CARIBOU AND LICHENS,
MUSKWA-KECHIKA MANAGEMENT AREA

For:

Muskwa-Kechika Trust Fund
Project I.D. #MKTF99-20 37

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EXECUTIVE SUMMARY

In 1999 Madrone Consultants Ltd. submitted a proposal to the Muskwa Kechika Trust Fund (MKTF) to develop a research proposal investigating the relationships between woodland caribou, lichens and natural ecosystems in the Spruce Willow Birch (SWB) and the Boreal White and Black Spruce (BWBS) biogeoclimatic zones of the Muskwa-Kechika Management Area (MKMA). Submission of this document effectively completes the first phase of the project (Project #MKTF99/20 37), i.e. the development of a research program.

The MKMA supports one of the largest intact predator prey ecosystems based on large mammal populations in North America. A significant goal in its establishment was to maintain the major wilderness based predator-prey systems in perpetuity. The successful management of wildlife habitats in the area in response to existing and changing resource demands and ecological conditions, including the influence of fire and of ungulate foraging, is paramount in meeting this objective.

Caribou herds are a high value and high profile resource with significant populations occupying portions of the MKMA. They generate considerable public interest and are of value for guide-outfitters and for wildlife viewing, as well as being an important food resource to First Nations in the area. The Northern caribou ecotype is generally considered to be effectively dependent upon lichens – predominantly terrestrial but also arboreal, for survival through the winter.

This proposed research project aims to increase our knowledge of caribou/habitat associations in Northern B.C., through investigating the significance of terrestrial and arboreal lichens in the diet of Northern caribou, and through collecting habitat data on lichen productivity and availability in the MKMA. Ecological relationships between caribou and lichens will be explored through caribou dietary studies, habitat surveys and investigations into caribou feeding sites.

The scientific results will be utilized to improve existing caribou habitat models to better predict the seasonal distribution of caribou by habitat type. The role of fire, both natural and prescribed, on lichen availability will be given specific attention. This will permit us to predict impacts not only of industrial developments, and of increased human recreational activities, but to also examine the implications of prescribed fire programs in the area. The information will thus be used to support decisions on habitat management. This will be essential in the future if the long-term sustainability of this wildlife resource is to be ensured.

CARIBOU AND LICHENS, MUSKWA-KECHIKA MANAGEMENT AREA

1 INTRODUCTION

1.1 Initial Project Proposal and Objectives

In 1999 Madrone Consultants Ltd. submitted a seed proposal to the Muskwa Kechika Trust Fund (MKTF) to develop a research proposal investigating the relationships between woodland caribou, lichens and natural ecosystems in the Spruce Willow Birch (SWB) and the Boreal White and Black Spruce (BWBS) biogeoclimatic zones of the Muskwa-Kechika Management Area (MKMA).

The overall objectives of the intended research proposal were initially to:

- Significantly improve our abilities to predict caribou winter habitat uses
- Improve caribou habitat models for capability and suitability mapping.
- Improve our understanding of the environmental variables and processes that govern lichen productivity.
- Provide information for assessing the potential impacts of proposed developments, forestry management practices, and the implications of fire.

1.2 This Report

This document presents the methods and results of the background work, and completes this first phase of the project, i.e. the development of a research program. Results are summarized in the form of a review of what is known on caribou and lichen - habitat relationships in the area, followed by presentation of a research proposal (in the form of a work plan).

2 BACKGROUND AND RATIONALE

Information on the ecological significance and the management goals of the Muskwa-Kechika Management Area are provided in the associated project report #MKTF99/20 36 (Radcliffe, 2000). In brief, the Muskwa–Kechika area is considered one of North America's last true wilderness areas south of the 60^{th} parallel. It is also considered globally significant for the diversity and abundance of its wildlife populations, in particular the many large mammals, and intact predator-prey systems, that it supports. The healthy ungulate, including caribou, populations not only support many wild predators, but are important foods for First Nations groups in the area, provide substantial income to a number of guide-outfitters and packers, provide for recreational hunting opportunities, wildlife viewing, and general wilderness-based tourism.

One of the key goals of the MKMA, supported by Provincial and Regional goals, is to protect the wildlife resources and the predator-prey systems relatively intact, while permitting some controlled resource development. However, potential developments and management activities are likely to result in conflicting objectives and often highly contentious issues. A solid scientific foundation is needed for making appropriate management decisions that will ensure the perpetuation of the wildlife habitats that support the major predator-prey systems in this area.

Caribou are considered to be a high profile species of provincial significance. Population estimates indicate the MKMA supports a very substantial proportion (approx. 30%) of B.C.'s Northern caribou population (see section 6.3). Arboreal and terrestrial lichens are key caribou forage items during the winter months. However, most habitat-use studies have been focused on woodland caribou and arboreal lichens in the southeast part of the province, due to conflicts between forest harvesting and declining populations (Stevenson, 1991). However, with increasing resource demands, the focus has expanded to include woodland caribou populations in the northern part of the province (Terry and Wood, 1998). Terrestrial lichens appear to be an increasing component of the winter diets as latitude increases.

To date, no studies have been conducted examining caribou-lichen-habitat relationships within the MKMA. Studies elsewhere in the province have been conducted under very different ecological conditions. The understanding of these complex ecological systems in natural or near-natural settings is imperative before we can understand the effects of alterations and management.

This proposed study aims to help fill critical information gaps by gathering relevant ecological information on the availability and productivity of lichens in the MKMA. It aims to also explore lichen-habitat relationships in the area, and clarify the degree of dependence on lichens (arboreal and terrestrial) by caribou in the area. The improved understanding of caribou habitat uses and the relationships between lichens and habitats will enable us to predict potential development impacts and plan habitat management, whether for conservation purposes, resource extraction, or provision of recreational opportunity. By contracting and employing from the northern communities, the project will also increase training for local people. It will increase knowledge of the area and its values, and will in addition inject further money into the local economy via local employment and contracts.

3 PHYSICAL SETTING

3.1 Physical Location

The study area (Figure 1) comprises the entire Muskwa–Kechika Management Area (MKMA); it is described in various other proposals and reports, including Barton (2000). It encompasses all of the Resource Management Zones, as described in the Fort Nelson and Fort St. John LRMP documents. Within this broad framework however, a core study area for some aspects of the project will be centered around Toad River, to take advantage of a proposed caribou ecology research project (project MKTF99/20 36), should it proceed, as well as relatively good access. This core area is described in detail in Radcliffe (2000). Thus, broad habitat-lichen data will be collated and analyzed from existing plots for the entire MKMA area, and a habitat-sampling plan to fill in data gaps will accommodate the whole area. However, specific aspects of caribou diet and seasonal habitat use, and more detailed lichen sampling, will center more specifically upon the “core” area. This will permit us to maximize use of the spatial data collected from the ecological study. Habitat sampling will also be linked to another research project if it proceeds, i.e. the sampling program for classification of the AT and SWB (project #MKTF99/20 38, Barton 2000), as well as to any future TEM mapping initiatives.

3.2 Access

The Alaska Highway provides the major existing ground access to study sites in the northern part of the area. There are in addition a number of roads and well-developed trails (many from guide-outfitter use), which make many parts of the core study area accessible by a combination of horseback, foot, and snowmobile (depending on season and conditions). The more recent seismic lines also provide some access. A road (Road 401, to an abandoned mine) runs south from the highway near the One Thirteen Creek crossing up into the Racing River system, towards Churchill Creek and Wokkpash. There are also some roads into the Toad River system, and further west, roads run through the MKMA through the Kechika Valley. More unsurfaced roads enter the MKMA in the south part of the area, in the Prophet, Sikanni and Graham systems in particular, so access into the southern portion of the MKMA is relatively good.

From road 401 there is a trail up into Wokkpash Lake, with a guide-outfitter camp at the north end of the lake, and a B.C. Parks cabin at the south end (B.C. Parks, 1999). A major trail also exists on the east side of the mountains, linking the Tetsa River up through Henry Creek into the top end of the Chischa. The Tuchodi system has relatively good access, and trails and jet boats access the main Tuchodi valley, from where it is possible to head north into Chlotopecta Creek and beyond. Parks trails also facilitate access in the existing Park areas, including trails in Muncho Lake and Stone Mountain Parks. North of the Alaska Highway, trails also exist along the Dunedin and up into the foothills north of Stone Mountain.

Winter access is generally good, and most areas can be accessed by snowmobile and on foot with snowshoes (Rob Honeyman, pers. comm.). This access will facilitate many aspects of the study (e.g. ground-based tracking of caribou trails, and winter feeding site/habitat surveys) so the study is not too heavily dependent upon helicopter and fixed wing aircraft support. However, some areas which have previously been poorly sampled for vegetation are likely to be very remote, and effectively accessible only be helicopter, at any time of year.

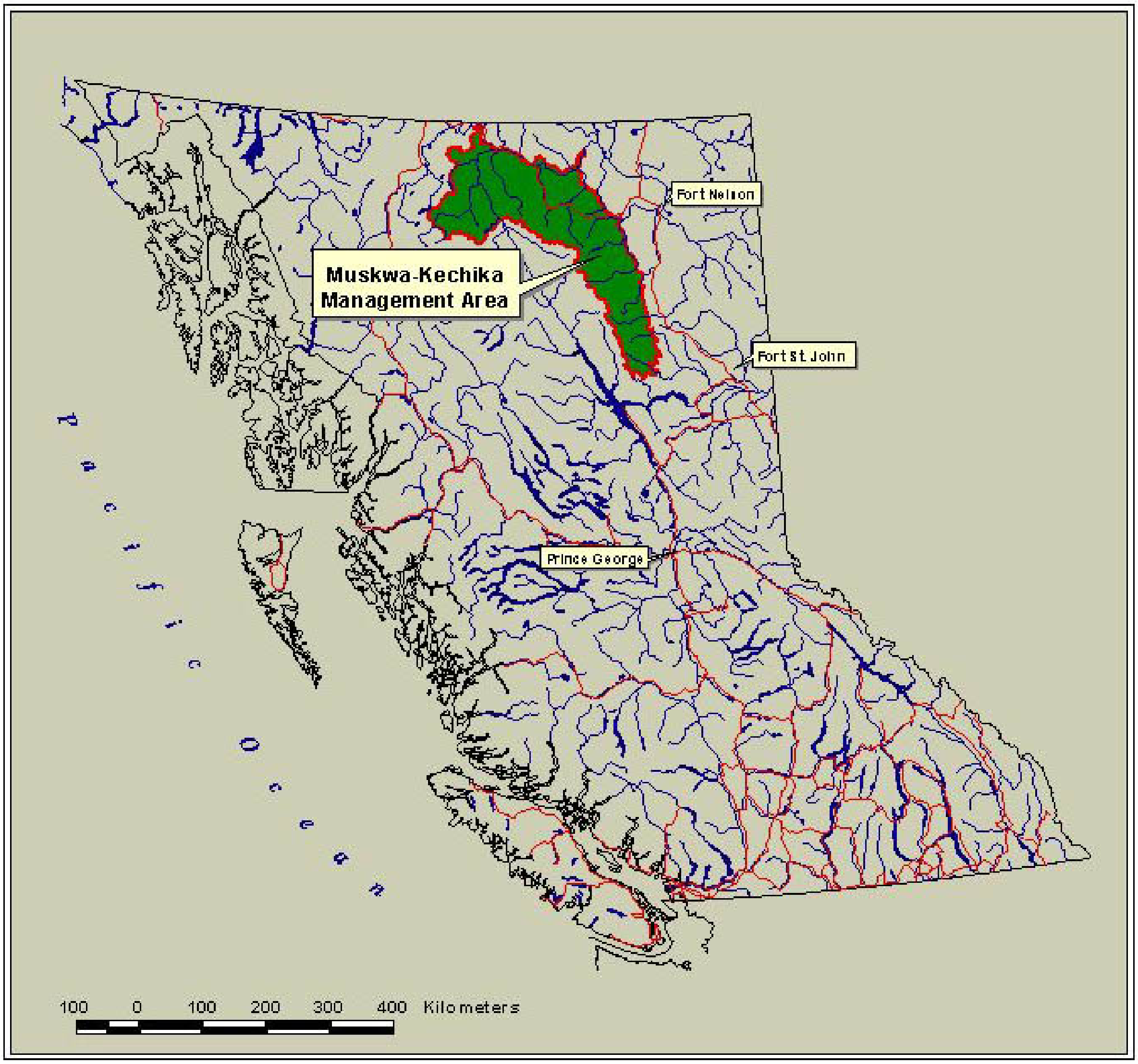

Figure 1. Study Area - Muskwa–Kechika Management Area.

4 METHODS

4.1 Meetings and Interviews

The project was initiated in 1999. A road trip to northern B.C., aimed at seeking information for both this project and a second caribou project (MKTF99/20 36) was completed in August 1999, and meetings were conducted with government agencies (MELP, MOF, B.C. Parks), First Nations, guide-outfitters, forestry licensees, university personnel (UNBC), and other biologists. Further telephone contacts and meetings with stakeholders, including oil and gas personnel, and with biologists working on other caribou projects elsewhere in B.C., were subsequently made. Appendix 1 identifies the various contacts made during this research (these contacts effectively apply to both projects and the same information is provided in both project reports). At these meetings and during discussions, stakeholder interests and project objectives were explored, and opportunities for collaboration to maximize use of the information to be collected were discussed. Where relevant, potential research opportunities and local employment opportunities were identified.

4.2 Literature Review

A literature search and review was also conducted and the findings are presented/summarized in this document. Information from past studies in northern British Columbia, current research and surveys, and, where applicable, information from other areas outside of northern British Columbia have been utilized. The Muskwa-Kechika annotated bibliography (UNBC, 1999) was also checked for source material. Table 3, Section 6.2, briefly identifies most of the work done to date on northern caribou in B.C., and indicates some of the key references. Most projects collect a mix of ecological, inventory and habitat data; only a few are lichen-specific.

4.3 Field Reconnaissance

A second road trip and a brief winter field reconnaissance took place in February 2000. During this trip Gillian Radcliffe held further meetings with stakeholders and interested parties (see Appendix 1). An aerial reconnaissance of part of the potential study area was made on February 19, 2000. This field review was conducted by Gillian Radcliffe in conjunction with Mary Duda of Slocan Forest Products Ltd., and Mr. David Wiens, the local guide-outfitter. Objectives were also to meet with needs of the associated caribou ecology project, and were to:

- Look at present winter distribution of caribou in the area (also for project MKTF99/20 36).
- Briefly look at the habitats being used (also for project MKTF99/20 36).
- Identify if any key lichen-type units were being used.
- Examine the feasibility of the intended project, including the field logistics of conducting a research project based in this area (also for project MKTF99/20 36).

[NB an additional objective, related more strictly to project MKTF99/20 36, was to identify core areas for initial collaring and telemetry work]

5 BIOPHYSICAL CONDITIONS

5.1 Ecosections, Physical Description

Based on the broad physiographic divisions, which form the basis of the Ecoregion Classification system described by Demarchi (1996), the proposed study area falls largely within the Polar Ecodomain. Table 1 summarizes the Ecosections represented in the MKMA.

Table 1. Ecoregion classification of the study area.

Ecodomain; Ecodivision	Ecoprovince	Ecoregion	Ecosection	Description
Humid Temperate; Humid Continental Highlands	Sub-boreal Interior	Central Canadian Rocky Mountains	Misinchinka Ranges	The Misinchinka Ranges Ecosection is a rugged mountain area, with deep narrow valleys. Moist Pacific air often stalls over these mountains, bringing high precipitation, both summer and winter.
			Peace Foothills	The Peace Foothills Ecosection is a blocky mountain area on the east side of the Rocky Mountains. Strong rainshadows exist.
Polar; Boreal	Northern Boreal Mountains	Boreal Mountains and Plateaus	Cassiar Ranges	The Cassiar Ranges Ecosection is the area with the highest and most rugged mountains in the Ecoregion. It has a broad band of mountains extending from the southeast corner of the Ecoregion to the northeast corner.
			Kechika Mountains	The Kechika Mountains Ecosection is an area with high mountains, but low, wide valleys in the rainshadow of the Cassiar Ranges to the west.
			Southern Boreal Plateau	The Southern Boreal Plateau Ecosection consists of several deeply incised plateaus. Extensive rolling alpine and willow/birch habitat occurs. This Ecosection is located in the south-central part of the Ecoregion.
			Hyland Highland	The Hyland Highland Ecosection is an area of rolling upland that extends from northern British Columbia into the Yukon and Northwest Territories. This Ecosection provides a low barrier between the Interior Plains to the east and the valleys of the Canadian Cordillera to the west.
		Liard Basin	Liard Plain	The Liard Plain Ecosection is a broad, rolling inter-mountain plain with a cold, sub-Arctic climate.
		Northern Canadian Rocky Mountains	Eastern Muskwa Ranges	The Eastern Muskwa Ranges Ecosection is the area with the highest, most rugged mountains in the Ecoprovince. It has more snowfall than the foothills to the east.
			Muskwa Plateau	The Muskwa Plateau Ecosection is a dissected upland area that rises above the Fort Nelson Lowland to the east
			Muskwa Foothills	The Muskwa Foothills Ecosection is an area of subdued mountains which are isolated by wide valleys. This area is in the rainshadow of the Rocky Mountains to the west; it is also more commonly under the influence of cold Arctic air in the winter.

(Adapted from Demarchi, 1996)

Lying where the Northern Canadian Rocky Mountains (Eastern Muskwa Ranges Ecosection) and associated foothills (Muskwa Foothills Ecosection) merge with the boreal plains (Muskwa Plateau Ecosection), it is an area encompassing great biophysical diversity. This ranges from the rugged peaks of the Rocky Mountains, through the expansive rolling country and wide valleys of the Muskwa Foothills, to the relatively subdued upland terrain that prevails in the Muskwa Plateau. Further east lie the plains of the Fort Nelson Lowlands.

5.2 Geology and Soils

Geology and Soils of the study area are well described in a variety of other publications, and the reader is referred to those documents for details (Barton, 2000; Barton *et al.*, 1998; B.C. Parks, 1999; Holland, 1976; Taylor, 1971; Valentine *et al*., 1978).

5.3 Climate

The Polar Ecodomain is characterized by low temperatures, severe winters, and small amounts of precipitation; it is commonly under the influence of cold Arctic air in winter (Demarchi, 1996). On the north and east sides, the lower peaks and foothills lie within the rain shadow of the Rocky Mountains, resulting in generally low precipitation, including low snowpacks. Within the Rocky Mountains, complex patterns of surface heating and cold air drainage occur due to the rugged relief. Snow generally increases with increasing elevation, but temperature inversions often occur, resulting in warmer conditions and sometimes less snow at the higher elevations than in the valley bottoms. Thus many of the higher ridges may have little snow and are in addition often windblown. There are apparently always a lot of bare ridges free of snow in the alpine in the northern part of the area (David Wiens, pers. comm.). This factor may significantly influence wildlife movements in the winter months.

There appears to have been limited systematic recording of precipitation within the study area. The only climate station listed in Canadian Climate Normals (Environment Canada, 1990) is at Muncho Lake; however, snow data has not been recorded there for the winter months. Otherwise, the nearest stations are outside of the MKMA, in Fort Nelson and Fort St. John, and to the southwest at Germansen. In previous years snow data was recorded at Summit station, 1280m elevation, along the Alaska Highway. Peck (1988, cited in Bergerud and Elliott 1998) also recorded snow depths in the Tuchodi valley. These data are summarized in Bergerud and Elliott (1998), and show accumulations of less than 40 cm at Summit on March 1 each of 7 years, from 1964 to 1970. Accumulations are a little deeper in the Tuchodi Valley, but were still below 40 cm in all but 3 years, from 1974 to 1990 inclusive. Recorded March 1 depths did not exceed 60cm.

Based on information provided by David Wiens and Al Hansen (pers. comms.), snow in the northern part of the MKMA usually starts to fall at the lower elevations from the middle to the third week in October. However, snow begins sitting at higher elevations around the end of September. Snow depths in most years are fairly low, but snow can fall in the summer months.

5.4 Vegetation and Biogeoclimatic Zonation (modified from Barton *et al*., 1998)

5.4.1 General Vegetation Description

The ecosystems of the study area are described in the Prince George Forest Region guides (DeLong *et al*., 1990; MacKinnon *et al*., 1990). The ecosystem classification of southeast Yukon also describes many of the vegetation types that occur within the study area (Zoladeski and Cowell, 1996). The Alberta Vegetation Inventory provides a useful reference (Nesby, 1997) especially for its classification and aerial photographs of boreal wetland types. Studies of fire-ecological relationships within the Fort Nelson T.S.A. (Parminter, 1983) are helpful in interpreting ecosystems of the area.

A patchwork of slow-growing forests, deciduous shrubs, and wetlands of varying ages and successional stages dominate vegetation of the study area. At the lower elevations, Black spruce is dominant in mixture with a variety of species including trembling aspen, white spruce, subalpine fir, lodgepole pine, paper birch, and balsam poplar. At higher elevations, intermittent white spruce and subalpine fir woodland and willow and birch scrub develop. Alpine meadows and unvegetated cliffs and rubble dominate the highest elevations.

The biogeoclimatic zones (BGC zones) that occur are the Boreal White and Black Spruce, the Spruce - Willow Birch, and small areas of Alpine Tundra. Good summaries of these zones can be found in Meidinger & Pojar (1991). Table 2 summarizes the general elevational boundaries of the different zones, subzones, and variants that occur (from Barton *et al*., 1998).

Table 2. Elevational Boundaries for Biogeoclimatic Units.

BGC Boundary	Elevation (m)		
	Warm Aspect	**Cool Aspect**	**Level**
BWBSmw2/wk3	950	900	900
BWBSmw2/SWBmk	1050	1000	1000
SWBmk/mks	1450	1340	1400
SWBmks/AT	1650	1550	1600

5.4.2 Boreal White and Black Spruce (BWBS) zone

The Boreal White and Black Spruce (BWBS) is a lowland to montane zone characterized by a northern continental climate with long, cold winters and short summers. Poor tree growth reflects the adverse climate, especially the short growing season and cold soil temperatures (DeLong *et al.*, 1990). The Fort Nelson Moist Warm (mw2) subzone covers lowland and undulating terrain. Forest cover varies, but white spruce, trembling aspen, and paper birch forests are usually present on moderately well-drained sites. Black spruce and lodgepole pine forests dominate poor sites. The Kledo Wet Cool (wk3) subzone occurs along ridgetops and is characterized by lodgepole pine, white spruce, and black spruce forests with black huckleberry in the understorey.

5.4.3 Spruce Willow Birch (SWB) zone

The Spruce Willow Birch (SWB) zone has an interior subalpine climate characterized by long, very cold winters and brief, cool summers. The Moist Cool (mk) subzone occurs at lower elevations of the SWB where intermittent white spruce and subalpine fir woodlands predominate. The Moist Cool Scrub (mks) subzone occurs at higher elevations where willow and scrub birch low shrub is interspersed with grass and sedge-dominated meadows and occasional patches of krummholz (MacKinnon *et al*., 1990).

5.4.4 Alpine Tundra (AT) zone

The severe climate of the Alpine Tundra (AT) zone is characterized by low growing season temperatures and a very short frost-free period. The AT is treeless and is dominated by dwarf woody plants, sedges, and lichens (MacKinnon *et al*., 1990).

5.4.5 Vegetation Disturbance

The most significant source of disturbance within the study area is fire. Mature conifer stands are relatively rare, and much of the variation in vegetation within the study area is due to a range of successional stages resulting from fires. Fire is most common within the BWBS zone, but also occurs in the SWB zone, especially on warm aspects. Barton *et al*. (1998) reported that significant disturbance due to fire at the SWBmk/mks and the SWBmks/AT boundary elevations made it difficult to generalize the upper limits of tree and low tree/krummholz growth from aerial photograph interpretation.

Although natural fires occur fairly often in this part of the province, many of the south aspect slopes in the study area have been burned through prescribed fires. Some of the slopes are burned fairly frequently, in some cases as often as every five years (David Wiens, pers. comm.), in order to enhance wildlife habitats and provide forage for packhorses. In some areas, e.g. in the Tuchodi and the Gathto, prescribed fires have burned extensive areas. This has had a very significant influence on wildlife habitats and populations within and around the study area. Once a site has been burned, multiple successional paths are possible depending on what seed sources and seedbeds are available at that site (Parminter, 1983).

Fluvial processes are another form of natural disturbance. Various successional stages are generally present on active floodplains in the area, due to depositional and erosional riparian processes. Disturbance due to beaver activity occurs along small streams, and the dams maintain fens along bodies of water in the lowlands.

Fungal rust disease affects some spruce trees in the SWBmk, at least in the northern part of the study area, but the extent of this disturbance is unknown (Barton *et al.*, 1998). The linear seismic lines that cross the study area are generally in shrubby stages of regeneration. Land clearing for pasture is of limited extent in the study area and is confined to small sections in the Alaska Highway Corridor.

6 NORTHERN CARIBOU IN THE MUSKWA-KECHIKA

6.1 Caribou Ecotypes

All caribou in British Columbia belong to the woodland subspecies (*Rangifer tarandus*) (Seip and Cichowski, 1996), but they can be further classified into three different ecotypes: the Mountain ecotype, the Northern ecotype, and the Boreal ecotype (Heard and Vagt, 1998). This division into ecotypes is based on behavioural and ecological differences (Heard and Vagt, 1998), primarily on winter diet and annual movement patterns (Shackleton, 1999).

The Mountain ecotype occupies mountain ranges in southeastern B.C. and has to cope with the highest snow accumulations and the most rugged mountains. They spend most of the year in alpine and subalpine habitats (Seip and Cichowski, 1996). Because the deep snowpack in this region prevents them from cratering for terrestrial foods, they winter at high elevations and rely primarily on arboreal lichens for food (Seip and Cichowski, 1996; Stevenson and Hatler, 1985). This ecotype is on the provincial Blue List and has been the subject of the most intensive studies.

The Boreal ecotype (included by some biologists in the Northern ecotype) occurs in low densities in the flatter landscapes of northeastern B.C., in areas dominated by the BWBS biogeoclimatic zone. They occur in small, dispersed groups that are relatively sedentary throughout the year (Heard and Vagt, 1998). Some authors include the Boreal ecotype under the Northern ecotype.

The Northern ecotype is the subject of this proposed study. This ecotype occupies the mountains in western and northern B.C., extending over a large area to the north and west of Prince George (Shackleton 1999), where there is low snowfall relative to caribou habitat (Bergerud, 1978). They generally summer in mountainous areas and winter in mature, low elevation lodgepole pine or black spruce forests or in windswept alpine areas (Seip and Cichowski, 1996; Heard and Vagt, 1998). Low snow depths in these habitats allows northern caribou to crater for terrestrial lichens, which are their primary forage during the winter (Heard and Vagt, 1998; Seip and Cichowski, 1996).

6.2 Caribou - Habitat Studies in Northern B.C.

Most caribou work, including most caribou habitat research, in B.C. has focused on the threatened Woodland ecotype in the south east of the province. Studies on the Northern ecotype have generally been much less detailed. Wood (1996) noted that at that time (1994) only two major studies of the Northern caribou ecotype had been conducted in the province. However, there are a number of projects currently in progress, and at least two of them are detailed, long-term studies on the Northern ecotype. A brief synopsis of the major recent and current northern studies is presented in Table 3.

It is important to note that other significant studies examining caribou and habitat relationships, including lichens, have mostly occurred in other biogeoclimatic zones. Thus, for example, the current work by McNay *et al*. (1999) and by Kent Brown (pers. comm.) are located in areas where the ESSF zone lies at the higher elevations, rather than the SWB which predominates at subalpine elevations in the MKMA. In the SWB, there is a history of extensive burning by wildfires and by prescribed fires to convert conifer areas to grasslands (Harrisson and Surgenor, 1996). Fire occurs only infrequently in the ESSF however, and thus the ESSF has older stands which support arboreal lichens (Harrisson and Surgenor, 1996). Snowfall is also generally much higher in these areas.

Table 3: Summary of caribou studies completed and currently taking place in North-Central and Northern British Columbia, and the Yukon.

Geographic Area	Herd(s)	Year(s)	Researchers	Key references	Notes
West of the MKMA: Horseranch/ Blue River Study Area	Rancheria & Horseranch herds	1998-present	MELP - Norm MacLean, Rick Marshall & Sean Sharpe	In house progress reports only at this stage of the study.	In conjunction with this project, some work is being conducted on natural disturbance/fire ecology in the in the BWBSdk2, especially around Blue River. Analysis of the impact of fire upon the caribou has been conducted in conjunction with collaring of caribou and wolves (Norm MacLean, pers. comm.). About 60 caribou are currently collared with VHF, and some with GPS collars as well. Although 15 wolves were originally collared, at present only 6 or 7 are thought to be actively collared. Research is also focused on general ecology and movements of the herds. The Kechika forms the eastern boundary, and Cassiar-Dease Lake the southern boundary of the study area. Background mapping includes a good Digital Elevational Model (DEM) for the area, good soils mapping, as well as broad ecosystem mapping.
West of the southern end of MKMA: west side of Williston Reservoir, Omineca Mountains	Chase & Wolverine herds	1992-1998	Peace/Williston F&W Comp. Program - Mari Wood & Elliott Terry	Wood 1996; Wood 1998; Terry and Wood 1999; Wood and Terry 1999	Eight years of telemetry conducted to examine habitat use, seasonal migrations, and general caribou ecology. As many as 29 caribou collared under Peace-Williston Fish and Wildlife Compensation Program. Similar work is being continued on the same herds, described below.
West of the southern MKMA: Omineca-Peace area	Wolverine, Chase & Akie herds	1999-present	Slocan Group, Mackenzie - Scott McNay & K. Zimmerman	McNay *et al* 1999	Conducting a detailed study in the Wolverine mountain range and surrounds. A monitoring program is underway to document habitat use patterns and population parameters of caribou, moose, and wolves; for use in a caribou management model. There are 217 collared animals including moose, caribou, and wolves. Telemetry is being conducted in the Akie/Ospika, Chase/Sustut, and the Wolverine ranges. This project has related TEM mapping, and satellite imagery for part of area.
West of the southern MKMA: west side of Williston Reservoir	Wolverine herd	1997-1999	UNBC - Chris Johnson	Johnson *et al.*1998	Caribou ecology and lichen research was carried out by UNBC grad student Chris Johnson (UNBC supervisor Kathy Parker). His thesis should be completed in spring/summer 2000.
West of the MKMA: Spatsizi	Spatsizi herd		Dave Hatler Debbie Cichowski	Hatler 1986	Detailed research has been conducted on the Spatsizi caribou herd.

Table 3 (Cont'd). Summary of caribou studies completed and currently taking place in North-Central and Northern British Columbia, and the Yukon.

Geographic Area	Herd(s)	Year(s)	Researchers	Key references	Notes
West of the southern MKMA: Valleau Creek	Wolverine herd	1997-present	CANFOR/IFS - Art Lance head biologist for IFS	FRBC project PG45960212	Purpose of study is to inventory habitat use by Northern caribou in relation to forest harvesting activity. Specifically, the study was designed to evaluate caribou habitat use within Valleau Creek – a drainage that was to be logged in 1998. Year one data suggested that the 6 radio-collared animals using the Valleau drainage in 1997 were from the Wolverine herd.
West of the northern MKMA: Atlin area	East and West Atlin herds	Current Research	MELP – Rick Keim and Rick Marshall		Environmental Assessment of proposed mine site and part of Southern Lakes Recovery Program. Defining herd mortality/survival, habitat use, and behaviour.
West – central B.C.; Tweedsmuir	Itcha-Ilgachuz-Rainbow herd & Tweedsmuir-Entiako herd	Started in 1983, intensive study 1985 to 1988	Debbie Cichowski, Allen Banner & Rick Marshall	Cichowski 1989; Cichowski 1996; Cichowski and Banner 1993	Initially a caribou winter range study, expanded into a caribou winter ecology study and winter habitat mapping. This was used to develop management tools including a winter range management strategy and options, and to support land use planning processes.
West – central B.C.: Tweedsmuir	Itcha-Ilgachuz-Rainbow herd	Present study started 1995	MELP - John Youds, James Young & Kerra Shaw	Young and Shaw 2000	Current work by MELP Williams Lake staff, continuing study outlined above; focusing on Itcha-Ilgachuz herd.
Southwest of MKMA: Telkwa Mtn Ranges, SW of Smithers	Telkwa herd	1995-Current Research	MELP - George Shultz & Sean Sharpe	Telkwa Recovery Plan 1997	Caribou recovery program – transplant. A total of 45 animals were collared in order to track survival and habitat use.
Southeast of MKMA: Red Willow Landscape Unit, Tumbler Ridge area, south of Dawson Crk.		Current Inventory Project	Kent Brown, John Kansas & Andrew deVries	Report in progress.	Kent and John, working for Andrew deVries of CANFOR, have been looking at lichen/caribou habitat modeling looking at different environmental variables and relationships to lichen growth. They are also pursuing similar research for Weyerhaeuser in Alberta.

Table 3 (Cont'd). Summary of caribou studies completed and currently taking place in North-Central and Northern British Columbia, and the Yukon.

Geographic Area	Herd(s)	Year(s)	Researchers	Key references	Notes
East of MKMA: Takla Caribou	Takla herd	FRBC project 1996-present	MELP – Doug Heard & Bill Arthur	FRBC project OP96182	Up to 14 caribou in the vicinity of Takla Lake have been radio-collared, and their movements documented once or twice per month to determine the time of year and locations when caribou use low elevation commercial forests. Takla caribou have been found to be typical northern caribou. They live in high sub-alpine and alpine areas from mid winter through summer, and in lower elevation forested areas in fall and early winter. There are many exceptions to this generalization. They feed primarily on terrestrial lichens throughout the year, but in May all animals descend to low elevations to feed on newly emerging vegetation growing in deciduous stands on snow-free south facing slopes.
Eastern MKMA – Graham River	Graham herd	1988 (10 animals collared) 1998 (42 presently collared)	MELP, Ft. St. John – John Elliott	Murray 1992	1988 – 10 collars placed on caribou in Graham River area, to northeast of Williston Lake. Currently, census work and development of a sightability index on the Graham herd in the MK area, is being conducted (John Elliott pers. comm.). Recently (started Nov 1998) tracking 42 collared animals in the Sikanni/ Graham areas. VHF collars used.
Eastern MKMA – Sikanni Chief and Profit River			John Elliott & Rob Woods		20 caribou collared in winter of 1990-1991
North of the MKMA: Yukon	Two herds	Current Research	Rik Farnell, Rick Marshall, Mark Williams & Rob Farquist		A telemetry study on caribou recruitment and population work, and predator impacts is underway in the Yukon. Monitoring occurs every 10-14 days in winter; there is little summer monitoring. In relation to this, some mapping using satellite imagery has been conducted. Also some involvement by Rick Marshall (Skeena Region) and Mark Williams. Data from this study indicates use of both terrestrial and arboreal lichens by caribou in the area are minimal. Caribou numbers appear fairly stable at roughly 1700 between two herds. The wolf population is believed to comprise 8 to 10 active packs in the study area.

In addition, there has been limited work done on the Boreal ecotype, although more has been done on this type in Alberta and the Yukon. At present there is one study being conducted in the Snake/Sateneh area on Boreal caribou, by Slocan and MELP.

6.3 Caribou herds in the Muskwa-Kechika

6.3.1 Populations in the MKMA

Heard and Vagt (1998) summarize the provincial status of caribou in 1996. The total caribou population is estimated to be in the order of 18,000, distributed among at least 39 recognized herds. Of this total, some 2,300 in 12 herds are Mountain caribou in the southeast. Only about 725 are thought to be Boreal caribou. These are scattered with no discrete herds recognized. The rest, some 15,000 in 27 identified herds, comprise the Northern caribou.

Several large caribou herds appear to have ranges largely within the MKMA. These include the Rabbit and Muskwa herds in the northern half of the area, and the smaller Graham herd in the southern half. The Pink Mountain herd has some animals which use the MKMA all year, some are outside all year, and some range across the boundary (John Elliott pers.comm.). We have considered this herd largely in the MKMA. The Horse Ranch herd occupies an area west of the Kechika, and may therefore range into the management area. The Wolverine and Finlay herds lie largely outside of the area, to the west of the southern portion of the MKMA.

Population estimates for the herds in the MKMA are as follows:

Largely in the MKMA:

Muskwa	1250
Rabbit	800
Pink Mountain	1300
Graham	800
TOTAL	**4,150**

Partially in the MKMA:

Horse Ranch	300

(NB: numbers are taken from Heard and Vagt 1998)

These figures indicate the MKMA supports a very substantial proportion - roughly 30% - of the estimated B.C. Northern caribou population [over 4,000 out of 15,600 animals (including Boreal) estimated in Heard & Vagt, 1998]. However, numbers within the study area may fluctuate substantially over time, either due to increases/declines, or to large-scale movements/shifts in ranges. Local informants in the northern part of the MKMA, for example, firmly believe populations have substantially declined over the past five years (Radcliffe, 2000). John Elliot (pers. comm.) considers the Muskwa herd is now smaller in size, the Pink Mountain herd may be about 900 animals, and the Graham herd is now down to about 200 animals. Specific information on population status, characteristics, and habitat use is entirely lacking for the MK biogeoclimatic zones within the Fort Nelson District (John Elliott, pers. comm. to Mary Duda).

6.3.2 Ranges and Movements

Caribou migrate between traditional calving, rutting, wintering, and post-calving ranges over a seasonal cycle (Child and King, 1991), and tend to show fidelity to seasonal ranges (Farnell and McDonald, 1989), including winter ranges. Many caribou winter within the MKMA area, but the extent of seasonal movements and the full extent of the herds and the ranges are not well documented, especially in the north.

Woodland caribou generally occupy large home ranges and migrate in response to seasonal habitat requirements. Stevenson (1991) reports the use of large home ranges allows caribou to select habitats offering acceptable combinations of snow conditions and food availability, select habitats that have given them an advantage over predators, and reduce their vulnerability to predators by dispersing themselves widely. However, home range size appears to be highly variable. In Spatsizi, caribou home ranges varied from $500km^2$ to $4,000km^2$. Edmonds (1988) reporting on caribou in west central Alberta found that migratory mountain caribou ranged over a much larger area ($11,000km^2$) than a more sedentary woodland population which occupied $4,000km^2$.

Animals do not necessarily return to the same winter ranges each year. Wood (1996) in fact found that most collared animals wintered on different ranges each year; i.e. there was a lack of fidelity to winter ranges. Thomas *et al*., (1996b) also report that caribou appear to rotate use of winter range by using one area for several winters, then shifting to another area. Caribou in the MKMA appear to periodically abandon certain ranges and shift to others, and they may not always winter and rut in the same places (John Elliott, pers. comm.). Some large-scale movements appear to have occurred over the years, e.g. in the Toad River area (see Radcliffe 2000 for more details). Range shifts could result from any number of factors (predation, mineral availability, changes in moose and elk numbers, response to different winter conditions, vegetation changes, e.g. through overgrazing or maturation and so on).

7 DIET, FOOD AVAILABILITY, AND HABITAT SELECTION

7.1 Factors in Habitat Selection

Shackleton (1999) reports that predators (wolves and cougars) snow conditions, and the availability of lichens appear to be the major determinants of caribou habitat use, especially in winter. Similarly, Bergerud *et al.*, (1984), and Bergerud (1992) consider caribou habitat selection is largely a function of 1) food availability and 2) predator avoidance. These factors are not independent of one another. However, winter lichen availability is generally considered critical in evaluating habitat. This lichen availability is thought to be strongly influenced by snow depth.

7.2 Food as a Limiting Factor

Seasonal food availability and diet quality, weather conditions, and predation are potentially all limiting factors for caribou populations. In the past, availability of food in late winter, and the effects of weather, have been considered major limiting factors. However, Bergerud and Elliott (1998) rejects the hypothesis that winter lichen supplies determine the abundance and set the carrying capacity for caribou, and, rather, hypothesizes that predation risk is the most important ecological variable in all seasonal distributions of caribou. Bergerud (1996) notes caribou will sacrifice high quality forage to remain in habitats above treeline with low predation risk. Other authors suggest that snow on the ground and lichens are the most salient habitat features that influence the behavior of caribou in winter (e.g. Schaefer 1996). It seems likely that the importance of the different factors varies from place to place, depending on local conditions.

7.2.1 Winter Range as a Limiting Factor

Various authors in the past have considered forage resources, and primarily the availability of lichens on winter ranges, to be limiting for caribou. For example, Rock (1992) suggests that if food does become a limiting factor, it is generally during late winter when unfavorable snow conditions force caribou out of lowland habitats onto upland sites where more terrestrial lichen species may be available. In a study discussed in Sharnoff and Rosentreter (1998) researchers observing caribou in winter at feeding craters (where the caribou had cratered through snow for *Cladina*) reported that competition for access to the craters was severe, with animals constantly trying to take over the craters of others.

Bergerud (1996) considers the abundance of lichens in winter does not determine carrying capacity, as it is density independent, and he rejects the critical winter range hypothesis. Certainly many other studies have also concluded that winter food is not limiting. Seip (1992), for example, reports that winter food resources - arboreal lichen availability - in his two study areas (Quesnel Lake and Wells Gray) greatly exceeded caribou requirements. However, in managed forest landscapes this abundance of lichens is unlikely to persist as harvesting of older forests removes the arboreal lichen resource. The degree of influence winter food availability exerts upon caribou populations may therefore be substantially altered, and lichen abundance will become increasingly critical where older forests are converted to young plantations.

7.2.2 Summer Range as a Limiting Factor

Counter to the commonly held belief that winter range is limiting, Bergerud (1996) reports that for a caribou population living without predators, the density regulating factor was the abundance of summer, rather than winter, foods. Bergerud (1996) contends that forage problems in the summer can predispose the animals to winter losses, quite independent of winter lichen supplies. On Slate Island, females entering winter were already at the threshold starvation weight, and Bergerud (1996) reports the meager winter lichen supplies might affect the slope of the overwinter weight change, but that lichen availability was still density independent. In studies on both Coats and Slate Islands, he reports that starvation was independent of winter forage abundance, and was non-regulatory. He suggests that as lichens grow so slowly they cannot, once reduced, show annual responses to rapidly changing animal numbers. However, summer vascular foods can respond rapidly.

7.3 Caribou Diets

Thomas *et al.* (1996b) note that dietary information is scanty for woodland caribou in boreal and cordilleran forests of western Canada, east of the divide.

7.3.1 Summer Diet

Caribou are mainly grazers. In general, little information has been collected on growing season diets as these were not usually considered limiting (see section 7.2). In summer Northern caribou feed on various grasses, sedges, horsetails, a variety of flowering plants, and the leaves of willow and dwarf birch, and lichens. In the foothills and Rocky Mountains in west central Alberta, willows, sedges, and lichens dominated summer diets (Thomas *et al.*, 1996b). Throughout the summer in the Kluane Range, Yukon Territory, Northern caribou fed disproportionately in birch-sedge meadows, sedge meadow communities, and other communities with high sedge components in the subalpine and alpine (Oosenburg and Theberge, 1980). Sedge was considered to be the most important forage in determining summer habitat selection (Oosenburg and Theberge, 1980); willows and other shrubs were also important components of the summer diet. Terrestrial lichens, when damp and where available, are consumed in summer by caribou (Thomas *et al.*, 1996b). Arboreal lichens are also consumed on occasion (Edwards and Ritcey, 1960).

7.3.2 Winter Diet

During winter, lichens provide a highly digestible energy source and are often exploited as principle forage (Russell and Martell, 1984). When snow is deep, lichens become a major food item, although weather-dried grasses, sedges, willow and birch tips are taken where available (B.C. MOE, 1992). Lichens preferred by caribou, including the fruticose *Cladonia*, *Cladina* and *Cetraria*, and the arboreal *Alectoria*, *Bryoria* and *Usnea* all contain a rough average of 2% crude protein, not enough for a complete year-round diet for caribou, although they can sustain themselves for extended periods on lichens alone (Sharnoff and Rosentreter, 1998).

Mountain caribou feed heavily on arboreal lichens pulled from the lower branches of the conifers, picked up from the surface of the snow when dislodged from the trees by wind, or taken from the branches of wind-thrown trees. Bergerud (1978) reported Northern caribou depend on ground lichens for winter foraging rather than on arboreal lichens, which constitute only a very minor component of the winter diet. Cichowski (1989) found that in pine forests of west-central B.C., Northern caribou feed predominantly by cratering for terrestrial lichens, and cratering sites were selected on the basis of terrestrial lichen abundance. Arboreal lichens were also used but appear to be less important than terrestrial lichens in the diet. Cichowski (1989) reports that arboreal lichen use is greater during late winter when snow conditions are less favorable for cratering.

Ground lichens made up about 70% of the winter diet of Northern caribou in the Yukon and northern B.C., with *Cladina* spp. and *Cladonia* spp. predominating in the diet (Farnell *et al.*, 1991; Farnell and McDonald, 1990; Farnell and McDonald, 1989; Kuzyk and Farnell, 1997; Stevenson and Hatler, 1985). For example, in a Yukon study the proportion of lichen in the winter diet was 70% for the Moose Lake herd, 74% for the Ethel Lake herd, and 76% for the Tay River herd. This amount of lichen is reported to be typical for other woodland caribou in the Yukon that live in forested environments (Farnell *et al.*, 1991).

Thomas *et al.* (1996b) assessed diet of west-central Alberta caribou populations in relation to season, snow characteristics, and geographic location. They found terrestrial lichens averaged 60-83% of faecal fragment densities. However, decreasing proportions of lichens and increasing proportions of conifer needles and moss occurred in the mountains (vs. foothills). They report this indicates decreasing accessibility of forage because of deeper/harder snow. Kuzyk and Farnell (1997) report mosses made up less than 3% of diets for three Yukon herds examined, and may be ingested during normal feeding. A low incidence of moss (less than 5%) in the diet is generally considered an indicator of good range quality (Russell and Martell, 1984). Thomas *et al*. (1996b) found that the diets of three subspecies of caribou that winter in boreal and cordilleran forests, where soft snow is generally less than 60cm deep, were remarkably similar. The authors note that the large caribou herds exploit terrestrial lichens without exception. All lichen species except *Peltigera* sp. occurred more frequently in caribou craters than in random snowplots, while *Stereocaulon*, despite high protein content, appeared to be eschewed by caribou where it was abundant. The authors considered conifer needles and moss were ingested incidentally with lichens.

Wood (1996) working in the Omineca Mountains, reports that fecal fragments suggested terrestrial and arboreal lichens were the primary food types used in winters when samples were collected. Samples from lodgepole pine habitats indicated cratering not only for terrestrial lichens, but also foraging on arboreal lichens. She found terrestrial and arboreal lichens and conifers were the main forage types in winter, and found that lichens in alpine samples were in similar proportions to those from the forested pine flats samples. Johnson *et al*. (1999) found caribou were feeding on both terrestrial and arboreal lichens in the forests, but suggest that cratering (for terrestrial lichens) was the predominant activity. Based on various other papers, they propose that selection of arboreal lichen may increase following some threshold in accessibility or availability of terrestrial lichen.

Horsetails, grasses, and sedges (primarily *Carex* spp.) can also be components of the winter diet (Farnell and McDonald, 1990; Thomas *et al.*, 1996b). Thomas *et al.* (1996b) report winter-green forms of *Equisetum* spp. are selected in winter; they have a protein content of 8% to 10% and are rich in minerals. Evergreen shrubs are also important. Kuzyk and Farnell (1997) report that they were the next most predominant food item (after lichens) in diets of three Yukon herds examined, ranging from 10% to 16%. However, they point out shrubs may be over-represented as shrubs are not as easily digested.

Forbs, where available, are also eaten, and in windswept alpine areas in Alberta, *Dryas* was the most consistent food item taken (Thomas *et al.*, 1996b). These authors noted that winter-green grasses and sedges are also important sources of protein in winter. Terry and Wood (1999) conducted occasional inspection of cratering sites in wetlands (Wolverine herd) and found caribou appeared to be feeding primarily on sedges when they were in wetland areas, and on terrestrial lichens when in adjacent pine forests. Johnson *et al*. (1999) recorded percent cover of evergreen shrubs, grasses and sedges in their study, but report that except for grass at alpine sites, there was no evidence of grazing on those types, so they were excluded from subsequent analyses. In the study by Wood (1996), conifers were absent in alpine samples, but 42% included mosses, grasses, sedges, and forbs (in declining order of prominence).

While caribou are considered lichen specialist feeders, Thomas *et al.* (1996b) report they can survive on graminoids, forbs, and low shrubs in certain environments. However, the authors consider such populations are generally insular, non-migratory, and not subject to much predation, nor severe insect harassment.

7.4 Influence of Lichens on Feeding Site Selection

In general, stands with more terrestrial lichen cover will be preferred by caribou, as less energy is expended in foraging (Coxson *et al.*, 1999). Various studies have found that caribou can "smell" lichens growing beneath the winter snowpack, possibly as a result of the presence of specific lichen substances (T. Goward, pers. obs.). Caribou thus tend to select crater sites where the relative abundance of certain lichen genera is greater, and avoid cratering at sites where they are scarce or absent. Frid (1998) working in the Yukon, found cratering probability increased as percent cover of *Cladina mitis* increased, but percent cover of the closely related *Cladina rangiferina* had no effect. Also Frid (1998) reports that cratering probability increased as percent covers of *Cetraria islandica* and *Cetraria cucullata* became greater, but was unaffected by the closely related *Cetraria nivalis*. Frid (1998) also found cratering probability increased as percent covers of *Cladonia* sp. increased, but was unaffected by covers of *Peltigera* sp. and *Stereocaulon* sp.

Thomas *et al*. (1996b) found that despite significant variation in major vegetation species in caribou feeding craters, the winter diet was very consistent. They considered caribou were thus selecting for *Cladina* type lichens, and were selecting against low shrubs and mosses. Anderson *et al.* (1999) studying peatlands in northern Alberta, found that caribou showed greater use of “high” *Cladina* habitats than “low” *Cladina* habitats for feeding. All high *Cladina* habitats were used more for feeding than would be expected randomly, while low *Cladina* habitats showed the opposite. The same observations was also made by Cichowski (1989) in her thesis on the Itcha-Ilgachuz herds. Goward hypothesizes that the size of the *Cladina* colony, rather than its identity, may be the most important factor in determining where caribou will crater. *Cladina* colony size is probably in part determined stochastically; but once determined, it tends to reinforce itself, as feeding accelerates the outward growth of the colonies selected (T. Goward pers. obs.).

Johnson *et al*. (1999) found caribou selected cratering sites based on percent cover of several lichen species. Within forests, *Cladina mitis* and *Cladonia* spp. were more abundant at cratered than uncratered sites, while random sites had greater cover of mosses and debris than cratered sites. *Cladonia* spp. had the greatest influence on crater site selection in forests. Many *Cladonia* species also contain lichen acids similar to those in *Cladina*. Frid (1998) found in the Yukon that increasing cover of *Cladonia* spp., *C. mitis*, *C. cucullata and C. islandica* increased the probability of caribou cratering. However, the amount of *C. rangiferina, C. nivalis*, *Peltigera* sp. and *Stereocaulon* sp. had no effect. Johnson *et al.* (1999) suggest that caribou feeding in less productive alpine areas (versus forests) may be less selective, taking advantage of sites with the greatest amount of lichens, regardless of palatability. The authors report that in alpine sites *Thamnolia* spp. had the greatest influence on selection of feeding sites, followed by *C. rangiferina* and *C. cucullata*. However, *Thamnolia* does not withstand prolonged burial by snow, so it may be the site rather than the lichen which is the most important variable here (T.Goward, pers. obs.). They also found *C.rangiferina* and *S.alpinum* provided important forage at alpine sites but were not selected, even though available, in forests. Other studies have shown these species – especially *Stereocaulon* spp. - to be relatively less palatable.

In a study of caribou-lichen ecology in the SBPSxc of the Chilcotin, Goward (in press 2000) suggests that cratering caribou are unlikely to discriminate among terrestrial lichens at the species level, as many species can grow intermised. Rather, for sampling purposes, he proposes assigning lichens to one of five generic groupings as follows – in descending order of recorded use by caribou:

1. *Cladina* (mainly *C. arbuscula*, but also *C. mitis, C. rangiferina* and *C. uncialis*)
2. *Cladonia ecmocyna*
3. *Cladonia* “browns” (*C. cervicornis, C.cornuta, C. gracilis, C. phyllophora* and miscellaneous others)

4. *Stereocaulon* (mainly *S. alpinum* but also *S. tomentosum*)
5. *Peltigera* (various species)

In forests, arboreal lichen biomass and community structure influence feeding site selection. Rominger and Robbins (1996), for example, have shown that mountain caribou tend to avoid foraging on *Alectoria sarmentosa*. The same authors also note that *Bryoria* at above-average loadings is preferred over the same species at lower abundance. Johnson *et al.* (1999) reached a similar conclusion, reporting that caribou selected trees with a greater biomass of *Bryoria* than in randomly available trees.

Goward (1998) examined the distributional ecology of *Bryoria* in oldgrowth ESSF stands in south-central British Columbia. He concluded that the within-stand occurrence of the most abundant *Bryoria* species (*B. fremontii and B. pseudofuscescens*) is controlled by two factors: first, by the presence of a well developed "cone of defoliation" within the tree crowns (*Bryoria* appears to require dead branches for optimum development); and second, by a distinct inability to withstand prolonged wetting. Old trees growing in open stands are therefore most productive of arboreal forage lichens in the south-central part of the province. Ridge crests, the margins of wetlands, and other forest openings therefore provide critical habitat for wintering caribou.

7.5 Influence of Snow on Feeding Site Selection

Travelling on and cratering through snow cover are energetic investments for caribou obtaining terrestrial lichens (Schaefer 1996). Johnson *et al*. (1999) report that snow can hinder both the accessibility and detection of caribou forage. Snow depth is considered to be a particularly important variable. Most studies report that when snow depths are low, caribou tend to remain at low elevations, while deep snow may force them onto high elevation, windswept slopes. Thus they move from early winter ranges to late winter ranges when snow depths become limiting. Wood and Terry (1999) suggest that annual snow conditions influenced habitat selection patterns by the Chase and Wolverine herds in winter. In normal and heavy snow years, caribou ascended to alpine ridges, but in a low snow winter they made more use of mid elevation forests. The authors suggest that in the low snow years caribou are likely choosing forested habitats that provide relatively more terrestrial or arboreal lichens than alpine areas. However, in deeper snow, they are forced onto the windswept ridges to forage on exposed terrestrial lichens, sedges and grasses. Hatler (1986) similarly reported that in winters of low snowfall, northern caribou will often remain in their early winter ranges (primarily lowland, coniferous forests) for the entire winter.

Snow depths exceeding 50 cm to 60 cm are reported to be limiting to single caribou cratering for lichens, and snow depths of 80 cm to 90 cm are considered limiting to cratering by groups of caribou (Russell and Martell, 1984). Beyond these snow depths or when hard-packed crusts develop, caribou are unable to locate and dig down to lichens (Russell and Martell, 1984).

The ability to crater is influenced by snow hardness and ice layers, as well as depth. Thomas *et al.* (1996b) considered that differences in apparent caribou diets between locations mainly reflected variations in forage availability caused by deep snow containing hard layers, including ice. Frid (1998) found crater site selection was unaffected by variability in snow depth or penetration, but was working in a shallow snowpack zone (mean SD snow depth = 31.5 5.8 cm). Johnson *et al.* (1999) similarly found that in the alpine, neither snow hardness nor density appeared to influence crater site selection. In the alpine, snow depths were much more variable than in the forests, due to uneven topography and drifting snow. Caribou appeared to select locations to crater where snow depths were relatively shallow.

Deep snow may reduce nutrition of caribou, in turn lowering conception rates and increasing adult and calf mortality in both winter and summer (Bergerud, 1996). Boertje *et al.*, (1996) cite studies that suggest adverse weather can cause decreased production and increased vulnerability to predation over a wide range of densities. However, Thomas *et al*. (1996b), report that apparent caribou diets on winter ranges in the Rocky Mountain foothills of Alberta varied little over 4 winters despite pronounced differences in snow depths. This would appear to imply that snow depths do not substantively affect winter food availability.

8 LICHEN - HABITAT RELATIONSHIPS

8.1 Environmental Variables and Species Composition and Productivity

Goward *et al.* (1999) notes successional trends in terrestrial lichens are likely to reflect the integration of a number of environmental variables. These include: regional climate, duration of snow cover, slope, aspect, soil type, humus form, soil moisture regime, soil pH, insolation, ventilation, tree spacing, stand age, time since fire, and competitive pressures.

8.2 Site Productivity, Stand Age, Tree Size, Spacing, and Canopy Closure

In Tweedsmuir, terrestrial lichen abundance was closely associated with site productivity. Cichowski (1989) found caribou selected mature stands with a combination of abundant terrestrial lichens (Dry Lichen/Lichen Moss, Lichen Moss understories) and low productivity (low and poor forest cover types). Because terrestrial lichens are poor competitors against vascular plants, they are most abundant on open, nutrient poor sites (Hale, 1983 and Rowe, 1984 cited in Cichowski, 1996). Coxson *et al.* (1999) working in the Mackenzie area, also report that the best sites are the drier, low nutrient sites where the productivity of other plants is low. These authors also report that higher terrestrial lichen cover occurs on crest and upper slopes of the landscape. Bradshaw *et al.*(1995) looked at winter peatland habitat selection by caribou in northeastern Alberta, and found that raised bogs provided more xeric substrate for increased lichen biomass. They conclude this is possibly a key factor in their selection during winter.

Terrestrial lichens are very slow growing and are most abundant in late successional forests (Cichowski, 1996). Thomas *et al.* (1996b) suggest lichen, especially *Cladina*, may take up to 100 years to grow to be useable forage, though rates of colony expansion can vary considerably under different circumstances. They found habitats where terrestrial lichens were relatively abundant were generally open pine-dominated forests older than 80 to 100 years in the Foothills and Rocky Mountains respectively. However, old spruce/fir dominated forests over 130 years old or 200 years old in the Foothills and Rocky Mountains had less snow and high arboreal lichens (and were used by some caribou in deep snow years). Thomas *et al.* (1996a) examined temporal changes in caribou ranges after fire and relative use of age-classes of forests by caribou in north-central Canada. They found different lichens attained peak biomass at different times after fires. Peaks were achieved as early as 40-60 years for *Cladonia* spp. to 150 years for *Cladina rangiferina* and *Cetraria nivalis*. *Cladina mitis*, the main caribou lichen, increased rapidly from 21-30 years after fire to 41-50 years, with a maximum biomass in the west at 81-90 years, and in the east at 41-60 years. This should depend in part on different levels of usage by caribou. They found total lichen biomass increased with forest age to 100-150 years, as *Stereocaulon* did not peak until after 100 years. However, the caribou lichens *Cladina* spp. and *Cetraria nivalis* stabilized earlier than this. Goward considers it is the length of time needed to for the habitat to develop that ultimately limits lichen establishment rates. Thus, for example, *Cladina* colonies growing in old pine stands that have been subjected to a light ground fire will develop much more rapidly than in early successional pine stands, originating after fire (T. Goward, pers. obs.).

Canopy closure reduces snow depth by intercepting snow, thus reducing the effort needed to expose lichens (Schaefer, 1996). However, open canopy stands are more productive of terrestrial lichens. In more northern lichen woodlands in the Northwest Territories and the Yukon, increasing canopy closure as the forest ages, and attendant increased shading of the forest floor, have been suggested as major factors controlling a shift in species from lichen to feather mosses (Kershaw, 1978 cited in Coxson, 1999). In many studies, caribou show a strong preference for pine type forest with a canopy closure of 10% to 15% or less. For example, in Tweedsmuir, the pine-lichen stands with the greatest percent cover of terrestrial lichens were those that had the most open canopies, generally under 10%. More productive sites, relatively early canopy closure and the establishment of understorey shrubs prevent effective competition by surface lichens. Occasional lichen mats occur in the more productive sites, but overall the biomass is small (Coxson, 1999).

Arseneau (1997) found arboreal lichen biomass and diversity were influenced by vertical tree axis and altitude. The diversity of lichens was positively correlated with tree height and diameter, and total lichen biomass on trees was predicted by tree diameter and vegetation belt (altitudinal zonation). This agrees with Goward (1998) who stressed the importance of a well developed "cone of defoliation" for hair lichen colonization.

8.3 Elevation, Slope and Aspect

Johnson *et al.* (1999) working in the Omineca area, found that the majority of lichens in forested areas appeared more vigorous, and occurred in greater abundance, than those in the alpine. They also report that at alpine sites clumps of lichen were more unevenly distributed, being separated by areas of rock or debris. Arseneau (1997) found that vegetation belt (determined by altitudinal zonation) was a key factor in predicting arboreal lichen biomass. However, these factors are closely interrelated with others, such as climate/elevation, and south-facing and southwest-facing slopes are more likely to support a copious lichen cover than are other aspects (Goward, pers. obs.).

8.4 Snow, Permafrost

Schaefer (1996) reports that although there are some studies being done on the energetic costs and nutritional benefits of caribou cratering for lichens, at present we know little of the association between snow and lichens, although this knowledge is fundamental for modeling caribou foraging behavior and for managing habitat. Schaefer (1996) studied the relationships between snow characteristics, lichen abundance, and canopy composition on a taiga range in Manitoba. He found that percentage cover of forage lichens (*Cladina* species) was positively correlated with maximum total thickness and with maximum vertical hardness of api (snow cover). This relationship, however, is unlikely to hold in all regions, as prolonged snow cover can be detrimental to the development of *Cladina* and other lichens (T. Goward, pers. obs.). Most terrestrial forage lichens, especially *Cladina*, are unable to endure prolonged cover by snow (Goward and Ahti, 1992).

The proposed study area lies within the zone of discontinuous permafrost (Valentine *et al*., 1978), Anderson *et al.* (1999) studying large peatland complexes in northern Alberta hypothesized that permafrost-underlain habitats would have greatest *Cladina* abundance and would therefore be selected for by caribou. However, they found permafrost peatlands did not have significantly higher *Cladina* abundance than other peatlands.

8.5 Fire

Goward *et al.* (1999) working in the SBPSxc in the Chilcotin, hypothesize that caribou and terrestrial forage lichens are linked in a positive feedback continuum dependent in the long term on periodic surface fire. Coxson *et al.* (1999) reports that seral stages after fire in lodgepole pine forests include a stage of terrestrial lichen dominance, for 80 to 120 years (in the Omineca Region, northern interior B.C.), after which mosses such as *Pleurozium schreberi*, *Hylocomium splendens*, and *Ptilium crista-castrensis* increase in dominance.

Terrestrial lichens that are usually destroyed by fires but at least some species can recolonize disturbed sites, becoming abundant again in mid-aged to mature stands. Severity of the initial disturbance (fire) influences lichen production (Coxson *et al*., 1999). Nietfeld *et al*. (1985, cited in R.A. Sims and Assocs., 1999) note that caribou avoid recently burned areas. Xeric growing sites support abundant terrestrial lichens for hundreds of years. However, on more productive sites, terrestrial lichens may be abundant in mid-aged stands but are replaced by mosses in older stands and thus require periodic disturbance to be perpetuated (see also Goward *et al.*, 1999). Very productive sites are usually dominated by vascular plants and never produce substantial amounts of terrestrial lichens (Seip, 1996).

The widely held view that lichen winter ranges were limiting to caribou led to the belief that forest fires were responsible for caribou declines in the middle of this century, as they reduced lichen pastures. However, Bergerud (1996) found no correlation in fluctuation of caribou numbers with burning. Wynes (1998) notes that fire on caribou range is a natural process that has affected caribou population dynamics for the past 10,000 years. Portions of the range that have been burned appear to be avoided by caribou in winter. He assumes burned areas are not used by caribou but natural succession will provide suitable caribou range in the future. He points out we need a clear understanding of how forest fires shape the boreal forest and change forest patterns.

Snyder and Woodard (1992) studied the effects of various logging practices and compared them to effects of wildfires. Terrestrial lichen recovery rates were found to be similar following logging to post fire rates. Significant differences in terrestrial lichen abundance related to Ecoregion, stand age, type of logging and cutblock size. They found subalpine areas supported more lichen overall. However, they found *Cladina* and *Cetraria* species (preferred species) were slow to regenerate, and only became an important component of the terrestrial lichen composition in old, unlogged and partly logged stands with a high percentage of residual lichens.

Saperstein (1996) studied the effects of fire on caribou on a tundra range in late winter. Variables examined included vegetation cover, production and snow characteristics at feeding and control plots on burned and unburned sites. She found significant differences in snow depth and hardness and in plant relative frequency data between burned and unburned plots and between craters and unused areas within plots, in each of two years. In one year, caribou craters had higher relative frequencies of lichens, and lower of bryophytes, than unused areas. Lichens were mainly *Cladina*, *Cetraria* and *Cladonia*. She found post-fire increases in protein content, digestibility and availability of *Eriophorum vaginatum* in burned tussock tundra. Benefits of fire may however be short lived on vascular plants. Saperstein (1996) suggests lowered availability of lichens and increased relative frequency of bryophytes will persist much longer.

It is likely that there are considerable differences in the effects of large, stand destroying fires versus smaller surface fires from prescribed burns. The time since the last fire, and the effects on tree spacing, may be key elements in understanding the impacts on lichens (Goward, 2000). Coxson *et al.* (1999) and Goward *et al.* (1999) suggest that in the absence of stand-destroying fires, pine-lichen woodlands will reach a seral stage that precludes continued growth of terrestrial lichen mats; this would significantly reduce their habitat value for caribou.

8.6 Grazing

Caribou can degrade their feeding ranges. Large herds, such as the Riviere George herd, have been shown to degrade their summer ranges through a substantial reduction in tundra shrubs, and reduction in forb diversity. Manseau *et al*. (1996) studying the Riviere George caribou found the lichen mat in shrub tundra stands was absent in grazed sites, and ground previously occupied by lichens was either bare, covered by dead lichen and moss fragments, or was recolonized by early succession lichen species. Dwarf birch shrubs were also reduced in cover and biomass at grazed versus ungrazed sites. Productivity of forage plant species over summer ranges was over double in the ungrazed sites, indicating a serious negative impact on plant productivity on summer ranges.

Studies on caribou introduced on an island in the Northwest Territories found a reduction in lichen standing crop associated with the increase in caribou numbers. In this area winter range was apparently restricted mainly to windswept areas almost free of snow, and the authors conclude that consequently these areas are showing signs of overgrazing (Ouellet *et al.*, 1993). Rotation of winter ranges is thought to occur to reduce grazing pressure on slow growing lichens (Bloomfield, 1980 cited in Wood, 1996). Similarly, Thomas *et al.* (1996b) suggest that caribou need to alternate (wintering) areas to prevent overgrazing, and to allow grazed areas to recover lichen biomass.

Although there have been some problems with overgrazing in the tundra, as indicated above, Sharnoff and Rosentreter (1998) note that overgrazing seems not to have been a serious problem in North America. Actually, in inland British Columbia, arboreal lichen biomass tends to be highest at subalpine elevations. Indeed, caribou might also enhance their own feeding opportunities. Goward (in press 2000) proposes that caribou may directly enhance *Cladina* and *Stereocaulon* availability through foraging. Foraging by caribou scatters lichen fragments beyond the margins of the colonies being foraged, giving rise to secondary colonies. The colonies eventually merge, and the resultant "supercolonies" would encourage further feeding, perpetuating accelerated growth rates. The presence of such supercolonies would in turn promote further foraging.

Similarly, for arboreal lichens, foraging by caribou has probably rarely caused a serious decline in biomass in the past. The situation is expected to change, however, in the managed forests of the future, which are likely to support *Bryoria* at much reduced loadings (T.Goward, pers. obs.).

There appears to be little information on how other ungulates might affect caribou ranges (and vice versa) when summer ranges are shared by several species, as in the proposed study area.

9 CARIBOU SEASONAL HABITATS

9.1 Caribou Habitat Models and Mapping

9.1.1 Broadscale Capability Mapping

Broadscale Habitat Capability mapping has been produced for the area by Demarchi (1994). Based on this, within the proposed study area, caribou habitat capability ranges from Class 2 (75-50) to Class 1 (100-75). The foothills around the northern edge of the study area is largely within Class 2, while the Eastern Muskwa ranges fall more within Class 1 habitat. Further north and east the capability in the Plateau country is rated as Class 3 (50-25) (B.C. Environment, 1992). The extensive plains of BWBS that predominate over the northern part of the study area may support low numbers of the Boreal ecotype of caribou, and may receive some use by the Northern ecotype, especially in the winter. The distinction between populations in this area is very unclear. For Northern caribou, however, habitat values are effectively concentrated in the mountains and foothills of the area, and adjacent forested lowlands.

The lack of consistent TEM mapping, of caribou dietary information for the MKMA, of lichen biomass/ecosystem information, and local snowpack data currently limit the interpretations that can be made.

9.1.2 Existing Species Models and Mapping

Barton *et al*. (1998) provides a species habitat model for caribou for the Dunedin study area, part of which is within the proposed area for this study. This model includes habitat ratings for the AT, SWB, and BWBS, i.e. all the zones, subzones and variants included within the study area. Only a small portion of the intended study area was actually TEM mapped however. Also, mapping was conducted at 1:50,000, rather than 1:20,000 scale; thus there are also scale limitations, which will limit its utility to some extent.

This model was developed from information elsewhere in the province and is at the present time untested and cannot be considered a strong model. It needs input on caribou ecology, including information on diet and habitat use, and improved climate information for the study area to be further refined. At this time the model also does not incorporate spatial relationships between different ecosystems (e.g. juxtaposition of different habitat types), does not incorporate adjustments for disturbances such as roads, and perhaps most importantly, does not include the influence of predation.

Other similar habitat models developed for areas in the MKMA are included in R.A. Sims and Associates (1999) for the Besa-Prophet Area (in the southern half of the MK) and Norecol, Dames and Moore (1998) for the Smith/Vents Rivers area. These cover some different ecosystem types. These models also do not include predation as a factor.

The model in Barton *et al.* (1998) has since been modified for the Mackenzie, Klawli area (Madrone Consultants Ltd., 1999). This is part of the Mackenzie caribou/wolf/moose study area, and data from that project will be used to refine the habitat model for the area. However, the study is being conducted in entirely different ecological conditions, and so although the general information on predator/prey interactions and model development will be of help, the enhanced habitat interpretations are unlikely to significantly improve habitat modeling for much of the MK. However, it is hoped that the population and habitat model can be refined (in conjunction with the model developed for the Dunedin) and can be tested with the empirical data gathered in this study, to see how well it applies to different areas.

9.2 Spring and Summer Habitats

9.2.1 General

For females, summer ranges are typically the same as calving habitats, with alpine, subalpine, and upper elevation spruce/balsam forests reported to be used. Wood (1996) reported use of low elevation forests decreased from April to October, while use of the alpine/subalpine increased.

Summer ranges for Northern caribou are typically alpine or subalpine, although some animals in some populations use low elevations (Stevenson, 1991). Throughout the summer and early fall, northern caribou were found to prefer flat to rolling terrain with slopes less than 20° and northern aspects in the Kluane Range, Northwest Territories (Oosenburg and Theberge, 1980). Use of these sites may have reflected their hygric nature and consequent predominance of sedges (Oosenburg and Theberge, 1980). Commonly used landforms during the summer season included ridges, plateaus, and stream bottoms (Oosenburg and Theberge, 1980). Thomas *et al.*, (1996b) report forb meadows in seepage areas and along alpine streams were used extensively in summer.

9.2.2 Study Area

In the MKMA there are many caribou up at high elevations in the summer, in alpine and subalpine meadows. They also use the forests and are often in the heads of the valleys in hot weather. They may also use bogs in the lowlands. Habitats of high value for calving are also likely to receive considerable summer use. Caribou have also been seen lying on small remnant patches of late-lying snow on the cool, north sides of the ridges in August, presumably for relief from insects and heat (Gillian Radcliffe, pers. obs.). Caribou have also been occasionally observed alongside the Trans Canada Highway in summer; one was observed swimming south across Summit Lake, by the highway. During the summer caribou also regularly use glaciers in the area (David Wiens, pers. comm.).

9.3 Winter Habitats

9.3.1 General

Northern caribou generally winter in low-elevation, mature pine or pine/spruce stands (Hatler, 1986). Open areas below timberline including muskegs and shrub or herb meadows are also used in winters of light snowfall (Hatler, 1986). Some of the primary early winter habitats are mature lodgepole pine or pine/spruce forests with abundant terrestrial lichens (Heard and Vagt, 1998; Wood, 1996). Wood (1996) found that Northern caribou in the Omineca Mountains foraged on terrestrial lichens in both lowland lodgepole pine flats and on windswept alpine slopes, and on arboreal lichens in upper elevation Engelmann Spruce Subalpine fir forests. Young and Shaw (2000) report as snow depths increased, caribou appeared to prefer pine stands on either dry or wet sites. They used moderately closed pine stands on poor sites and fairly level terrain, from 1,200 m to 1,600 m. Boreal caribou in northeastern Alberta were found to concentrate feeding in forested, raised bogs throughout the winter (Bradshaw *et al.*, 1995). The high peatland coverage in these areas provided a xeric substrate for increased production of terrestrial lichens (Bradshaw *et al.*, 1995). These caribou may use denser forest stands when there are heavy snow depths (late winter); especially when snow is crusted (Bradshaw *et al.*, 1995). Snow crusts were found to be thinner and less solid in denser stands than in open areas, allowing for easier movements and foraging (Bradshaw *et al.*, 1995).

Another habitat used during the winter is alpine slopes with low snow accumulations. Northern caribou have been found to move to the alpine when snow conditions below tree line restrict their ability to move around or to forage (Hatler, 1986; Terry and Wood, 1998). Wood (1996) found that by early winter (Nov. to Jan.) over half caribou locations were in forests, including stands at lower elevations, while in late winter with deep snow they were all in high elevations. In late winter with less snow only about half were at the higher elevations, the rest in lower elevation forests. Wood (1996) reports that most collared individuals used different winter ranges in each year. Telemetry locations from the Graham River Northern caribou herd indicated that the caribou spent a significant portion of at least late winter in the alpine tundra or subalpine forest. Northern caribou in this area were speculated to spend the majority of the year in alpine or subalpine habitats (Murray, 1992).

Surveys on the east side of Williston Reservoir in the Chase Mountain and Wolverine Ranges also showed high use of the alpine in the late winter (Corbould, 1993). Young and Shaw (2000) report some caribou wintering on high, windswept alpine ridges in the Itcha and Ilgachuz Mountains in some years, while in other years caribou remained at lower elevations in forested habitats. Young and Shaw (2000) report two different wintering strategies used by the Itcha-Ilgachuz and Rainbow Mountain caribou herds. Most wintered in low elevation forested areas all winter. However, in 1995-1996 winter, about 10% of the population wintered on windswept alpine ridges on the north side of the Itcha and Ilgachuz Mountains.

It thus appears that during the late winter season, caribou will move to high wind-swept ridges where there is access to terrestrial lichens (Stevenson and Hatler, 1985). In studies that have covered multiple years, northern caribou have been found to use this alpine habitat in winter only when snow depths preclude the use of lower elevation forests (Cichowski, 1996; Hatler, 1986; Terry and Wood, 1998; Wood, 1996). Hatler (1986) suggested that such use of alpine by northern caribou indicates a stressed situation occurring in severe winters and should not be interpreted as a preferred winter habitat. Commonly, it appears the alpine is used by a small proportion of caribou or by many caribou for a short time. However, some recent studies have found that some northern caribou populations regularly winter in alpine habitats. For example, Kuzyk *et al*., (1999) report that caribou in the southwest Yukon, living in the snow shadow region, winter in the alpine and subalpine. Conversely, those in high snowfall areas, in central and eastern Yukon, have traditional winter ranges in forested lowlands (Kuzyk *et al*., 1999).

In winter, large contiguous patches of unfragmented habitat may provide security cover since the preferred stands for pine-lichen tend not to have understorey characteristics useful for security cover (small trees, shrubs, etc.). Habitats that offer good visibility for avoiding predators, such as the alpine, also afford some security during the winter. Caribou have been observed using lakes during early winter (M. Wood, pers. comm.) possibly for drinking overflow water containing dissolved minerals (Edwards and Ritcey, 1960).

9.3.2 Study Area

Early winter habitats are fairly available in the area, where a mosaic of habitats occurs. Winter use above treeline occurs and caribou in the area are often on the rolling tundra habitats in November/December. However, as winter progresses, available habitats may become more limiting. Based on the field reconnaissance and existing TEM mapping, pine stands with good ground lichen availability appear to be extremely limited in most of the MKMA. Consequently, late winter habitats at lower elevations appear to be very limited, and high elevation shrub/meadow habitats may be especially important.

During the field reconnaissance in February 2000 many groups of caribou were observed on alpine meadows, despite very low snow accumulations at lower elevations. The forested habitats at lower elevations appeared to be readily accessible at that time. Local sources (David Wiens, Al Hansen, pers. comms.) report that when snow is not deep the caribou do often stay lower down, on the rolling foothills in winter. However, due to temperature inversions, which are common in the area, warmer conditions can occur higher up, so the caribou may still be at high elevations even in low snow conditions. Snow-free ridges in the alpine in the area apparently get a lot of caribou use in winter, and David Wiens (pers. comm.) reports they will often remain high up for months, where there appears to be very little to eat. During the February field reconnaissance, caribou were also observed using frozen high elevation lakes. Caribou antlers were observed in a number of locations in the SWB in birch scrub and willow sedge habitats close to the open meadows in the northern MKMA.

10 RESEARCH NEEDS AND WORK PLAN

10.1 Recommendations

The findings of the background review, road trips and field reconnaissance support the initial contention that there is a paucity of information on caribou ecology in the area, including caribou-habitat information, despite significant caribou herds. Furthermore, during background work it was discovered that there is even a paucity of information on caribou diets in the study area, and little knowledge of just how dependent caribou in the MKMA are on ground and arboreal lichens. In addition, there is little information on the availability of forage items, especially lichens, in the area, and on the relationships between lichen productivity and the habitats present in the MKMA.

General broad habitat capability mapping for the whole area, together with the more detailed existing mapping and species modeling conducted for TEM, provides a valuable tool for assigning habitat ratings for caribou by season, and provides an important habitat management tool. However, predictions badly need to be field checked and refined. TEM is currently completed for approximately 22% of the MKMA (Madrone Consultants Ltd. in prep., 2000).

As a result of these investigations, the initiation of program to investigate caribou – lichen habitat relationships in the MK is recommended. Accordingly, a proposal to conduct this work has been developed and is presented in Section 11.0 in the form of a work plan. If this outline receives conceptual support from the Advisory Board, it is intended that the work will be submitted for funding for the 2001-2002 year. In the interim, some additional and alternative funding sources for this work will also be pursued.

10.2 Lichen Habitats in the Muskwa Kechika

In the northern Muskwa-Kechika, forested habitats with high lichen availability appear to be very few and far between. Based on existing TEM mapping and discussions with locals (David Wiens, Al Hansen, Rob Honeyman) and past field observations, there are a few forested sites with sandy soils where there is considerable terrestrial lichen. Those that do exist apparently do get high caribou use, all year (David Wiens, pers. comm.). There are also some mid-elevation rolling ridges with some lichen availability. However, at the high elevations routinely used in late winter, there appears to be very little lichen. Direct observations during a road trip in August, and during a field reconnaissance in February, support the impression that the area does not have extensive lichen ranges. Rather, there are small, scattered patches of high lichen biomass (G. Radcliffe, pers. obs; D. Seip, pers. comm.). This may make it particularly difficult to predict and manage for high lichen sites if these are in fact significant to caribou in the area. There is also little information on arboreal lichens in the MKMA. However, based on the relatively high frequency of fire in the SWB and BWBS, it seems likely that forest stands with abundant arboreal lichens are also very limited in the MKMA, at least where the SWB occurs at the subalpine elevations (i.e. most of the MKMA), rather than the ESSF.

10.3 Research Needs

Based on the information gathered during this review, some fundamental questions around caribou ecology and the relationship with lichens in the study area need to be explored:

- Are lichens a significant component of caribou diets within the area? All year, or at specific times?

- Are terrestrial and arboreal lichens both used/important, or do the caribou depend more on one or the other? All year, or at specific times?

- Is food limiting at any season? Is winter really the critical season for food availability, or is the quality of summer range more significant?

- How available are terrestrial and arboreal lichens in winter? In what habitats?

- Are caribou in the area actively selecting for lichens? What foraging sites are being selected?

- How do the local snow conditions influence terrestrial and arboreal lichen availability? What about time since last fire, severity of fire, site productivity and canopy closure?

- Are the important habitats easily predicted (based on recognizable environmental parameters) and are they readily identifiable from existing mapping, satellite imagery etc?

- How does fire affect the productivity of lichens in the area? How have wildfires and prescribed burns affected lichen availability? What are the broadscale spatial patterns and how do they influence caribou ranges/movements?

- How is lichen availability affected by grazing by caribou, and by other ungulates in the area? Is there any evidence for range degradation by caribou and/or other ungulates? Or evidence for caribou grazing enhancing *Cladina* availability.

- Are there any discernable trends in lichen availability by zone/subzone, trends from north to south and west to east? Are the trends reflected in caribou strategies – e.g. different feeding habits/patterns during the seasons?

11 WORK PLAN

11.1 Objectives

This section outlines a work plan for 2000-2001 based on the information gaps and research needs identified in the previous sections. This plan is contingent on future funding. Some of the work would be ideally carried out in conjunction with other vegetation/mapping programs and with existing and potential caribou projects.

The plan would complete the following:

- Clarify caribou seasonal diets within the MKMA.
- Collect and analyse existing plot data for lichen/ecosystem relationships, and fire history/lichen relationships.
- Examine percent cover by ecosystem of other potentially important caribou foods (dependent on outcome of dietary studies), to improve habitat interpretations.
- Identify the major information gaps regarding lichen production and availability by ecosystem type.
- Develop and conduct a field program to collect the missing vegetation, especially lichen, and wildlife data in the field, and analyse the data from previous projects with the newly collected data.
- Develop estimates of arboreal and terrestrial lichen production by ecosystem unit, for all units with significant lichen resources.
- Substantively improve existing caribou habitat models for the MKMA, with interpretations for all subzones and variants. This should greatly improve our predictive abilities with respect to caribou winter ranges in particular.

11.2 Study Components

The studies needed to complete this work plan fall under three separate components, detailed below; these all link together in the final habitat models and mapping:

1. Dietary Studies.
2. Caribou feeding site selection (actual habitat use) - this ideally would be done in conjunction with radio-telemetry work, although it can proceed independently.
3. Mapping and habitat predictions, habitat studies (including snow information).

Background information to be collected and summarized includes climate data and especially any snow data for the MKMA, in addition to all existing plot data from previous habitat and mapping studies. The past climate/snow data for the whole area would be collected. We can then determine if there are any additional data needs and if it is feasible/economically viable to collect data (e.g. in conjunction with this or other caribou studies). By overlaying spatial data from caribou collaring projects (including Graham River, and possibly Toad River) and the TEM mapping data, we can then test the habitat predictions made from the caribou habitat model with empirical data gathered from the area. Assuming a good model fit, the habitat models can then be applied to the rest of the MKMA with greatly increased confidence.

11.3 Dietary Studies

Fundamental questions on the actual diets of the caribou, including summer diets, need to be addressed. The basic assumptions regarding Northern caribou diets, and dependency on ground lichens, based on studies elsewhere, may not be fully applicable to the study area.

A combination of fecal analysis and rumen analysis would be used. Fecal analyses are the easiest to conduct and the technique lends itself to dietary studies. However, vascular plants in particular tend to be underestimated which may limit the applicability of the technique. However, this technique can be complemented by rumen analyses from freshly killed caribou.

Fecal pellets will be collected at sites at different elevations, and diets will be estimated from microhistological analysis. Pellets can be collected in winter in conjunction with the feeding site selection work below. Summer pellets can be collected during vegetation sampling, whether for this project and/or for other potential ecological projects (e.g. any TEM mapping or data collection for SWB/AT analysis). However, as Wood (1996) notes, analysis of plant fragments in fecal pellets usually overestimates proportions of mosses and shrubs. Thomas *et al.* found in mid August caribou consumed at least 19 species of forbs in alpine areas that went undetected in fecal samples.

Rumen samples would be collected as opportunity arises, to supplement the fecal analyses. Caribou are hunted in the fall in the area and by working in conjunction with the guide-outfitters, it should be possible to obtain fresh rumen samples in the fall. In the winter months in particular there are also routinely a number of road kills along the Alaska Highway, and it should be possible to opportunistically obtain rumen samples from a number of these animals for analyses. Occasional summer roadkills do occur and the opportunity to sample rumens in the summer would also be taken, especially as vascular vegetation, poorly sampled by fecal analyses, is likely to be very important in the summer.

11.4 Caribou Feeding Site Selection

Lichen availability and caribou site selection will be explored through examination of lichen species composition and biomass, and environmental variables at selected and non-selected sites during winter. If possible this work will be linked to collaring/monitoring in the Graham Rive area, and to the Toad River study if proceeding. By focusing the study within areas where longer-term caribou ecology projects are underway, valuable information from each study will serve to enhance the utility and applicability of the other.

Habitats that are used and not used by caribou will be selected, preferably in a variety of different aged stands and in alpine tundra. Site history, including time since last fire and fire severity would be essential information (this can be linked to TEM). Cratering sites would ideally be located from air (if the project is done in conjunction with radio-telemetry projects), or from ground surveys and backtracking along caribou trails. Along caribou trails, it is anticipated 100m transects will be located to sample feeding and non-feeding sites, for both terrestrial and arboreal feeding sites. Sites would be examined for telltale signs of cratering, such as broken lichen fragments. Potential rates of colony development would be estimated using the preferred lichen species, i.e. *Cladina*. Along each transect, sites would also be randomly selected for measuring environmental variables.

In the alpine, Johnson *et al*. (1999) found that safety reasons and the aggregated distribution of feeding sites rendered the 100m transect approach unusable. Instead, 50m by 50m quadrats were used to assess feeding and non-feeding sites. Saperstein (1996) used a different approach to look at caribou feeding sites in burned and unburned habitats. She used replicate 30m by 30m plots, each with feeding craters and undisturbed snow – in burned and unburned, preferably adjacent sites. Plots were randomly oriented with respect to direction and distance from edges of craters. Exact details of sampling methodology will be fine tuned as the study progresses and initial fieldwork permits an assessment of what methods would be best suited to the field conditions and habitats prevalent in the area.

Important variable will be measured or estimated as appropriate, in an effort to identify what broad environmental patterns explain terrestrial (and arboreal) lichen distribution and caribou use at stand and site level. Key factors to be evaluated include:

1) time since last stand-replacing fire;
2) time since last groundfire;
3) soil porosity;
4) snow depth and duration;
5) competing vascular species; and
6) incidence of use by caribou.

Analysis of the resulting data can be expected to yield important insights into how caribou in the study area are selecting feeding sites, and into what variables are influencing this site selection. This knowledge can then be applied to the species-habitat models for broader application across the landscape.

11.5 Habitat Sampling and Habitat Predictions

11.5.1 Analysis of Existing Data

Thomas *et al* (1996a) report the biomass of terrestrial lichen species can be predicted from their cover. It should therefore be possible to analyze existing plot data (which includes percent cover information) to get an initial indication of lichen biomass in different ecosystems TEM mapped to date. We therefore propose to compile existing data from TEM projects, range plots and other appropriate sources (see Table 4). Plot data will be analyzed to examine the percentage cover of various lichens, lichen groups and cover types. Potentially significant ecosystem units will then be examined further in the field, with an emphasis on better quantification of lichens (species and percent cover) and on identifying how consistent lichen cover is in these units. We will also review species/habitat predictions for caribou for these habitat units. It is likely that many of the lichen species may not have been identified to species during TEM mapping, but there should be percent cover estimates for lichens, certainly for any significant species (probably identified to genus) in each plot. This would at least provide a good starting point. However, it is likely there are many gaps – many plot types will have only one or two plots and these may not be very representative of the lichen flora, which is often quite heterogeneous.

Table 4. Sources of existing vegetation plot data within the study area.
(From Barton, 2000)

Project Name	Plots Sampled By	Sampling Year	Data Form	Spatial Locations
North East Burn TEM	Dave Clark, Bob Maxwell	1991	VPro	digital
Smith Fishing TEM	Norecol, Dames and Moore and ECO-concepts Ecological Services	1997	Venus	digital
Dunedin TEM	Madrone Consultants	1997	Venus	digital
Besa Prophet TEM	R.A. Sims and Associates	1998	Venus	digital
North East Burn Evaluation – Bison Habitat Monitoring	Dave Clark, Bob Maxwell, Bill Harper, Andy Stewart, and Jamie Duncan	1992	hard copy	hard copy
Range Reference Area Exclosures (Fort St. John and Fort Nelson Forest Districts)	Perry Grilz and other contractors	1998-99	Access	hard copy
Liard Hotsprings Provincial Park Biophysical Habitat Mapping	JMJ Holdings	1994	VPro	?
Fort Nelson East Slope Wildlife and Forest Capability Mapping	Chris Clement	1992	VPro	?

In addition, relevant data from areas close to the MKMA will be utilised if appropriate. This might include data from the Akie project, the Klawli mapping project, and possibly from vegetation work done in the Horse ranch area (see Madrone Consultants Ltd., 2000).

Some portions of the study area are well sampled, including watersheds of the Vents, Dunedin, Tuchodi, Muskwa, Prophet, Besa, and Sikanni Chief Rivers. Other areas have barely been sampled, including the watersheds of the Turnagain, Rabbit, Toad, Halfway, and Graham Rivers (Barton, 2000). It is likely that more detailed sampling will be necessary to adequately characterize lichen availability by ecosystem type. The main effort would likely be focused on xeric and subxeric sites, but with some sampling in peatlands and moister forest types as well. For arboreal lichens, there may be less information available, unless it was specifically quantified as an additional component in the TEM mapping projects. Arboreal lichen plots may not have been conducted during mapping and therefore there may be no data on this component. However, terrestrial lichen data should have been collected for all full TEM plots within the area.

The applicability of the existing mapping/ecosystem types should cover the entire study area. Unfortunately, due to poorly developed classification for the AT and SWB, the existing TEM projects have each developed their own project-specific ecosystem units. Some initial work needs to be done to correlate and standardize the nomenclature, to facilitate analysis of existing TEM plot data. If a current proposal to refine classification of the SWB/AT proceeds, this dilemma will be resolved. If not, then there needs to be an initial step for a vegetation ecologist to work in conjunction with the Regional Ecologists to standardize units, before the data can be properly analyzed.

11.5.2 Field Sampling Program

Following analysis of existing data and a review of existing mapping, a detailed sampling plan for field work, using maps and aerial photographs, will be prepared. Depending on data and plots already available, plots would be selected to sample the cross section adequately. Once existing data has been examined it will be possible to determine if sampling should cover all subzones and variants or whether it can be limited to specific ones (e.g. certain subzones of the SWB and BWBS). Within the different ecosystem types lichen availability and heterogeneity will be characterized. Consistency of lichen plot data by ecosystem type will be examined, in order to understand how well the ecosystems predict lichen availability.

Due to the remoteness of the majority of the study area, sampling sites will be selected based on access as well as ecosystem type, to minimize costs. Transportation methods may include truck, helicopter, float plane, and/or boat. Helicopter access, though expensive, may be necessary for some of the field work. Costs could be minimized, however, by restricting helicopter trips to moves between temporary base camps every few days.

Detailed sampling will follow the general approach used by Goward *et al.* (1999), although some of the details may be modified. Goward *et al.* (1999) compared a linear method with a second method biased in favor of caribou forage lichens, to evaluate which was best for assessing terrestrial woodland lichens in a dry subzone/variant. The second method yielded results consistent with method 1, but was less labor intensive. They recommend it be used in future in studies on relation of caribou to forage lichens.

As many variables as possible would be controlled for in the plots. A relatively large plot size will be used to smooth out microscale and mesoscale anomalies of lichen succession. The plots can then be divided into subplots along a transect. Vegetation plots will collect data on percent cover of the different vegetation layers, including total lichens, the cover of individual bryophyte species, of dominant vascular plants, as well as of debris, mineral soil. Rock-dwelling lichens are considered of little importance to caribou and may be disregarded. Plots will also be assessed for soil and site characteristics (TEM plots site and soils forms), and for ventilation as per Goward *et al.* (1999) on a five point scale.

Data would be examined for broadscale patterns by subzone and variant, by ecosection, and by ecosystem type. The influence of variables such as time since fire, stand age, slope and aspect will be explored through a variety of statistical analyses. The data will also be linked to the winter feeding site selection data for further analysis. The data will be explored for any continuum from south to north to west. e.g. sites in the Graham River area, through the mountains and foothills south of Toad River, and across to the Cassiar Mountains to the west.

Once broad-scale patterns of lichen development and caribou habitat use in the MK have been ascertained, the methodology would then be substantially simplified for use at the larger scale of the MKMA. To some degree however the finer details of the field program will need to be responsive to the findings of the initial fieldwork.

This work will yield information on the availability and productivity of lichens in different ecosystems, as well as improve understanding of the influence of different variables, including fire. It will provide an understanding of how well important caribou habitats can be predicted, and whether they can be readily be defined and identified through mapping. Together with the information on caribou feeding site selection, a better understanding of the influence of snow on the vegetation and habitat values will be gained. The three study components together should provide a greatly strengthened caribou habitat model for the north, as well as a greatly improved ability to predict how potential management actions will affect lichens and caribou in the area.

11.6 Communicating Project Results

It is anticipated that the objectives and results of this research work will be communicated to the public and the scientific community through a variety of forums. Options to be considered and discussed with the board before finalizing the work program include:

- A program of public talks in northern communities, to present the work, objectives, current activities and preliminary results, and solicit feedback/information input from the public.
- A project website linked to the main MK website.
- A color poster presentation for public information.
- Presentation of papers at relevant professional conferences as appropriate.
- Progress reports and a project technical report.
- A short newspaper brief for local and provincial media.
- An insert for the MOF fieldguide for the Prince George Region giving a brief overview of caribou requirements in the area and identifying the different lichen - caribou habitat values by site type.

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APPENDIX 1: PEOPLE CONTACTED FOR CARIBOU ECOLOGY AND CARIBOU - LICHEN PROJECTS

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Ann Mercier	Not Listed	First Nations, Lower Post
Barry Clarke	250 232 5202	Trapper and past guide-outfitter, also Toad River representative on Ft. Nelson LRMP
Brian Churchill	250 561 0008	MK Advisory Board Coordinator
Bryan Webster	250 787 3418	Resource Officer, MELP, Ft. St. John
Cam Allen	250 352 5411	Pilot for Canadian Helicopters, Fort Nelson
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NAME	PHONE	AFFILIATION
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