and coarse woody debris (Beiber 2001).

4.5 Prescription Development

4.5.1 Stand Level Decision Tools

Stand level decision-making tools should be used to help analyze the effects of various stand management treatments, and to assist in rationalizing treatment decisions. However, these tools are limited in scope and have a limited ability to model different treatments, especially in complex, mixed species stands. Therefore, their results should be tempered with local knowledge.

Some of the more common models and tools available include:
TIPSY – only allows one thinning at height 4 m, with even-aged management.
Stand Density Management Diagrams (SDMDs) – graphs of relationships between top height, mean diameter, stem density and mean volume per trees, as stands develop from various establishment densities.
PROGNOSIS – not well calibrated for the ICHwk and ESSFvc; however, allows even and uneven-aged management, models mixed species and permits PCT and CT entries.

Refer to Appendix I for a table listing other stand level decision support tools.

4.5.2 Prescriptions

Stand Management Prescriptions (SMPs) and Silviculture Prescriptions (SPs) are legally required for treatments. SMPs cover all post free growing treatments such as spacing and pruning, whereas an SP is required for commercial thinning and any harvesting. It is important to rationalize the chosen silviculture treatments. The long-term objectives should be clearly stated, including quantifiable stand structural objectives, rotation age, number of planned entries, etc., as this is the only way that the prescription can be effectively evaluated years later.

It is important to build flexibility into the prescription, with the option to amend the prescription as new and better information becomes available.

A new MOF SMP form is available to address non timber objectives. It is meant for riparian management zones; however, it can probably be easily adapted to caribou habitat recruitment prescriptions.

5.0 Methodology for Ranking Stands for Caribou Habitat Recruitment in the Revelstoke TSA

This section is divided into three levels of scale: landscape, drainage, and stand level criteria.

The following maps and references were used to assist with ranking (Appendix D):

- Caribou Locations and Census Map, 1999. 1:250,000.
- Ministers Advisory Committee Composite Map, 1999. 1:250,000.
- Topographic map (100 m contours).
- Map of the Revelstoke TSA with Forest Stand Age, 1996. 1:150,000.
- Biogeoclimatic Units of Columbia Forest District, 1999. 1:250,000.
- Overlay of Priorities for Caribou habitat recruitment based on ranking criteria.

The following sections list the ranking criteria and the rationale used to identify and priorize second growth stands for treatment feasibility for recruitment of caribou habitat.

5.1 Landscape Level Criteria

The *Revelstoke and Area Land Use Planning Minister's Advisory Committee Recommendations* determine the present management options in caribou habitat (See Appendix A). The proposed criteria below are derived directly from the MAC plan mapped caribou areas, and caribou management guidelines.

- ***1st Priority – MAC Plan – Caribou Habitat – Managed to Guidelines (current immature stands)*:** Potential caribou habitat in presently immature stands**.**
- ***2nd Priority – MAC Current Habitat – Manage to Guidelines:*** Maintain connectivity between fragmented areas within the current caribou habitat zone.
- ***3rd Priority – MAC Caribou Habitat – Manage to Intermediate Biodiversity:*** This area is a lower priority for recruitment because the retention guidelines are reduced; hence it is assumed that they are not as important.

With limited funds, post free growing activities should focus on the first and second priority areas.

5.2 Drainage (Subunit) Level Criteria

The following criteria are proposed for ranking drainages within the above listed caribou management areas. These criteria are listed in their perceived order of importance:

1. **Connectivity** between valuable habitats should be maintained and improved to try to rejoin subpopulations where feasible in strategic locations.

   1a) ***Degree of Present Fragmentation.***

   - ***1st priority –*** The area from Revelstoke north to the Goldstream: where reservoir, powerlines etc. have resulted in extensive fragmentation within Caribou habitat. Calf recruitment is down in this area, and this population needs the most intervention now.
   - ***2nd priority –*** North of the Goldstream: This area has not as yet been as heavily impacted. It is more important to ensure that new cuts are "Caribou friendly".

   1b) ***Implications of Not Treating:*** For example, if densely stocked second growth is blocking off more than 50% of movement through existing habitat, it may become a high priority for treatment.
2. **Age Class Distribution.** While older stands are more suitable for treatment, it is more important at this scale to give priority to areas with a *range* of the following age classes: 50 years +, 40-50 yrs, and < 40 years. Such a distribution contributes to landscape biodiversity and provides options to influence a variety of stands.
3. **Terrain** – Gentler, contiguous terrain is preferred to steeper. Slopes less than 40% are preferred habitat, although the MAC guidelines say that caribou habitat includes slopes up to 80%.
4. **Conflicting Use** – Areas with high levels of motorized recreation, such as snowmobile use and potentially heavily used heliski areas, may be a lower priority for treatment. This includes Frisby Ridge, Sale Mountain, and may

include the Keystone area in the future. If there are any known areas where proposed development may interfere with caribou use, such areas may be a lower priority.

5. **Planned Harvesting Development** – Proposed habitat treatments must be tied to the forest development plans for future harvesting and road building. In some cases, new roads may increase access in areas that were previously lower priority due to lack of access. In other cases, planned harvesting that will provide additional fragmentation to the area may change the priorities for treatment.
6. **Past and Future Silviculture Activities**- Past spacing and pruning operations should be identified in relation to caribou habitat to evaluate their current or potential recruitment value and determine if additional treatments might enhance existing recruitment. It may be appropriate to modify planned silvicultural activities to ensure that they achieve caribou recruitment goals as well as silvicultural goals. Silvicultural activities will need to be strategically planned to deal with landscape level issues, such as projected timber supply shortages.
7. **Adjacent to National Park/Protected Area** – These areas may be higher priority for treatment to recruit habitat to help maintain the herd that seasonally uses the parks.
8. **Biogeoclimatic Ecosystem Classification (BEC)** Presently the ICH is viewed as a higher priority for recruitment treatment because it has been more fragmented than the ESSF. Using the BEC subzone to rank the value of caribou habitat recruitment silvicultural treatments may be appropriate: ICHmw3>ICHwk1>ICHvk>ESSF.

5.2.1 Landscape and Drainage Level Priorities

Each drainage or major area should be evaluated in terms of past development, silviculture history, connectivity, caribou use and future concerns. Evaluation of the areas listed below should follow this approach. It is also important to evaluate the stand characteristics to establish the potential for treatment. This requires site history information as well as field reviews and surveys. It is also important to spatially identify vertical and horizontal "corridors" or "proposed recruitment" areas. This should be done in conjunction with a Ministry of Environment wildlife specialist. If this is not done, it is difficult to determine the best place to spend silviculture funds to recruit habitat.

Based on the criteria listed in Section 4.1 and 4.2, the following is a list of general areas within the Revelstoke TSA north of Revelstoke that would be appropriate for caribou habitat recruitment, following the criteria listed in the previous sections.

The following areas are identified on the map (Appendix D).

First Priority:

- Near Mount Revelstoke/Sale Mountain/Mars Basin (east side of Lake Revelstoke reservoir), Tangiers and Woolsey drainages.
- North of Downie River along Lake Revelstoke.
- South face of Mount Revelstoke.
- Lookout Mountain area.

Second Priority:

- West side of Lake Revelstoke Reservoir – North of Jordan River to Big Eddy, and Big Eddy to Kirbyville.
- North of the Goldstream – The priority for treatment in this area is expected to increase with time. There is a significant amount of private land (Beaumount Tree Farm), which has been heavily harvested in the past. The private land is a high priority for treatment.
- Other areas that were identified as a high priority are Nichol Creek and Bench Road areas.

5.3 Stand Level Criteria

The following is a list of criteria to be considered when evaluating individual stands for silviculture treatment. The weighting of these criteria will change, depending on the objectives for the treatment and the stand age.

1. **Existing stand structure**:
    a. Densely stocked stands are a high priority for treatment (3500 total sph or greater suggested).
    b. Complex vertical structure is a higher priority for treatment than simple structure, as silviculture treatment can add to the existing attributes.
    c. Crown closure (prefer 30 – 50%; depends on stand age).
    d. Stocking distribution: stands with an existing clumpy distribution may be a higher priority for treatment as silviculture treatment can add to the existing attributes.

2. **Age Class:** This assumes that older stands are more suitable for treatment. This reduces the risk and long time period to determine if the silvicultural intervention is successful. Ideally, trials should cover the range of age classes that can effectively be treated.
    i. 1st Priority – 50 years +
    ii. 2nd Priority – 40-50 yrs
    iii. 3rd Priority - < 40 years (It may be appropriate to thin out corridors to permit travel – 200 m wide vertical corridors).

3. **BEC (site series) for both the ICH and ESSF:** the first priority for treatment are submesic to xeric sites. Second priority are mesic, and lower priority are subhygric and wetter. In the ICH, the drier sites are rated as a higher priority for treatment due to falsebox and lichen ecology (Section 2.3). In the ESSF, it was noted in Section 2.1 that during late winter, caribou prefer low canopy closure, usually attributed to low site productivity (Apps et al,in press).

4. **Potential for lichen production:** the proximity of the stand to old growth, for a lichen source may be a factor in determining its priority for treatment. Wind is the primary mode of dispersal for both *Bryoria* and *Alectoria*. Lichen establishment and dispersal rates have been observed to be higher at or near

residual trees or wildlife tree reserves. However, it has also been observed that lichen substrate is more critical than lichen dispersal, and the dispersal of *Bryoria* spp is not limiting (Quesnel and Waters, 2001). Well-ventilated sites may also be preferred for treatment, because increased ventilation allows the development of very high lichen biomass.

5. **Accessibility:** roaded access into the area for silviculture treatments is a higher priority than areas with no access, owing to increased costs when road access is not available.

6. **Terrain:** < 40% slopes have higher priority than steeper slopes as these are favoured caribou habitat.

7. **Timber Supply Review**: it may be appropriate to rank silviculture treatments based on predicted shortfalls in the timber supply. For example, pre-commercial thinning or spacing can set up a stand for future economical commercial thinning.

Refer to Appendix I for two "Stand Level Ranking Guides", one for stands less than 50 years, and one for stands greater than 50 years. These simplified guidelines can be used to help evaluate a stand's potential for caribou habitat recruitment treatment. It is important to consider the factors, and modify them as necessary with local experience. In their present form they represent both subzones, however, it may be appropriate to modify them for the ICH or the ESSF subzones.

These guidelines will require further review and field verification to ensure that the criteria and ranking are appropriate. They should be used as a tool for ranking stands and prompting foresters to consider the various factors when evaluating a stand, and to rationalize decisions and clearly state the stand structural objectives.

6.0 Keystone Area Case Study

The Keystone face was chosen as a case study because it is already heavily fragmented. Within the Keystone area, Revelstoke Community Forest Corporation (RCFC) has tried innovative silviculture prescriptions in the past, and have identified Mature Forest Retention Areas (MFRAs) to address caribou, biodiversity and ungulate winter range issues. These MFRA provide vertical and horizontal linkages. A key consideration when planning and priorizing treatments and stands is to understand where future development and reserves will be located. RCFC will consider alternative silvicultural systems to enhance wildlife habitat between these MFRAs.

This area has been heavily cut over and is currently in a timber deficit for old and mature targets within the identified caribou habitat. The first partial cutting trial (Keystone Group Selection) that was completed by the Small Business Forest Enterprise Program in this area in 1995 is being monitored for windthrow and has been monitored for lichen dispersal.

There is a range of second growth stand ages and complexity. RCFC has completed some spacing and pruning in the area and plan future silviculture work. This area will be used as a pilot project for assessing other areas.

This case study uses the suggested ranking methods and recommended silviculture treatments to manage more effectively for caribou habitat. This process has narrowed down the areas that should be field reviewed to see if they should be treated (Appendix E).

7.0 Adaptive Management Framework for Caribou Habitat Recruitment in the Revelstoke TSA

The intent in using an adaptive management approach for managing caribou habitat is to evaluate results of different silviculture treatments and apply the knowledge gained to the next projects. It is important to set up a process for implementing and monitoring the success of operational silviculture trials for caribou habitat recruitment now. This will ensure that we have some answers as it becomes increasingly urgent to address these issues over the next few decades. The management solutions can then be based on improved knowledge of caribou movement, habitat uses, and results of a range of potential silvicultural treatments, which have been designed to provide good caribou habitat as well as address the timber supply issues of volume and wood quality.

If carefully planned and implemented, an adaptive management approach to recruit caribou habitat will provide the information necessary to address these issues much faster than relying solely on research.

7.1 Definition of Adaptive Management

"Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. In its most effective form, "active" adaptive management employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the systems being managed." (MOF Website http://www.for.gov.bc.ca/hfp/amhome/amhome.htm).

Some of the differentiating characteristics of adaptive management are:

1. Acknowledgement of uncertainty about what practice is "best" for the particular management issue;
2. Thoughtful selection of the practices to be applied;
3. Careful implementation of a plan of action designed to reveal the critical knowledge that is currently lacking;
4. Monitoring of key response indicators;
5. Analysis of the management outcomes in consideration of the original objectives; and
6. Incorporation of the results into future decisions. (MOF Website http://www.for.gov.bc.ca/HFP/AMHOME/Amhome.htm)

7.2 Steps to initiate and set up adaptive management for caribou habitat recruitment

7.2.1 Problem Assessment

The need to identify, improve and recruit habitat for mountain caribou has been identified by wildlife managers in the face of low population numbers and ongoing harvesting of old-growth forests on which this species depends. The information synthesized in this report serves as a starting point from which specific management objectives for caribou habitat recruitment have been identified.

Overall goals:

1. Maintain and supplement the 40% retention target for mature and old forests in caribou management areas (as laid out in the MAC plan) over time to ensure a sustainable supply of habitat for the future.
2. Increase use of late seral second growth forests by mountain caribou for forage and cover habitat in the Revelstoke TSA.

Management objectives:

1. Mimic attributes of late seral stands favorable to caribou in second growth forests using silviculture techniques (i.e., open forests with large trees and complex structure).
2. Accelerate the development of suitable connectivity habitat for caribou in second growth forests to facilitate movement between foraging habitats and predator avoidance.
3. Increase the amount of available lichen for caribou in second growth forests.

Important: While trying to create or recruit caribou habitat it is critical to minimize the creation of good habitat for other ungulate species such as deer and moose at the same time. The intent is to avoid attracting predators such as wolves, cougars and bears to the caribou recruitment areas and thereby decrease the risk of opportunistic predation of caribou by these carnivores.

7.2.2 Design of management plan and operational trials

The trials should be designed to test the alternative management actions proposed in the *problem assessment* phase. Ideally, two or three alternative silviculture treatments should be evaluated in the study, which will give some useful information but keep associated costs at a reasonable level. The different proposed treatments to recruit caribou habitat should be assessed in a carefully laid out 'management experiment' (Taylor et al. 1997). Each of the treatments should be replicated on the landscape (3 replicates is a good target for statistical validity) and have associated untreated controls.

Ideally the entire trial could be replicated in several locations in the Revelstoke TSA to assess the success of silviculture treatments in different BEC subzones. This management experiment differs from research in that the treatments will be done on an

operational scale in an operational setting, and forest managers will have input as to what silviculture treatments will be assessed.

This is a critical step in the proposed management scheme, and due time and resources should be given to plan the management experiment to ensure that the information gained from this trial will be statistically valid and useful in managing caribou habitat. It is crucial to keep relevant managers, licensees and Ministries staff (MELP and MoF) informed and involved in the planning and implementation of the management experiment to ensure the success and communication of the project.

7.2.3 Implementation of management experiment

In this phase the management experiment is implemented on the landscape. Good communication is essential between those that design the management experiment and the operators, contractors and other people 'on the ground' that are going to carry out the silviculture treatments. Care must be taken to ensure that the replicates of each treatment are as consistent as possible with regard to the resulting stand structure.

7.2.4 Monitoring

Monitoring of the management experiment over time is a key element in the adaptive management process. Typically this is the stage that gets neglected in standard operational trials. The monitoring scheme should be set up to provide useful information that will specifically address the management objectives laid out for caribou habitat recruitment. In general, monitoring should be focused on providing answers for the big management questions, and detailed data collection is left for applied research trials.

Key Steps in Setting up Monitoring Program for Caribou Habitat Recruitment

- Identify indicators that can be monitored to determine success of silviculture treatments (from workshop)

  Suggestions:

  - Changes in lichen biomass and availability
  - Falsebox cover and quality
  - Canopy closure
  - Caribou foraging
  - Desired stand structural attributes
  - Timber production

- Determine how data will be collected (modified silviculture survey)
- Determine frequency of monitoring (establishment, 5 years, then every 10 years)
- Establish **accessible** database (or use existing one) for collected data
- Identify central agency responsible for collecting and maintaining records of caribou habitat recruitment trials (MELP, MOF)

The data collected in the monitoring program should be entered into a database established just for caribou habitat projects. Ideally, this database should be accessible by all licensees and government agencies in the Revelstoke TSA. The database would provide information as to the location and current status of all blocks in the management trials.

7.2.5 Evaluation

In this phase the data collected during *monitoring* is analyzed. The results are then related back to the management objectives and expected outcomes forecasted in the *problem assessment* phase. The evaluation should include explanations of the results. In adaptive management it is important to recognize that negative or unexpected results can provide just as much information as those that are considered successes.

7.2.6 Adjustment of plan and practices based on new information

In this phase the original assumptions and hypotheses are adjusted using the new information gained in the management experiment. This in turn will result in changes in management practices to recruit caribou habitat and possibly may lead to new management experiments.

8.0 Research and Decision Support Needs

Research into the ecology of caribou and their habitat requirements is a vital component in the adaptive management scheme for caribou habitat recruitment. Applied research should be conducted concurrently with any management experiments dealing with this issue. Information provided by research is used to refine management objectives and reduce the risk associated with the key gaps in knowledge of caribou and their habitat.

The following is a list of research and modeling needs to address identified gaps in knowledge (some of these studies have been initiated already):

- Caribou ecology
  - microhabitat requirements and foraging patterns, use GPS collars to track caribou continuously
  - effect of landscape patterns on habitat use, can we ‘create’ contiguous suitable habitat?
  - effect of habitat recruitment activities on populations of other ungulate species and predators (is there increased predation of caribou in treated stands?)
  - factors affecting caribou calf survival in spring habitat
  - habitat supply modeling using SIMFOR or other similar model

- Old growth
  - develop an Old-Growthness Index as it relates to caribou habitat for the ICHmw3, wk, vk and the ESSFvc, vv and wc4.
  - assessment of caribou reserves in Revelstoke area to determine proportion of those areas that provide good caribou habitat

- Lichen
  - modeling and tracking of future lichen growth in treated second growth stands
  - enhancing lichen growth in young stands
  - impact of more open stand structure on lichen growth

- Stand development
  - retrospective studies to identify stand development patterns
  - modeling of stand development over time with alternative silvicultural interventions for caribou habitat recruitment

- Stocking Standards re-evaluation – model different stocking standards at different stand ages and determine the impact on the timber supply. Determine future volume and value considerations in relation to timber supply.

- Spacing and pruning- retrospective studies looking at results of these activities completed in the past to determine how they are meeting historical or current silviculture objectives. Track understory response.

- Falsebox ecology – although there is considerable information about falsebox ecology, there should be some further work conducted on falsebox growth, management, palatability, etc., by BEC subzone and canopy closure.

8.1 Research and extension databases

Provincial research and extension databases can provide information about current and ongoing research, as well as published papers and reports on mountain caribou and their habitat.

Natural Resources Information Network (NRIN) – searchable web based research and extension database developed and maintained by the Southern Interior Forest Extension and Research Partnership (SIFERP) that should be available by 2002.
http://www.siferp.org/NRIN/

Adaptive Management Database – funding has been applied for by the MoF to establish a database for all Adaptive Management (AM) Projects in B.C. Current information on the status of the database can be obtained by contacting the Ministry of Forests manager of Adaptive Forest Management.
http://www.for.gov.bc.ca/hfp/amhome/am_contacts.htm

8.2 Extension

Results and information from caribou habitat recruitment projects can be disseminated through reports, workshops, meetings, courses, etc. Some organizations that can facilitate such information extension:

Columbia Mountains Institute of Applied Ecology (CMI) http://www.cmiae.org/

Forest Management Institute of B.C (FMIBC) http://www.fmibc.org/index.shmtl

9.0 Recommended Action

The following is a proposed action plan.

Year	Work to be done	Suggested Silviculture Treatments
2001	1. Conduct retrospective study on past spacing, pruning and alternative silviculture treatments to determine extent of existing managed stands that may provide situations for caribou habitat recruitment. Stands with potential should be included in the monitoring plan. 2. Conduct adaptive management workshop (1-2 days) to develop overall management plan and objectives for caribou habitat recruitment. 3. Review backlog sites for potential treatment. 4. Review planned 2001/02 enhanced forestry projects for potential sites. 5. Develop a Habitat Silviculture Plan (5-10 year plan) as part of the Resource Management Plan/Regional Investment Plan, including "studies" and monitoring to support the adaptive management approach. 6. Communicate information and research needs to funding partners.	▪ Study ▪ Plan ▪ Reconsider existing SMPs for CHR silviculture treatments
2002	1. Conduct assessments and reconnaissances to determine priority areas, identify corridors, field review stands and rank the need for silviculture surveys. 2. Focus on the ICH, survey and lay out treatments and controls for management experiments/silviculture trials. 3. Implement projects of the highest priority, to the targets identified in the Habitat Silviculture Plan, as funding permits. 4. Establish monitoring of the implemented projects and any qualifying previously treated areas, as per retrospective study done in 2001. 5. Develop an extension/communication plan, with activities to pass information on to other parts of the province where caribou are being managed.	▪ Assessments ▪ SMPs, SPs ▪ **PCT Trial** – Use three different stand densities (600, 800 and 1000 sph), plus a control. Use two methods of applying PCT – uniform and clumped (variable – depending on original stand structure). ▪ **Espacement Trial** – reduce planting densities on 2 sites. ▪ **Girdling Trial** – on an older stand 40-80 yrs, to act as spacing and snag recruitment
2003	1. Monitor treatments and controls conducted in 2002 in the ICH using identified indicators to determine if treatments initially meet objectives. 2. Replicate treatments and controls in the ESSF as funding permits. 3. Implement additional projects in the ICH as funding permits.	▪ **PCT Trial** – Use different densities, uniform and clumped, on 4 blocks. ▪ **CT Trial** – Thin from below to recruit late seral stand attributes. ▪ **Girdle Trial** – In stands aged between 40-80 years, try girdling techniques to create snags and thin the stand.
2004/ 2005…	1. Monitor treatments and controls conducted in 2003 in the ESSF using identified indicators to determine if treatments initially meet objectives. 2. Based on initial surveys, add 2 more replicates of treatments in other areas in the ICH and ESSF as funding permits.	PCT, CT, STS, Girdle, Espacement

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