FINAL DATA REPORT FOR 2004/2005

CARIBOU POPULATIONS AND ECOLOGY, NORTHERN MUSKWA-KECHIKA

(M-K-2004-2005-18)

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Muskwa-Kechika Trust Fund
150 – 10003 – 110th Avenue
Fort St. John, B.C. V1J 6M7

Prepared by:

Gillian Radcliffe, *R.P.Bio.*, Tania Tripp, *R.P.Bio.*, and Trystan Willmott, *B.Sc.*

MADRONE ENVIRONMENTAL SERVICES LTD.

1081 Canada Avenue, Duncan, BC V9L 1V2

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Gillian Radcliffe and Tania Tripp

EXECUTIVE SUMMARY

The Muskwa-Kechika Management Area (MKMA) supports one of the largest intact predator-prey ecosystems based on large mammal populations in North America. In order to support future wildlife management and conservation objectives for these predator-prey systems, this project aims to establish baseline ecological information on one of the main caribou herds in the northern Muskwa – Kechika (MK), the Muskwa Herd, for which little was known at project inception. The research objective is to increase knowledge of population parameters, caribou/habitat associations through habitat mapping, and analysis of caribou seasonal habitat use.

It is hoped that the scientific results of this study will be utilized to develop management tools for pre-tenure planning, to predict impacts not only of industrial developments, but also of increased human recreational activities, and to support decisions on wildlife management, and resource developments. This study will also provide baseline data for future population monitoring, and long-term sustainability of this wildlife resource.

Results Overview - October 2000 to June 2004

- Of the 46 animals collared between 2000 and 2003, 9 collared animals were recently relocated as of June 2004, one of which was a mortality. A total of 16 collars are now considered active; two collars have dropped off; three collars have failed (*i.e.,* originally presumed missing but subsequently observed during fieldwork); and the remainder are considered missing in action (no signal received for at least 6 months).
- In November of 2003, five additional female caribou were collared in order to maintain the number of functioning collars in the study area.
- Of the 12 known mortalities that have occurred over the period of this study, two occurred during the first fiscal year (October, 2000 to March, 2001), another two in the second fiscal year (April, 2001 to March, 2002), seven in the third fiscal year (April, 2002 to March, 2003), and one in the fourth (April, 2003 to June, 2004).
- A total of 906 VHF telemetry re-location points have been collected from aerial telemetry flights while monitoring the collared animals since the start of the project in October, 2000. The number of location points per animal range from 3 with the newly collared animals, up to 45 for one of the animals collared in 2000.
- Of the three Argos satellite collars fitted in October 2001, one ceased to transmit in December, 2001. The other two collars ceased transmitting satellite data as of December, 2002 and April, 2003 respectively. VHF remains operational on all three VHF/ARGOS collars for continued monitoring.
- A total of 1508 satellite re-location points (location class 3, 2, or 1) were received during the monitoring (over 18 months) with the Argos collars (October 22, 2001 to April 8, 2003). Collar ID 39M39 (Argos ID 20766 quit April 8, 2003) received 336 re-location

points. Collar ID 40M40 (Argos ID 14200 quit December 10, 2001) received 48 re-location points. Collar ID 41M41 (Argos ID 26338 quit December 8, 2002) received 1124 re-location points.

- In addition to fixed wing telemetry flights, three helicopter-based surveys were conducted in order to characterize important life stages of the species. These were a spring cow/calf census in June, a fall rut count in October, and a late winter census in February or March of each year.
- The late winter (March) survey was not conducted in 2004 due to lack of funding. However, two fixed wing flights took place in late February, 2004, and April 2004
- Vegetation habitat plots and information from other mapping projects in the area were used in developing a broad unit vegetation (caribou habitat) map for the entire study area (890,424 hectares).
- Previous projects (three PEM projects, one TEM project) were correlated with project-specific Caribou Habitat Units. A large area (280,368 hectares) previously unmapped was then mapped using the existing biogeoclimatic mapping, topographic mapping, and satellite imagery. A digital elevation model was applied to model aspect for this newly mapped area.
- Several iterations of the habitat mapping were run, with internal quality control applied through plot review and examination of orthophotos of the study area. Ultimately, a seamless Caribou Habitat Map was developed for the entire area, to support habitat use analyses and model development.

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1.0 INTRODUCTION

Despite the national and international significance of the large mammal predator-prey systems of the Muskwa-Kechika Management Area (MKMA), studies have not previously been conducted upon caribou ecology in the northern half of the area until recently. Population estimates indicate this area supports a very substantial proportion (approximately 13%) of BC's northern caribou population (Radcliffe, 2000).

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 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 BC 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 major predator-prey systems in this area remain relatively intact.

This project aims to establish baseline ecological information on one of the two main caribou herds in the MK, the Muskwa herd, 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 the Muskwa herd, including population sizes, sex ratios, recruitment, mortality, home ranges, especially winter ranges and calving areas, seasonal movements and habitat use.

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. Project objectives are thus fully consistent with the purposes of the MKTF.

This report presents the data collected from project initiation in 2000 up to data collected in June of 2004, which covers the planned four-year field project on the population and ecology of the Muskwa caribou herd in the northern MKMA.

1.1. Research Objectives

Overall goals are to:

1. Establish baseline ecological information on the main caribou herd, 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, and 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;
- Develop/fine tune existing caribou habitat models to predict caribou distributions across the landscape;
- Develop the model into a management tool that will permit the evaluation of proposed development impacts, including cumulative effects assessment, and that will provide a solid foundation for making decisions regarding caribou management in the area; and
- Communicate project results to members of the public as well as to fellow researchers in both the public and private sectors.

1.2. Applicable MKMA Objectives

- To support wildlife and wilderness resources of the management area through research and integrated management of natural resource development; and

To maintain in perpetuity the diversity and abundance of wildlife species and the ecosystems on which they depend throughout the Management Area.Activities conducted in 2003-2004 continued to build on the previous years of data. The following specific activities were carried out during the 2004-2005 fiscal:

- A spring census to determine cow/calf ratios and identify calving areas(June 2004 - fourth year of spring calving data);
- Regular telemetry work to identify seasonal habitats and movements via fixed wing and helicopter flights;
- Refinement of the habitat map base (broad ecosystem units).
- Data entry and analysis (all phases);
- Preliminary analysis of data; and
- Completion of data summaries and final report.

2.0 BACKGROUND

This project was initiated in 1999 with seed funding from the MKTF to produce a background review. The initial year of a proposed four-year field research project was funded by the MKTF and Slocan in 2000 and 2001. The background review by Radcliffe (2000) provides a detailed synopsis of information relevant to caribou population and ecological research in the Muskwa-Kechika, completed as Phase 1 of this project. Phase 2 consists of the applied 4-year field program, which began in October of 2000.

2.1. Study Area Location

The project is based out of Toad River (logistically the most feasible center of operations), in management units on either side of the Alaska Highway (see Figure 1). Heard and Vagt (1998) reported that the Muskwa herd ranges within the Mt. Dall, Crest, Toad, and Racing River areas. The 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 Chischa River system, then north and east towards Tetsa River Park.

The study area incorporates diverse topography and a wide range of habitat types. It ranges from the rugged peaks of 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 (BWBS) at the lower elevations, the Spruce - Willow Birch (SWB), and some areas of Alpine Tundra (AT). Substantial large mammal numbers exist within the study area, with healthy populations of Stone’s sheep, mountain goat, Rocky Mountain elk, moose, and caribou, black and grizzly bears, and wolves.

Portions of the study area are located within three of the Muskwa-Kechika Resource Management Zones (RMZs): Eight Mile/Sulphur, Stone Mountain, and Churchill. A number of protected areas also fall within the study boundaries, including:

- Muncho Lake Provincial Park (eastern portion)
- Stone Mountain Provincial Park
- Wokkpash Provincial Recreation Area
- Northern Rocky Mountains Protected Area (Tetsa and Chischa River Areas)

Study area boundaries were refined after the first year of data collection, as the extent of the caribou ranges became more clearly identified. Subsequent data collection since the first year has not resulted in any further changes.

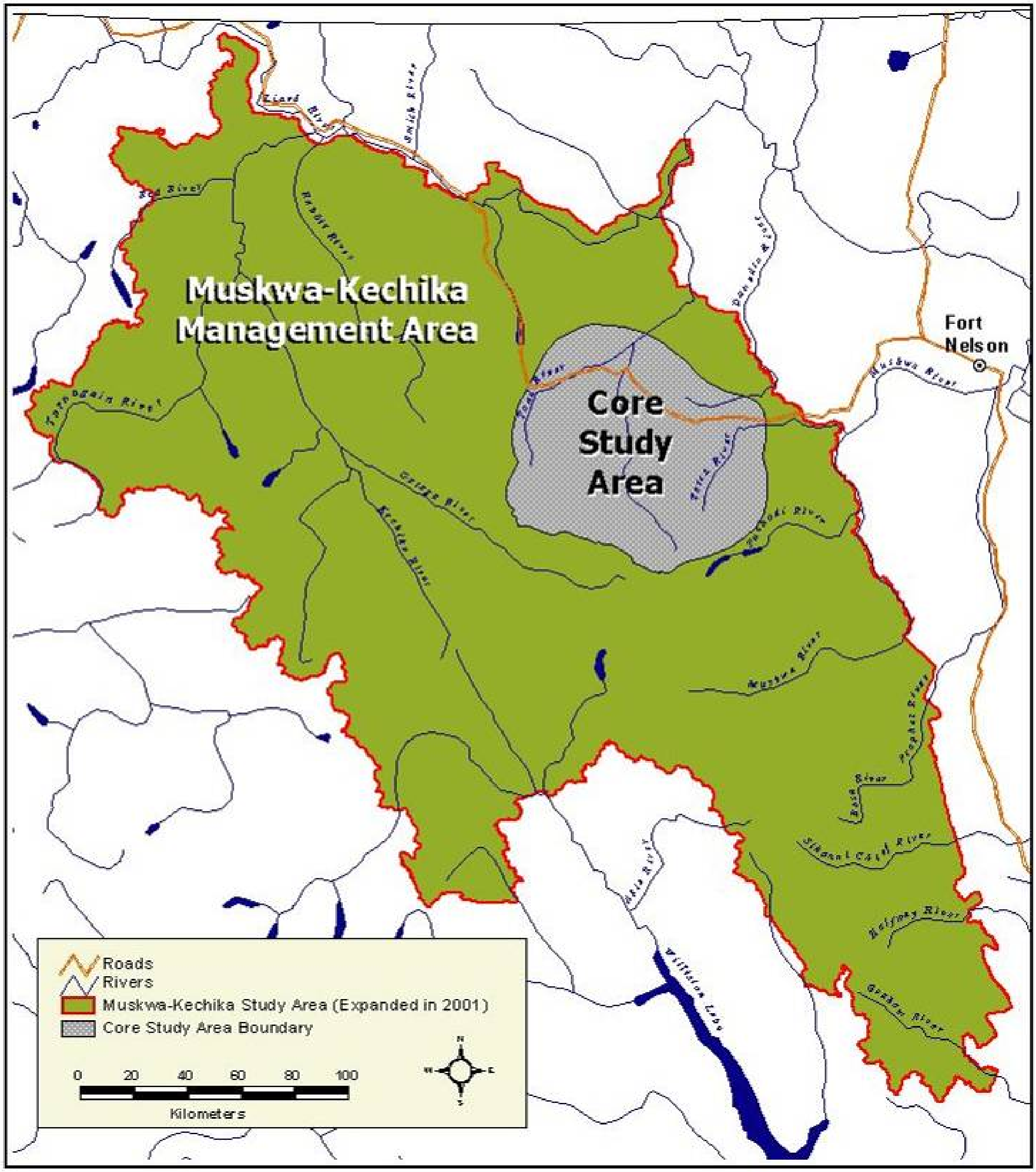

Figure 1: Caribou study area within the MKMA.

3.0 METHODOLOGIES

Background preparatory work was conducted during the summer of 2000, but the main thrust of the work began in the fall of 2000, with the onset of the field program. Caribou capture and collaring occurred following the fall rut in late October 2000, 2001, and again in 2003. Regular data collection began after initial collaring was completed.

3.1. Capture and Collaring

Individual adult female caribou from the Muskwa herd were captured and collared with VHF radio transmitters for re-locating and tracking their movements. One of the original research data collection goals was to maintain 20-25 collared animals over the duration of the project if possible, and to assess the value of installing a subset of ARGOS units during the second year of the study.

3.1.1. Animal Care

As we were concerned about stress to the caribou from handling, we met with Helen Schwantje (provincial MWLP vet) and Ian Hatter (MWLP ungulate specialist) in Victoria to discuss this issue prior to capturing any animals. We reviewed general methods and standards, and left with an increased level of comfort in our study design and approach.

As outlined in approved permits from BC Parks and MWLP, Fort Nelson, obtained prior to capture, all animals were released in a timely fashion. No animals were held in captivity, and no immobilization drugs were used. The caribou were caught individually using a net shot from a helicopter over appropriate habitat (open, flat ground with minimal shrubs and snow to cushion the fall). Animals were processed as quickly as possible, and all efforts were made to minimize stress.

3.1.2. Biological Samples and Data Collection

Helen Schwantje and Bryan Webster (BC Parks, Fort Nelson) requested that we collect body measurements, as well as hair, blood and fecal specimens for Provincial studies. Helen provided details and the necessary equipment for sample collection and storage.

Data collected for each captured animal typically included: observation date, species code, session label, observation #, surveyors, general location, UTM (using a hand held GPS unit), sex, age class, reproductive condition (lactating, post lactating or estrus), evidence of nursing, # of young, age of young, serial #, radio frequency, tooth wear (minimal, moderate or heavy), pelage colour and condition, scarring, and body condition (rump, shoulders, and withers). When possible measurements were collected as per Shackleton (1999).

3.1.3. Additional Capture and Collaring 2003

An additional five animals were planned to be collared in October 2003 (immediately after the rut count) in an effort to maintain at least 20 active collars. Replacement of collared animals that had malfunctioning signals (*i.e.*, weak signals, no signals, or false mortality signal) was intended as the priority over collaring new animals. However, lack of snow in

October and limited budgets constrained capture opportunities, and instead five new females were collared in November 2003. All crew members involved in the capture and handling of the caribou were fully qualified to complete the tasks assigned to them. Qualified, experienced net gunners and helicopter pilots were hired (Grant Lordie was the net-gunner in 2000, and Brad Culling in 2001 and 2003) (Helicopter pilots were Zvonko Dancevic and Cam Allen - QWEST Helicopters, Fort Nelson).

3.1.4. Radio Frequencies and Collars

The approved VHF frequencies for the collars were researched by Mary Duda who received approval for use of 148.00 to 149.99 mhz. In theory there should be no overlaps with other animals in the study area or adjacent areas.

A Victoria based company, Human Animal Biotelemetry Instrumentation Technology (H.A.B.I.T.), produced the VHF and Argos collars for this study. A total of 46 low profile rubber-belted VHF collars, three of which had the additional Argos satellite capability, were purchased. Specifications included collars adjustable in 1” increments to fit neck circumference between 16 to 32”; 60 Pulse per minute; signal strength of 25-30 milli Watts; duty cycle to save battery life (off from 10PM-4AM, 6 hours shut down); mortality sensors on all collars with a faster pulse in order to detect using the scanner function on the receiver, otherwise it might be missed (120 pulses per minute for ease of distinguishing from live pulse); mortality was signaled by no movement for 6 hours; a battery life of at least three years was specified.

3.2. Field Data Collection

The project involves the detailed characterization of the herd, including population size, sex ratio, recruitment, mortality, home ranges, especially winter ranges and calving areas, and seasonal movements and travel corridors. To accomplish this, a total of 46 female caribou in the study area were captured and collared with VHF radio transmitters, for re-locating and tracking their movements (30 caribou collared in 2000, 11 in 2001, and 5 in 2003). Three of the collars also had additional Argos satellite capability. The data collected from relocating these collared animals, combined with the recently completed habitat mapping, also permits us to examine the seasonal habitat uses of the herd.

Geographic locations were collected in three main ways.

1. Aerial fixed wing telemetry surveys were conducted as regularly as the weather and budgets would permit from October 2000 to June 2004. This data provides information on year round and seasonal home ranges, and some information on elevational use and broad habitat use.

2. Seasonal helicopter surveys were conducted in late winter, spring (June) and in the fall, primarily to collect more detailed population data, however all caribou observations are given a fixed geographic location that can then be plotted on a map, providing additional data for assessing ranges and habitat use. Each point on the map may represent an individual or a

group of caribou observed.

3. Satellite transmitters were fitted on three of the radio collared individuals and location information for these animals was received via e-mail on a daily basis. Quality of the information varies however, and in order to accurately track the movements of the caribou only the better location classes (3, 2 or 1) were accepted as re-location points and used to plot distribution maps.

These methods are described in more detail below. All geographic data is stored in project databases.

3.3. Telemetry Re-location Surveys

Re-location surveys by air were attempted on a monthly basis when weather and funding permitted. Weather in the study area is often inclement, however, resulting in what can be prolonged periods without data collection. Ground based telemetry was conducted opportunistically but was generally of very limited benefit, so we placed little emphasis on this approach. Animals continued to be located from the air approximately monthly.

As in prior years, a combination of fixed wing (mainly 185 model) and helicopter were used to conduct the re-locations. The LoTech Receivers (STR 1000 and SRX400 - frequency range is 142-152) were used to relocate the animals. Jim Hart was the pilot for all fixed wing telemetry flights. During these solo flights Jim flew the plane, and collected the re-location data. On helicopter re-location flights Gillian Radcliffe, and either Tania Tripp, Peter Smilie, or Nancy-Anne Rose collected the re-location data. Cam Allen of QWEST was usually the pilot.

Re-locations were collected in decimal degrees or UTM depending on technology available (*e.g.,* handheld units vs. helicopter and fixed-wing units). Additional information collected whenever possible included: visual confirmation of collared animals, number in the group, sex of other animals in the group, general location and habitat description, and in some cases behavioural notes (*i.e.,* feeding, bedding, traveling, birthing, etc.). Generally this level of detail was only possible to collect during helicopter surveys.

3.4. Argos Satellite Re-locations

Three Argos satellite transmitters were added to VHF collars in October 2001. An Argos account was maintained and satellite re-location points were received daily as latitude and longitude coordinates from Argos Data Collection Systems via email. The information was entered into an Excel spreadsheet and converted to UTM format for plotting locations on maps. Additional information collected included animal ID and VHF frequency, receiving satellite, location class, and the number of times the satellite received information during its pass. Only satellite locations of class level 1 (<100 m accuracy), 2 (100-500 m), and 3 (500 to 1000 m) were considered useful for incorporating in the project databases, as all other classes were too low in accuracy to consider.

3.5. Population Surveys

In addition to monthly telemetry re-location data, aerial census and counts were conducted three times a year: during the spring calving in June, the fall rut in October, and again in late winter (February-March).

Surveys conducted in the first half of June are intended to provide data on the productivity of the population – ie the number of calves produced. We can also follow each individual collared cow to monitor subsequent survival of the cow and calf in later surveys. Data on group composition and habitat use is also collected.

In the fall (October), a population composition survey, or “rut count” is conducted. This provides information on the proportion of calves and bulls in the population over time, in order to identify population trends. It also permits us to follow calf survival from June.

In late winter – February or March, another survey or count gives important information on the population size/status and on what habitats are being used at that time. It provides critical information on overwinter survival and recruitment of the calves, and information needed to assess population trends.

Surveys were of two basic kinds:

- conducting standard census counts and classification following pre-established set routes without the use of the radio telemetry
- telemetry re-location, counting and classifying as many animals as possible within the study area, using the collared animals to relocate groups.

As per provincial standards, the following information was collected during aerial census surveys: Observation #, Species, Tag ID if applicable, Time, Group Total, Age, Sex, UTM, Activity (*e.g.,* feeding), Visual, Habitat and other comments.

3.6. Mortalities and Habitat Use Investigations

Re-location data was attempted at least monthly to monitor movements of the collared caribou and status (alive or dead). Collars were programmed to emit a mortality signal following no movement for 6 hours. A mortality signal was twice as fast as the regular (alive) beep and therefore distinct. When a mortality signal was detected the site was visited as soon as possible in order to determine the cause of death (*i.e.,* species of predator). If left too long it is extremely difficult to determine the cause of death because of the number of other animals that are quickly attracted to the carcass.

At each mortality investigation a detailed form was completed containing information on cause of death, date of death, sex, age, ID#, snow depth, photographs, and comments on the circumstances and surroundings. A tooth from the animals was collected where possible, and sent to the provincial veterinarian (Helen Schwantje, MELP, Victoria) for aging. The radio collars were recovered for re-use.

During aerial surveys, habitat use investigations were conducted at a few sites that telemetry indicated were being utilized by the caribou. Habitat assessments were completed for each site visited, and a GPS location was recorded. Additional ground surveys, based by combinations of truck, snowmobile, foot, and horse, were conducted at a small number of sites to collect further telemetry data and habitat use investigations.

3.7. Seasonal Use Patterns

Three types of location data were collected during this project for assessment of seasonal use patterns: 1) VHF telemetry signals from collared caribou collected by fixed wing flights (monthly when weather permitted), and helicopter; 2) ARGOS satellite signals from three VHF/ARGOS collars; and 3) visual locations collected for marked and unmarked animals during census flights conducted in June (calving), October (rut), and February-March (late winter).

For seasonal analysis of the data, points were classified according to one of six categories:

- Spring (April 1st to June 16th)
- Calving sub-category (May 25th to June 16th)
- Summer (June 17th to September 15th)
- Fall/Rut (September 16th to October 31st)
- Early Winter (November 1st to December 31st)
- Late Winter (January 1st to March 31st)

3.8. Data Entry

All field data has been entered into appropriate spreadsheets and databases such as Excel (*e.g.,* telemetry locations, census data, etc.) and Venus (for vegetation plots). Separate spreadsheets were used for census, telemetry, and habitat data. Original completed field forms were photocopied and stored in a binder as a back-up reference. Site locations were translated for use in ArcView 3.1 in order to illustrate plot locations and animal movements.

3.9. Progress Reports

During each year of the project, progress reports were submitted to the MKTF to summarize and communicate results and to track expenditures. In addition to the progress reports, an annual data report was provided in March 2001, 2002, 2003, and 2004.

4.0 HABITAT MAPPING

One of the key challenges for this project has been in developing a consistent and appropriate habitat map base across the area to support the caribou work. The following sub-sections describe the approach and process of creating broad Caribou Habitat Units (CHU's) from the existing ecosystem mapping in the Muskwa-Kechika Management Area. With a limited budget and a need for a seamless map base to support future interpretations and analyses, we decided to overcome the mapping hurdle by running a form of broad ecosystem mapping, using previous plot data from the caribou study, and prior projects in and around the area. Our approach involved utilizing all of the existing ecosystem mapping projects, grouping the units into broader caribou habitat units, then using BEC, TRIM, LANDSAT 7, and other data sources to run this caribou habitat mapping for the missing area (an area of over 280,000 hectares). Thus the mapping now depicts the caribou habitat units for the whole area (i.e. for over 890,000 hectares), giving fairly consistent coverage, but the original dataset remains nested within this, with all of the detail available from the PEM and TEM mapping, where there is coverage.

The actual habitat units are described in Appendix 1. A more detailed methodology of mapping CHU's in areas with no existing ecosystem mapping is intended as the subject of a subsequent report.

4.1.1. Existing Ecosystem Mapping

Relatively detailed ecosystem mapping, at scales of 1:20,000 to 1:50,000, covers about 70% of the study area. The different mapping projects are summarized in Table 1.

About 15% of the area had previously had Terrestrial Ecosystem Mapping (TEM) completed at a scale of 1:50,000 (Madrone Consultants Ltd. 1999); some 50% of the area was mapped in 2001-2002 in three separate predictive ecosystem mapping (PEM) projects by EBA; and another 8% had PEM mapping completed in 2003 by Madrone Environmental Services Ltd. and Atticus. The remainder (about 27% of the caribou study area) was entirely unmapped; there was also no forest cover or other vegetation mapping for any of this area, limiting our options for developing a PEM. There was also insufficient budget for a full PEM using air photo interpretation for bioterrain.

Table 1: Ecosystem mapping in the Muskwa-Kechika Management Area.

Type of map	% Area	Contractor	Year Completed	% of study area
Terrestrial Ecosystem Map (TEM)	Dunedin River	Madrone	1998	15%
Predictive Ecosystem Map (PEM)	Toad, Racing, & McDonald rivers	EBA Engineering	2002	50%
Predictive Ecosystem Map (PEM)	Gataga River	Atticus/Madrone	2003	8%

4.1.2. Biogeoclimatic Units

The basic unit of most ecosystem mapping under 1:50,000 (including TEM and PEM) is the biogeoclimatic site series, stratified by biogeoclimatic subzones and variants. The Biogeoclimatic classification of the area thus provides the basic framework for developing the habitat mapping. The biogeoclimatic subzones and variants that occur within the study area, and a brief description, are listed in Table 2. In the areas where TEM or PEM mapping occurs, additional information contained within the map databases includes bioterrain, vegetation structural stage, and site modifiers.

Table 2: Biogeoclimatic units of the study area.

BEC zone	Subzones	Elev.	Location	Comments
Black and White Boreal Spruce (BWBS)	Dry cool (BWBSdk)	600 – 1000 m	Found in western parts of the study area, below the SWBmk	Climate is drier and cooler than the BWBSmw2, forests dominated by Sw and Pl, aspen found on warm aspects and on burnt areas
	Moist warm (BWBSmw2)	600 – 1100 m	Occupies rolling topography on lower elevations on eastern flanks of the northern Rockies	High aspen component; longer growing season than BWBSwk3
	Wet cool (BWBSwk3)	600 – 1100 m	Found on foothills and lower to mid slopes of northern Rockies	Dominated by Sw and Pl
Spruce-Willow-Birch (SWB)	Moist cool (SWBmk)	1000-1300	Middle elevations of northern Rocky Mountains	Subalpine zone above BWBS; open forests, mixed with shrublands
	Moist cool scrub (SWBmks)	1300-1600	Middle-upper elevations of northern Rocky Mountains	Transitional to AT, shrub and grasslands
Alpine Tundra (AT)		> 1600	All high elevation areas	Tundra, rock and ice

4.2. Plot Data Sources

In order to develop and improve the habitat modeling, detailed vegetation plots were conducted. Priority was given to areas of use to the south of the Alaska Highway, as there were very few detailed vegetation plots in that part of the study area.

Data from vegetation plots done in the study were drawn from two projects:

- plots done during the caribou surveys (80 plots)
- plots from the Gataga PEM project (96 plots)

In September of 2001, 38 plots were completed in the study area. During September 2002, four biologists conducted additional habitat surveys within the study area, within the Wokkpash and Racing River Areas, to add to the existing vegetation database. In addition, another 42 GIF plots (as well as 54 visuals) were completed just to the south, within the Gataga, during a separate PEM mapping exercise jointly conducted by Madrone and Atticus. This vegetation data was also highly applicable to the area. These plots were classified to ecosystems, but also into the broader Caribou Habitat Units (see below), and the information was used to calibrate the Caribou Habitat map for the study area.

4.2.1. Caribou Habitat Units

Although most ecosystem mapping is based on site series, it is difficult to correlate caribou use of habitats to these units which, in many cases, occupy small areas on the landscape. Instead, caribou appear to favor more general, larger habitats that share similar structural stages or aspects (Pojar 1986.). Such habitats (*e.g.*, tundra or north-facing open forest) will have several site series nested within them. For example, the closed forest type might include within it areas of drier pine forest and mesic forests dominated by white spruce or subalpine fir. A review was done on existing documentation describing caribou habitat in different locations in northern BC, ranging from Spatsizi Park, Cassiar Mountains, Rocky Mountain Trench, and northern Rocky Mountains. Based on these documents, the major habitat types associated with Caribou in the north appear to be the following:

- Closed forest
- Open forest
- Moist to wet forest (TEM and PEM areas only)
- Wetlands
- Grasslands
- Shrub and scrub
- Tundra
- Sparsely vegetated (rock, cliff)
- Wetlands and rivers
- Permanent snow

The BEC site series used in the different mapping projects (TEM, PEM) were grouped into the above categories. Thus the classification is primarily a physiognomic, or structural stage grouping. However there are ecological affinities within each of the groups. The closed forest groups, for example, are circum-mesic, ranging from slightly dry to moist. Once selected, the site series groupings were entered into a project-specific database. All mapped ecosystem units from all of the included projects were correlated with these Caribou Habitat Units. Database manipulations included the "search and replacing" of ecosystem map codes, the use of site modifiers (assumed and mapped) to model aspect, and creating new themes. Maps were created and viewed in ArcView.

4.2.2. Refining the Mapping

Feedback from a brief field review of the initial satellite mapping in the summer of 2003 was used to refine the new mapping for the missing area and run another iteration. We also smoothed out various edge matching problems between all the different mapping projects. Office based QA of the mapping using orthophotos for the area, as well as checking against prior plot data, was also done.

4.2.3. Habitat Map Limitations

Creating a generalized classification is by nature a simplification of the landscape, with an accompanying loss of information. A map of the BHU's does not have the same amount of information associated with each polygon that an ecosystem map at 1:20,000 has. However, drawing on the existing ecological information available for each site series contained within each grouping, one can nevertheless make some conclusions about the attributes of each BHU.

The database BHU groupings that were made selected only the dominant site series per polygon, with the result that the less common site series are not recognized. For example, in a terrestrial ecosystem map polygon with the label **6**BL **3**WV **1**FE, only the BL would have been used in the grouping of site series ecosystems, and WV and FE would not be mapped, in spite of the fact that these "remainder" units may be valuable habitat. Site series that are rarely the dominant unit in a polygon will therefore be under-represented in the final map product. Of course, the original maps are always there if more detailed analysis is required.

Another issue concerned certain ecosystem units, which could have been classified into two different BHU's. An example is a forested bog, which could be classified as either a wetland or wet forest.

Obviously the area without original air photo interpretation does not achieve as high a quality of habitat mapping as the areas that had the benefit of bioterrain mapping (i.e. direct air photo interpretation), and there is of course room for improvement. It is hoped that at some point budget may be available to run a final field test/QA followed by a final iteration of the mapping. However, due to budgetary constraints, the product is currently being used as the basis for analyses.

5.0 RESULTS

5.1. Capture and Collaring

During Oct 22nd to Oct 25th, 2000 Northern Mountain Helicopters (Zvonko Dancevik and Grant Lordie) assisted by Madrone Consultants Ltd. (Gillian Radcliffe and Tania Tripp) and Slocan Fort Nelson (Mary Duda) completed the initial collaring project goal of 30 female caribou from the Muskwa caribou herd. Animals were captured from selected sites distributed throughout the study area; concentrated in the McDonald Creek, Flowering Lake, Nonda Creek, Tetsa River, Henry Creek, Ram Creek and Dunedin River areas (Madrone 2001).

An additional 11 animals were collared on October 21st and 22nd, 2001 by Talon Helicopters (Zvonko Dancevic and Brad Culling), assisted by Madrone Consultants Ltd. (Gillian Radcliffe, Tania Tripp and Jared Hobbs). Animals were captured in the Flowering Lake, Summit Lake, McDonald Creek, Eight Mile South of Tower and Yash Creek areas (Madrone 2002). No collaring was deemed necessary in 2002. A final collaring session took place in November of 2003. Five animals were collared by Brad Culling (net-gunner) and Zvonko Dancevik (QWEST Helicopters). Individual capture and collaring locations for all 46 animals are shown in Figure 2.

We had hoped to maintain a minimum of 25 collared animals over the duration of the project. However, while approx. 30 animals remained collared by the end of this year (2003-2004), only 16 of these are ones we now consider “active”. Inevitably there has been a dwindling of numbers of active collars as batteries fail or animals move right out of the study area altogether. Mortality was also higher in the second year than the first. We considered further collaring in winter 2002/2003, but decided the additional expense was not justified, at that time, given the number of active collars and that the field portion of the project was planned to wind-up in the fall of 2003. However, as the program could not be completed in 2003, we collared an additional five animals in fall of 2003, in an effort to keep the number of active collars over 20.

The overall condition of the 46 animals captured was fair to good. Body condition ratings (rump, ribs and withers) were given for 32 of the 46 animals. Pelage was brown and assessed as good for all animals. As well, minimal scarring was present on all 46 animals. Tooth wear was highly variable depending on the age of the animal.

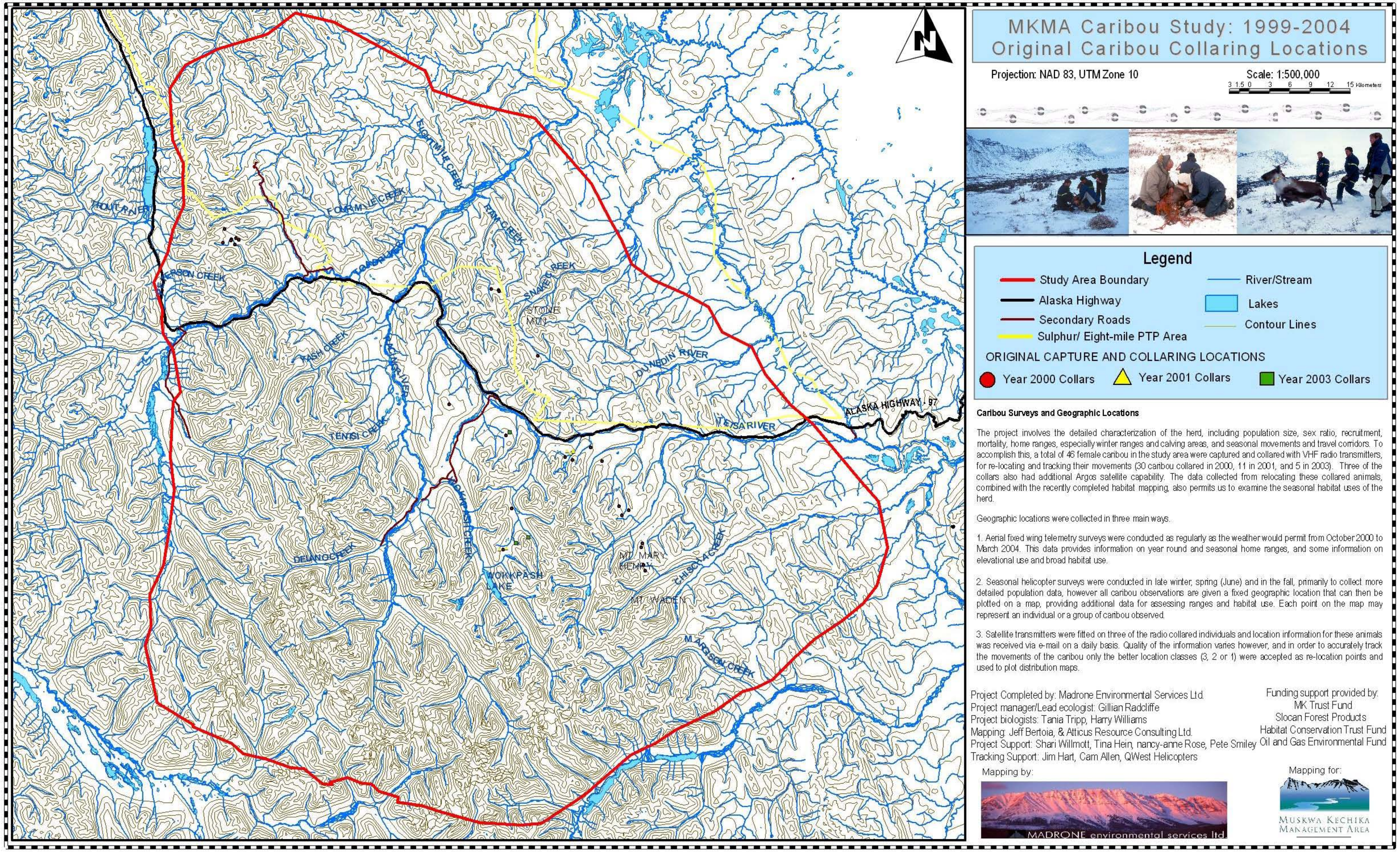

Figure 2: Original collaring locations.

5.2. Biological Samples

As per Helen Schwantje (provincial veterinarian) and Bryan Webster's (BC Parks) request, we attempted to collected blood, hair and fecal samples for each collared animal for Provincial studies. We were successful in collecting a total of 43 blood, 45 hair and 43 fecal samples. Fecal samples were separated for parasite as well as possible dietary analysis. No further analysis has been conducted at this time. However, blood samples and the data collected during collaring have been provided to a Ph.D. candidate studying large mammal genetics in northern B.C.

Four body measurements were collected during collaring in 2000: hind foot length, shoulder height, chest girth and total length. These same measurements were also collected again in 2001 and 2003 with the addition of neck girth. Measurements were taken as per *Hoofed Mammals of BC* page 77, figure 40 (Shackleton, 1999). Initial assessment of the measurements compares closely with those for woodland caribou cited in Shackleton (Table 3).

Table 3: Measurements of Caribou in the Study Area Compared to Provincial Averages.

Measurement	Shackleton Citation Mean (range) (sample size)	MK Measurements Mean (range) (sample size)
Total Length – female	200.7 cm (176-220) (n=70)	212.5 cm (183-240) (n=45)
Hind Foot – female	52.8 cm (38-66) (n=48)	58.4 cm (52-65) (n=45)
Chest – female	127.7 cm (118-144) (n=75)	128.8 cm (115-140) (n=44)
Shoulder – female	122.2 cm (103-139) (n=43)	121.2 cm (100-138) (n=45)
Neck - female	*	**46.7 cm (44-56) (n=16)

*Note: Neck girth is not given by Shackleton (1999).
**Note: Neck girth was not recorded in October 2000.

5.3. Caribou Relocation Data

5.3.1. Satellite Re-location Surveys

Three Argos satellite collars were installed in October 2001. Location information was received via e-mail on a daily basis, and included lat/long coordinates and an associated data quality class of 3, 2, 1, 0, A, B or Z (where 3 is the best signal class * (accuracy within 100 m) and Z is no location determined). In order to track the movements of the caribou only the better location classes (3, 2 or 1) were counted as satellite re-location points and used to plot distribution maps. A total of 1508 satellite re-location points (location class 3, 2, or 1) were received during the monitoring (over 18 months) with the Argos collars (October 22, 2001 to April 8, 2003). Collar ID 39M39 (Argos ID 20766 quit April 8, 2003) received 336 re-location points. Collar ID 40M40 (Argos ID 14200 quit December 10, 2001) received 48 re-location points. Collar ID 41M41 (Argos ID 26338 quit December 8, 2002) received 1124 re-location points (Table 6).

Table 4: Number of satellite re-locations for caribou with Argos collars, 2001-2003.

Animal ID	Satellite Location Class			Total # of Re-locations
	1	2	3	
39M39	100	124	112	336
40M40	11	26	11	48
41M41	403	420	301	1124
Total	**514**	**570**	**424**	**1508 data points**

* In Section 3.4 within this report, class 3 is described as being the worst signal class (500-1000m accuracy). Class 1 is described as being the best (accuracy within 100m).

5.4. Telemetry Re-location Surveys

5.4.1. Fixed-wing VHF re-locations

Since the initial collaring in October 2000, 104 aerial telemetry flights (51 re-location sessions) have been conducted by fixed wing and by helicopter between October 2000 and June 2004. A total of 905 VHF telemetry re-location points have been collected from aerial telemetry flights, with an average of 17.7 re-locations obtained per aerial survey session (~2 days of flying) (Table 4 and Figure 6). The 30 caribou collared in 2000 have been re-located an average of 22 times per individual (range of 2 to 45); the 11 caribou collared in 2001 have been re-located an average of 20.2 times per animal (range of 10 to 29); and the 5 caribou collared in 2003 have been re-located an average of 4.2 times per animal (range of 3 to 5) Aerial surveys were determined to be a relatively efficient means of tracking the animals on a regular basis.

Aerial sampling intervals for VHF re-locations ranged from 5 to >60 days among data sets. Stormy and windy conditions posed some logistical problems in the very mountainous study area, and surveys have had to be rather opportunistic, dictated to some degree by weather. They were therefore less regular than would be ideal.

Of the original 46 animals collared between 2000 and 2003, 9 collared animals were recently relocated (active) as of June, 2004 (one of these relocations was a mortality); a total of 16 are considered active; two collars have dropped off; three collars have failed (*i.e.,* originally presumed missing but subsequently observed during fieldwork); an additional 13 collared animals are considered missing in action (no signal received for at least 6 months); and 12 have died. Table 5 indicates the status of the collared animals as of the end of June, 2004.

It is possible that the 'missing' animals have a home range that is outside of our study boundary, and therefore are not within the re-location survey area. In one case a cow caribou with a white collar was seen in a mountain area some 70 km north of the northern study area boundary. Subsequent efforts to relocate this cow were unsuccessful. In another case it took 6 months to re-locate an animal that had left the area right after capture and then returned. It could also be that the missing collared animals have faulty VHF transmitters, which prevents us from re-locating them. We know this to be true for at least three caribou that have been visually re-located but the collars did not emit any signal, and hence the transmitters had clearly failed.

Table 5: Aircraft type, flight dates, and number of animals detected.

Aircraft	Flight Dates	# of Animals Re-located
Helicopter	October 22-24, 2000	30 Captured & Collared
Helicopter	October 25, 2000	N/A (census without telemetry)
Fixed Wing	November 14 & 19, 2000	12
Fixed Wing	November 27 & 29, 2000	27
Fixed Wing	December 27-29, 2000	27
Fixed Wing	January 10 & 12, 2001	12
Fixed Wing	January 17, 2001	15
Helicopter	January 25 & 27, 2001	24
Fixed Wing	March 13 & 14, 2001	26
Helicopter	March 24, 25 & 27, 2001	23
Fixed Wing	April 10 & 11, 2001	26
Fixed Wing	April 26 & 27, 2001	25
Fixed Wing	May 7 & 10, 2001	23
Fixed Wing	May 24 & 25, 2001	25
Fixed Wing	June 6 & 7, 2001	24
Fixed Wing	June 12 & 13, 2001	25
Fixed Wing	June 29 & 30, 2001	18
Fixed Wing	July 12 & 21 2001	19
Fixed Wing	July 29 & 31 2001	18
Fixed Wing	August 13 &14, 2001	18
Fixed Wing	August 29 & 30, 2001	20
Helicopter	October 20, 2001	3
Helicopter	October 21 & 22, 2001	11 Captured & Collared
Fixed Wing	December 13 & 15, 2001	22
Fixed Wing	January 13, 2002	14
Fixed Wing	January 29 & 31, 2002	25
Fixed Wing	February 18, 2002	8
Helicopter	February 20, 21 & 22, 2002	26
Fixed Wing	February 23, 2002	16
Fixed Wing	March 21 & 22, 2002	25
Fixed Wing	May 6 & 7, 2002	26
Fixed Wing	May 22 & 23, 2002	23
Fixed Wing	June 2 & 3, 2002	21
Helicopter	June 10 & 11, 2002	23
Fixed Wing	July 6 & 7, 2002	20
Fixed Wing	July 23 & 24, 2002	15
Fixed Wing	Aug. 30 & Sept. 5, 2002	16
Fixed Wing	September 11 & 12, 2002	15
Helicopter	October 23 & 24, 2002	18
Fixed Wing	Nov. 23-29, 2002	7
Fixed Wing	Dec. 4, 2002	7
Fixed Wing	February 2 & 5, 2003	13
Helicopter	March 4, 5, 6, 7, 2003	12
Fixed Wing	March 24 & 25, 2003	11
Helicopter	June 15 & 16, 2003	20
Fixed Wing	Sep 21 & 30, 2003	11
Helicopter	Oct 25 & 26, 2003	9
Helicopter	Nov 11, 2003	5 Captured & Collared
Fixed Wing	Dec 14, 2003	6
Fixed Wing	February 24 & 25, 2004	13
Fixed Wing	April 9th &15th, 2004	13
Fixed Wing	June 7th, 2004	5
Helicopter	June 16th, 2004	9
Total	**Days = 104**	**Data points = 905**

Table 6: Status of Collared Caribou 2000-2004.

Tag ID	Frequency	Collaring Date	# of Re-locations (includes original collaring location)	Last Re-location Date	Current Collar Status
1M1	148.300	Oct 22, 2000	10	May 25, 2001	mortality
2M2	148.328	Oct 23, 2000	19	Oct 24, 2002	no signal
3M3	148.353	Oct 24, 2000	33	November 23, 2002	missing
4M4	148.375	Oct 24, 2000	30	June 12, 2002	mortality
5M5	148.401	Oct 23, 2000	13	June 29, 2001	missing
6M6	148.419	Oct 22, 2000	9	Oct 23, 2002	no signal
7M7	148.452	Oct 24, 2000	18	Aug 30, 2001	missing
8M8	148.478	Oct 23, 2000	34	June 15, 2003	missing
9M9	148.501	Oct 23, 2000	39	April 15, 2004	weak signal
10M10	148.525	Oct 22, 2000	44	June 16, 2004	active
11M11	148.552	Oct 23, 2000	24	December 4, 2002	missing
12M12	148.577	Oct 22, 2000	45	June 16 , 2004	active
13M13	148.602	Oct 22, 2000	14	October 25, 2003	no signal
14M14	148.626	Oct 23, 2000	17	June 11, 2002	missing
15M15	148.651	Oct 23, 2000	4	Dec 29, 2000	mortality
16M16	148.677	Oct 24, 2000	20	Aug 29, 2001	missing
17M17	148.700	Oct 22, 2000	29	July 23, 2002	mortality
18M18	148.725	Oct 24, 2000	20	June 15, 2003	weak signal
19M19	148.753	Oct 25, 2000	5	Jan 27, 2001	missing
20M20	148.776	Oct 22, 2000	28	July 23, 2002	mortality
21M21	148.802	Oct 22, 2000	33	June 15, 2003	missing
22M22	148.825	Oct 24, 2000	2	Nov 29, 2000	mortality
23M23	148.850	Oct 24, 2000	25	May 6, 2002	missing
24M24	148.876	Oct 24, 2000	39	April 15, 2004	active
25M25	148.902	Oct 25, 2000	14	June 29, 2001	mortality
26M26	148.926	Oct 25, 2000	16	Aug 29, 2001	missing
27M27	148.953	Oct 24, 2000	16	Feb 22, 2002	dropped
28M28	148.976	Oct 24, 2000	22	May 22, 2002	mortality
29M29	149.001	Oct 24, 2000	11	May 25, 2001	dropped
30M30	149.028	Oct 25, 2000	27	October 25, 2003	active
31M31	148.298	Oct 21, 2001	13	Aug 30, 2002	mortality
32M32	148.312	Oct 21, 2001	22	February 25, 2004	active
33M33	148.341	Oct 21, 2001	23	October 25, 2003	**false mortality signal**
34M34	148.388	Oct 21, 2001	14	Oct 23, 2002	mortality
35M35	148.651	Oct 21, 2001	24	June 16, 2004	active
36M36	148.827	Oct 21, 2001	10	May 22, 2002	mortality
37M37	148.902	Oct 21, 2001	28	June 16, 2004	mortality
38M38	149.002	Oct 21, 2001	28	June 16, 2004	active
39M39	149.299	Oct 21, 2001	13 (336!)	July 23, 2002	missing
40M40	149.100	Oct 21, 2001	29 (48!)	June 7, 2004	vhf active
41M41	149.200	Oct 22, 2001	19 (1124!)	Sept 30, 2003	vhf active

Table 6 (cont'd): Status of Caribou Collared During 2000-2003.

Tag ID	Frequency	Collaring Date	# of Re-locations	Last Re-location Date	Current Collar Status
42M42	148.953	Nov 11, 2003	5	June 16, 2004	active
43M43	148.975	Nov 11, 2003	5	June 16, 2004	weak signal
44M44	148.700	Nov 11, 2003	4	June 16, 2004	weak signal
45M45	148.375	Nov 11, 2003	4	June 16, 2004	active
46M46	148.826	Nov 11, 2003	3	April 15, 2004	active
		Total # of VHF Re-locations	**904 (should be 905!!)**		**Mortalities = 12**
					Dropped Collars = 2
					No signal = 3
					Missing for >6 months = 13*
					Active collars = 16
					Total collars = 46

* Date in brackets refers to last time VHF signal was heard
! refers to number of Argos Satellite re-locations

5.5. Helicopter Surveys

In addition to VHF telemetry re-location flights, a series of detailed aerial survey flights were completed between 2000 and 2004 in order to characterize important life stages of the species. These were a spring cow/calf survey in June, a fall rut count (October), and a late winter population survey (between January and March). The late winter survey was not conducted in 2004 due to lack of funds. Additional fixed wing flights were conducted in February and April 2004 (two flights for each session)

An overview of the location data collected from the fixed wing VHF telemetry surveys and from the helicopter surveys combined is presented in Figure 6. This gives a good visual overview of the overall range and core areas of caribou activity within the study area, but does not distinguish between seasonal uses or different years.

5.6. Home Range and Habitat Use Analyses

Detailed seasonal and individual habitat analyses have not yet been completed, as the focus in the past year has been on completing the habitat map base. The broad habitat unit base map is now complete and ready for the final project stage of project: habitat analysis, home range estimates, seasonal habitat models, and recommendations for inclusion in pre-tenure plans.

Initial data from year one showed that animals moved highly variable distances between re-locations, with some animals moving great distances and others remaining close to where they were originally captured. Distances were measured direct between points in km using ArcView 3.1 (underestimating the actual distances moved). Initial observations are borne out by subsequent data collection. Indeed, preliminary assessments appear to suggest that the animals fall into one of three groups:

- Animals that range widely and appear to show little fidelity to seasonal ranges; their movements are unpredictable and highly variable
- Ones that also range widely, making long distance movements, but show considerable fidelity to either calving and/or wintering ranges, travelling long distances to return to the same general areas at these times;
- Animals that generally stay within a much smaller range, usually within one watershed, utilizing different elevations at different times, but never making long distance movements.

With inclusion of data from the cow-calf and fall rut census surveys in 2003, three years of data covering each season, are available on which to base analyses of home ranges, travel corridors, and seasonal habitat requirements.

5.6.1. Calving habitat

Calving occurs at relatively high elevations in the mountains. Cows with new calves are typically found in high alpine valleys, which are generally steep-sided, with abundant talus. Individual cows appear to head even higher up onto fairly steep slopes, often on talus, to actually give birth. They then rejoin the other females in the valley directly below where they calve.

As for calving habitats, detailed habitat analyses of fall and winter habitats have not yet been completed. However, with the habitat base now complete, in conjunction with the rutting season and winter relocations, this can be used to more adequately characterize the seasonal ranges and habitats. Figure 9 illustrates the VHF fixed wing and helicopter census data collected during the late winter for the study area, and in relation to the Sulphur-Eight Mile Pre-tenure Planning Area boundary.

5.6.2. Travel Corridors

Information collected to date has helped to clarify which valleys receive high caribou use and when and where main caribou movements occur. For example, data suggests that there are a number of well-used travel corridors in the study area, especially the valleys of the Wokkpash River, Nonda, and Eight Mile Creek.

5.7. Mortality

Of the 12 known mortalities that have occurred over the period of this study, two occurred during the first fiscal year (October, 2000 to March, 2001), another two in the second fiscal year (April, 2001 to March, 2002), seven in the third fiscal year (April, 2002 to March, 2003), and one in the fourth (April, 2003 to June, 2004) (Table 7).

Table 7: Known Mortalities of Collared Caribou.

Collar Date	Tag ID	Mortality Date	# Months Collared	# Locations Obtained	Likely Cause of Death
October 22, 2000	22M22	Nov 29, 2000	1	2	Wolf predation
October 22, 2000	15M15	Dec 29, 2000	2	4	Undetermined
October 22, 2000	1M1	May 25, 2001	7	10	Undetermined
October 22, 2000	25M25	June 29, 2001	9	14	Undetermined
October 22, 2000	36M36	May 22, 2002	18	9	Grizzly bear
October 21, 2001	28M28	May 22, 2002	7	22	Wolf/Grizzly bear
October 22, 2000	4M4	June 12, 2002	19	30	Breech birth
October 22, 2000	17M17	July 23, 2002	20	28	Vehicle
October 22, 2000	20M20	July 23, 2002	20	28	Undetermined - collar not recovered
October 21, 2001	31M31	Aug 30, 2002	10	12	Undetermined - collar not recovered
October 21, 2001	34M34	Oct 23, 2002	12	13	Wolf predation
June 16, 2004	37M37	June 16, 2004	32	28	Possible wolf predation

During the first season of tracking collared caribou, two mortalities were investigated. The mortality in November of 2000 was a result of wolf predation. The cause of another mortality in December was unknown. The animal was completely consumed by the time we were able to reach it, more than a month after the mortality signal was first detected. Poor weather conditions and difficult access prevented us from investigating the mortality sooner. Two more of the collared animals died in the spring (May and June, 2001), with cause of death undetermined.

In early June, 2002 we retrieved collars from animals #4, #28 and #36. One cow (#4) had died during calving; possibly a breech birth. She had been observed alive on June 10th high on a mountain slope, on a tiny shelf on an otherwise relatively steep talus/rock face. She was giving birth at that time but appeared to be having difficulty in the delivery. She had been a healthy young female when collared in fall 2000.

Animal Number 28 died south of Wokkpash Lake, and had been fed on by both wolves and bear. Number 36 died in the Tetsa River area, of uncertain cause but likely by predators, then was washed down the river for a kilometer or so. Animal #17 was killed by vehicle on the Alaska Highway. Two additional mortalities detected in July and August 2002 could not be located as the signal had stopped transmitting between detection of mortality signals from a fixed wing and subsequent helicopter based investigation. In October of 2002 another animal appeared to have been predated by wolves. Animal number 37 died in the upper Wokpash area, and was discovered on June 16th 2004. The carcass had probably been there for over one month, as there was very little in the way of remains. It is probable that this animal was killed by wolves, indicated by the presence of wolf scat, which also appeared to be at least one month old.

In summary, from October 22, 2000 to October 22, 2001, 30 animals were collared of which 4 mortalities (13%) were confirmed. From October 2001 to 2002, 37 animals were collared, and 7 died (~19% mortality). Animal survival from October 2002 to 2003 improved greatly, with 0% mortality detected. From October 2003 to June 2004, one animal died. Thirteen of the collared animals, however, were and still are "Missing In Action" (*i.e.*, not relocated for 6 consecutive months). In addition, three collars are no longer transmitting a signal, four others have very weak signals (barely detectable hovering over the animal), and one has a false mortality signal that requires visual confirmation of status. Some of these missing animals are likely dead.

An additional five mortalities of caribou without collars were investigated during the study, and included two road kills adjacent to the highway. Another mortality was an adult bull caribou located along the edge of a frozen lake during the fall rut census. Judging from the well-worn teeth, and what was left of the body, the animal was likely an old bull in poor condition that died of natural causes. There was no evidence of wolf or coyote scavenging around the carcass, as it was relatively intact. During vegetation work for the SBW and AT classification project by Madrone, an intact adult skeleton was located in the Alpine Tundra. Cause of death was undetermined. As well, during ground surveys for caribou in January 2001 one mortality was observed adjacent to a well-used wet mineral lick. Cause of death was also undetermined.

6.0 CONCLUSIONS AND RECOMMENDATIONS (FUTURE DIRECTIONS)

6.1. Using the Information

6.1.1. Public Information/Participation/Partners

Over the past three years we have attempted to disseminate project information to locals, industry, and government contacts through a series of public presentations, a poster, and internet web-site information. During the initial year of the project, Madrone Consultants Ltd. produced a project website linked to the main MK website (www.slocan.com\homepage.html). Information specific to the Muskwa Caribou herd study, however, does not appear to be available through this site any longer. Public presentations, using Power Point and slides, were conducted in Toad River (2001 and 2002) and Fort St. John (2002). In addition, a poster was designed in 2001 to present at an Oil and Gas Conference in Fort Nelson. In addition to these products, regular progress reporting has been completed, as well as the year end data reports. Information tailored to specific needs has also produced upon request.

6.1.2. Support for Other Projects

The data and products of this project are available to provide input into other studies, research, and management planning exercises. In addition to providing information for Pre-Tenure Planning (see below), prior project reports and information have also been provided to support a Conservation Area Design (CAD) exercise being conducted for the MK. The biological samples collected during caribou capture and collaring have been released by the provincial vet to Brian Churchill who is conducting a DNA study. This data will therefore hopefully serve a valuable purpose in contributing genetic information on northern caribou herds. We have also provided the data collected in conjunction with the capture and collaring, including locations, animal measurements and other observations, and this will hopefully support future analyses.

6.1.3. Management Applications

Development and management of the land and resources in the MKMA must be conducted in accordance with the Muskwa-Kechika Management Plan. Under this plan landscape level "pre-tenure planning" is a legislated pre-requisite before any oil and gas exploration, development or allocation can occur. The core study area for this caribou work covers all of Stone Mountain Resource Management Zone (RMZ) of the Muskwa-Kechika, and the majority of the Eight Mile / Sulphur and Churchill RMZ's, both of which are "Pre-tenure Planning Areas" (PTP Areas 2 and 3 respectively).

Pre-tenure Planning is designed to identify sensitive issues that need to be considered in planning oil and gas development, and is intended to ensure the maintenance of identified values through managing the activities to minimize impacts, developing suitable mitigation strategies, using appropriate technologies, and coordinating access planning and management. The Draft Guide to Pre-Tenure Planning identifies the key environmental deliverables of a pre-tenure plan as:

- An inventory of biophysical information and resource values and any associated objectives (descriptive and interpretive information), and
- A description and location of sensitive environmental values and the expected impacts of oil and gas development on these (evaluative information).

An important goal of this project is to collect information that will permit the evaluation of proposed development impacts, and that will provide a solid foundation for making decisions regarding caribou management in the area. Figures 8 and 9_ both show the Sulphur-Eight Mile Pre-Tenure planning boundary in relation to some of the caribou location data; the known calving areas and the late wintering areas. The maps thus illustrate highly sensitive areas where disturbance to the animals in June (for calving season), or in January to April (late winter season) would be especially detrimental.

This is just one illustration of how the information gained from this study can be applied in a management context, and when assessing potential impacts of proposed developments. Far more information is available form the large project dataset, but at this time lack of funding prevents further more detailed analyses and product development.

7.0 FUTURE RESEARCH

Detailed analysis of the substantial data set for population size, demography and trends, including productivity rates and calf and adult survivorship, can now be completed (subject to funding). Analyses can also be conducted on other herd attributes such as group size by season, and seasonal home range fidelity. The habitat map base will provide the support for more detailed analyses of seasonal habitat preferences.

Observations and trends must be considered preliminary in nature. Several more years of good field data collection are ideally needed to develop more reliable population estimates, detect trends, and gather an adequate picture of caribou habitat use, encompassing annual variability. Longer term studies are needed for large mammal populations such as this in order to accommodate year to year variability, and the fact that population responses to events, including weather and changes in predation, often take a number of years to be affected.

8.0 CONCLUSION

With the collaring of 46 caribou between October of 2000 and November 2003, four years of regular telemetry data collection, and Caribou Habitat Mapping, is now completed. The project is now entering the final phase, which will focus on habitat analysis, with field data collection planned to terminate in the late fall of 2004, subject to funding availability.

Activities for this final year therefore primarily will focus on completion of a variety of in-progress activities, including completion of the habitat and range and use analyses. The following specific activities are proposed for project completion 2004/2005:

- Develop a monitoring program.
- Disseminate information (e.g., publication submissions)
- Develop extension tools for public presentations (e.g., update Power Point presentation and Poster).

Data gathered during the four years of research has solidly established movement and habitat use patterns in the area, and demographic data is giving preliminary indications of population trends. Ideally several more years of good field data collection at a lower intensity, and periodic future monitoring, are needed to get adequate predictors of population trends. The habitat base should however be well established, and should only need periodic updates to reflect any major changes in habitat, such as large fires.

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APPENDIX 1: DETAILED DESCRIPTIONS OF ECOSYSTEM UNITS BY SUBZONE

The following section provides indicates the BEC site series included in each habitat type along with a description of the habitat type itself. Tree species abbreviations are used frequently (Table 1).

Table 1. Tree codes applicable to the area of study.

Common name	Latin name	Code
Black spruce	*Picea mariana*	Sb
White spruce	*Picea glauca*	Sw
Lodgepole pine	*Pinus contorta* var. *latifolia*	Pl
Tamarack	*Larix laricina*	Lt
Subalpine fir	*Abies lasiocarpa*	Bl
Trembling aspen	*Populus tremuloides*	At*

*not to be confused with the abbreviation for Alpine Tundra (AT).

Closed forest (CF)	
BEC Subzone & Variant	**Broad Ecosystem Units**
BWBSdk	• SM Sw - Knight'splume – Stepmoss • BL Sb – Lingonberry - Knight's plume • BF Sb–Labrador tea–Moss (north aspect)
BWBSmw2	• AM SwAt – Step moss • BK Sb – Lingonberry – Knight's plume moss • BL Sb–Lingonberry–Coltsfoot (north aspect)
BWBSwk3	• FH Subalpine fir - Black huckleberry
SWBmk & mks	• SB Sw - Willow-Birch
Description	Closed forests are typically conifer dominated, and are more or less continuous at low elevations in the major valleys. Such forests can extend up into the SWBmk but become more and more open with increasing elevation. On warm aspects trembling aspen is common, especially after forest fires or prescribed burns. The latter situation is very common in the Toad River region. The main tree species are Sw, Bl, Pl, and At. In mature conifer forests thick mosses covers are common along with scattered willows and herbs. Aspen forests, on the other hand, have a richer cover of herbs and grasses including fireweed, delphinium, western meadowrue and cowparsnip (on moist, rich sites).
Habitat value(s)	• winter use • arboreal lichens

	• terrestrial lichens, especially on dry, pine sites (uncommon in study area) • horsetails on moist sites • more predators, less vision (can't see the forest for the trees!)

Moist to Wet Forest	
BEC Subzone & Variant	**Broad Ecosystem Units**
BWBSdk	• SH Sw - Currant-Horsetail • BT Sb-Labrador Tea–Sphagnum
BWBSmw2	• BB Sb–Feathermoss–Bluebells • BS Sb–Cloudberry–Sphagnum • BW Sb–Willow–Glow moss • SD Sb - Devil's Club • SH Sw - Currant-Horsetail • TB Lt-Buckbean • TH Lt – Horsetail
BWBSwk3	• LB Pl – Bluejoint
SWBmk & mks	• SH Sw-Cinquefoil-Horsetail • SS Sw-Willow-Stepmoss
Description	This unit includes site series that occur on lower slopes, seepage areas, and level to gently sloping valley bottom forests including riparian. These are the most productive sites for conifers, but boast few deciduous trees. Understory vegetation of shrubs, herbs and mosses is well developed and diverse. Lower slope seepage forests are often rich in horsetails, particularly scouring rush (*Equisetum scirpoides*) which is eaten by the caribou.
Habitat value(s)	• food (horsetails, lichens) • adjacent to valley bottom wetlands

Open Forest	
BEC Subzone & Variant	**Broad Ecosystem Units**
BWBSmw2	• LL Pl–Lingonberry–Velvet-leaved blueberry • LC Pl–Crowberry
BWBSwk3	• LC Pl–Crowberry
SWBmk	• PL Sw-Birch-Cladina • SH Sw-Cinquefoil-Horsetail • SK Sw-Juniper-Wildrye • SS Sw-Willow-Stepmoss • SW Sw-Lupine-Stepmoss
SWBmks	• SH Sw-Cinquefoil-Horsetail • SK Sw-Juniper-Wildrye

	• SS Sw-Willow-Stepmoss
Description	The open forests are typically found at higher elevations as a transition between continuous forest and alpine. These are areas rich in grasses, herbs, lichens and shrubs, due to the open nature of the stands. On warm aspects species such as trembling aspen and juniper are found. These areas are often referred to as parkland. The trees become more and more grouped into "tree islands" with increasing elevation. Arctic lupines, sagewort, Altai fescue, alpine milk-vetch, violas, and diverse-leaved cinquefoil are common plants.
Habitat value(s)	• Abundant forage • Good vision for predators • Close to tundra and higher elevations • Abundant terrestrial lichens • Ease of travel

North Aspect Open forest (OFn)	
BEC Subzone & Variant	**Broad Ecosystem Units**
SWBmk	• SP Sw–Polargrass • SC "open stunted subalpine woodland" • SL Sw-Willow-Crowberry • SL Sw-Willow-Crowberry
SWBmks	• SL Sw-Willow-Crowberry
Description	These are cold, nutrient poor sites with pockets of permafrost. However, due to the open nature of the stands, terrestrial lichens (*Cladina* spp.) are often abundant. Herbs and grasses are sparse, but willows and scrub birch is common. Snow can remain on these north aspects well into the growing season. The dominant trees are white and black spruce, however they are often stunted and slow growing due to the cold soil.
Habitat value(s)	• Abundant lichens • Presence of scrub birch and willows • Well developed crust on late season snow – easier travel • Cool in summer • Good vision

Wetlands (WL)	
BEC Subzone & Variant	**Broad Ecosystem Units**
BWBSmw2	• SS Scrub birch–Willow–Water sedge fen
All subzones	• FE Fen • LA Lake • RI River

Description	The most common wetlands in the study area are nutrient rich, sedge-dominated fens. Wetlands also include swamps, and shrub-dominated fens. Rivers and lakes are included as wetlands due to high amount of forage found along their shores. Forage is of high quality. Plants include sedges, buckbean, cattail, and bulrush. In winters of light snow the tops of these plants will be available to browsing animals.
Habitat value(s)	• Not used by caribou as often as moose • Easy areas for travel in winter

Grasslands (GR)	
BEC Subzone & Variant	**Broad Ecosystem Units**
BWBSmw2	• JB Tall Jacob's ladder–Bluejoint • ME Wet meadow
BWBSwk3	• JB Tall Jacob's ladder–Bluejoint
SWBmk	• JB Tall jacob's ladder-Bluejoint • MA Mountain avens-Arctic lupine
Description	Grasslands typically occur at higher elevations on dry, warm aspects. Soils are often thin, but nutrient-rich. Dominant grasses include Altai fescue, polargrass, western fescue, Rocky Mountain fescue, and alpine bluegrass. Herbs and willows are also common. Drier sites will have kinnickinnick and dwarf blueberry. Well-developed grasslands can occur at surprisingly high elevations given the right combination of slope and aspect.
Habitat value(s)	• Warmer temperatures in winter • Forage all year round in windy areas • High quality forage

Shrublands and scrublands (SH)	
BEC Subzone & Variant	Broad Ecosystem Units
BWBSdk	• WV Willow – Sitka valerian
BWBSmw	• SB Sandbar Willow • WA Willow–Alder • WB Avens–Dwarf Willow
BWBSwk3	• BA Bog blueberry-Alpine bearberry • WA Willow–Alder
SWBmk	• AW Avens-Dwarf willow • WA Willow-Mountain arnica • WH Willow-Common horsetail • WS Willow - Sedge • WV Willow-Sitka valerian • WY Willow - Yellow mountain avens • WM Willow-Mountain sagewort

SWBmks	• BS Birch-fescue • SA Scrub birch - Altai fescue • SC Bl - krummholz • WA Willow-Mountain arnica • WV Willow-Sitka valerian • WM Willow-Mountain sagewort
Description	Shrublands typically occur in subalpine areas and upper slopes. Mosaics of open forest, shrubland, and grassland are common. The main shrub species are willows, scrub birch, and krummholz conifers (Bl and Sw). Stunted aspen occasionally occurs on warm, steep, coarse soils.
Habitat value(s)	• High quality forage • Close to grasslands and lichen rich areas

Tundra	
BEC Subzone & Variant	**Broad Ecosystem Units**
SWBmks	• AW Entire-leaved mountain avens-Netted willow • MA Mountain avens-Arctic lupine
AT	• AW Avens-Dwarf willow • MA Mountain avens-Arctic lupine • ME Wet meadow • ML Moss campion-Limestone sunshine lichen • WV Willow-Sitka valerian
Description	Tundra, by definition, occurs primarily in the Alpine – Tundra zone, although elements of it are found in the SBSmks. Likewise elements of lower elevation grass and shrublands are found in the tundra. Tundra is defined both by physiognomy (life-form) and species composition. The majority of herbs and shrubs are dwarf, and have adaptations to the harsh climate found at higher elevations. The diversity is nevertheless rich, and forage quality can be high, depending on soil characteristics, slope, aspect, and moisture. Ground lichens are numerous and alpine species such as few-finger lichen, rock worm lichen, tumble lichen, curled cetraria are common. Grasses include Altai fescue and alpine sweetgrass, and alpine bluegrass. Shrubs are typically dwarf willows, stunted scrub birch, and dwarf blueberries. Scattered krummholz may be present.
Habitat value(s)	• Insect protection due to wind • Winter forage in snow free areas • Escape terrain is often close • Close to calving areas • High quality forage in summer months • Cool summer temperatures

Sparsely Vegetated	
BEC Subzone & Variant	**Broad Ecosystem Units**
BWBSwk3	• FL Fragrant wood-fern – Lichen
All Subzones	• CL Cliff • RO Rock outcrop
AT	• GL Glacier
Description	This unit includes steep rocky peaks, cliffs, talus slopes, and boulder fields. Vegetation is sparse, but pockets of high quality forage exist, especially on the lower alpine slopes. Climate is very harsh and windy, however snow-free ridges are common.
Habitat value(s)	• Predators are scarce • Calving frequently occurs in narrow alpine valleys • Some forage is available in snow-free areas