Central Selkirk Mountain Caribou Habitat Model

Prepared for:
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Executive Summary

Mountain caribou are a species at risk in British Columbia and the Central Selkirk herd experienced a significant population decline during 1996-2002. We conducted Resource Inventory Standards Committee (RISC)-approved ground sampling and capability-suitability modelling to map caribou habitat throughout the range of the Central Selkirk mountain caribou herd.

We collected data at 91 plots within the Central Selkirk Mountains study area, outside of TFL 23. Many of these plots were in the ICHwk1 biogeoclimatic subzone variant where few plots had previously been sampled to RISC standards. In addition, many of the plots were within the area of the Kootenay Lake predictive ecosystem map (PEM), where no RISC-standard plot work had previously been conducted.

We developed 4 seasonal suitability and capability models and accompanying maps that illustrated the value of ecosystem units for caribou. We also tested the goodness-of-fit of the models with respect to telemetry point data collected during inventory projects in the Central Selkirk Mountains. We found that habitats rated *high* were used more than expected, based on their availability within the study area, for each of the 4 seasons. Similarly, habitats rated *low* were used less than expected and *moderate* habitats were used in proportion to their availability.

We also developed a zonation strategy based on the results of this and previous projects. The zonation attempted to maximize the benefit to caribou habitat of mature and old forest guidelines in the Kootenay Boundary Higher Level Plan by spatially stratifying the range of the Central Selkirk mountain caribou herd into areas within which different forest practices are recommended. The zonation strategy requires a timber supply, economic impact and trade-off analysis before it is adopted.

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Acknowledgements

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Introduction

Mountain caribou (*Rangifer tarandus*) are a red-listed "species at risk" in British Columbia. Of the 13 sub-populations in southeastern British Columbia, the Central Selkirk caribou sub-population was considered to be of "medium" conservation concern by Simpson et al. (1997). Management for the species could potentially cause considerable socio-economic disruption (Simpson et al. 1997, MCTAC 2002).

In 1996, Forest Renewal British Columbia (FRBC), in cooperation with Pope & Talbot, Meadow Creek Cedar, Slocan Forest Products and the Ministry of Environment, Lands and Parks established a funding agreement to study the mountain caribou sub-population of the Central Selkirk Mountains. Pope & Talbot, with funding from FRBC, supported the study from 1997 through 2001.

The first four years of the caribou study was a comprehensive examination of mountain caribou distribution and habitat use in the Central Selkirk Mountains. It involved caribou capture and collaring with VHF radio transmitter collars (n = 36), aerial telemetry (n = 1942 locations), population censuses in 1995, 1997, and 1999, investigation of collared caribou mortality, trailing of caribou during the early winter season, and field sampling of caribou use and random sites with a focus on habitat use in relation to forest cover and terrain attributes at the stand and landscape scales (Hamilton et al. 2000).

The project estimated a population of approximately 230 animals between the Nakusp area and the upper Duncan River valley. Telemetry locations suggested that there is little interaction between caribou in the Duncan and the southern part of the study area, although observations of uncollared caribou suggest that there is some exchange between areas. Habitat use in the Duncan is concentrated primarily in the main valley while caribou in the Nakusp area use high elevation ridges and plateaus.

Building off the inventory study results, key projects were completed in 2002; however, these were limited to in scope to Tree Farm License 23 (TFL 23) because Pope & Talbot alone provided the funding. A species-habitat model was completed that included a mountain caribou species account and PEM-based habitat ratings table (Hamilton and Wilson 2002a). The model was used to develop 1:20,000 scale PEM-based mountain caribou capability-suitability maps for 4 seasons within the TFL 23 portion of the range of caribou within the Central Selkirk Mountains.

The second project involved a multi-disciplinary planning team that piloted a landscape unit planning strategy for caribou within the Trout, Fish and Halfway landscape units of TFL 23. This pilot project, which encompassed approximately 35% of the known caribou habitat in the Central Selkirk Mountains, led to the development of caribou-focused management zoning, stand level field assessment and reporting procedures, silviculture and harvesting strategies to be considered in caribou areas, a monitoring program and adaptive management strategy. An economic (Arrow Forest District, *unpublished report*) and caribou-focused environmental assessment (Hamilton 2002) finalized the strategy, which was implemented through a district level agreement in May 2002. An amendment to the field sampling and report component of the strategy has since been adopted (Hamilton and Leitch 2002), to reflect results of field-testing during summer and fall of 2002.

A mark-resight census in March 2002 suggested that the Central Selkirk mountain caribou herd was experiencing a significant decline (Hamilton and Wilson 2002b). Although caribou population estimates have declined in every census year since surveys began in 1996 (Hamilton et al. 2000), the 2002 census was the first year in which a trend could be established statistically.

The caribou species-habitat model and capability-suitability mapping (Hamilton and Wilson 2002a) and caribou management strategy (Landscape Unit Planning Project Working Group 2002) provided the framework for extension and application of the TFL 23 results to the remainder of known caribou habitat within the Central Selkirk Mountains. In recognition of this, and with funding provided by Slocan Forest

Products Ltd., Meadow Creek Cedar Company, BC Timber Sales Branch of the BC Ministry of Forest and the BC Ministry of Water, Land and Air Protection (Victoria), we conducted a 1-year project to generate a supplemental PEM-based species habitat model, capability-suitability mapping and caribou management strategy for the entire known range of mountain caribou in the Central Selkirk Mountains.

The project area (Figure 1) covered 6 090 km^2 and was located within the North Columbia Mountains ecoregion and the Central Columbia Mountains and Northern Kootenay Mountains ecosections. The area is characterized by steeply sloping mountainous terrain dominated by mature forest within the Interior Cedar-Hemlock (ICH), and Engelmann spruce-Subalpine fir (ESSF) biogeoclimatic zones. The Selkirk Wet Cold Engelmann Spruce-Subalpine Fir variant (ESSF wc4) and Selkirk Wet Mild Engelmann Spruce-Subalpine Fir variant (ESSFwm) dominate the mid to upper elevation forest zone. Mid to lower slope forests include the Interior Cedar-Hemlock moist warm variant 1 (ICHmw1), Interior Cedar-Hemlock moist warm variant 2 (ICHmw2), Interior Cedar-Hemlock moist warm variant 3 (ICHmw3) and the Interior Cedar-Hemlock wet cool variant (ICHwk1). Alpine tundra (AT) dominates upper elevations.

Methods

Field Sampling and Data Collection

A preliminary species-habitat model was developed for the study area based on work previously completed on the TFL 23 portion of the Central Selkirk caribou study area. Field sampling to improve the reliability of the preliminary caribou species-habitat model was conducted in the summer of 2002 to address knowledge gaps regarding site characteristics and habitat suitability and capability for mountain caribou. The goal was to sample as many plots as possible in subzone variants that had not been sampled, or only poorly sampled, during previous projects (*i.e.*, outside the ESSFwc and ICHmw2; Hamilton et al. 2000, Hamilton and Wilson 2002; Ketcheson et al. 2001).

At each sampling location, sites were classified according to procedures outlined in Standards for Describing Ecosystems in the Field (Braumandl and Curran 1992, RIC 1998). Wildlife habitat ratings for mountain caribou were assigned according to British Columbia Wildlife Habitat Rating Standards (RIC 1999), and plots were assigned lichen abundance estimates (Armleder and Stevenson 1992). Field data was recorded using standardized Ground Inspection Forms (RIC 1998) for site series classifications and Wildlife Habitat Assessment field forms (RIC 1999) for habitat data and caribou ratings. All field data were entered into a VENUS database.

Species-Habitat Model and Capability/Suitability Mapping

Development of the mountain caribou species-habitat model, consisting of a species account and habitat ratings table, followed procedures outlined in British Columbia Wildlife Habitat Ratings Standards (RIC 1999). Habitats were rated against the provincial benchmark (*i.e.*, Cariboo Mountains Ecosection) that represented the highest capability caribou habitat in the province. The ratings table was based on the results of Hamilton et al. (2000) and Hamilton and Wilson (2002), and on information collected at sampling plots.

The 6-class habitat ratings for each of 4 seasons were applied to PEM coverages of the Arrow and Kootenay Lake forest districts developed for the BC Ministry of Forests by JMJ Holdings, Inc. A capability map was based on the highest rated structural stage for each ecosystem unit. For suitability maps, structural stages were inferred from forest ages derived from the forest cover database.

Caribou telemetry locations collected during the inventory study (Hamilton et al. 2000, Hamilton and Wilson 2002) were overlaid on the seasonal suitability maps and examined graphically for goodness-of-fit. We pooled habitats rated *very high* and *high*, as well as those rated *low* and *very low*. We compared the proportion of locations in each habitat category ("used") with the proportion of each habitat category on the study area ("available"). Differences in proportional use and availability were compared with Bonferroni-adjusted confidence intervals (Neu et al. 1974).

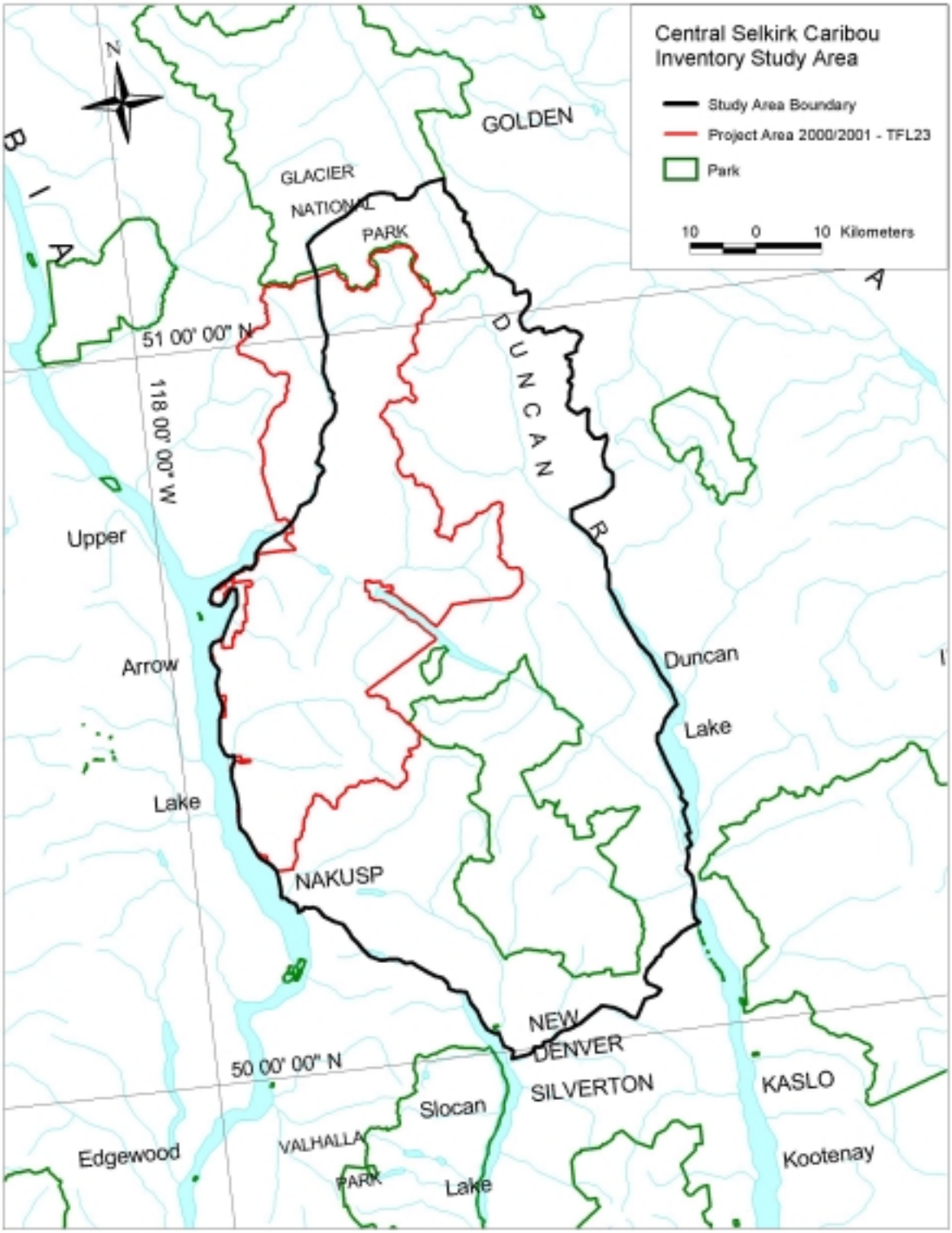

Figure 1. Project area for developing a species-habitat model for mountain caribou in the Central Selkirk Mountains. Also illustrated is the extent of TFL 23, where a ratings table and zonation strategy were completed previously.

Caribou Management Strategy

We developed a zonation strategy for the remainder of the Central Selkirks caribou range using criteria consistent with the zonation strategy in the TFL 23 Pilot Project. The purpose of the strategy was to develop a spatial approach to caribou habitat management in relation to Higher Level Plan objectives. The Central Selkirks caribou range was stratified into a series of zones according to the value of habitats for mountain caribou, to provide spatial guidance for the location of mature and old forest requirements (*Kootenay Higher Level Plan Order* 2002). We recommended different forest management practices in each zone. Zones were based on an evaluation of caribou habitat that used all available information, including: caribou telemetry data, habitat suitability mapping, and site-specific field observations by project personnel.

The zonation strategy and preliminary line work were presented to the Kootenay Regional Caribou Committee, Ministry of Sustainable Resource Management, Ministry of Water, Land and Air Protection, Arrow District Ministry of Forests, and Kootenay Lake District Ministry of Forests (Appendix I). Kootenay Lake District planners had already identified "Old Seral Patches" (OSPs) in several Landscape Units that were intended to meet caribou guidelines. Most OSPs were not included in the final zonation map because of considerable overlap between OSPs and Zone 1 and 1a areas and objectives. However, OSPs and related objectives were included as part of the zonation strategy in the upper Duncan.

Results

Field Sampling and Data Collection

Data were collected at 91 plots throughout the range of the Central Selkirk mountain caribou herd outside TFL 23. All but 8 plots were located in the Central Columbia Mountains ecosection. Approximately a third of plots were located in subzone variants outside the ESSFwc and ICHmw2 (Table 1). Most plots were located in either structural stage 3 (n = 31), 6 (n = 25) or 7 (n = 13).

Table 1. Distribution of sampling plots among subzone variants and site series.

Zone	Subzone variant	Site series	*n*
ESSF	wc1	01	3
ICH	mw1	05	2
ICH	mw2	01	13
ICH	mw2	02	2
ICH	mw2	03	13
ICH	mw2	04	15
ICH	mw2	05	9
ICH	mw2	06	8
ICH	mw2	07	1
ICH	mw2	08	1
ICH	wk1	01	4
ICH	wk1	02	2
ICH	wk1	04	8
ICH	wk1	05	5
ICH	wk1	06	3
ICH	wk1	07	2

Species-Habitat Model and Capability/Suitability Mapping

The species account for the project is presented in Appendix II. Goodness-of-fit tests suggested that the ratings table produced suitability maps for all seasons that predicted the rank order of habitat selection by

caribou among ecosystem units (Figure 2). That is, *high>moderate>low>nil* in terms of relative use. Differences between "used" and "available" proportions were significant for high- and low-ranked habitats in all seasons (Figure 2).

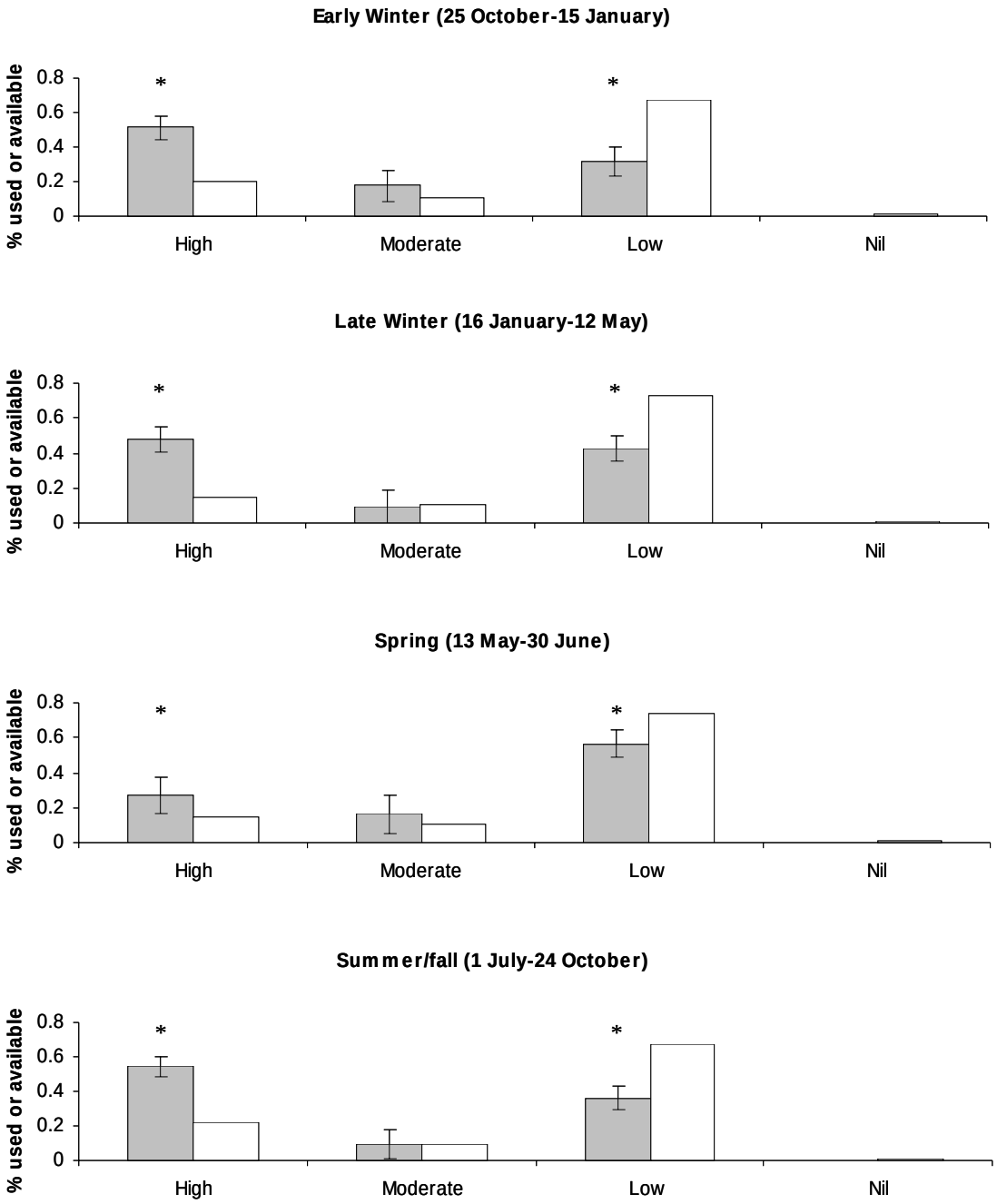

Figure 2. Goodness-of-fit of caribou telemetry point locations to habitat ratings, grouping high and moderately high, and low and moderately low, into single high and low categories. Dark and white bars represent "used" and "available" proportions, respectively. Asterisks indicate "used" proportions significantly different from "available" proportions, based on Bonferroni-adjusted confidence intervals ($P < 0.10$, k = 3; no use was recorded in habitats rated "nil").

Caribou Management Strategy

Figure 3 illustrates the approved caribou zonation strategy for TFL 23 and proposed zonation for the remainder of the range of the Central Selkirk mountain caribou herd.

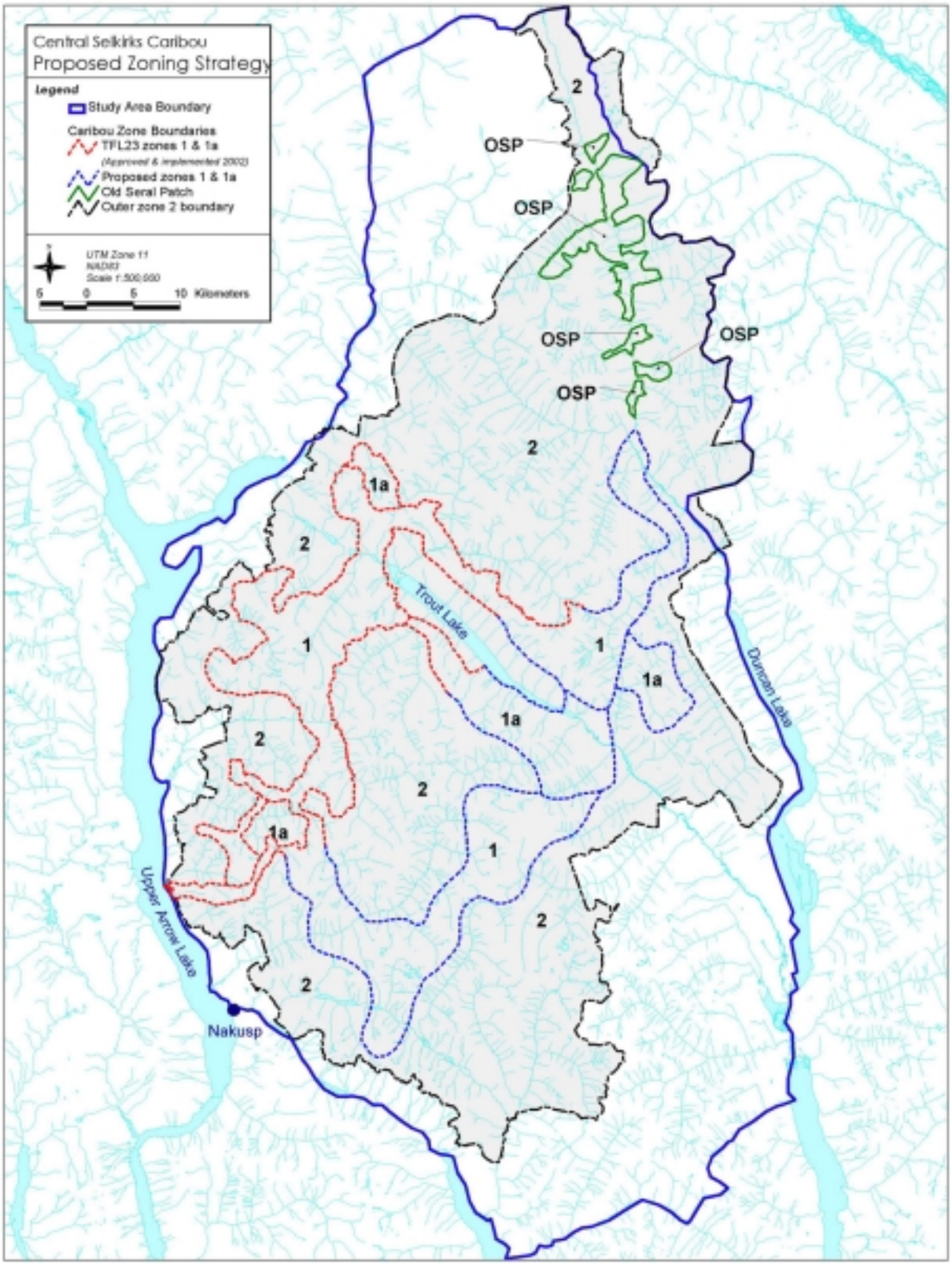

Figure 3. Proposed zonation strategy for the range of the Central Selkirk mountain caribou herd. Zone 1 areas are no harvest zones, Zone 1a are deferred harvest, and Zone 2 areas are special management zones. Old seral patches are also illustrated. Management objectives in these areas are compatible with caribou and general biodiversity objectives.

The strategy identified 3 zones on the landscape that meet criteria related to caribou habitat and that are associated with specific management objectives (Table 2). The zonation strategy also included Old Seral Patches managed for caribou habitat.

Table 2. Proposed caribou management zones with criteria and recommended forest management.

Zone	Criteria	Recommended Management
1. Caribou Connectivity	▪ High habitat suitability for caribou (based on habitat mapping and field assessments) ▪ High use areas (based on telemetry data, flight observations, population census, field assessments) ▪ High connectivity to seasonal habitats (based on telemetry data, flight observations, field assessments) ▪ Low fragmentation	Full retention of all forest (salvage logging for disease and insects permissible with DEO approval)
1a. Caribou Interim Management	▪ Medium to high habitat suitability for caribou and/or other key wildlife species such as deer, elk, moose, goat and grizzly bear ▪ Medium to high use by caribou ▪ High connectivity to seasonal habitats	Deferred harvest until results of experimental harvesting trials in caribou special management zone are reviewed
2. Caribou Special Management	▪ Medium to high habitat suitability for caribou ▪ Known caribou use areas ▪ Connectivity at drainage level (*i.e.*, valley crossings)	Partial harvest with retention of mature/old forest stand characteristics important to caribou (*i.e.*, appropriate forest stocking levels, old forest attributes and lichen productivity) Site assessments involving caribou experts is recommended to identify appropriate silviculture practices to maintain site-specific habitat attributes and caribou movement areas.
Old Seral Patches	▪ Specific stands with high suitability for caribou ▪ High to moderately high use ▪ Key locations for landscape and drainage-level connectivity	Retain to meet HLPO caribou guidelines unless alternate OSP of equivalent value to caribou is identified, and/or unless expert site assessment indicates harvesting is compatible with caribou values.

Discussion

Field Sampling and Data Collection

The 91 plots sampled during this project were in addition to 49 plots sampled on TFL 23 in 2002, bringing the total number of plots sampled for caribou suitability to 140 throughout the range of the Central Selkirk mountain caribou herd. Because RISC-standard ground inspection forms (RIC 1998) were also used at sampling plots, data collected during this project could be used to update or test existing PEM coverages, or could be used to develop or update models of stand level habitat attributes (*e.g.*, Huggard 2000, Wilson et al. 2003).

Many of the plots were in the rarely sampled ICHwk1, and in the area covered by the Kootenay Lake PEM, where no plot work had been done previously.

Species-Habitat Model and Capability-Suitability Mapping

The species-habitat models and accompanying capability-suitability models provide a useful extension of the method used successfully on TFL 23 to map caribou habitat. We built on the broad knowledge acquired during >800 field days and on extensive data analyses and modelling exercises to provide models of caribou habitat that reflect the current state of knowledge regarding mountain caribou in the Central Selkirk Mountains.

Goodness-of-fit tests suggested that the models fit telemetry data well at the resolution of *high-moderate-low-nil* suitability habitat. That is, habitat rated *high* were used more than expected on the basis of their availability in the study area, habitats rated *low* were used less than expected, *moderate* habitats were used in proportion to their availability, and *nil* habitats were not used at all. These relationships broke down when data were examined on the basis of a 6-class ratings system. That is, telemetry points in habitats rated *very high* and *high*, as well as those rated *low* and *very low* did not follow the expected pattern of distribution. As a result, we suggest that habitat management be based on a 4-class system where management objectives in *very high* and *high areas* are similar.

One underlying concern with the models is the reliability of the PEM on which they are based; however, PEM is a new technology that is continuously being updated and improved and caribou models can similarly be updated very quickly to reflect the latest ecological information. Also, ecosystem units that are difficult to distinguish in PEM are often assigned similar capability ratings for caribou. As a result, the PEM likely demonstrates higher accuracy with respect to caribou capability than with respect to ecosystem units.

The constant updating of the PEM on a jurisdictional basis can also be a liability because it can create edge effects between jurisdictional boundaries. The project area covered portions of 3 separate PEM coverages: TFL23, Arrow TSA and Kootenay Lake TSA. These 3 datasets were merged into a seamless PEM covering the entire study area. This resulted in some edge-matching problems; in some areas, there were gaps between the adjacent datasets. At the scale of the mapping, this was only a minor problem.

There were also situations where different ecosystems were mapped across PEM project boundaries. The most prominent example was the mapping along the north shore of Trout Lake. The TFL 23 PEM was mapped ICHdw 01, and the Arrow TSA PEM ICHdw 02, 03, or 05. This was probably due to differences in the PEM input layers, such as forest cover, and different algorithms used for the TFL and TSA. The problem can be addressed only through further enhancements of the PEM model.

A large number of combination units were mapped within the Kootenay Lake PEM. These were areas where the PEM model predicted a tie between two or more site series. In this project, these combination units were assigned sites series randomly, based on the composition of the combination units.

Caribou Management Strategy

The caribou management strategy proposes a method of integrating caribou inventory data and Higher Level Plan objectives to ensure that mature and old forest management constraints are applied in areas that provide the maximum benefit to caribou. This represents a significant improvement to the aspatial guidelines in the Kootenay Boundary Higher Level Plan.

The next step in the strategy is to conduct a timber supply and economic impact analysis. This analysis will lead to a further trade-off analysis before the line work is revised and approved. There are obviously additional costs that will be incurred if the zonation strategy is adopted. The deferrals will likely impact timber supply and ground assessments in Zone 2 areas will increase costs; however, the ground assessment data will be used to refine the zonation mapping and will collect important information that

will be used to refine the caribou habitat models. Together with harvesting trials in Zone 2 areas, these initiatives will greatly improve the defensibility of forest management in caribou habitat. The intention is to review the line work every 3-5 years on the basis of ground sampling and the results of harvesting trials.

Critique of Inventory Protocols

RISC-standard capability/suitability methods (RIC 1999) provided a number of important advantages over other types of habitat modelling:

1. Ratings accommodate broad knowledge instead of just telemetry points (in the case of resource selection functions; Manly et al. 1983), which are inherently biased. Habitat suitability index models (USFWS 1981) can also incorporate broad knowledge but are difficult to test and update because assumptions related to individual habitat suitability curves and the modelling equation are generally untestable.
2. Models are not affected by definitions of "available habitat."
3. Models are simple to test with animal use data.
4. Methods are transparent and easy to understand.
5. Ratings for all structural stages allow models to be used in habitat supply projections.
6. The method addresses both stand and landscape scales because ecosystem units are characterized at the stand scale but mapped at the landscape scale.
7. Ecosystem units are well-defined and consistent province-wide.

There are also a number of disadvantages to the method:

1. Ratings tables cannot be reproduced exactly by someone else if provided with the same data and methods.
2. Ratings tables can be difficult to update when new data become available.
3. Long tables can be plagued by inconsistencies.
4. Sometimes expert knowledge of animal behaviour can be wrong.

We have concluded that the method's advantages outweigh their disadvantages; however, there are knowledge gaps related to the PEM that affect the reliability of the caribou models:

1. There are several poorly characterized subzone variants, either because plot data have not been collected and used to develop and/or test the reliability of the PEM in these areas, or because they are new and descriptions of their ecosystem units are not yet widely available.
2. Methods and standards are required for structural stage mapping. We used a simple crosswalk from forest age class; however, better methods might be available or could be developed.

Management Recommendations

This latest iteration of habitat capability and suitability maps represents the state of knowledge regarding mountain caribou habitat use in the Central Selkirk Mountains. Together with the distribution of telemetry points recorded during previous inventory projects, and stand level data collected at sampling plots, the maps should be used as the knowledge base on which caribou habitat management decisions are made.

Models and maps should continue to be updated as PEM coverages evolve. In some cases this can be accomplished by applying the current ratings table; however, where new ecosystem units are added to the PEM, the ratings table must be revised.

A structural stage model should be developed and applied to the existing PEM coverages. This will improve the reliability of suitability mapping.

We strongly encourage the use of Ground Inspection forms for all plot work in the Arrow Forest District. These baseline data that can be used to update and test PEM coverages, as well as contribute to a database on stand structure information that can be used in a variety of projects.

The timber supply and economic implications of the proposed caribou management strategy should be investigated as soon as possible. In the interim, the proposed line work should be incorporated in forest management planning.

Annual aerial surveys of the caribou herd in the Central Selkirk mountains should be conducted annually to monitor population trends.

Literature Cited

Armleder, H. M., S. K. Stevenson, and S. D. Walker. 1992. Estimating the abundance of arboreal forage lichens. BC Ministry of Forests, Land Management Handbook, Field Guide Insert 7. Ministry of Forests Research Program, Cariboo Forest Region.

Braumandl, T. F., and M. P. Curran. 1992. A field guide for site identification and interpretation for the Nelson Forest Region. Land Management Handbook No. 20. BC Ministry of Forests, Victoria.

Hamilton, D. 2002. TFL 23 Landscape unit pilot project: environmental assessment. Prepared for Arrow TFL 23 Landscape Unit Planning Working Group, Castlegar, BC.

Hamilton, D., and C. Leitch. 2002. Amendment to TFL#23 landscape unit planning pilot project: summary and recommendations-Appendix 3 and Caribou management in TFL#23 agreement for district-level implementation issues-Appendix 2. Prepared for Arrow Forest District, Castlegar, BC, and Pope & Talbot Ltd., Nakusp, BC.

Hamilton D., and S. F. Wilson. 2002a. Central Selkirk mountain caribou habitat use and species-habitat model for TFL#23. Prepared for Pope & Talbot Ltd., Nakusp, BC.

Hamilton, D., and S. F. Wilson. 2002b. Population census and telemetry monitoring for the Central Selkirk caribou inventory project. Prepared for: Pope & Talbot Ltd., Nakusp, BC.

Hamilton, D., S. F. Wilson, and G. Smith. 2000. Mountain caribou habitat use and population characteristics for the Central Selkirks caribou inventory project. Prepared for: Forest Renewal British Columbia.

Huggard, D. 2000. A deadwood projection model for managed ESSF and ICH forest. Prepared for: The Arrow Forest License Group.

Ketcheson, M. V., T. Dool, and S. F. Wilson. 2001. TFL 23 predictive ecosystem mapping final report and maps. Prepared for: Pope and Talbot Limited, Nakusp, BC.

Landscape Unit Planning Project Working Group. 2002. Caribou management in TFL#23 agreement for district-level implementation issues. Prepared for Arrow forest District, Castlegar, BC.

Manly, B. F. J., L. L. McDonald, and D. L. Thomas. 1993. Resource selection by animals. Chapman & Hall, London, UK.

Mountain Caribou Technical Advisory Committee (MCTAC). 2002. A strategy for the recovery of mountain caribou in British Columbia. BC Ministry of Water, Land Air Protection, Victoria.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. Journal of Wildlife Management 38:541-545.

Resource Inventory Committee (RIC). 1998. Field manual for describing terrestrial ecosystems. Land Management Handbook No. 25. BC Ministry of Forests and BC Ministry of Environment, Lands and Parks, Victoria.

Resource Inventory Committee (RIC). 1999. British Columbia wildlife habitat rating standards, version 2.0. BC Ministry of Environment, Lands and Parks, Victoria.

Simpson, K., E. Terry, and D. Hamilton. 1997. Toward a Mountain Caribou Management Strategy for British Columbia – Habitat Requirements and Sub-population Status. Ministry of Environment, Lands and Parks; Wildlife Branch. Wildlife Working Report No. WR-90.

United States Fish and Wildlife Service (USFWS). 1981. Standards for the development of habitat suitability index models for use in the Habitat Evaluation Procedures, USDI Fish and Wildife Service. Division of Ecological Services, ESM 103.

Wilson, S. F., C. Steeger, and D. Hamilton. 2003. Habitat supply modelling on the Arrow Timber Supply Area draft. Prepared for: BC Ministry of Water, Land and Air Protection, Victoria, and Arrow Forest License Group.

Appendix I

The Central Selkirk mountain caribou zonation strategy was presented at workshops attended by:

Nelson Region	Arrow Forest District	Kootenay Lake District
Guy Woods (MWLAP, regional caribou committee)	Mike Knapik (MWLAP)	Dale Anderson (MOF)
Mike Knapik (MWLAP)	Greg Goldstone (BC Timber Sales)	Mike Knapik (MWLAP)
	Al Skakun (BC Timber Sales)	Bill Kestell (Meadow Creek Cedar)
	George Edney (MOF)	Stewart Clow (MSRM)
	Simon Martin (Slocan Forest Products)	Jim Annuziello (BC Timber Sales)
	Norbert Kondla (MSRM)	

Appendix II

Species Account for Mountain Caribou of the Central Selkirk Mountains

Species data

Common Name:	Mountain caribou
Scientific Name:	*Rangifer tarandus caribou (mountain ecotype)*
Species Code:	M-RATA-MO
BC Status:	Red-listed (BC Conservation Data Centre, 2000)
Identified Wildlife Status:	Yes
COSEWIC Status:	Designated as vulnerable in Canada (COSEWIC, 2000)

Project data

Area:	Central Selkirk Mountains
Ecoprovince:	Southern Interior Mountains
Ecoregions:	Northern Columbia Mountains
Ecosections:	Central Columbia Mountains and Northern Kootenay Mountains
BEC variants:	AT, ATp, ATun, ESSFwc1, ESSFwc4, ESSFwcp4, ESSFwcu4, ESSFwm, ESSFvc, ESSFvcp, ICHdw, ICHmw1, ICHmw2, ICHmw3, ICHvk1, ICHwk1
Map Scale:	1:20,000

Distribution

Provincial Range

Historically, two subspecies of caribou, Dawson's (*Rangifer tarnandus dawsoni*) and woodland caribou (*R.t. caribou*) were recognized in British Columbia. Inhabiting only Graham Island on the Queen Charlotte Islands, Dawson's caribou has been extinct since 1910.

All surviving caribou in British Columbia belong to the woodland subspecies and are divided into three ecotypes, based on differences in habitat use, behaviour and seasonal migration patterns (Heard and Vagt 1998). The mountain ecotype of woodland caribou are found in the southern interior, notably the Purcell, Selkirk and Monashee Ranges, Nelson Mountains, Wells Gray Park, and the Quesnel Highlands. The most southerly herds are small and isolated (Shackleton 1999).

Provincial Context

Mountain caribou have recently been red-listed in British Columbia (considered threatened or endangered; www.srmwww.gov.bc.ca/cdc). The current population estimate is 1900 mountain caribou distributed among 13 sub-populations in central and southeastern British Columbia. The Kootenay region supports an estimated 400 caribou (MCTAC 2002). The Central Selkirk caribou sub-population is estimated at 131 animals (Hamilton and Wilson 2002) and is considered to have medium overall conservation ranking with management needs potentially having a high impact on timber supply (MCTAC 2002).

Distribution in the Project Area

The project area covered the entire known range of the Central Selkirk Mountain caribou sub-population (Table 3).

Table 3. Expected Occurrence of Mountain Caribou in Ecological Units of the Central Selkirk Mountains.

Ecoprovince	Ecoregion	Ecosections	BEC variants
Southern Interior	Northern Columbia	Central Columbia Mountains (CCM)	AT ATp ATun ESSFwc1 ESSFwc4 ESSFwcp4 ESSFwcu4 ICHdw ICHvk1 ICHwk1 ICHmw2 ICHmw3
		Northern Kootenay Mountains (NKM)	AT ATp ATun ESSFvc ESSFvcp ESSFwc1 ESSFwc4 ESSFwcp4 ESSFwcu4 ESSFwm ICHvk1 ICHwk1 ICHmw1 ICHmw2

Ecology

Mountain caribou, an ecotype of woodland caribou, inhabit the mountainous terrain of southeastern and east-central British Columbia (Shackleton 1999). These areas include the moist coniferous forests of the Columbia and Rocky Mountains of southeastern British Columbia and northern Idaho. The mountain caribou ecotype is associated with late-successional forests that support arboreal lichens *Bryoria* spp and *Alectoria sarmentosa* – their primary winter forage (Stevenson and Hatler 1985, Antifeau 1987, Stevenson *et al*. 2001). Because of this seasonal dependence on arboreal lichens provided in mature/old forests, and other aspects of their ecology, mountain caribou may be susceptible to the loss of effective habitat through forest harvesting and perhaps by displacement caused by human disturbance (Simpson *et al.* 1997, Stevenson *et al.* 2001).

Seasonal Migrations

Caribou use seasonal habitats within the full range of elevations from low-elevation cedar/hemlock to mid and high elevation spruce/fir forests, including fir/spruce parkland habitats. They spend most of the year in high elevation sub-alpine forest and alpine habitats, descending to low elevation forests during early winter and spring periods when snow is unconsolidated (Simpson and Woods 1987, Stevenson and Hatler 1985). Although the times of seasonal migrations and habitat use by caribou may vary between populations, four seasonal habitat use patterns are generally recognized (Stevenson and Hatler 1985, Simpson and Woods 1987, McLellan et al. 1994). These four periods are late winter, spring, summer/fall and early winter. Research biologists in the USA consider calving to be a fifth seasonal habitat for the South Selkirk caribou population (Scott and Serhveen 1985).

Snow depth and snow consolidation are an important factors that influence caribou habitat use and seasonal migrations. Caribou use low to mid elevation habitats during early winter, where dense forest canopies reduce snow depths and allow animals greater mobility and access to forage (vegetation, lichen on litterfall and blowdown). The greatest use during early winter is in the ICH/ESSF transition zone (Hamilton et al. 2000). By late winter, when snow has consolidated and sinking depths are reduced,

caribou migrate to higher elevation ESSF and ESSF parkland habitats where animals rely entirely on arboreal lichens for food.

Home Ranges

Simpson and Woods (1987) reported that annual home ranges in the Revelstoke sub-population varied between 112 km^2 and 860 km^2. Home ranges in the South Selkirk Mountains varied between 131 km^2 and 173 km^2 (Scott and Servheen 1985). Among Central Selkirk Mountains caribou, annual home ranges of males were 218 ± 51 km^2 and females were 167 ± 20 km^2 (Hamilton et al. 2000).

Reproduction

Mountain caribou breed in late autumn and gestation averages seven to eight months. Calves are born in late May-early June and a cow will average only six calves over her lifetime. Single births are most common. Calves are conspicuous and must be able to travel with cows almost immediately after birth (Hunter 1972). Migration of caribou to upper-elevation calving areas is attributed to predator avoidance (Seip and Cichowski 1994).

Life Requisites

The Central Selkirk mountain caribou inventory project assessed habitat use and population characteristics in the project area (Hamilton et al. 2000, Hamilton and Wilson 2002). Caribou require terrestrial vegetation and arboreal lichen for food, cover to provide protection from predators and weather, and the spatial arrangement of these life requisites over four distinct seasons.

Feeding (FD) Habitat

Feeding requirements for mountain caribou are tied closely to food availability, particularly arboreal lichens during the critical winter period.

Early Winter

Caribou populations in high snowpack ecosystems make early-winter movements to mid and lower elevations and remain there until snows deepen and consolidate (Simpson et al. 1985, Antifeau 1987). Early winter forage habitats are often dominated by *Paxistima myrisinites* and/or *Pyrola* species (Servheen and Lyon 1989, Simpson et al. 1997). As snowpack increases, caribou shift their diet to arboreal lichen (*Alectoria* spp and *Bryoria* spp) obtained from litterfall and on windthrow trees or branches (Simpson et al. 1985, Antifeau 1987, Rominger and Oldemeyer 1989, Hamilton et al. 2000).

Late Winter

Movement of mountain caribou to late-winter ESSF/parkland habitat occurs when snowpacks deepen and consolidate, allowing movement on top of the snow and enabling the caribou to reach the lichen-bearing portion of the forest canopy (Scott and Servheen 1985, Simpson et al. 1985, Rominger and Oldemeyer 1989, Servheen and Lyon, 1989). Lichens on windthrown trees and litterfall are used when available, but the major source of food during late winter is arboreal lichens found on both living and dead standing trees (Simpson et al. 1985, Antifeau 1987, Hamilton et al. 2000).

Spring

Spring feeding sites are those that are the first to be snow free and green-up in the spring. These areas are important for animals recovering from a winter-long lichen diet, and for cows preparing for the demands of lactation in relatively food-deficient calving areas (Scott and Servheen 1985). Calving areas typically have high lichen densities because vascular forage is unavailable due to late snowmelt (Scott and Servheen 1985, Servheen and Lyon 1989).

Summer/Fall

Summer/fall forage includes a wide range of herbaceous green vegetation and shrubs including grasses, sedges, buds, lichens and flowering plants (Hamilton et al. 2000). Because food is available almost everywhere, caribou are widely distributed and are in smaller groups than in winter. This is likely a predator avoidance strategy.

Security (SH) Habitat

Caribou prefer areas with high visibility for predator detection (*e.g.*, they tend to avoid areas where tall shrubs, conifer regeneration, or other obstructions restrict horizontal visibility; Stevenson et al. 1994, Hamilton et al. 2000). Older forest habitats characterized by low shrub cover, low levels of conifer regeneration and gentle to moderate slopes characterize good security cover habitat for caribou. These late-succession forest stands also tend to support arboreal lichen forage.

Thermal (TH) Habitat

Thermal habitat allows caribou to expend less energy to maintain body temperature and allow allocation of conserved energy to growth and reproduction. Thermal cover is considered an important component of ungulate habitat. It has been defined as overstory vegetation that, for a given combination of solar radiation flux density, ambient air temperature and wind speed, allows an animal to remain in its thermoneutral zone (air temperatures in which animals exist most comfortably) or minimize thermoregulatory costs (Demarchi and Bunnell 1993). Thermal cover also provides snow interception that can lower an animal's energy expenditures for locomotion (Parker et al. 1984). Energy is a limiting factor under adverse environmental conditions for many ungulates. In summer, increased metabolic costs associated with heat dissipation can translate into decreased summer weight gain while in winter animals lacking sufficient energy reserves are more vulnerable to winter-spring mortality (Mautz 1978).

Mature to old forests provide caribou thermal habitat in all seasonal habitats. These forests also provide snow interception, greater mobility and forage availability during winter.

Combining Life Requisites

Caribou feeding habitat is generally associated with habitat that provides security and thermal cover. Arboreal lichens, the primary food source during winter, are associated with mature and old growth forests that have both thermal and security cover attributes. Spring foraging sites appear to be selected more for their forage availability than for their cover attributes. As a result, habitat ratings for "living" were generally weighted 80% in favour of feeding (FD) and 20% in favour or security/thermal cover (SH/TH).

Seasons of Use

Based on results reported by Hamilton and Wilson (2002), we identified 4 seasons of habitat use for mountain caribou in the Central Selkirks (Table 4).

Table 4. Seasonal habitat use patterns for mountain caribou in the Central Selkirk Mountains.

Season	Code	Dates
early winter	WE	October 25 – January 15
late winter	WL	January 16 – May 12
Spring	P	May 13 – June 30
summer fall	S/F	July 1 – October 24

Mountain caribou require primarily feeding habitat in winter and feeding and security/thermal habitat for the spring, summer and fall growing season (Table 5).

Table 5. Monthly Life Requisites for mountain caribou.

Life Requisite	Month	Season
Feeding	January	early winter/late winter
Feeding	February	late winter
Feeding	March	late winter
Feeding	April	late winter
Feeding and cover	May	late winter/spring
Feeding and cover	June	spring
Feeding and cover	July	summer
Feeding and cover	August	summer
Feeding and cover	September	summer/fall
Feeding and cover	October	fall/early winter
Feeding	November	early winter
Feeding	December	early winter

Early Winter (October 25-January 15)

- Important period when animals are forced to lower elevation forest habitats due to increasing snow accumulations at higher elevations
- Use of mid to lower elevation, moderately sloped ICH zone and ESSF/ICH ecotone forested habitats
- Selected habitats usually consist of mature/old forests that support arboreal lichens and offer snow interception, thermal cover, and reduced ground snow accumulations for forage availability. Low height shrub cover (*i.e.*, obstructions to visibility and movement are low) are generally selected over areas with heavy, high shrub or dense small tree cover
- Feed on *Paxistima* species and other vegetation when not snow covered, otherwise rely on arboreal lichens from standing trees, litterfall (broken branches), or windthrown trees

Late Winter (January 16-May 12)

- Migrate upslope from lower/mid elevation habitats to high elevation forested ESSF/ESSF parkland habitats, but only when snow consolidation supports travel on top of snow and snow accumulation is such to allow access to conifer supported arboreal lichens for feeding
- Use high elevation mature to old growth ESSF and ESSF parkland habitats characterized by gentle to moderate slope, open canopies (20-50% crown closure) and low basal area
- Feed entirely on arboreal lichens (primarily *Bryoria* spp and *Alectoria sarmentosa*) found on live and dead standing trees, blowdown and litterfall

Spring (May 13-June 30)

- Migrate from higher elevation habitats to lower elevation snow-free habitats, sometimes on a daily basis, when snow conditions at higher elevations become restrictive to movement and access to arboreal lichens is reduced
- In snow-free habitats in the ICH and ICH/ESSF ecotone, caribou select sites where obstructions to visibility and movement are low *(e.g.*, closed canopy forest habitats, gentle to moderate slopes in association with early snow-free areas such as bog, seeps, etc.)
- Pregnant cows may again move from lower elevation habitats to food-limiting but predator-free higher elevation habitats for calving. Calving usually occurs in the ESSF or AT, at or near the snowline, in secluded areas in proximity with security forest cover attributes
- Forage includes arboreal lichens in snow covered habitats and new green vegetation in snow free habitats

Summer/Fall (July 1-October 24)

- Use upper ICH/ESSF ecotone, ESSF and AT zones, particularly relatively open, older age class forest stands in association with seeps, bogs and riparian type habitats where vegetation is succulent and abundant
- Forage includes a wide range of herbaceous green vegetation and shrubs including grasses, sedges, buds, lichens and flowering plants

Ecosystem Attributes

Table 6. Predictive ecosystem mapping (PEM) relationships and life requisites for mountain caribou in the Central Selkirk Mountains.

Life Requisite	PEM Attributes
Feeding	• *site*: structural stage, elevation, slope, aspect • *soil/terrain*: moisture regime, bedrock, terrain texture • *vegetation*: species composition, lichen abundance • *mensuration*: tree species composition, density, blowdown, lichen abundance
Feeding/security habitat	• *site*: structural stage, slope, elevation • *soil/terrain*: moisture regime • *vegetation*: % cover by layer • *mensuration*: tree species, density, crown closure

Ratings

Provincial Benchmark

The Cariboo Mountains (CAM) ecosection is the provincial benchmark for mountain caribou. The CAM, CCM and NKM ecosections accommodate Class 1 ratings for caribou in ESSF for the winter and growing seasons. The ESSFwk, Englemann Spruce-Subalpine Fir unit, structural stage 6 (EF/6) is the winter season benchmark, and the ESSFwk, Subalpine Meadow (SM) is the growing season benchmark.

Ratings Assumptions

Life requisites were combined as outlined above. Industrial and secondary roads were assumed to have little or no effect on habitat ratings. Recreation impacts (*e.g.*, commercial heliskiing, snow-cat skiing and snowmobile use) were not considered in the ratings because intensity, extent and duration of these activities were difficult to validate and map (Table 7).

Table 7. Ratings assumptions for mountain caribou in the Central Selkirk Mountains project area.

Class	Season	Life Requisite	Structural stage	Requirements
1	Early winter	FD	6-7	• abundant lichen available on standing live and dead trees, lichen litterfall from windthrow and broken branches • *paxistima myrisinites* and *Pyrola* often present • <80% slope
	Late winter	FD	6-7	• abundant lichen • presence of white bark pine (good indicator) • gentle, rolling terrain
	Spring	FD	2-3, 6-7	• early green-up sites • <80% slope • warm aspects
	Summer/fall	FD, SH	6-7	• <80% slope • abundant vegetation • moist, cool sites

Class	Season	Life Requisite	Structural stage	Requirements
2	Early winter	FD	6-7	• abundant lichen available on standing live and dead trees, lichen litterfall from windthrow and broken branches • *paxistima myrisinites* and *Pyrola* often present • <80% slope • generally moister sites than Class 1
	Late winter	FD	6-7	• abundant lichen • presence of whitebark pine (good indicator) • <80% slope
	Spring	FD	2-3, 6-7	• early green-up sites • <80% slope
	Summer/fall	FD, SH	2-3, 6-7	• <80% slope • abundant vegetation
3	Early winter	FD	6-7	• lichen available but not as abundant as Classes 1 or 2 • <80% slope
	Late winter	FD	All	• less lichen than Classes 1 or 2 • <80% slope
	Spring	FD	2-3, 6-7	• <80 slope
	Summer/fall	FD, SH	All	• <80% slope
4	Early winter	FD	5-7	• lichen available but less abundant than Classes 1 or 2 • can be >80% slope • generally moister sites
	Late winter	FD	5-7	• limited lichen production • >80% slope
	Spring	FD	All	• can be >80% slope
	Summer/fall	FD, SH	All	• less vegetation • can be >80% slope
5	Early winter	FD,MS	All	• limited food, cover, lichen • can be > 80% slope
	Late winter	FD	All	• limited food, cover, fewer trees
	Spring	FD, MS	All	• limited food, cover • can be >80% slope
	Summer/fall	FD, MS	All	• limited food, cover • can be > 80% slope
6	All	All	All	• non-habitat (no food or shelter available, impassable terrain such as lakes, cliffs, etc.)

Ratings Adjustments

Summer/fall ratings for the ICH reflect that, although food is abundant and available in the ICH, caribou generally remain at higher elevations in order to avoid predators (Seip and Cichowski 1994, Stevenson and Hatler 1985; Hamilton and Wilson 2002; Table 8).

Table 8. Habitat ratings adjustments for mountain caribou in the Central Selkirk Mountains project area.

Habitat Feature	Description	Season(s)	Suitability Rating Adjustment
Highway 6	Highway from Nakusp to Trout Lake	All	Reduce habitat ratings by 2 classes within 200 m of highway (lowest rating Class 5)

Reliability Qualifier

A reliability qualifier of *high* was assigned to reflect the confidence of the species-habitat model. Species-habitat relationship information was based on a long-term caribou inventory study initiated in 1995, as well as stand, landscape and multi-scale habitat models, population censuses, field sampling and expertise gained over the term of the project. The project biologist also has experience with mountain caribou management throughout the Kootenay region, provincially and internationally. A reliability qualifier of *medium* was assigned to the accuracy of the PEM-based ecosystem classifications, in light of deficiencies highlighted in Smith and Wilson (2002).

Literature Cited

Antifeau, T. D. 1987. The significance of snow and arboreal lichens in the winter ecology of mountain caribou (*Rangifer tarandus caribou*) in the North Thompson watershed of British Columbia. M.Sc. Thesis, University of British Columbia, Vancouver.

Demarchi, M. W. and F. L. Bunnell. 1993. Estimating forest canopy effects on summer thermal cover for Cerviae (deer family). Canadian Journal of Zoology 23:2419-2426.

Hamilton, D., S. F. Wilson, and G. Smith. 2000. Mountain caribou habitat use and population characteristics for the Central Selkirks caribou inventory project. Prepared for: Forest Renewal British Columbia.

Hamilton, D., and S. F. Wilson. 2002. Population census and telemetry monitoring for the Central Selkirk caribou inventory project. Prepared for: Pope & Talbot Limited, Nakusp, BC.

Heard, D. C., and K. L. Vagt. 1998. Caribou in British Columbia: a 1996 status report. Rangifer Special Issue 10:117-123.

Hunter, T. 1972. British Columbia's natural history: caribou. BC Department of Recreation and Conservation Wildlife Review Spring 1972.

Mautz, W. W. 1978. Nutrition and carrying capacity. *In:* J. L. Schmidt and D. L. Gilbert [editors]. Big game of North America: ecology and management. Stackpole Books, Harrisburg, PA.

McLellan, B. N., J. Flaa and J. Woods. 1994. Mountain caribou censuses in the North Columbia Mountains. BC Ministry of Forests Research Branch, Revelstoke.

Mountain Caribou Technical Advisory Committee (MCTAC). 2002. A strategy for the recovery of mountain caribou in British Columbia. BC Ministry of Water, Land Air Protection, Victoria.

Parker, K. L., C. T. Robbins, and T. A. Hanley. 1984. Energy expenditure for locomotion by mule deer and elk. Journal of Wildlife Management 48:474-488.

Rominger, E. M. and J. L. Oldemeyer. 1989. Early-winter diet of woodland caribou in relation to snow accumulation, Selkirk Mountains, British Columbia, Canada. Canadian Journal of Zoology 68:2691-2694.

Scott, M. D., and G. Servheen. 1985. Caribou ecology. Idaho Department of Fish and Game Project Report No. W-160-R-11.

Seip, D. R., and D. B. Cichowski. 1994. Population ecology of caribou in British Columbia. 6th North American Caribou Workshop, Prince George, BC.

Servheen, G. and L. J. Lyon. 1989. Habitat use by woodland caribou in the Selkirk Mountains. Journal of Wildlife Management 53:230-237.

Shackleton, D. 1999. Hoofed mammals of British Columbia. UBC Press.

Simpson, K., G. P. Woods and K. B. Hebert. 1985. Critical habitats of caribou in the mountains of southern BC. BC Ministry of Environment Wildlife Report No. WR-23.

Simpson, K., and G. P. Woods. 1987. Movements and habitats of caribou in the mountains of southern British Columbia. BC Ministry of Environment Wildlife Bulletin No. B-57.

Simpson, K., E. Terry and D. Hamilton. 1997. Toward a mountain caribou management strategy for British Columbia – habitat requirements and sub-population status. BC Ministry of Environment, Lands and Parks, Wildlife Working Report No. WR-90.

Stevenson, S. K., H. M. Armleder, M. J. Jull, D. G. King, B. N. McLellan, and D. S. Coxson. 2001. Mountain caribou in managed forests: recommendations for managers. Second Edition. BC Ministry of Environment, Lands and Parks Wildlife Report R-26.

Stevenson, S. K., and D. F. Hatler. 1985. Woodland caribou and their habitat in southern and central British Columbia. Volumes 1 and 2. BC Ministry of Forests Land Management Report Number 23.