CARIBOU POPULATIONS AND ECOLOGY, NORTHERN MUSKWA-KECHIKA

for:

Muskwa-Kechika Trust Fund
Project I.D. #MKTF99-20 36

by:

Gillian Radcliffe, *M.Sc., R.P.Bio.*
MADRONE CONSULTANTS LTD.
2053 South Ogilvie Street, Prince George, BC V2N 1X1

March 2000

MADRONE
ECOLOGY & EARTH SCIENCES

PART ONE
BACKGROUND STUDY

ACKNOWLEDGEMENTS

This study was made possible through funding provided by the Muskwa-Kechika Trust Fund, and I would like to thank the Advisory Board for supporting this project. I also thank the people listed in Appendix 1, who provided information, advice, contacts, and/or stimulating discussions which aided in developing this project. A few individuals in particular gave considerable time to meet with assistants, or myself, and to help in development of the project. I would therefore especially like to thank David Wiens for a lot of local information and for assisting in the field; Al Hansen and Rob Honeyman for additional local information; Brian Churchill for sharing his knowledge of the area and for suggesting many useful contacts; Mary Duda for productive meetings and the joint fieldtrip; John Elliott for stimulating discussions of caribou ecology in the north; Dale Seip and Chris Johnson for their help and for providing many useful references; and members of the Kaska Dene First Nations for the meeting at Lower Post in August 1999. Thanks also to Madrone staff - Tania Tripp for gathering lots of useful background information, Sandra for formatting this report, and Bryan Tasaka for preparing the figures.

PART ONE: BACKGROUND STUDY

PART TWO: RESEARCH PROPOSAL

List of Tables

List of Figures

EXECUTIVE SUMMARY

In 1999, Madrone Consultants Ltd. submitted a seed proposal to the Muskwa-Kechika Trust Fund (MKTF) to develop a research proposal investigating caribou populations and ecology in the northern portion of the Muskwa-Kechika Management Area (MKMA). Submission of this document effectively completes the first phase of the project (Project #MKTF99/20 36), 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 this major wilderness based predator-prey system in perpetuity. The successful management of the dynamic predator-prey systems in the area, in response to existing and changing ecological conditions and resource developments, 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. In conjunction with the other ungulates, including moose, elk, mule and white-tailed deer, and Stone's sheep, they support a great abundance and diversity of predators, including wolves, black and grizzly bears, and wolverine.

This proposed research project aims to gather ecological and population parameters for what is thought to be the largest herd of caribou in the northern MKMA, and for which there is currently a paucity of information. Built around this existing caribou population as a key, the project aims to increase our knowledge of caribou/habitat associations, to elucidate some of the key ungulate population parameters, including interactions between key prey species, and clarify local predator-prey dynamics. Ecological relationships between caribou and alternate prey (primarily moose and elk) and predators (especially wolves) will be explored through ungulate and predator surveys, including a telemetry study.

The scientific results will be utilized to develop management tools to predict impacts not only of industrial developments, but also of increased human recreational activities, and to support decisions on predator control, hunting allocations, and resource developments. This will be essential in the future if the long-term sustainability of this wildlife resource is to be ensured.

MADRONE
ECOLOGY & EARTH SCIENCES

CARIBOU POPULATIONS AND ECOLOGY, NORTHERN MUSKWA-KECHIKA

1.0 INTRODUCTION

1.1 Initial Project Proposal and Objectives

In 1999, Madrone Consultants Ltd. submitted a proposal to the Muskwa-Kechika Trust Fund (MKTF) to develop a research proposal investigating caribou populations and ecology in the northern portion of the Muskwa-Kechika Management Area (MKMA). This project aims to establish baseline ecological information on a large caribou herd in the northern Muskwa–Kechika, to support future wildlife management and conservation objectives. The overall objectives of the intended research proposal were initially to:

- Facilitate the long-term maintenance of caribou populations in the MKMA area.
- Provide information for assessing the potential impacts of proposed developments.
- Improve our understanding of the local caribou herds, the boundaries between woodland and boreal types, and the movements made by caribou within the area.
- Significantly improve our abilities to predict caribou habitats both in the study area, and to apply this knowledge elsewhere in the MKMA, through improvement of caribou habitat models for capability and suitability mapping.
- Help improve caribou management practices and the identification and maintenance of critical caribou winter and birthing habitats, and have potential implications for forest management practices in the Boreal White and Black Spruce biogeoclimatic zone.

1.2 This Report

This document presents the methods and results of this preliminary work, and effectively 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 general and caribou ecology in the area (PART ONE), followed by presentation of the research proposal (PART TWO). As the research proposal has already been submitted (December 1999, revised February 2000), it has been retained as a separate document (Madrone Consultants Ltd. and Slocan Forest Products Ltd. 2000, attached). Since the initial proposal, much more detailed project objectives have now been identified, and they are incorporated within the attached research proposal.

1.3 Revisions to 1999 Research Proposal

Under the initial proposal it was intended to bound the study on the west by the Kechika River valley, and extend it to the eastern boundary of the MKMA, in the vicinity of Tetsa River Park. As a result of this preliminary work however, study area boundaries have been reduced from those originally identified. Some baseline inventory work on the Rabbit herd in the west portion of the northern MKMA is to be conducted by MELP this winter (John Elliott, pers. comm.). This latter herd is logistically more difficult to access, and it would be relatively expensive to use it as a focus for more detailed ecological work. At the present time the western portion of the area, incorporating the range of the Rabbit herd, has therefore been excluded. The current proposal focuses on conducting more detailed work around the range of the Muskwa herd. However, it is anticipated that the ecological information gained, together with information from a study to the immediate west of the Kechika (Horseranch/Blue River study, see Table 5), will also assist in interpreting data for the Rabbit herd, so the studies should complement one another. Should the Rabbit inventory data indicate a need, the work could be expanded or combined in the future to look at the northern MK population as a whole.

2.0 BACKGROUND AND RATIONALE

2.1 Significance of the Muskwa-Kechika Wilderness Area

With its wealth of natural beauty, natural resources, and few roads, the Muskwa–Kechika (MK) 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. Caribou, elk, moose, and Stone's sheep are especially abundant, and healthy populations of black bear, grizzly bear, wolves, wolverines, coyotes, and cougars occur. The abundant large animal populations are not only an integral part of the wilderness character of the area but also support many significant consumptive and non-consumptive human uses. As well as supporting many wild predators, the ungulates in the MK 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.

2.2 Management Goals

2.2.1 Muskwa-Kechika Objectives

The Muskwa-Kechika Management Area was established with the goal of protecting all significant values including tourism, visual quality, fish and wildlife habitat, wilderness, backcountry recreation, and major river corridors, while permitting development of the wealth of natural resources that occur, including oil and gas and mineral developments and timber harvesting (Land Use Coordination Office, 1997). A solid scientific foundation is needed for making appropriate management decisions that will ensure the perpetuation of the major predator-prey systems in this area.

2.2.2 Provincial Objectives

The Province, in addition to establishing the MKWA and setting the goals and objectives for this huge area, also has a number of other objectives relevant to this study. Woodland caribou conservation has been a high profile resource management issue in British Columbia for many years primarily because of the conflict between forest harvesting and conservation of caribou habitat (Seip, 1996). Most habitat-use studies have been focused on the woodland caribou populations in the southeast part of the province due to the more immediate conflicts between forest harvesting and declining populations in this area (Stevenson, 1991). However, with the increasing demands for forest products throughout the province and decreasing availability of these resources, the focus has expanded to include woodland caribou populations in the northern part of the province (Terry and Wood, 1998). Caribou are thus considered to be a high profile species of provincial significance. Population estimates indicate the proposed study area (i.e. the northern MK) supports a very substantial proportion (approx.13%) of B.C.'s northern caribou population.

2.2.3 Regional Objectives

At the regional level, key wildlife goals identified under the Fort Nelson Land and Resource Management Plan (LRMP) include: the maintenance of wildlife diversity and abundance; maintaining the integrity of functional large predator-prey systems; and provision for recreational uses such as viewing, hunting, and wildlife appreciation (Province of British Columbia, 1998). LRMP objectives include special attention for regionally important species (which include caribou), management for sustainable populations, and for consumptive and non-consumptive uses, identification of critical winter ranges, and maintenance of high capability sites.

2.2.4 Resource Management Zone (RMZ) Objectives

Within the Fort Nelson Region and the MK, more specific objectives for each RMZ have also been established. For those within the proposed study area, the objectives all include the maintenance of wildlife diversity and abundance, and of habitat and ecosystem diversity and integrity. Goals also require the provision for recreational uses such as hunting and viewing. Priorities for each RMZ vary slightly, but all main areas for this study are in RMZ's which involve an emphasis on caribou and/or elk and/or moose.

2.3 Anticipated Future Demands and Conflicts

Within the MKMA, future years can be expected to bring to the fore a variety of significant issues with regard to the management of caribou herds, and the predator-prey systems in general. Potential developments and management activities such as oil and gas development, management to meet B.C. Parks objectives, future guide-outfitting demands, and timber development, are likely to result in conflicting objectives and often highly contentious issues. There will be a need to develop an area-specific management plan tailored to the ecological conditions, predator-prey systems, and human resource demands that operate in this area. Solid information to support management decisions on predator control, hunting allocations, and to predict impacts not only of industrial developments but also of increased human recreational activities, will be needed if the long-term sustainability of the wildlife resource is to be ensured.

2.4 Role of Proposed Project in Supporting the Management Objectives

Despite the national and international significance of the large mammal predator–prey systems of the MKMA, the provincial significance of the caribou herds, regional and local objectives, and anticipated information demands, studies have not yet been conducted upon caribou ecology or predator-prey relationships in the northern half of the MK area. Although studies have been conducted elsewhere in the province, often in response to timber resource development, in this study area very different ecological conditions and resource demands prevail. Harrison and Surgenor (1996) noted that for northeastern B.C. in general, there are few published data of woodland caribou, and information is lacking on the numbers, their seasonal movements, their habitat requirements, and their interaction with other species. Nowhere is this more true than for the northern portion of the MK. The MK offers an ideal opportunity to study predator-prey systems relatively intact. As Ballard and van Ballenberghe (1998) point out, before predator/prey populations in altered ecosystems can be understood, much less managed, the understanding of these systems in natural or near-natural settings is imperative. The authors note that the northern ecosystems of Canada and Alaska offer the best opportunities for understanding these relationships, as most habitats remain relatively undisturbed.

This proposed study aims to help fill the critical information gaps through a systematic program of gathering relevant population and ecological information on a major caribou herd, on alternate prey, and on the predators. As a multi-faceted study, the project supports multiple MK management plan objectives. The improved understanding of caribou populations and ecology will enable us to predict potential development impacts and plan management, whether for conservation purposes, resource extraction, or provision of recreational opportunity. As such, the project fulfills MK objectives to support the resources through research, which will in turn permit us to manage the wildlife resources in perpetuity. Objectives such as avoidance of fragmentation and provision for wildlife corridors will also be supported by this project, thus supporting conservation objectives and planning initiatives. This study also supports the individual RMZ objectives for the main study area.

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 (with air and helicopter charter companies, employment of First Nations biologists, guide-outfitters, and so on).

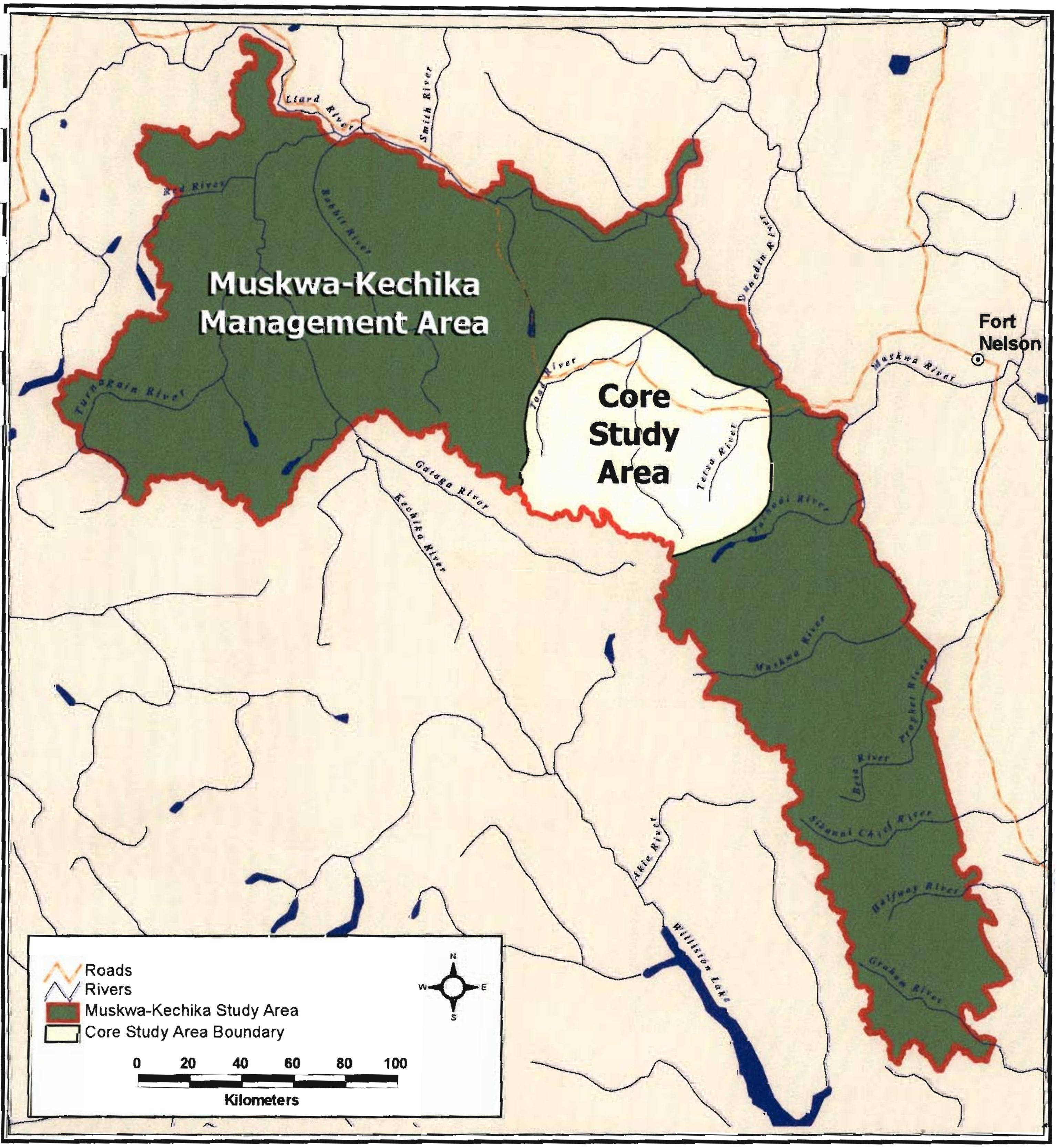
3.0 PHYSICAL SETTING

3.1 Physical Location

The study area (Figure 1) comprises a large region within the northern half of the Muskwa–Kechika Management Area (MKMA), primarily areas to the north and south of the Alaska Highway. Initially it was proposed that the research project would be based somewhere between Muncho Lake and the Toad River area, and would cover a very broad area, between the Kechika and Muskwa River valleys. However through review of existing knowledge, two brief reconnaissance trips (August 1999 and February 2000), and discussions with government personnel and local guide-outfitters, this has since been refined.

The proposed project now bases out of Toad River (logistically the most feasibly center of operations), and focuses more intensively on the range of the Muskwa caribou herd. Heard and Vagt (1998) report that this herd ranges within the Mt. Dall, Crest, Toad, and Racing River areas. The proposed study area thus climbs from the lowlands of the Snake and Dunedin Rivers, up through the Dunedin foothills, into Stone Mountain. It then extends west across Toad River to the eastern portion of Muncho Lake Park, south around Racing River, across Wokkpash to the Chisca River system, then north and east towards Tetsa River Park.

Figure 1: STUDY AREA



3.2 Resource Management Zones

Most of the study area falls within a mix of Special Management Category RMZs and Parks or Protected Areas (Table 1). The main RMZs included are Eight Mile/Sulphur, Stone Mountain, and Churchill. A number of Provincial Parks and Protected Areas fall within the study boundaries, including parts of Muncho Lake Park, all of Stone Mountain Park and Wokkpash Protected Area, and part of the Northern Rocky Mountains Protected Area. In addition, the Alaska Highway Corridor RMZ (enhanced resource development category) and Toad River Corridor RMZ run through parts of the study area. Other surrounding RMZs will be included as required as the study progresses.

Table 1. RESOURCE MANAGEMENT ZONES WHOLLY OR PARTIALLY WITHIN THE STUDY AREA

Resource Management Category	Zones
Special Management	Eight Mile /Sulphur
	Stone Mountain
	Churchill
	Toad River Corridor
Provincial Parks	Muncho Lake Provincial Park (east portion)
	Stone Mountain Provincial Park
Protected Areas	Wokkpash Protected Area
	Northern Rocky Mountains Protected Area
Enhanced Resource Development	Alaska Highway Corridor

3.3 Access

The Alaska Highway provides the major existing ground access to study sites. There are in addition a number of roads and well-developed trails (many from guide-outfitter use), which make many parts of the study area accessible by a combination of horseback, foot, and snowmobile (depending on season and conditions). 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 is then 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 southern end of the study area can also be accessed via the Tuchodi system. Trails and jet boats access the main Tuchodi valley, and from here it is possible to head north into Chlotopecta Creek and beyond. Parks trails also facilitate access, e.g. Flowersprings Lake trail in Stone Mountain Park, south of the highway. North of the 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 predator and ungulate tracking surveys, mortality investigations) so the study is not too heavily dependent upon helicopter and fixed wing aircraft support.

Study boundaries are likely to be modified further as the study progresses and the extent of the caribou ranges and movements is more adequately identified.

4.0 METHODS

4.1 Meetings and Interviews

The project was initiated in 1999. A road trip to northern B.C. was completed in August 1999, and meetings 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. 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 5 (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.

4.3 Field Reconnaissance

The research project was then developed late in 1999 and was refined following a second road trip in February 2000 by Gillian Radcliffe, and a winter field reconnaissance. During this trip further meetings were held with stakeholders and interested parties (see Appendix 1). An aerial reconnaissance 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 to:

- Examine the feasibility of the intended project, including the field logistics of conducting a research project based in this area.
- Look at present winter distribution of caribou in the area.
- Briefly look at the habitats being used.
- Identify if any key lichen-type units were being used—this is related to Project #MKTF 99/20 37.
- Identify core areas for initial collaring and telemetry work.

Enquiries into current radio telemetry equipment were also made before finalizing project needs. Core areas for initial collaring/telemetry work and project details were finalized during the above reconnaissance visit in February 2000 (under year one of the project).

5.0 BIOPHYSICAL CONDITIONS

5.1 Ecosections, Physical Description

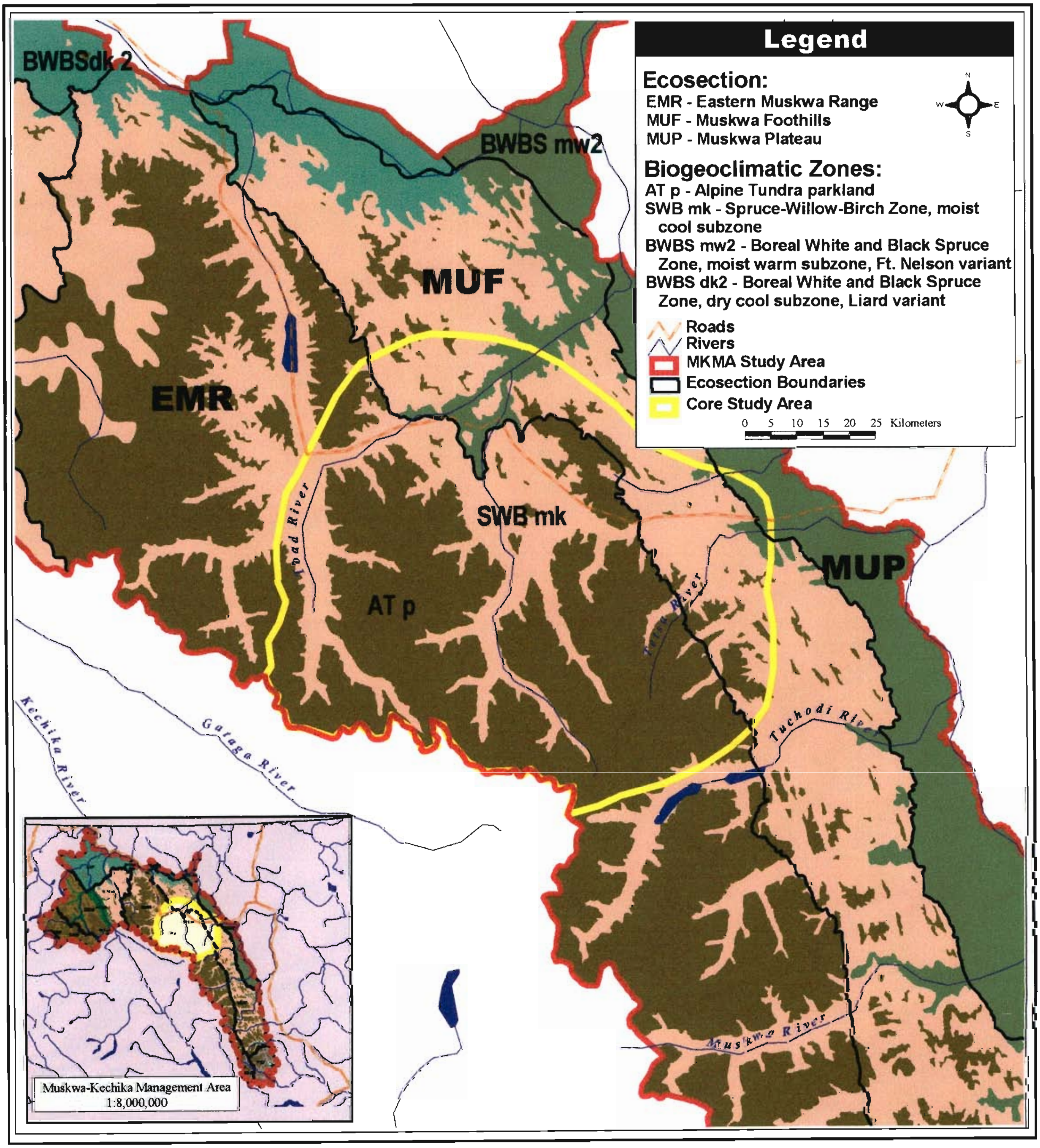
Based on the broad physiographic divisions, which form the basis of the Ecoregion Classification system described by Demarchi (1996), the proposed study area falls within the Polar Ecodomain. Lying where the Northern Canadian Rocky Mountains (Eastern Muskwa Ranges Ecosection) and associated foothills (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, best expressed in Stone Mountain Park and areas south, through 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 expansive plains of the Fort Nelson Lowlands. The ecoregion classification of the study area is summarized in Table 2.

Table 2. ECOREGION CLASSIFICATION OF THE STUDY AREA

Ecodivision	Ecoprovince	Ecoregion	Ecosection
Sub-Arctic	Taiga Plains	Muskwa Plateau	Muskwa Plateau
Sub-Arctic Highlands	Northern Boreal Mountains	Northern Canadian Rocky Mountains	Muskwa Foothills
Sub-Arctic Highlands	Northern Boreal Mountains	Northern Canadian Rocky Mountains	Eastern Muskwa Ranges

The Northern Rocky Mountains are extremely rugged, comprising a series of northwest to southeast trending valleys and ridges. Numerous peaks occur within the core study area, including Mt. Socrates and Mt. Aristotle in the west part, Stone Mountain at the northern end, and Chischa and Tetsa Peaks to the south. Mt. Mary Henry is the highest peak in the area at 2,614 m. The foothills to the north and east are more subdued, and generally lie between 1,350 m and 1,650 m. A more rolling topography with broad, open ridges and wide valleys prevails. From the foothills, the study area drops progressively north and east into the Fort Nelson Lowlands.

Figure 2: ECOSECTIONS AND BIOGEOCLIMATIC ZONES WITHIN STUDY AREA



5.2 Geology (modified from Barton *et al.*, 1998)

The Muskwa Ranges are composed of quartzites, conglomerates, slates, limestones, and shales of the late Precambrian and Cambrian ages. The Ranges show evidence of complex tectonic deformation. The Eastern Slopes are mainly limestone, which has been eroded in bold relief (B.C. Parks, 1999). In the foothills, Mesozoic formations of calcareous sandstones, shales, and siltstone predominate (Taylor, 1971). Paleozoic formations in the foothills have been thrust over younger Mesozoic formations, and the grey Paleozoic limestone is easily visible in Stone Mountain and neighbouring peaks (Barton *et al.,* 1998).

Further east, Cretaceous marine sandstones and shales underlie the Fort Nelson Lowlands. The Lowlands lie below 610 m, while the Plateau rises up to just over 1,200 m. The bedrock is horizontally bedded or dips gently to the east, giving rise to asymmetrical ridges and valleys with steeper, west-facing slopes and gently sloping, east-facing slopes.

Glaciation has been a major force shaping the landscape. Cordilleran ice from the west left behind medium-textured, stony, calcareous till often less than 3 m thick as it retreated; this till predominates in the mountains. Lowland areas to the north and east were covered by Keewatin ice, which advanced from the northeast and left behind fine-textured till (silty clay loam and silt loam) with very few coarse fragments. At high elevations in the mountains, remnant glaciers and icefields still exist.

Fine-textured glaciolacustrine deposits mark locations of ice-dammed lakes, while coarser glaciofluvial deposits mark old meltwater channels. Fluvial deposits are limited in extent and range from medium to coarse textured. Where the foothills meet the lowlands, the rivers deposit their

tat use by Northern caribou in Specifically, the study was use within Valleau Creek – a . Year one data suggested that Valleau drainage in 1997 were
mine site and part of Southern d mortality/survival, habitat use,
xpanded into a caribou winter ng. This was used to develop nge management strategy and g processes.
staff, continuing study outlined
t. A total of 45 animals were bitat use.
eVries of CANFOR, have been nodeling looking at different ips to lichen growth. They are haeuser in Alberta.

6.0 CARIBOU POPULATIONS AND RANGES

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. This factor may significantly influence wildlife movements in the winter months. Typical climate parameters for the different biogeoclimatic zones in the study area are provided in Table 4.

There appears to have been little systematic recording of precipitation within the study area. The nearest station in Canadian Climate Normals is at Muncho Lake; however, snow data has not been recorded for winter months. In previous years snow data was recorded at Summit station, 1280m elevation, within the proposed study area. Peck (1988, cited in Bergerud and Elliott 1998) also recorded snow depths in the Tuchodi valley at the southern end of the proposed study area. 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 usually starts to fall at the lower elevations around mid October, usually by Oct. 20. However, snow begins sitting at higher elevations around the end of September. Snow depths in most years are fairly low (although 1999/2000 winter has been unusually low). There are always a lot of bare ridges free of snow in the alpine. Inversions often occur within the proposed study area, so warmer conditions may prevail higher up. In 1999, spring was very late and snow was still on the hills by July; indeed quite a lot of snow fell in July.

5.5 Vegetation and Biogeoclimatic Zonation (modified from Barton *et al.*, 1988)

5.5.1 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 3 summarizes the general elevational boundaries of the different zones, subzones, and variants that occur (from Barton *et al.*, 1998). Typical climate parameters for the different zones and subzones are provided in Table 4.

Table 3. ELEVATIONAL BOUNDARIES FOR BGC 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

5.5.2 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.

5.5.3 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).

5.5.4 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).

Table 4. BIOGEOCLIMATIC CLASSIFICATION OF THE PROPOSED STUDY AREA AND SUMMARY CLIMATE DATA
(Barton *et al.* (1998), adapted from DeLong *et al.*, 1990 and MacKinnon *et al.*, 1990)

Zone	Subzone	Variant	Seasonal Precip. May Sept Mean (mm)	Annual Precip. Mean (mm)	Annual Mean Temp.	Annual Snowfall Mean (cm)	Frost-free period Mean (days)
BWBS Boreal White and Black Spruce	mw Moist Warm	2 Fort Nelson	295	460	-1.6	185	105
	wk Wet Cool	3 Kledo					
SWB Spruce Willow Birch	mk Moist Cool		350	580	-1.9	270	35
	mks Moist Cool Scrub						
AT			425	1460	-0.8	1265	50

5.5.5 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, immediately to the south, 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.

6.0 CARIBOU POPULATIONS AND RANGES

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, 1996; Seip and Cichowski, 1996).

6.2 Caribou Studies Elsewhere in Northern B.C.

Most caribou work in B.C. has focused on the threatened Woodland ecotype. 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 5.

Table 5: 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.	Predator-prey work being conducted on the Rancheria herd (Horseranch). 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. 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.
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 1994; 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 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 5: (Cont'd)

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 5: (Cont'd)

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 Populations, Densities and Trends

6.3.1 Provincial

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.

6.3.2 Populations in the MK

Population estimates indicate the northern MKMA supports a very substantial proportion of the estimated B.C. Northern caribou population [over 2,000 out of 15,600 animals (including Boreal) estimated in Heard & Vagt, 1998]. Assuming estimates are correct, the Muskwa herd (estimated 1,250) and the Rabbit herd (estimated 800) together comprise about 11% of total B.C. caribou and about 13% of the Northern ecotype. However, no complete census of caribou numbers in the northern MK has been conducted, there is little historic information available, and no detailed ecological studies have been conducted anywhere within the geographical areas believed to support these relatively large herds.

Only four of 39 identified B.C. herds exceed the Muskwa herd (estimated) in size; two of these (Spatsizi and Itch-Ilgachuz) have had detailed, long-term studies conducted, and a third (Pink Mountain) has had at least some telemetry work done. Range information based on telemetry data is apparently available for 22 herds, i.e. well over half. However there is minimal information available on both the Muskwa and Rabbit herds, and population trends for both are reported to be unknown (Heard & Vagt, 1998). Bergerud and Elliott (1998) conducted ungulate/wolf studies in the Kechika and collected data on the Horseranch caribou herd; in the Muskwa they mainly examined moose, sheep and elk, although they also measured recruitment of some cohorts of caribou.

MELP is planning a winter census of the Rabbit herd this year (John Elliott, pers. comm.) so some improved information for areas to the west should be available soon. Southern parts of the MK also support substantial numbers of Northern Ecotype caribou, and some inventory work, including some radio telemetry, has been conducted on populations further to the south, especially in the Sikanni and Graham River areas (see Table 4).

6.3.3 Results of Field Reconnaissance

A field reconnaissance was made of the proposed study area on Feb. 19th, 2000. This was an overview reconnaissance flight, not a direct caribou survey, and it is highly probable that some, and possibly a considerable number of animals were missed on this flight. Viewing conditions were poor as snowpack was unusually shallow for the time of year, and snow cover was very inconsistent, with bare ground exposed in patches through most areas. The caribou were hard to spot against such a discontinuous brown/white background. Strong winds also hampered the second half of the flight. Altogether 344 caribou were observed in the core area, all on high elevation, windblown meadows.

Both the guide-outfitter (David Wiens) and the helicopter pilot (Cam Allen, pers. comm.) reported that:

a) The caribou regularly occur in the areas surveyed in the winter.

b) They would normally have expected to see about double this number within the area reviewed.

Both believe caribou numbers in the area have substantially declined over the past five years.

As there is no baseline information, it is impossible to know if this locally perceived trend is real. Even if numbers have declined locally, it would be impossible to identify if an actual population decline has occurred, or if it is simply due to shifts in range. It is unclear where the boundaries of the different herds are and unclear how accurate the numbers are. 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). Numbers within the study area may fluctuate substantially over time, either due to increases/declines, or to large-scale movements/shifts in ranges. 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).

6.3.4 Population Densities

Seip (1992) recorded caribou densities of 0.04/km^2 over the whole annual range (densities on winter ranges were higher) for the Quesnel Lake herd. Seip and Cichowski (1996) reported caribou densities between 0.03 and 0.05 caribou/km^2 for four herds that space out in the alpine and subalpine during summer. For the Itcha-Ilgachuz and Spatsizi herds (i.e. for herds that aggregate in summer on alpine plateaus) densities of 0.15 to 0.21/km^2 were calculated. Wood (1998) estimated 0.07/km^2 for the Wolverine herd. Bergerud (1992) calculated the mean density of 24 caribou populations in North America, where caribou co-exist with wolves, as 0.06/km^2. Bergerud and Elliott (1998) report that caribou densities in noninsular situations are generally less than 0.4/km^2 when caribou share range with only lightly exploited bear and wolf populations. However, in the absence of wolves, caribou densities often exceed 1/km^2 (Bergerud and Elliott 1998).

There are no adequate data on which to base density estimates of caribou for the proposed study area at this time.

6.3.5 Population Structure

Adult sex ratios are generally weighted to females as they have greater longevity, and there is differential mortality. Low numbers of males are generally a result of predation, hunting pressure and winter starvation, and/or poor recruitment (Bergerud, 1980, cited in Wood 1998).

Bull/cow ratios of 10 herds through northern B.C. in the 1970s were between 35 and 50 bulls: 100 cows, with a mean of 36% bulls in the total population (Bergerud, 1980, cited in Wood 1998). Similar ratios were observed in the Wolverine and Chase herds in late winter in 1993. In 1996, the bull:cow ratio was 67:100, with a total of 40% bulls, and 10% calves. In a study in Alaska, herd composition was found to be 57% cows, 14% calves, and 29% bulls (Dale and Adams, 1999).

Recruitment (the number of individuals entering the population at 1 year of age) is low (Rock, 1992). Caribou do not twin; therefore potential population growth is slow. Wood (1998) calculated calf/cow ratios of 19/100 for the Wolverine herd, in 1996. That is 10% of the population was calves, down from earlier estimates of 16% (1989) and 12% (1993). Elsewhere in the Williston reservoir, calf percentage of the population ranged from 9% to 17%, but again was lower in 1996 than in earlier surveys. Bergerud and Elliott (1986) estimated fall calf recruitment for four northern B.C. herds to range between 10-13%. Census data from the Muskwa area, reported in Bergerud and Elliott (1998), yielded calf/cow rations of between 39 and 65 per 100 for 5 month old calves. Recruitment at 9 months was substantially lower, ranging from 17.5/100 to 45.7 calves/100 cows. Examining two other northern herds, both in decline, Bergerud and Elliott (1986) report a low calf survival, with a mean of 55% calves dying in the first two weeks of life. Seip and Cichowski (1996) reviewing data from ten caribou studies in BC, report that during post-calving surveys in June, most populations reviewed had about 40 calves per 100 cows.

Bergerud and Elliott (1986) reported recruitment of 15.1% calves in the fall for northern B.C., when wolf numbers were low, compared to 7.5% calves when wolves were more abundant. Bergerud (1988) suggested herds increase when recruitment of yearlings exceeds 12-15%; populations with calf recruitment of 10-12% in March show little change.

When calf recruitment is good, it leads to a younger age structure in the herd. This tends to increase the ratio of males to females in the population. Bergerud (1978) found that for four herds with calf recruitment of more than 10%, the bull:cow ratio was 49:100. In six herds with calf recruitment of less than 10%, the bull:cow ratio was 33%.

Neonatal mortality results from emaciation, stillbirths, congenital defects, accidents, and predation (various studies cited in Seip and Cichowski 1996). Adult mortality across ten B.C. studies averaged 15% per annum. Seip and Cichowski (1996) report that herds with low calf recruitment also generally had high adult mortality. Where cause of death was determined, wolf and bear predation were the main causes of adult mortality; in some areas, avalanches also cause adult mortality. This is unlikely to be a significant factor within the Muskwa area due to the relatively low snowpacks.

A number of population parameters need to be collected to look at population dynamics and assess the impacts of predation. These include population size, calf recruitment, adult sex composition, and adult survival.

6.4 Caribou Ranges and Movements

6.4.1 General

Unlike their barren ground counterparts, woodland caribou do not form large herds but instead move in relatively smaller groups (B.C. MELP, 1992). They generally occupy large home ranges and migrate in response to seasonal habitat requirements; 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. 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 (Stevenson, 1991).

Caribou are characterised by a horizontal migratory behaviour as they frequent traditional calving, rutting, wintering, and post-calving ranges over a seasonal cycle (Child and King, 1991). They tend to show fidelity to core areas for calving (Hatler 1986; Cichowski 1989; Edmonds 1988; Farnell and McDonald 1989; Wood and Terry 1999), for rutting (Farnell *et al.,* 1991), and to seasonal ranges (Farnell and McDonald, 1989).

In general they use high elevation forests and alpine habitat for calving, post-calving, summer, and rutting grounds, and move to lowland forested areas in the winter (Fenger *et al.*, 1986). Females generally move to upper elevation calving areas in mid to late May (e.g. Wood, 1996). Summer and rutting ranges are often in the vicinity of the calving ranges (e.g. Wood, 1996). When snow conditions become prohibitive in the winter, caribou may move to windswept slopes in the alpine where terrestrial lichens will be available (Heard and Vagt, 1998). However, 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.*, (1996) also report that caribou appear to rotate use of winter range by using one area for several winters, then shifting to another area.

6.4.2 *Study Area*

The range of the Muskwa caribou herd is poorly known at present. Certainly many animals winter within the proposed study area, but the extent of seasonal movements and the full extent of the herd and the ranges is unclear. Caribou in the area appear to periodically abandon certain ranges and shift to others (e.g. Thomas *et al.*, 1996), 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, and caribou in the Toad River area may have shifted ranges. There were apparently no caribou in the area to the southeast of Toad River or up around Summit 12 years ago, but caribou then began to appear in this area. Prior to this, they were apparently all in the upper Toad, on the south side of the highway. (John Elliott pers. comm.).

It is unclear why range shifts may occur, and numerous factors could be involved (predation pressure, competition, vegetation condition through maturation or burns etc.). There is also no way of knowing how far the caribou are moving from the area. For example, John Elliott (pers. comm.) suggests that in the past caribou used to move out of the mountains in this area to the east in winter, then back into the mountains in spring for calving.

Caribou continue to appear regularly in the Summit and Toad River area at the present time, and a number of winter road kills occur between Summit and East Muncho Lake each year. Rob Honeyman (pers. comm.) reports the highest concentration in the general area appears to be around the Stone Mountain and the Stone Mountain Park areas. Based on information provided by John Elliott, David Wiens, Barry Clark, Al Hansen, Rob Honeyman, and Cam Allen (pers. comms.), it is clear that caribou range throughout the proposed study area, and that there is a significant resident population. Groups of animals have been variously reported as being: north and south of Summit Lake; Flowerspring Ridge; ridges in East Muncho Lake Park; MacDonald Creek; along Racing River; in Wokkpash, above Whitestone Ridge; at the top end of Chischa Creek; down to the Tuchodi; and in the upper end of Henry Creek.

In summer 1998, a number of well-worn travel routes were observed in the Dunedin area leading from the lower elevation forests of the BWBS, up onto and along ridgetops and main valley bottoms and rivers and through low passes between the foothills and adjacent drainages. For example, trails link the headwaters of the Snake River and the adjacent Toad River. Some of the best-worn appeared to be horse trails (packers and guide-outfitters), but considerable caribou use was observed in places. These routes are likely being used to travel between seasonal ranges and possibly to mineral licks (Barton *et al.*, 1998).

7.0 LIMITING FACTORS

7.1 General

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, current thought is that predation is a much more significant factor in limiting and regulating caribou. Bergerud (1998) soundly 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. Similarly, Bergerud and Elliott (1998) report that predation by wolves and bears is now recognized as a major limiting factor in the growth of moose and caribou populations in northern ecosystems of North America. Bergerud (1996) notes caribou will sacrifice high quality forage to remain in habitats above treeline with low predation risk. Rock (1992) working in Saskatchewan, also suggests caribou habitat selection is probably related more to predation considerations year-round, and also to thermal cover/insect harassment factors during the summer, than it is to any of the food requisites. Rock, (1992) considers that late winter habitat, although important, was historically over-emphasized at the expense of other considerations such as predation.

The influence of predation is considered in more detail in the next chapter (8.0); in this chapter a brief review of the role of diet and food availability, and the role of weather, are considered.

7.2 Food

7.2.1 Summer Diet

Caribou are mainly grazers. In general, little information has been collected on growing season diets as these are not usually considered limiting (but see discussion below). 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.*, 1996). 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.*, 1996).

7.2.2 Winter Diet

During the winter, when snow is deep, winter foliose lichens become a major food item, although weather-dried grasses, sedges, willow and birch tips are taken where available (B.C. MOE 1992). 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. However, 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, 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 over 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 and McDonald, 1990; Farnell and McDonald, 1989; Farnell *et al.*, 1991; Stevenson and Hatler, 1985). Horsetails, grasses, and sedges (primarily *Carex* spp.) can also be components of the winter diet (Farnell and McDonald, 1990; Thomas *et al.*, 1996). Forbs, where available, are also taken, and in windswept alpine areas in Alberta, *Dryas* was the most consistent food item taken (Thomas *et al.*, 1996). The study by Thomas *et al.* (1996) in the foothills and Rocky Mountains of west-central Alberta found terrestrial lichens averaged 60-83% of fecal fragment densities. However, decreasing proportions of lichens and increasing proportions of conifer needles and moss occurred in the mountains. They report this indicates decreasing accessibility of forage because of deeper/harder snow.

While caribou are considered lichen specialist feeders, Thomas *et al.* (1996) 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.

7.2.3 Food 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. This has led to the common belief that forest fires were responsible for caribou declines in the middle of this century, as they reduced lichen pastures. However, Bergerud (1996) reports on his earlier work in which he found no correlation in fluctuation of caribou numbers with burning. Bergerud (1996) concludes we have had it wrong for 30 years and rejects the critical winter range hypothesis. He considers the annual abundance of wintering lichens does not determine carrying capacity, as it is density independent. Certainly many other studies have 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.

In studies for a caribou population living without predators, Bergerud (1996) reports that the density regulating factor was the abundance of summer, rather than winter, foods. This is counter to the belief held by many authors. 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. 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.

Caribou can certainly degrade their feeding ranges. Large herds, such as the George herd, have been shown to degrade their summer ranges through a substantial reduction in tundra shrubs, and reduction in forb diversity. 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. Thomas *et al.* (1996) note that caribou need to alternate (wintering) areas to prevent overgrazing, and to allow grazed areas to recover lichen biomass.

7.3 Weather

Bad weather conditions have also been considered a limiting factor to caribou populations in the past. A number of authors believed that hypothermia could be responsible for deaths in newborn calves. However, Bergerud (1996) cites a number of studies that illustrate that almost no exposure deaths for newborn caribou have ever been recorded. He concludes that the hypothermia hypothesis must be discarded.

Caribou population fluctuations have also been attributed to natural cycles in the weather. However, Bergerud (1996) suggests human influences via the predator prey systems, rather than weather cycles, better explain large scale population changes. Nevertheless, successive years of good (or inclement) weather, combined with predator control programs, do appear to have a substantial influence on population recovery/declines (e.g. Boertje *et al.*, 1996). This would concur with the suggestion of Rock (1992) that predators interact in an additive or compensatory way with other regulatory factors such as hunting mortality, climatic extremes, and food limitations in their degree of influence on caribou populations.

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. 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). When snow depths become limiting, northern caribou will move from early winter ranges to late winter ranges. However, in winters of low snowfall, northern caribou will often remain in their early winter ranges (primarily lowland, coniferous forests) for the entire winter (Hatler, 1986) (see section 9.6 for more information on winter ranges).

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.* (1996), 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.

Weather can however influence predator success, in particular via the effects of deep snow. Adams *et al.*, (1995) and Mech *et al.,* (1996, cited in Boertje *et al.,* 1996) observed increased wolf predation on caribou when snow was deep and herds were at relatively low densities. However, as Bergerud (1996) notes, weather at times favors the prey, and at other times the predator, but it is not, in itself, a density-dependent, regulatory factor.

8.0 INTERACTIONS WITH OTHER SPECIES

8.1 Competition with Other Ungulates

In addition to caribou, there are substantial populations of Rocky Mountain elk and of moose in the study area, as well as small numbers of mule and white-tailed deer. Mountain goat and Stone's sheep are both relatively abundant. The species with the greatest habitat overlap are moose and elk. However, there is very little information available on moose-caribou interactions (Boer, 1998), nor on caribou-elk interactions, despite the fact that moose, caribou, and/or elk are often sympatric, as they are in this study area. Although direct competition between caribou/elk/moose may be limited due to niche separation and behavioral separation, indirect interactions via the effect of prey species on predators may be very significant. Alternate prey abundance may directly influence predation rates. This is discussed below in section 8.6. Moose and elk are considered in more detail below.

Of the other ungulates, deer populations in the area appear to be generally low. During 1998 summer fieldwork in the Dunedin area, only a single mule deer was observed. Light summer deer use was observed in the high elevations, but overall sign was minimal (Barton *et al.,* 1998). Several mule deer were observed in fields near Toad River in February 2000, but none were seen during the field reconnaissance of the study area on February 19. It would appear that deer occur only in low numbers.

Stone's sheep populations within the study area appear to be healthy, and considerable numbers occupy the mountains, where they graze in high elevation meadows near to escape terrain. They could therefore conceivably compete with caribou to some extent, through their influence on suitable pasture in summer/winter. During 1998 summer fieldwork, small groups were observed on various occasions in the foothills and mountains north of the highway, around Stone Mountain, and sheep pellets were abundant at high elevations. Small groups of generally 4-6 individuals were observed. They were also observed travelling down washes in the area, descending to the roadsides for minerals (Barton *et al.* 1998). During a field reconnaissance on Feb 19th, 66 Stone's sheep were observed in the study area.

Best value habitats in the mapping area were considered to be warm aspect alpine and subalpine meadow and shrubby habitats (Barton *et al.*, 1998).

Mountain Goats are also present, although there is almost no inventory information available.

8.2 Moose

8.2.1 General

Boer (1998) reports that habitat partitioning and discrete altitudinal preferences may keep moose and caribou populations segregated and their (direct) interactions nominal and inconsequential. Direct competition between moose and caribou for food and habitats is thus unlikely to be significant. There is some overlap in summer diet, but caribou are more specialised, consuming forbs and deciduous vegetation in summer and lichens in winter (Servheen and Lyon, 1989). Moose are more dependent on browse, but do use forbs and deciduous vegetation in summer (Eastman and Ritcey, 1987). Moose winter at low densities and thus may be able to use scattered winter forage more efficiently than large concentrations of ungulates such as elk or caribou might. This might give moose a competitive edge where food resources are widely scattered (Boer 1998).

8.2.2 Study Area

There is limited information on moose numbers within the study area, although they certainly appear to be plentiful and to occur in most habitats, throughout. At the end of the Little Ice Age (c. 1860) there were few, if any, moose (or elk) in this area (Bergerud & Elliott 1998). However, in more recent history the area appears to have supported healthy moose populations.

In recent years there may have been some changes in moose populations in response to prescribed fires. In addition, populations fluctuate in response to the predator situation. In the absence of wolves, moose densities can exceed 1.5/km^2, but where wolves have been only lightly exploited, they are usually less than 0.4/km^2 (Bergerud and Elliott 1998). Data in Bergerud and Elliott (1998) indicate that moose numbers (densities) for the Muskwa were:

YEAR	POPULATION	DENSITY
1982	18,500	(0.97/km^2)
1985	14,600	(0.77/km^2)
1989	26,800	(1.41/km^2)

Moose numbers in the Muskwa area were apparently down 53% in 1993 from the larger 1989 populations (Bergerud and Elliott 1998).

During summer fieldwork in Dunedin, north of Stone Mountain, moose activity was widespread throughout, especially in the lower elevation, BWBS habitats. However, there was also a lot of moose sign in the SWB zone. Feeding in open wetlands in the BWBS was common. In the higher elevations of the SWB, good summer feeding occurs in various habitat types (see Barton *et al.*, 1998 for more details). Winter surveys to the north found most use by moose in subalpine habitats, burns, and riparian areas, all with abundant shrubs, especially willows (Goulet and Haddow, 1985). Bergerud and Elliott (1998) report that moose in their study area in the Kechika (to the west) were generally below treeline (below 1300m) during the winter. In the Dunedin area, north of Stone Mountain, shed antlers were found in birch/willow shrublands in the SWB (ie above the treeline), as well as in BWBS wetlands (Barton *et al.*, 1998). On the field reconnaissance on February 19th, 2000, a total of 26 moose were observed in open high elevation habitats.

MELP has recently conducted some moose counts over the northern MK (John Elliott, pers. comm.), and so improved information on moose populations in the area should be available in the near future.

8.3 Elk

8.3.1 General

Elk are primarily grazers, but are also successful browsers, and Flook (1964, cited in Boer 1998) reports they have the potential to out compete moose for food. There appears to be almost no information on their interactions with caribou. As elk have flexible foraging habits and an ability to use a wide variety of terrain types, and also have high fecundity, they can be a very effective competitor (Boer 1998). The different ungulates may compete for food resources even when using habitats at different times of year. For example, high elk numbers browsing in riparian habitats in summer may reduce the amount of browse available to moose the next (Telfer and Cairns, 1986, cited in Boer 1998). Elk and moose may compete for willow forage, and both use riparian habitats a lot. Elk are reported to prefer open grass or brush/grass vegetation with trees (for thermal protection) nearby. Introduced into Banff and Jasper National Parks in 1917 and again in 1920, where moose, mule deer, and mountain sheep were present, elk expanded into ranges occupied by the other ungulate species. The elk reportedly dominated competition for food and are believed responsible for declines in moose and mule deer populations that followed. Mountain sheep numbers remained fairly stable

(Boer 1998).

8.3.2 Study Area

Rocky Mountain elk within the study area are nearing the northern limits of their distribution in western Canada. There is limited inventory data available for elk for the general area. Winter surveys to the north, in the Liard valley, identified small groups of elk and noted they seemed to be expanding their range (Goulet and Haddow, 1985). To the east, some radio tracking of elk (and wolves) has been conducted for the last five years, and periodic monitoring is conducted (Ross Peck pers. comm.). Bergerud and Elliott (1998) report elk numbers in the Muskwa as follows:

YEAR	POPULATION	DENSITY
1982	4,200	(0.22/km^2)
1985	4,600	(0.24/km^2)
1989	6,300	(0.33/km^2)

Prescribed burns (primarily for wildlife enhancement and for horse forage production) have strongly influenced elk populations in the area (see Section 5.5.5) and there has been a very substantial increase in the elk population in response (David Wiens, Ross Peck, Brian Churchill, pers. comm.). In a broader area around the proposed core study area, Ross Peck (pers. comm.) suggests elk populations have more than tripled in recent years, going from the numbers above to approximately 15,000 to 20,000 animals at the present time. Many of the elk are to the east of the study area, (this includes elk all down the east side, including the Tuchodi and Gathto systems). However, of these some 2,000 to 3,000 are now present in the Toad River system, where many overwinter (David Wiens, pers. comm.). This appears to be again in response to local burning of warm aspect slopes. John Elliott (pers. comm.) suggests that elk numbers may now be beginning to decline.

During fieldwork in summer 1998, elk activity was recorded in a number of locations in the foothills, and elk were observed on a couple of occasions. During the field reconnaissance on Feb. 19, 2000, a herd of 12 bull elk were observed at very high elevations in the mountains, crossing windblown meadow habitat. Elk have a more limited tolerance for deep snow than either moose or caribou, which may influence distributions in winters with relatively heavy snow loads. They will use open grass areas with low snow in winter, either south facing or wind blown. In the proposed study area, caribou appear to utilize similar habitats, although elk may be more limited in their use of the higher elevation meadows, due to a paucity of good thermal cover nearby. However, the proposed study area has relatively low precipitation compared to many mountainous areas further south and west.

The elk in the study area are living at the northern edge of their range, in a snow shadow, and have been reported to have starved in the past (Peck, 1980, cited in Bergerud and Elliott 1998), suggesting food is a limiting factor for these animals in the general area.

8.4 Predators

Wolf is generally considered the main predator of caribou in the area. However, black and grizzly bears, and wolverine are also present and will predate caribou at times. Seip (1992) reports bear predation in spring and early summer, in both Quesnel Lake area and Wells Gray area, was a significant cause of mortality. Golden eagle, lynx and coyote also occur; these will predate caribou calves (Kuzyk and Farnell 1997). Cougars are a significant caribou predator in some areas, and cougar numbers appear to be increasing in the study area, as there have apparently been more and more sightings in recent years, possibly in response to increased elk numbers (David Wiens, pers, comm.).

8.5 Wolf Control

Predator control has had a significant influence upon the predator-prey systems operating in this area (David Wiens, pers. comm.). Wolves have historically been controlled in the study area, at one time through a provincial control program of aerial gunning. In recent years formal wolf control programs have not been implemented, but some guide-outfitters regularly trap wolves within their own areas of activity.

Bergerud and Elliott (1998) report on the wolf control programs of the eighties and the effects on ungulates in the Kechika and Muskwa areas. There is thus some information available on wolf densities in the general area. Wolf densities reported by Bergerud and Elliott (1998) prior to wolf reductions were lower in the Muskwa (10/1000km^2) than the middle and southern Kechika (15.5/1000km^2), and were well below levels predicted by prey biomass in the area. The authors attribute this to wolf reductions by local outfitters (1978 to 1980). They report these reductions then ceased and the population increased, to reach 39/1000km^2 by 1984, prior to the first official wolf reduction.

They note that the percentage of wolves removed from the Muskwa was 66% +/- 5.7%, for a total of 505 wolves. Wolves officially removed from the Muskwa area were:

YEAR	# WOLVES REMOVED	%REMOVED	AREA OF REMOVAL
1984	182 out of 303	60%	6775km^2
1985	198 out of 256	77%	13570km^2
1987	125 out of 210	62%	10000km^2

At the end of the study, the density of wolves was 22/1000km^2 in 1990. Wolf populations made a considerable recovery each year by the time they were recensused in Feb-March of the subsequent year.

The following account for the local study area is based on information provided by David Wiens and Al Hansen. During the 1980s wolves in the Dunedin area reportedly almost eliminated moose, and it subsequently took almost a decade for moose populations to recover. During the wolf hunt years of the 1980'S, about 1000 wolves were removed from David Wien's territory (NB: this combines wolves removed through the official wolf control program {see above} and those killed by the guide-outfitters). Following wolf control, ungulate populations increased, and elk in particular took off. Prior to wolf control, caribou calf survival in the study area was down as low as 5%. After one year, in which about 500 wolves were removed, it was about 35%; after a second year, with about another 500 removed, it was up to 70%. At the present time calf survival in the Stone Mountain Park area and surrounds is extremely low again. Wolves are trapped and shot in the area by the guide-outfitters, but they are unable to adequately control the wolf populations (Al Hansen, David Wiens, pers. comm.).

8.6 Predator-Prey Interactions

Predation is thought to be the major limiting factor for caribou (see section 7.1). Caribou are generally thought to separate themselves spatially from other ungulate prey in order to reduce predation risk. A spatial separation between caribou and moose, which generally occupy lower elevations, forces predators to search large areas, reducing their capture success (Bergerud *et al.*, 1984). Inflated numbers of early seral stage species (e.g. moose) tends to support increased numbers of predators such as wolves and bears (Seip, 1992). Seip (1992) reports that wolves in the Quesnel Lake area were sustained primarily by moose through the year, but became a major predator on caribou during summer, when caribou, wolves, and moose occupied similar areas and habitats. The moose provided wolves with alternate prey in winter; prior to this, the low prey base could not sustain high densities of wolves in winter. However, the Wells Gray caribou, using rugged, mountainous summer ranges, were spatially separated from moose and wolves, and experienced a low level of wolf predation.

Provincially, Bergerud and Elliott (1986) report that caribou declined in the late 1930's and 40's following expansion of moose range (following logging) and an increase in wolves. The increased moose support increased numbers of wolves, which do not then exhibit any density dependency on caribou (Bergerud *et al.*, 1984; Seip, 1992, Seip and Cichowski, 1996). Caribou then expanded after a wolf control program (1949 to 1962) peaked in the late 1960's, then diminished as wolf numbers increased again.

A number of recent studies have documented the changes in ungulate, including caribou, populations in response to wolf control programs. In Alaska and the Yukon, substantial increases in moose and caribou have been documented following wolf control. Boertje *et al.* (1996) report that over a 20 year history in Alaska, 7 initial winters of wolf control, and 14 initial years of favorable weather, resulted in 19 years of growth in moose populations and 14 years of growth in caribou populations, plus high average fall wolf densities after control ended. Bergerud and Elliott (1998) report caribou, elk, moose, and Stone's sheep populations in two areas of northeastern B.C. were decreasing or stable in 1981 to 1982, prior to wolf reductions. Recruitment for all ungulate species improved two to four times following a reduction in wolf numbers. In the Muskwa area, the removal of 505 wolves was followed by an increase in moose and elk of a total of 10,000 animals (20 per wolf removed) (Bergerud and Elliott 1998).

These predator-prey effects do not of course operate only in one direction. Coady (1980) considered an increase in moose numbers in northern Alaska to be due to a preference by wolves in that area for caribou. Singer and Dalle-Molle (1985) considered increasing moose numbers in part of Alaska's Denali National Park may have resulted from increased availability of caribou as alternate prey for wolves.

Adverse weather conditions can cause decreased production and increased vulnerability to predation (see also section 7.3). Adams *et al.* (1995) observed increased wolf predation on caribou where snow was deep and herds were at low densities. Boertje *et al.* (1996) indicate caribou declines coincided with the combined effects of adverse weather and associated increases in wolf numbers. The authors conclude that wolf control, together with favorable weather, can enhance long-term abundance of wolves and their primary prey.

There is no empirical data on predation and caribou (or ungulate) mortality rates in the northern MK. Predation and mortality data are considered to be important as high caribou mortality rates are currently being documented in the Fort St. John part of the MK (Bryan Webster, pers. comm. with Mary Duda).

There may have been some changes in moose populations in the study area in response to prescribed fires, and there certainly appears to have been a very substantial increase in elk population in the general area in response to prescribed fires (see Section 7.3.2). Elk populations have reportedly more than tripled in recent years, and this substantial increase in elk numbers may similarly be expected to influence predator and thus alternate prey populations. The complex ungulate interactions are further influenced through changing patterns of human intervention via predator control.

The mechanisms which determine which ungulate species (caribou, moose, or elk) is most influenced, via predation, by the presence and changes in the other species, are very unclear and require much more detailed study. The species clearly have some form of association through predation.

9.0 HABITAT RELATIONSHIPS

9.1 Habitat Selection

This chapter focuses primarily on seasonal habitat uses and on developing habitat models. Shackleton (1999) reports that predators (wolves and cougars) snow conditions, and the availability of lichens appear to be the major determinants of 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. The influences of snow and of predation are discussed in sections 7.3 and 8.6 respectively. Lichen availability is thought to be strongly influenced by snow depth, and winter lichen availability is generally considered critical in evaluating habitat. The relationship between habitat conditions and lichen production are very briefly reviewed below; more detail is provided in an associated project report, for project #MKTF99/20 37.

9.2 Lichen/Habitat Relationships

Terrestrial lichens, believed to be the most important winter food for Northern caribou, are very slow growing and are most abundant in late successional forests (Cichowski, 1996). Disturbances such as logging drastically alter lichen populations, which can require 50 to 100 years to regenerate (Hale, 1983 and Rowe, 1984 in Cichowski, 1996). 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 in Cichowski, 1996). Coxson *et al.* (1998) 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. Undisturbed areas within the winter range are important for maintaining winter forage availability (Cichowski, 1989).

Terrestrial lichens that are usually destroyed by fires but recolonize disturbed sites become abundant in mid-aged to mature stands. Severity of the initial disturbance (fire) influences lichen production (Coxson *et al.*, 1998). 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. Very productive sites are usually dominated by vascular plants and never produce substantial amounts of terrestrial lichens (Seip, 1996).

9.3 Calving Habitats

9.3.1 General

Most calving occurs during late May through mid-June with the peak of calving around the first week of June (Hatler, 1986; Wood, 1996). During the calving season, Northern caribou move to areas that minimise risks from predation. Thus they either use escape terrain with good visibility such as steep, isolated rock outcrops higher than the usual areas travelled by terrestrial predators, or they disperse widely over shrubby vegetation that affords concealment and lowered probability of detection (Fenger *et al.*, 1986). High elevations also afford some protection from wolves, which generally use valleys as travel routes (Bergerud and Elliot, 1986). By calving at high elevations, female caribou space themselves away from wolves. Calving sites are thus usually on secluded alpine ridges, above tree line, or are in high elevation coniferous stands. In the Itcha and Ilgachuz Mountains in west-central

B.C., female caribou forgo forage quality at lower elevations in late May/early June, to calve high in the mountains (Cichowski, 1989). In north central B.C. northern caribou were found to calve in upper elevation balsam/spruce forests, in rocky outcrops at tree line, or in alpine/subalpine areas (Wood, 1996). Hatler (1986) also documented use of calving areas below treeline for collared caribou in Spatsizi. In the central Yukon, northern caribou calved in alpine habitats in a widely dispersed pattern (Farnell *et al.*, 1991).

Woodland caribou often show fidelity to specific areas for calving (Hatler, 1986; Farnell and McDonald, 1989; Farnell *et al.*, 1991). This use of traditional calving grounds and the highly dispersed pattern employed by woodland caribou is thought to be an anti-predator tactic of female caribou to reduce the vulnerability of calves and to make use of previously successful sites (Bergerud *et al.*, 1984; Seip, 1992). For woodland caribou, undisturbed mountainous habitat is important for calving success and early calf survival (Bergerud *et al.*, 1984).

9.3.2 Study Area

Locally, calving is reported to occur from mid May to about the third week in June (Al Hansen, pers. comm.). A number of high elevation meadow sites in the proposed study area, particularly several sites in and near the upper end of the Chischa, are reported to be regular caribou calving grounds (Cam Allen, David Wiens, pers. comms.). Some of the subalpine SWB ridges north of Stone Mountain are also suspected of being calving areas (G.Radcliffe, pers. obs.). Evidence of relatively high use by adults and young was observed on the ridges during a June 1998 reconnaissance flight. High value calving habitats, providing both reasonable feeding and some security (in the form of relatively high elevations and high visibility for detecting predators) are probably alpine meadows, and subalpine meadow and scrub habitats which occur on the SWB ridges (Barton *et al.,* 1998). However, more information on caribou use of the area is needed to improve these species model predictions.

9.4 Spring and Summer Habitats

9.4.1 General

Spring habitats are often found at low-elevations, with caribou moving to alpine or subalpine ranges in summer, although use of lower elevations also occurs (Stevenson and Hatler, 1985). During the spring, northern caribou occupy the lowest elevations of the year (Hatler, 1986). Wood (1996) found northern caribou primarily in low elevation lodgepole pine and pine/spruce forests in the spring (April/May). At this time of year, northern caribou also forage in meadows and younger seral stands of pine and pine/aspen stands (Wood, 1996). Terry and Wood (1998) found that in spring "other" (non-forested areas, lakes) habitats were used more extensively than their occurrence. In spring and summer bulls and single animals are often in the forests. 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.,* (1996) report forb meadows in seepage areas and along alpine streams were used extensively in summer.

Insect harassment has been suggested as one of the reasons that caribou move to alpine habitats during part of the summer (M. Wood, pers. comm.). Cooler weather and constant breezes provide relief from insects. Farnell and McDonald (1990) found that caribou will often move to patches of snow, glaciers, and windy ridges that act as 'relief habitat' to escape harassment by insects and/or heat stress. For woodland caribou the summer period would appear to be the most critical in terms of thermal cover requirements. Alpine habitats provide cooler temperatures during periods of hot weather

9.4.2 Study Area

Rob Honeyman (pers. comm.) reports that in summer there are many caribou up beyond Wokkpash Lake, and in behind Whitestone Ridge in the alpine, as well as high up on tops on either side of the highway, and up around Flowerspring Lake. David Wiens (pers. comm.) notes in the summer, during hot weather the caribou often seem to be in the forests or around the head of the valleys. They also reportedly use bogs at the north end of the area, in the lowlands.

Habitats identified as high value for calving are also likely to receive considerable summer use. During a reconnaissance flight in June 1998, small groups of caribou were observed on a number of the ridges in the Rocky Mountain foothills north of Stone Mountain. Sightings comprised 3 separate groups of 3 animals, 1 group of 5 animals, and a group of 11, i.e. 25 in total. These animals were travelling across the meadow-dominated slopes in the foothills area north of Stone Mountain or were lying on small remnant patches of late-lying snow on the cool, north sides of the ridges, presumably for relief from insects and heat. During a TEM mapping field trip in August 1998, small numbers of caribou were seen up in the alpine and also down alongside the Trans Canada Highway near the study area, and 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.).

9.5 Rutting Habitats

9.5.1 General

The rut generally occurs between late September and mid-October (Fenger *et al.,* 1986). Alpine habitats appear to be preferred during the rutting period. The Klaza caribou herd in the Yukon moved to form large aggregations on rutting ranges on north aspect alpine areas (Farnell *et al.,* 1991). Rutting ranges were also found in the alpine by numerous authors including Farnell and McDonald (1990), Fenger *et al.,* (1986), and Terry and Wood (1998). Rutting generally occurs on "gently sloping or rolling terrain with low vegetation where herd members are easily visible to each other" (Fenger *et al.,* 1986). Wood (1996) reported that by the fall (Sept/Oct) only 8% of caribou locations were below 1300 m elevation.

9.5.2 Study Area

The following local information was provided by Al Hansen, David Wiens and Rob Honeyman (pers. comms.). Locally, caribou start grouping for the rut in September, and rutting peaks between about Sept. 22 and October 5. They apparently remain congregated for about a month after this however. In the Summit area, many caribou occur in summer around One Fifty Creek and on the plateaus above; they head up onto those plateaus for rutting and remain in the vicinity most of the winter. They also occur around 438 Creek, near Toad River bridge. A small group—generally around 25—occurs in vicinity of Racing River Highway. Caribou also regularly occur along the first few miles of highway into Muncho Lake Park. Groups of 50 to 60 at a time can be seen licking salt along the highway. A lot of rutting also occurs on the hilltops around this area, in September. They also use the rolling tundra around One Fifty Creek and Summit. Al Hansen (pers. com.) notes that in the early 1990's he used to see as many as 200 or even 300 along the road but now usually only sees around 50.

Mineral use along the roads is reported to occur all year, but with the main use seems to be between September and November, i.e. during the rut and in early winter. It should be noted that in 1995 B.C. Parks began a mineral lick program in Stone Mountain and Muncho Lake Parks, placing salt licks along well used caribou (and sheep) trails a few kilometers back from the highway, in an effort to reduce road kills. This may have influenced ungulate movements around the road in recent years.

9.6 Winter Habitats

9.6.1 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). For northern caribou, 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 (1993) found that northern caribou in the Omineca Mountains foraged on terrestrial lichens in both lowland lodgepole pine flats and 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, 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 (Terry and Wood, 1998; Hatler, 1986). 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 (Terry and Wood, 1998; Cichowski, 1996; Wood, 1996, Hatler 1986). 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.

9.6.2 Study Area

Following the rut, caribou reportedly remain in large groups but begin to break up when heavier snows arrive (Al Hansen, pers. comm.). In winter bulls often appear around 401 and 408; in early winter many caribou appear along the roads between Summit and Muncho Lake Park, but they disappear as winter progresses (Al Hansen, pers. comm.). Winter use above treeline in the Summit Lake area also occurs, and caribou occur in upper McDonald in winter. David Wiens (pers. comm.) reports they are generally up on the rolling tundra south of Stone Mountain Park in November/December.

Within the study area, snow-free ridges in the alpine get a lot of caribou use in winter, and they will remain high up for months, where there appears to be very little to eat (David Wiens, pers. comm.). The deeper the snow, the higher up they seem to go. When snow is not deep they often stay lower down, on the rolling hills in winter. However, due to temperature inversions, which are common, warmer conditions can occur higher up, so the caribou may still be at high elevations even in low snow conditions.

Caribou antlers were observed in a number of locations in the SWB in birch scrub and willow sedge habitats close to the open meadows. During the February field reconnaissance, caribou were observed using frozen high elevation lakes, possibly for minerals.

9.7 Caribou Habitat Models and Mapping

9.7.1 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 between Muncho Lake in the northwest and down to the Tuchodi River system at the southern edge, 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, 1994).

The extensive plains of BWBS that predominate over the northern part of the study area may support low numbers of the boreal ecotype, and/or 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. Early winter habitats are fairly available in the area, where a mosaic of habitats occurs. However, as winter progresses, available habitats may become more limiting. Pine stands with good ground lichen availability appear to be extremely limited in the study area. Consequently, late winter habitats at lower elevations appear to be of very limited availability, and high elevation shrub/meadow habitats may be especially important. The lack of local snowpack information limits the interpretations that can be made.

9.7.2 Existing Species Models and Mapping

Barton *et al.* (1988) provides a species habitat model for caribou for the Dunedin study area, part of which is within the proposed are 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. However, 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 the north are included in R.A. Sims and Associates (1999) for the Besa-Prophet Area (in the southern half of the MK) and Norecol, Dames & Moore (1998) for the Smith/Vents Rivers area in Fort Nelson area. These cover some different subzones/variants and habitat 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. A population model is also being developed in that study and may have some relevance for the MK 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 the northern part 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.

10.0 SUMMARY AND RECOMMENDATIONS

The findings of the background review and road trips support the initial proposal that there is a paucity of information on caribou ecology in the area despite significant caribou herds. There is, similarly, a lack of information on ungulate populations in general, on caribou interactions with the other ungulates, and on predator populations and their interactions with ungulates in the area.

General broad habitat capability mapping for the whole area, together with the more detailed existing mapping conducted for TEM, provides a valuable tool for assigning habitat ratings for the different species and provides an important habitat management tool. However, it badly needs to be tested and refined through the application of some empirical data for the subzones and variants in this area. This empirical data is entirely lacking at this time. Although TEM is only available for a portion of the study area, its applicability should cover the entire study area. Ideally, TEM or an alternate (such as PEM, or TEM conducted at a lower mapping intensity) will be completed for the entire area in the future. However, if TEM or an alternate does not become fully available as the project progresses, it would be possible to develop a suitable substitute using satellite imagery and forest cover. That is, the success of the project is not wholly dependent upon completion of TEM mapping.

As a result of these investigations, the initiation of a multi-year research program on caribou ecology in the northern portion of the MK is strongly recommended. Accordingly, a proposal to conduct this work has been developed (Madrone Consultants Ltd. and Slocan Forest Products Ltd., 2000). However, due to timing of proposal calls (due December 1999), the research proposal was developed and submitted originally prior to full completion of the background work. The proposal was subsequently refined, in the light of review and discussions, and following a winter field reconnaissance. It was resubmitted in February 2000. Since then some minor additions and further details on some aspects are available.

11.0 REFERENCES

Adams, L.G., Singer, F.J., and Dale, B.W. 1995. Caribou calf mortality in Denali National Park. J. Wildl. Manage. 59: 584-594.

Ballard, W.B. and V. Van Ballenberghe. 1997. Predator/prey relationships. In: Franzmann, A.W. and C.C. Schwartz (Eds.). Ecology and Management of the North American Moose. Wildlife Management Institute, Washington, D.C. pp. 247-273.

Barton, K., L.Veach, G.Radcliffe, and P.Williams. 1998. Terrestrial ecosystem mapping and wildlife interpretations for the Dunedin study area. Report by Madrone Consultants Ltd. for Slocan Forest Products Ltd., Fort Nelson.

B.C. Parks. 1999. Protected areas of the Muskwa-Kechika Management Area. Background Document. Ministry of Environment, Lands and Parks, Fort St. John. B.C.

B.C. Ministry of Environment, Lands and Parks. 1992. Caribou in British Columbia. MEL, Wildlife Branch, Victoria, B.C.

Bergerud, A. T. 1978. The status and management of caribou in British Columbia. B.C. Fish and Wildlife Branch Report, Victoria, B.C.

Bergerud, A. T. 1980. A review of the population dynamics of caribou and wild reindeer in North America. In: Reimers, E., E. Garre and S. Skjenneberg (eds.), Proc. 2nd Int. Reindeer/Caribou Symp. Roros, Norway. 1979. pp. 556-581.

Bergerud, A. T. 1988. Caribou, wolves and man. Trends in Ecology and Evolution. 3:68-72.

Bergerud, A.T. 1992. Rareness as an antipredator strategy to reduce predation risk. In: D.R. McCullough and R.B. Barrett (eds.). Wildlife 2001: Populations. Elsevier, London.

Bergerud, A.T. 1996. Evolving perspectives on caribou population dynamics, have we got it right yet? Rangifer, 9: 95-118.

Bergerud, A. T., H. Butler, and D. Miller. 1984. Antipredator tactics of calving caribou: dispersion in mountains. Can. J. Zool. 62: 1566-1575.

Bergerud, A.T. and J.P. Elliot. 1986. Dynamics of caribou and wolves in northern British Columbia. Can. J. Zool. 64: 1515-1529.

Bergerud, A.T. and J.P. Elliot. 1998. Wolf predation in a multiple-ungulate system in northern British Columbia. Can. J. Zool. 76 (8): 1551-1569.

Boer, A. H. 1998. Interspecific relationships. In: Franzmann, A.W. and C.C. Schwartz (eds.). Ecology and Management of the North American Moose. Wildlife Management Institute, Washington, D.C. pp. 337-349.

Boertje, R.D., P. Valkenburg, and M.E. McNay. 1996. Increases in moose, caribou and wolves following wolf control in Alaska. J. Wildl.Mgmt. 60 (3): 474-489.

Bradshaw, C. J. A., D. M. Herbert, A. B. Rippin, and S. Boutin. 1995. Winter peatland habitat selection by woodland caribou in northeastern Alberta. Can. J. Zool. 73: 1567-1574.

Child, K. and D. King. 1991. Regional wildlife plan for the Omineca Sub-region, Northern Region. B.C. Environment Wildlife Branch.

Cichowski, D. B. 1989. Seasonal movements, habitat use, and winter feeding ecology of woodland caribou in west-central British Columbia. M.Sc. Thesis, Univ. B.C., Vancouver, B.C.

Cichowski, D. B. 1996. Managing woodland caribou in west-central British Columbia. Rangifer. Special Issue No. 9. Sixth North American Caribou Workshop, Prince George, B.C. pp. 119-126.

Cichowski, D. B. and A. Banner. 1993. Management strategy and options for the Tweedsmuir-Entiako caribou winter range.

Coady, J.W. 1980. History of moose in northern Alaska and adjacent regions. Can. Field. Nat. 94: 61-68.

Corbould, F. B. 1993. Chase Mountain/Butler Range Caribou Inventory. Peace/Williston Fish and Wildlife Compensation Program, Prince George, B.C.

Coxson, D., J.Marsh and R.Sulyma. 1998. Factors affecting terrestrial lichen abundance in Woodland Caribou Habitat. Final report 1997/98 fiscal year. Forest Renewal British Columbia, No. OP96029-RE.

Dale, B.W. and L.G. Adams. 1999. Sex, age, and condition of wolf-killed caribou. Abstract. 8th North American Caribou Workshop.

DeLong, C.; MacKinnon, A.; Jang, L. 1990. A field guide for identification and interpretation of ecosystems of the northeast portion of the Prince George Forest Region. Land Management Handbook Number 22. B.C. Ministry of Forests, Victoria, B.C.

Demarchi, D. A. 1996. An Introduction to the Ecoregions of British Columbia. B.C. Ministry of Environment, Lands, and Parks, Wildlife Branch, Victoria, B.C.

Eastman, D.S. and R. Ritcey. 1987. Moose habitat relationships and management in British Columbia. Swed. Wildl. Res. (Suppl.) 1: 101-118.

Edmonds, E.J. 1988. Population status, distribution, and movements of woodland caribou in west central Alberta. Can. J. Zool. 66: 817-827.

Farnell, R., and J. McDonald. 1989. Inventory of the Wolf Lake caribou herd. Final Report, Yukon Dept. of Renewable Res., Whitehorse, Yukon.

Farnell, R., and J. McDonald. 1990. The distribution, movements, demography, and habitat use of the Little Rancheria caribou herd. Final Report. Yukon Fish and Wildl. Br., Whitehorse, Yukon.

Wood, M. D. 1996. Seasonal Habitat Use and Movements of Woodland Caribou in the Omineca Mountains, North Central British Columbia.. Rangifer. Special Issue No. 9. Sixth North American Caribou Workshop, Prince George, B.C. pp. 365-378.

Wood, M. D. 1998. Inventory of Woodland Caribou on the Wolverine Mountain Range, March 1996. Peace/Williston Fish and Wildlife Compensation Program. Report No. 128, 16 pp. plus appendices.

Wood, M.D. and E.L. Terry. 1999. Seasonal movements and habitat selection by woodland caribou in the Omineca Mountains, North-Central British Columbia. Phase 1: The Chase and Wolverine Herds (1991 – 1994). Peace/Williston Fish and Wildlife Compensation Program Report No 201.

Young, J. and K. Shaw. 2000. Towards Integrated Management Solutions: Summary. For the Cariboo-Chilcotin Land Use Plan. BC Ministry of Environment, Lands and Parks.

Zoladeski, C. A. and Cowell, D. W. 1996. Ecosystem Classification for the Southeast Yukon Field Guide (First Approximation). Yukon Renewable Resources, Whitehorse, Yukon.

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

NAME	PHONE	AFFILIATION
Al Hansen	250 776 3486	BC Parks Ranger, Muncho Lake Park
Andy deVries	250 788 4358	Wildlife Biologist, CANFOR, Chetwynd
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 3285	Resource Officer, MELP, Ft. St. John
Cam Allen	250 352 5411	Pilot for Canadian Helicopters, Fort Nelson
Chris Johnson	250 964 8044	Caribou-Lichen Research UNBC
Dale Seip	250 565 6224	MOF wildlife Biologist, Prince George
Darwin Coxson	250 962 9091	Wildlife Ecologist
David Wiens	250 232 5469	Guide-outfitter, Toad River area
Debbie Cichowski	250 847 3775	Wildlife Biologist/Consultant, Smithers
Debbie Groat	250 779 3461	First Nations, Lower Post
Dennis Demarchi	250 387 9772	Senior Habitat Biologist, MELP, Victoria
Dixon Lutz	Not Listed	First Nations, Lower Post – Resides Watson Lake, SE Yukon
Don Eastman	250 479 8382	Wildlife Biologist, Professor, UVic
Doug Heard	250 565 6425	Regional Wildlife Biologist, MELP, Prince George
Doug Russell	250 784 1239	MELP, Dawson Creek
Ian Hatter	250 387 9792	MELP, Victoria
Jeff Goodyear	250 381 9425	H.A.B.I.T. Research Ltd. (Biotelemetry Instrumentation Technology)
John Elliott	250 787 3412	Senior Wildlife Biologist, MELP, Ft. ST. John
John Kansas	403 282 1194	Wildlife Biologist/Consultant, Alberta
Jules Paquette	250 787 3327	GIS, MELP, Ft. St. John
Kathy Parker	250 960 5812	Professor, UNBC
Kent Brown	403 240 1995	Wildlife Biologist, Alberta/BC
Lisa Wilkinson	250 787 3407	MELP FRBC Coordinator, Ft St John (now in Alberta)
Mari Wood	250 565 4191	Wildlife Biologist, Peace/Williston Fish and Wildlife Comp. Program, Prince George
Mary Duda	250 233 6500	FRBC Coordinator, Slocan Forest Products Ltd., Fort Nelson
Michael Wood	250 787 3327	GIS, MELP, Ft. St. John
Norm MacLean	250 771 8105	FES, Dease Lake
Norm Quayle	250 787 3407	BC Parks Planner
Pierre Johnstone	250 774 5503	FES, Fort Nelson (now with MELP in Ft ST John)
Raymond Morris	Not Listed	First Nations, Lower Post
Rik Farnell	867 668 4683	Wildlife Biologist, Whitehorse, Yukon
Rick Marshall	250 847 7274	Wildlife Biologist, MELP, Smithers
Rob Honeyman	250 787 3407	BC Parks Ranger/ Fort ST. John
Rob Woods	250 787 3285	Wildlife Biologist, MELP Fort St. John
Roger Wheate	250 960 5865	UNBC professor, geography (mapping)
Ron Rutledge	250 787 3534	LUCO, Ft. St. John
Ross Peck	250 785 2774	Guide-outfitter, Ft. St. John

Sam Donnessey	Not Listed	First Nations, Lower Post
Scott Fraser	250 261 5719	Oil and Gas Commission, Ft. St. John
Scott McNay	250 997 2585	Wildlife Biologist, Slocan Forest Products Ltd., Mackenzie
Sean Sharpe	250 847 7298	Wildlife Head, MELP, Smithers
Shirley Ross	250 774 7257	First Nations, Fort Nelson Band
Steve Jakesta	250 779 3181	First Nations, Lower Post
Tom Bergerud	250 653 4346	Wildlife Biologist, Saltspring Island, BC
Val Loewen	867 633 6765	Whitehorse, Yukon

PART TWO
RESEARCH PROPOSAL

1 FORM3 - CONTINUING PROJECTS PROPOSAL SUMMARY

Muskwa-Kechika Management Area Funding 2000-2001

✓ Has This Project Been Previously Applied For Yes ✓No
ORIGINAL MKMA PROJECT # MKTF99/2036 2000-2001MKMA PROJECT #

NAME OF APPLICANT/PROJECT LEADER
Gillian Radcliffe (alternate: Mary Duda of Slocan Forest Products Ltd.)

LEGAL NAME OF ORGANIZATION
Madrone Consultants Ltd. in partnership with Slocan Forest Products Ltd.

ADDRESSES
Madrone - Prince George: 2053 South Ogilvie St., Prince George, BC V2N 1X1
Slocan - Fort Nelson Division: Mile 294 Alaska Highway, Fort Nelson, BC V0C 1R0

TELEPHONE S
Madrone - Prince George: 564-5495; Duncan: 746-5545
FAX (250) 564-2019; 746-5850 EMAIL: wildlife@cowichan.com
Slocan - (250) 233-6607
FAX (250) 233-6565 EMAIL: frbc@pris.bc.ca

SHORT TITLE OF PROJECT
Caribou Population and Ecology, Northern Muskwa - Kechika

BRIEF OUTLINE OF PROJECT
This project aims to establish baseline ecological information on one of the main caribou herds in the northern Muskwa – Kechika (MK), to support future wildlife management and conservation objectives for the predator-prey systems in the northern part of the MK. The work involves the detailed characterization of one of the two main herds, including population sizes, sex ratios, recruitment, mortality, home ranges, especially winter ranges and calving areas, seasonal movements and habitat use. The identification of alternate prey populations and key predator populations are also important components of the study and are key to understanding caribou ecology in the area. Anticipated products include the development of a population model to explain the dynamics of this multiprey system, and refinement of current habitat models for northern BC, to better predict caribou seasonal distribution in the area. Together these models will combine into an innovative management model that should permit the assessment of proposed activities, including prescribed burning, predator control, increased recreation or industrial developments. A dynamic management strategy aimed at evaluating and managing the cumulative effects of multiple resource use within the home ranges of the main caribou herds is the eventual project goal.

Status : Year **2** of **5** years Overall Project Costs: approx. $900,000

M-KTF Funds Requested: ThisYear $123,000 Total M-KTF Funds approx. $640,000

YEAR	MKMA Amount Requested	MKMA Amount Approved	MKMA Amount Expended	PROJECT PARTNERS (name, include actual $ and whether funding confirmed or requested or note if there is volunteer labour)
1	19,800	12,000	Still in progress	➢ Confirmed
2	123,000			➢ Confirmed- Slocan Forest Products $50,000 plus additional support of approx. $20,000 labour ➢ Confirmed – Madrone Consultants $28,000
3	Approx 190,000			➢ Confirmed– Slocan Forest Products $50,000 plus additional support of approx. $20,000 labour ➢ Confirmed – Madrone Consultants $28,000
4	Approx 190,000			➢ Confirmed – Slocan Forest Products $50,000 plus additional support of approx. $20,000 labour ➢ Confirmed – Madrone Consultants $28,000
5	Approx 130,000			➢ Requested

*Some possible additional funding sources will also be pursued for year 2001-2002, including the Wildlife Habitat Conservation Fund and the forthcoming Oil and Gas Fund.
*Slocan Funding contributions are subject to the terms and conditions of the Agreement with FRBC.

MUSKWA-KECHIKA PURPOSE

✓ (a) To support wildlife and wilderness resources of the management area through research and integrated management of natural resource development;

PROJECT TYPE

✓ (b) To conduct research into wilderness management, fish and wildlife biology and ecology, with emphasis on large predator/prey ecosystems;

✓ (c) To conduct research into integrated management of wilderness, wildlife, fish, recreation and resource development; and

✓ (e) To support planning initiatives regarding wildlife, recreation, parks, access and resource development.

IN WHICH MUSKWA-KECHIKA RESOURCE MANAGEMENT ZONES (RMZ) WILL THE PROJECT PRIMARILY BE CONDUCTED OR APPLY TO.
1.) 8 Mile/Sulphur 2.) Stone Mtn 3.) Churchill ALL

LOCATION:
The project will base out of Toad River and will focus on management units on either side of the Alaska Highway, with the main focus on the range of the Muskwa caribou herd. This herd appears to range largely within the Mt. Dall, Crest, Toad and Racing River areas as well as within Stone

Mountain and Wokkpash Protected Areas, and possibly within part of the Northern Rocky Mountain Protected Area.. Other surrounding RMZ's will be included as required as the study progresses.

THIS TO AUTHORIZE the routine release of all information submitted in this proposal, EXCEPT for information contained in Sections on Methodology and Workplan, until such time as the project receives MKMA funding, Sections on Personal Data, and if attached, the "not for disclosure" schedule. The routine release of information will occur at several points - upon receipt of proposals, after proposal evaluation, after project approval, on signing of contracts/contribution agreements and, on receipt of progress and final project reports. Note: The results of proposal evaluations will be released on request.

PROPONENT NAME	PROPONENT SIGNATURE	DATE
Gillian Radcliffe		Dec. 20th 1999, Revised Feb 23, 2000

ORGANIZATION'S AUTHORIZATION TO APPLY FOR MKMA FUNDING:

MIKE HARRIS, OFFICE MANAGER

2 Project Proposal Outline

1. Site Description (Brief)

a) Study Area Location

The study area comprises a substantial part of the northern half of the Muskwa – Kechika Management Area (MKMA), primarily areas to the north and south of the Alaska highway, from Muncho Lake Park at the western edge, to the eastern boundary of the MKWA, in the vicinity of Tetsa River Park. A number of protected areas fall within the study boundaries, including Muncho Lake Park, Stone Mountain Park, Wokkpash, and parts of the Northern Rocky Mountains. Study area boundaries are expected to be refined as the extent of the caribou ranges are more adequately identified.

b) Habitat Attributes and/or Biophysical Descriptions

This study area incorporates diverse topography and a wide range of habitat types. It ranges from the rugged peaks best expressed in Stone Mountain Park , through expansive rolling foothill country, to the relatively subdued terrain that prevails to the north and east, in the Liard Plain. Several wide river valleys support a range of riparian habitats. The biogeoclimatic zones that occur are the Boreal White and Black Spruce at the lower elevations, the Spruce - Willow Birch, and some areas of Alpine Tundra.

2. Project Rationale

a) Executive Summary

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 major wilderness based predator-prey system in perpetuity. The successful management of the dynamic predator-prey systems in the area, in response to existing and changing ecological conditions and resource developments, is paramount in meeting this objective. Built around the existing caribou populations as a key, this project aims to increase our knowledge of caribou/habitat associations, to elucidate some of the key ungulate population dynamics, including interactions with other key prey species, and clarify local predator - prey dynamics. The study aims to gather ecological and population parameters for one of the two large herds of caribou that occupy the northern MKMA, and for which there is currently a paucity of information. Ecological relationships with alternate prey (moose and elk) and predators (especially wolves) will be explored through ungulate and predator surveys, and using telemetry data. The scientific results will be utilized to develop management tools to predict impacts not only of industrial developments, but also of increased human recreational activities, and to support decisions on predator control, hunting allocations, and resource developments. This will be essential in the future if the long-term sustainability of this wildlife resource is to be ensured.

b) Issue

Despite the national and international significance of the large mammal predator – prey systems of the MKMA, studies have not previously been conducted upon caribou ecology in the northern half of the area. Population estimates indicate this area supports a very substantial proportion (approx.13%) of BC's northern caribou population. Although studies have been conducted elsewhere in the province, often in response to timber resource development, in this study area very different ecological conditions and resource demands prevail. Future years can be expected to bring to the fore a variety of significant issues with regard to the management of caribou herds, and the predator prey systems in general. Oil and gas development, management for meeting Parks objectives, future guide-outfitting demands, and timber development, are likely to result in conflicting objectives and often highly contentious issues. There will be a need to develop an area specific management plan tailored to the ecological conditions, predator - prey systems, and human resource demands that operate in this area. A solid scientific foundation is needed for making appropriate management decisions that will ensure the perpetuation of the major predator-prey systems in this area remain relatively intact.

c) Project Objective(s)

The initial project objective was to develop a detailed research program to investigate caribou populations and ecology in the northern part of MKMA. As a result of initial activities more detailed objectives have been identified as follows:

Primary goals are to:

- Establish baseline ecological information on the main caribou herds, primarily the Muskwa herd, in the northern Muskwa – Kechika, to support future wildlife management and conservation objectives, and future population monitoring.
- Develop a caribou management strategy geared to the ecological and resource use activities that prevail in the northern MKMA.

These will be achieved through meeting the following subsidiary objectives:

- Identify the population parameters, including overall numbers, sex ratios, recruitment, mortality, (including predation rates) for the Muskwa caribou herd.
- Identify the seasonal ranges of the herd, especially winter ranges and calving areas; identify seasonal movements, travel corridors.
- Document habitat use patterns and improve knowledge of seasonal habitat needs in the north, including security habitat for predator avoidance.
- Identify if there is any exchange between the populations, or with adjacent animals, including boreal caribou to the north and east (please note that Slocan is currently conducting a collaring study on caribou in the Snake/Sahtaneh watershed further east in the Fort Nelson Forest District).
- Identify and enumerate moose and elk populations within the boundaries of the caribou ranges, through aerial census and ground based surveys.
- Identify seasonal population changes in these alternate prey sources.
- Identify the different wolf packs operating within the study areas, estimate numbers and monitor status over the duration of the project.
- Document past and existing predator control programs.
- Develop/fine tune existing caribou habitat models to predict caribou distributions across the landscape.
- Develop a caribou population model to explain the relationship between the above components (i.e. habitat, moose, elk, wolves).
- Combine the models into a management tool (management model and strategy) that will permit the evaluation of proposed development impacts, including cumulative effects assessment, and will provide a solid foundation for making decisions regarding ungulate-predator management in the area.

It should be noted that for these last three objectives we anticipate working with MELP in Ft. St. John so that the work can also be applied to the Rabbit herd further west, which MELP is planning to inventory this year. We also propose to liaise with MELP over this research on the Muskwa herd. The project is thus intended to be incremental to government programs.

3. Progress in 1998-1999

a) Activities/Technique(s)

The project was initiated in 1999. A road trip to northern BC was completed in August 1999, and meetings conducted with government agencies, First Nations, guide-outfitters, forestry, university personnel and other biologists. Further telephone contacts have since been made and various literature sources gathered and reviewed. A field reconnaissance trip was also conducted on February 19th 2000. This work is currently being written up, and details will be provided in the project report due in March 2000.

b) Measures of Results

Project objectives for the initial part of the project – i.e. development of a detailed research proposal, will be fully completed and submitted by March 15, as per project deadlines.

c) Public Reaction

No public information sessions or media coverage were planned or conducted at this stage. However, from general discussions with the members of the public during a road trip conducted in August, many people with whom we engaged in casual discussion en route expressed a relatively high level of interest in the work. Further more formal exposure to the public is planned over the life of the proposed research project.

c) Contractor Performance

N/A

e) Remaining Activities in 1999-2000

- Complete literature review and interviews/meetings with stakeholders.
- Conduct further meetings/discussions with MELP, BC Parks, UNBC, First Nations, guide-outfitters, forestry licensees and oil and gas commission re: objectives, opportunities for collaboration to maximize use of the information to be collected, and to identify research and local employment opportunities.
- Conduct a brief field reconnaissance (anticipated in mid February, depending on weather conditions) in conjunction with local guide-outfitters to identify core areas for initial collaring and telemetry work.
- Complete inquiries into current radio telemetry equipment to finalize project needs.
- The full research proposal will be submitted on schedule, on or before March 15 1999.

4. Proposal for 2000-2001

a) Activities/Technique(s)

- Capture and radio tag a minimum of 30 caribou from Muskwa herd (collar lifespan anticipated to be 52 months);
- Conduct aerial surveys every ten days to two weeks; conduct ground based telemetry;
- Enumerate other ungulates within caribou ranges through aerial surveys and ground based transects;
- Conduct snow tracking surveys for ungulate and predator activity;
- Investigate mortalities;
- Complete seasonal habitat plots in any new habitat types and in areas where there is no plot data available (NB this data would be made available to any ongoing mapping project to utilize also);
- Enter data, begin preliminary analyses;
- Liaise with UNBC on satellite imagery/mapping. Utilize mapping within a GIS framework as it becomes available. The project will utilize current TEM mapping conducted for the Dunedin area

(Madrone Consultants Ltd. 1988) as a support tool for habitat interpretations, and will use additional PEM/TEM mapping as it progresses. If PEM/TEM does not become available for adjacent areas over the duration of the project, then forest cover will be utilized as a substitute. (See project proposal #MKTF99/2051);
- Produce /color poster for public information. Conduct public talks (early 2001), produce and maintain a project website, attend/give papers at relevant conferences as appropriate, and prepare a media brief; and
- Produce progress reports and year-end report to summarize project to date (March 2001).

b) Measures of Success
The following criteria are suggested as initial measures of project success:

- Caribou capture/collaring objectives met;
- Preliminary telemetry data successfully captured and entered;
- Aerial census data and snow tracking data captured and entered;
- Provision of preliminary baseline population data;
- Integration of the inventory data with the existing TEM mapping;
- Production of information/media as described above; and
- Progress reports completed.

d) Benefits/Risks
Benefits include increased knowledge to support management (information on the caribou and other ungulate populations, and on predators); improved local contracting and employment – injection of funds into local economy; increased public awareness among local population of both MKMA goals and wildlife resources, and of research efforts and results;

Risks include – inability to make sound management decisions – poor decisions may result in irreparable damage to predator prey systems, loss of guide-outfitting income, hunting income/opportunities, and so on. Inability to predict potential development impacts.
Risks associated with collaring the animals are considered to be very low as capture with net guns is a low risk procedure, and there are no risks to non-target species.

e) Relevance to Regional Priorities
Caribou are a regionally significant resource and are a high profile species which generate considerable public interest. They are also an important food resource to First Nations in the area, are of interest for guide-outfitters, and for wildlife viewing. Moose and elk are also important regional resources and are high profile species.

f) Animal Care
No animals will be held in captivity. Caribou will be captured using the net gun method, with an appropriately qualified and experienced crew conducting capture and tagging. Animals will be processed as quickly as possible, and all efforts will be made to minimize stress. No immobilization drugs will be used. However, if required veterinary assistance will be provided during capture/handling if deemed necessary at any point.

f) Public Information/Participation

Research work objectives and results will be communicated through a variety of forums with the objective of educating and involving members of the public as well as other professionals. This will include the following:

- Conduct a program of public talks in northern communities (early 2001), to present the work, objectives, current activities and preliminary results, and solicit feedback/information input from the public.
- Slocan to produce and maintain a project website linked to the main MK website.
- Develop a color poster presentation for public information.
- Attend/give papers at relevant professional conferences as appropriate.
- Produce progress reports and a year-end report (March 2001), including an annual summary;
- Prepare a short newspaper brief for local and provincial media.
- Contribute to the "Forest Renewal Reporter" with interviews and stories featuring components of the program.

Please note that Slocan Forest Products Ltd. has committed to participate in a communications program in partnership with FRBC. Slocan is also developing a website page and will use this to inform the public of the research. Madrone and Slocan also commit to further exploring ways to promote awareness of the MKTF, the management area, and its wilderness values.

3 FORM 4- RESEARCH PROJECT INFORMATION

Muskwa-Kechika Management Area Funding 2000-2001

BACKGROUND & RATIONALE

Population estimates indicate the northern MKWA supports a very substantial proportion of the estimated BC northern caribou population [15,600 animals estimated in Heard & Vagt, 1998]. The Muskwa herd (estimated 1,250) and the Rabbit herd (estimated 800) together comprise about 11% of total BC caribou, and about 13% of the northern ecotype. Despite this, no detailed ecological studies have been conducted anywhere within the geographical areas believed to support them. Only four of 39 identified BC herds exceed the Muskwa herd in size; three of these (Spatsizi, Itch-Ilgachuz and Pink Mountain) have had detailed, long-term studies conducted. Range information based on telemetry data is available for 22 herds, i.e. well over half. However there is minimal information available on both the Muskwa and Rabbit herds, and population trends for both are reported to be unknown (Heard & Vagt 1998).

Most caribou work in BC has focused on the threatened woodland ecotype. Studies on the northern ecotype have generally been much less detailed, although there are a number of projects currently in progress. A brief synopsis will be presented in the research proposal being developed under year one (Gillian Radcliffe, in progress). Current northern studies include predator-prey work being conducted to the west of the MKWA, on the Rancheria herd (Norm MacLean, pers. comm); and census work and development of a sightability index on the Graham herd in the MK area, (John Elliot pers. comm.). There is also a detailed study continuing in the Omineca-Peace area, south of MKWA (Scott McNay, pers. comm.). Some past work has also been conducted to the east, in the Peace Region. However, in all of these areas ecological and human conditions are significantly different to those that prevail in the northern MK.

In this area, climatic conditions are considerably drier than in areas west and south, where other studies are underway. In addition, past human activities, particularly active burning (primarily for wildlife enhancement and production of horse forage) and predator, especially wolf, control, have had a significant influence upon the predator prey systems operating in this area (David Wiens pers. comm.). Elsewhere in the province, an increase in moose numbers following logging has been cited as a key factor in the subsequent decline of caribou numbers (e.g. Seip 1992). The increased moose support increased numbers of wolves, which do not then exhibit any density dependency on caribou (Bergerud *et al.* 1984, Seip 1992). In this study area, a very substantial increase in elk numbers appears to have occurred in recent years as a result of active burning (David Wiens, Brian Churchill pers comms), and this may similarly be expected to influence predator – and thus alternate prey – populations. The complex ungulate interactions are further influenced through changing patterns of human intervention via predator control.

Future years can be expected to bring to the fore a variety of significant issues with regard to the management of caribou herds, and the predator prey systems in general, in this area. Potential developments and management activities are likely to create conflicting and often highly contentious issues. Solid information to support management decisions on predator control, hunting allocations, and to predict impacts not only of industrial developments but also of increased human recreational activities, will be needed if the long-term sustainability of the wildlife resource is to be ensured.

OBJECTIVES & DELIVERABLES

Overall long-term goals:

1. Establish baseline ecological information on the main caribou herds, primarily the Muskwa herd, in the northern Muskwa – Kechika, to support future wildlife management and conservation objectives, and future population monitoring.

2. Develop a caribou management strategy geared to the ecological and resource use activities that prevail in the northern MK

These will be achieved through meeting the following subsidiary objectives:

- Identify the population parameters, including overall numbers, sex ratios, recruitment, mortality, (including predation rates) for the Muskwa caribou herd;
- Identify the seasonal ranges of the herd, especially winter ranges and calving areas; identify seasonal movements, travel corridors;
- Document habitat use patterns and improve knowledge of seasonal habitat needs in the north, including security habitat for predator avoidance;
- Identify if there is any exchange between the populations, or with adjacent animals, including boreal caribou to the north and east (please note that Slocan is currently conducting a collaring study on caribou in the Snake/Sahtaneh watershed further east in the Fort Nelson Forest District);
- Identify and enumerate moose and elk populations within the boundaries of the caribou ranges, through aerial census and ground based surveys;
- Identify seasonal population changes in these alternate prey sources;
- Identify the different wolf packs operating within the study areas, estimate numbers and monitor status over the duration of the project;
- Document past and existing predator control programs;
- Develop/fine tune existing caribou habitat models to predict caribou distributions across the landscape;
- Develop a caribou population model to explain the relationship between the above components (i.e. habitat, moose, elk, wolves); and
- Combine the models into a management tool (management model and strategy) that will permit the evaluation of proposed development impacts, including cumulative effects assessment, and will provide a solid foundation for making decisions regarding ungulate-predator management in the area.

It should be noted that for these last three objectives we anticipate working with MELP in Ft. St. John so that the work can also be applied to the Rabbit herd further west, which MELP is planning to inventory this year. We also propose to liaise with MELP over this research on the Muskwa herd. The project is thus intended to be incremental to government programs.

Deliverables include progress and annual reports, and a varied forum of communication products including poster development, delivery of a public talk program, development and maintenance of a web page and attendance/presentations at professional conferences and meetings as appropriate.

METHODOLOGY & WORK PROGRAM

Background preparatory work will be conducted during the summer, but the main thrust of the work will begin in the fall of 2000. At this time, when the caribou begin to gather, conditions are usually best for locating and capturing animals. Following approximately two weeks of intensive work locating and collaring the animals, regular data collection will begin. Fall and winter aerial surveys will then be conducted in addition to frequent ground based surveys wherever accessibility permits this.

Aerial census for ungulates throughout these ranges will follow standard provincial RIC methodologies wherever possible. Telemetry will be conducted at the same time. On other days ground surveys (based by combinations of truck, snowmobile and access on foot) will be conducted to collect further telemetry data and to conduct snow-tracking surveys for both ungulates and predators (following RIC standards). Mortalities located from the air or from ground based telemetry data will be investigated on foot to identify causes and characterize the prey (age, sex, condition etc.). Analysis of this data will provide insights into the effects of predation and spatial analysis may yield information upon the effect of linear corridors, habitat types etc. in relation to predation.

Habitat assessments will be conducted in each season, with the emphasis on areas with high caribou use. This data will then be entered and linked to the telemetry data within a GIS framework to gradually improve our caribou habitat model for the north. It will also be linked to any existing ecosystem mapping where available (e.g.; for the Dunedin TEM area). We expect to work closely with UNBC to utilize existing and future ecological mapping as it becomes available over the duration of the project.

RELEVANCE TO MUSKWA-KECHIKA MANAGEMENT PLAN AND RMZ OBJECTIVES

As a multi-faceted study this project supports most of the MK management plan objectives, to varying degrees. The improved understanding of caribou populations and ecology will enable us to predict potential development impacts and plan management, whether for conservation purposes, resource extraction, or provision of recreational opportunity. As such, the project fulfills MK objectives to support the resources through research, which will in turn permit us to manage the wildlife resources in perpetuity. It thus supports conservation objectives and planning initiatives. 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 (with air and helicopter charter companies, employment of First Nations biologists, guide outfitters and so on).

This study also supports the RMZ objectives for the main study areas, as these include the maintenance of wildlife diversity and abundance, and of habitats and ecosystem diversity and integrity. Goals also require the provision for recreational uses such as hunting and viewing. Priorities for each RMZ vary slightly but all main areas for this study involve an emphasis on caribou and/or elk and/or moose. Objectives such as avoidance of fragmentation and provision for wildlife corridors will also be supported by this project.

ORGANIZATION OF WORK, COLLABORATION AND LINKAGES

The work will be co-ordinated and managed by Madrone Consultants Ltd. out of the Prince George office, with additional support in co-ordination, fieldwork and logistics from Slocan Forest Products Ltd. in Fort Nelson. It is intended that we will establish a field station in the immediate vicinity of Toad River for the duration of the project, beginning in fall 2000. Madrone will assume responsibility for subcontractors, and for project deadlines and reporting.

Madrone Consultants Ltd and Slocan Forest Products Ltd. are partners in this proposed project. The project offers opportunities for local employment as project assistants and project biologists, and aims to develop the work in collaboration with UNBC and with government agencies. It is expected that there will be a direct opportunity for a First Nations employee (preferably a student at UNBC), as well as direct part-time employment for some of the existing guide-outfitters in the area. Mr. David Wiens, the main guide outfitter for the proposed study area, is supportive of the project and is interested in having some of the guide-outfitters assist with fieldwork. We plan to work in close conjunction with David Wiens and, if the study area extends to surroundings, with the adjacent guide outfitters also (Dale Drinkall to the west and Ross Peck to the south), to ensure that field plans do not conflict with guide outfitter hunting operations.

Opportunities will also exist for other researchers to utilize the data or collaborate on the project to look at a wide range of other factors, e.g. interspecific competition between moose/elk/caribou; wolf ecology and predation strategies, use of the habitat data for ecosystem mapping, and so on.

Linkages exist with current and potential work on ecosystem identification and mapping, and ecosystem research in the MK.. Linkages with caribou projects in adjacent geographical areas (the Snake/Sahtaneh project to the east, the Rancheria herd to the west, the Graham herd and work in the Omineca-Peace to the south) also occur. These will be explored through our supporting and participating in current initiatives to develop a 'Northern Caribou Working Group". Slocan – MacKenzie Division and Donohue Forest Products are conducting a significant caribou-habitat project in MacKenzie and it is anticipated this group will provide some scientific and logistical support to this project. MELP in Fort St. John have expressed interest and may also provide some logistical and scientific support. MELP in Victoria has committed to assist on a Madrone proposal to conduct TEM/PEM mapping for the MK, and the products provided will equally support this initiative.

REFERENCES

Bergerud, A.T., H. Butler, and D. Miller. 1984. Antipredator tactics of calving caribou: dispersion in mountains. Can. J. Zool. 62: 1566-1575.

Elliott, John. Personal Communication. BC Ministry of Environment, Lands and Parks. Fort St. John Forest District.

Heard, D., and K.L. Vagt. 1998. Caribou in British Columbia: A 1996 status report. Ministry of Environment, Lands and Parks, Prince George, B.C.

MacLean, Norm. Personal Communication. Forest Ecosystem Specialist, Cassiar Forest District Dease Lake, BC.

Radcliffe, Gillian. 2000 (in progress). Caribou Population and Ecology, Northern Muskwa – Kechika. Proposal for the MKMA by Madrone Consultants Ltd., Prince George, B.C.

Scott McNay. Personal Communication. Senior Biologist. Slocan Forest Products Ltd., Makenzie Division, B.C.

Seip, D.R. 1992. Factors limiting woodland caribou populations and their interrelations with wolves and moose in southeastern British Columbia. Canadian Journal of Zoology. 70: 1494-1503.

Weins, David. Personal Communiation. Guideoutfitter, Stone Mountain Safaris, Toad River, BC

PERSONAL DATA RESEARCH PROPOSALS
To be completed for each key person engaged in project *see below

Given Names	**Surname**	**Telephone No.**	
Gillian	Radcliffe	250 746 5545	
Position, Department	**Organization**	**City & Postal Code**	
Head, Ecology Division	Madrone Consultants Ltd.	Prince George V2N 1X1	
Degrees/ Diploma (Specify)	**College, University or Institution**	**Subject**	**Year**
B.Sc.(Hons)	Polytechnic of Central London	Life Sciences	1978
M.Sc.	University of Aberdeen, Scotland	Ecology	1980
[NB one year towards a PhD at University of Victoria completed in 1986; withdrew from program]			

RELEVANT RESEARCH MANAGEMENT AND INDUSTRIAL EXPERIENCE (LAST 10 YEARS):

Position Held **Dates** **Department** **Organization**

(N/A as I have been in the same company since initiation in 1988. I am therefore providing a short precis of my industrial background)

With Madrone Consultants Ltd. I have been responsible for the management of numerous wildlife, ecological and habitat projects over the last 12 years. As one of two principals in the company I have specifically developed the ecological consulting side (both vegetation and wildlife ecology) for Madrone, initially conducting, and over the years increasingly delegating and supervising others on numerous habitat and wildlife inventory projects. Northern experience includes work in mapping and developing wildlife habitat models for a variety of species including caribou, moose and Rocky Mountain elk, and includes work in Sandy, La Biche, and Dunedin study areas. I have managed major studies (ongoing) in the Chilcotin, including detailed amphibian, bat, bird, bear, furbearer and ungulate inventories, habitat mapping, impact assessment and mitigation. I also managed and conducted a project in the Chilcotin on Mule Deer winter habitat. Past work has included direct census of a variety of ungulates, including considerable work on deer and mountain goats, as well as habitat and impact work on grizzly bears and other species. I review and supervise all significant ecological projects, including research projects, at the present time, including, for example, a multiple year Coarse Woody Debris project in Vanderhoof. Inevitably I deal with all the key issues, changes in direction or focus, and any significant technical concerns. I have also worked on and produced reports on many wildlife habitat, wildlife viewing, restoration and biodiversity projects, and many integrated projects.

In addition to good field competence, my strengths lie in managing and co-ordinating teams of well qualified biologists to tackle projects of almost any scope and scale, and in writing and editing quality reports.

While I have good strengths as a generalist, I have two senior wildlife ecologists in mind as senior advisors for this project who are both more experienced in caribou, research. Assuming their co-operation, details will be forthcoming by mid March 2000 (final report due) or earlier if required. Madrone also has a number of staff and associates with considerable experience in radio-telemetry studies and who have worked on caribou projects. They will work alongside any new (northern) employees in the initial stages of the project until adequate experience is gained

LIST **RELEVANT** PUBLICATIONS, REPORTS, ARTICLES, PATENTS, LICENSES, ETC. (Attach 1 extra sheet if necessary)
1994 Madrone Consultants Ltd. Directory of Biological Diversity Inventories for British Columbia. Prepared for Ministry of Environment, Lands and Parks, and Resources Inventory Committee, Victoria. 1992. Radcliffe, G. & G. Porter. Naikoon Provincial Park: vegetation and biodiversity assessment. Madrone Consultants Ltd. for Ministry of Environment, Lands and Parks, Northern B.C. Region. 1994. Radcliffe, G., G. Porter, B. Bancroft & C. Cadrin. Biodiversity of the Prince Rupert Forest Region. Ministry of Forests Land Management Report No. 62., Ministry of Forests, Victoria, B.C. 1994. Radcliffe, G., & J. Teversham. Ecosystem Mapping and Wildlife Interpretations, Kitsumkalum (Beaver) River. Report to Skeena Cellulose Inc., Terrace. 1998. Radcliffe G., Barton K., Veach L., Willams P. Terrestrial Ecosystem Mapping and Wildlife Interpretations for the Dunedin, Sandy Creek and LaBiche Study Areas. Report to Slocan Forest Products Ltd., Fort Nelson BC 1999. Radcliffe G., Barton K., Veach L., Willams P. Terrestrial Ecosystem Mapping and Wildlife Interpretations for the Klawli Study Area. Report to Slocan Forest Products Ltd., Mackenzie BC 1997. Radcliffe G., D'Arcy M. Inventory of Mule Deer Winter Habitats in the Ft. St. James and Vanderhoof Forest Districts. For Canfor Isle Pierre Division, BC.
LIST ALL RESEARCH SUPPORT (FEDERAL & PROVINCIAL) FOR PERIODS PROCEEDING AND/OR OVERLAPPING THE CURRENT APPLICATION. (If similar to present application indicate differences). None at present, however we do anticipate seeking additional/alternative funding sources.

*NB Senior Advisor and Project Biologist information will be submitted with research proposal in March, 2000.

PERSONAL DATA RESEARCH PROPOSALS
To be completed for each key person engaged in project.
* MAXIMUM 1 PAGES PER PERSON

Given Names		**Surname**	**Telephone No.**	
Mary Isabel		Duda **(R.P. Bio)**	250-233-6607	
Position	**Department**	**Organization**	**City & Postal Code**	
FRBC Co-ordinator	FRBC	Slocan Forest Products	Fort Nelson BC, V0C 1R0	
Degrees/ Diploma (Specify)		**College, University or Institution**	**Subject**	**Year**
M. Sc.		Lakehead University	Fisheries/Forestry	1997
Honours. B. Sc.		Guelph University	Biological Sciences	1993

RELEVANT RESEARCH MANAGEMENT AND INDUSTRIAL EXPERIENCE (LAST 10 YEARS):

Position Held	Dates	Department	Organization
FRBC Co-ordinator Staff Biologist	1997-Present	FRBC	Slocan Forest Products
Graduate Student	1995-1997	Forestry	Lakehead University

RELEVANT RESEARCH MANAGEMENT AND INDUSTRIAL EXPERIENCE (LAST 10 YEARS):

As the staff biologist and program co-ordinator I am responsible for working with industry, government agencies, First Nations, and a wide range of stakeholders to determine district planning/ management needs and priorities which have included the following annual and multi-year programs: *Resource Inventory Program, Watershed Restoration Program, Forestry Studies, Wildlife Population & Habitat Monitoring* (including current caribou habitat assessment program and planned ungulate assessment projects*), and Backlog Silviculture*. Professional and operational contract supervision for all of the above programs including the full scope of activities of project management and supervision including planning and designing project objectives, diverse field work, quality assurance and final deliverable approval.

Mary Duda has solely implemented the FRBC program for Slocan Forest Products from 1997-Present.

Forest Renewal BC	1999-2000	$2,700,000
Forest Renewal BC	1998-1999	$3,000,000
Forest Renewal BC	1997-1998	$3,000,000

BUDGET AND TIME FRAME FOR YEAR APPLIED

Accounting Officer (If other than applicant, specify person in charge of financial records)
Name: Mike Harris (Office Manager, Madrone Consultants Ltd.)
Address: 1081 Canada Ave., Duncan, B.C. V9L V2
Telephone #: 250 746 5545 Fax #: 250 746 5850

PROJECTED EXPENDITURES

ELIGIBLE CATEGORIES:	QUARTERLY BUDGET 1st	2nd	3rd	4th	Total this year
a) Salaries & Stipends (not including benefits)	3,700	11,300	13,100	57,000	85,100
b) Employee Benefits	300	700	900	5,000	6,900
c) Equipment	30,000	4,000	6,000	6,000	46,000
d) Travel	500	1,500	4,500	4,500	11,000
e) Materials & Supplies	-	500	2,500	2,000	5,000
f) Others (List on next page)	1,000	14,000	14,000	26,000	55,000
g) Indirect Costs (written justification required)	1,000	1,800	3,000	3,000	8,800
h) Administrative Costs	500	700	1000	1000	3,200
TOTALS	5,500	28,000	71,000	100,500	221,000

***Equipment** includes 16,000 for vehicle and snowmobile rentals, 26,000 for radio collars/tags and telemetry equipment, and 4,000 for additional field equipment.
***Others** includes contract money for fixed wing and helicopter surveys, for guide-outfitter support, and capture/collaring crew.
***Indirect Costs** covers in-house mapping and GIS costs to produce various habitat maps, locational data etc. to support the project.

IS YOUR ORGANIZATION AND/OR COLLABORATORS
MAKING A CONTRIBUTION TOWARDS PROJECT COSTS? <u>YES</u>

IF YES, PLEASE DISCUSS THE NATURE OF THE CONTRIBUTION, INCLUDING ITS VALUE.
SLOCAN FOREST PRODUCTS LTD. : $70,000
ANNUALLY OF $50,000 FRBC MONEY AND ADDITIONAL SUPPORT-IN –KIND WORTH APPROX. $20,000

MADRONE CONSULTANTS LTD: $28,000
MADRONE WILL PROVIDE OFFICE SPACE, ADMINISTRATIVE SUPPORT, COMPUTERS, SOFTWARE PACKAGES, INSURANCE AND MAPPING AND GIS SUPPORT; MADRONE WILL ALSO SUPPLY ONE FOUR WHEEL DRIVE VEHICLE FOR PROJECT USE, AND USE OF A SNOWMOBILE.

4 FORM 5- BUDGET SUMMARY

Muskwa-Kechika Management Area Funding 2000-2001

Has This Project Been Previously Applied For No

SHORT TITLE OF PROJECT

Caribou Population and Ecology, Northern Muskwa - Kechika

Status : Year 2 of 5 years Overall Project Costs: $900,000

M-KTF Funds Requested: ThisYear $123,000 Total M-KTF Funds approx. $600,000

Other Funding Sources *not yet finalized

From: Slocan Forest Products Ltd. This Year $70,000 *Total $210,000
From: Madrone Consultants Ltd. This Year $28,000 Total $84,000

Accounting Officer (If other than applicant, specify person in charge of financial records)
Name: Mike Harris (Office Manager, Madrone Consultants Ltd.)
Address: 1081 Canada Ave, Duncan, BC V9L 1V2
Telephone #: 250 746 5545 Fax #: 250 746 5850

Proposed Expenditures Total Project:	QUARTERLY BUDGET 1st	2nd	3rd	4th	Total this year
a) Administration Fee (if applicable)	500	700	1,000	1,000	3,200
b) Salaries & Stipends (including benefits)	4,000	12,000	14,000	62,000	92,000
c) Contracts (fees/rates)	1,000	14,000	14,000	26,000	55,000
d) Travel	500	1,500	4,500	4,500	11,000
e) Equipment rentals	-	-	2,000	2,000	16,000
f) Materials & Supplies	-	500	2,500	2,000	5,000
g) Vehicle Rentals	-	-	4,000	4,000	8,000
h) Equipment Purchases (with Justification)	-	-	30,000	-	30,000
i) Indirect Costs (mapping)					8,800
TOTALS	5,500	28,000	71,000	100,500	221,000

IS YOUR ORGANIZATION AND/OR COLLABORATORS MAKING A CONTRIBUTION TOWARDS PROJECT COSTS? YES

SLOCAN FOREST PRODUCTS LTD. : $70,000
COMPRISING $50,000 FRBC MONEY AND ADDITIONAL SUPPORT-IN –KIND WORTH APPROX. $20,000
MADRONE CONSULTANTS LTD: $28,000
MADRONE WILL PROVIDE OFFICE SPACE, ADMINISTRATIVE SUPPORT, COMPUTERS, SOFTWARE PACKAGES, INSURANCE AND MAPPING AND GIS SUPPORT; MADRONE WILL ALSO SUPPLY ONE FOUR WHEEL DRIVE VEHICLE FOR PROJECT USE, AND USE OF A SNOWMOBILE.

Proponent Name Proponent Signature Date