Home Range and Habitat Selection of Female Caribou in the Telkwa Mountain Range, British Columbia

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Prepared by

A. Roberts[1], M. Leung[2], L. Turney[1] and N. MacLean[3]

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[1]Ardea Biological Consulting, Smithers, BC
[2]Wild Tracks Ecological Consulting, Smithers, BC
[3]LGL Limited, Environmental Research Associates, Whitehorse, YT

Executive Summary

From 1997 to 1999, 32 woodland caribou (*Rangifer tarandus caribou*) from the Sustut herd were transplanted to the Telkwa Mountains of west-central British Columbia to augment the nearly extirpated Telkwa caribou herd. Thirty-nine caribou were radio-collared and monitored from 1997 to 2002 to gather data on population demographics and survival. These data were used to determine habitat selection and home ranges and will be used to make recommendations in access management and forest harvesting plans that would protect the Telkwa caribou herd.

Habitat selection and home range from radio-collar data were analysed by season for each year. Seasonal home ranges were estimated by the 50% and 95% kernel method. Home range sizes were analysed with a single-factor ANOVA on the 50% kernel home range. The only seasons with significantly different home range sizes were spring and calving when ranges were limited in size. Habitat selection was determined by comparing habitat-use data collected from radio-telemetry locations, to habitat available, defined as the 100% minimum convex polygon of all radiolocations. Four variables were chosen for characterizing habitat selection: aspect classes, slope classes, biogeoclimatic zones, and broad ecosystem types. We first analysed data to see whether animals chose similar habitats within seasons each year, then we used the log-likelihood Chi-squared test to determine whether overall selection occurred. In general, the data indicate that caribou in the Telkwa Mountains select cool aspects, moderately steep slopes, alpine tundra and high elevation forests in greater proportion to their availability.

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INTRODUCTION

All caribou in British Columbia (BC) belong to the woodland subspecies (*Rangifer tarandus caribou*), which can be further divided into two different ecotypes, the mountain ecotype and the northern ecotype (Stevenson 1991). Mountain caribou live in south-eastern and east-central BC and spend most of the year at high elevations in subalpine forests and alpine habitats. Mountain caribou winter in high elevation habitat and forage almost exclusively on arboreal lichen because snow prevents access to terrestrial lichens (Stevenson *et al*. 1994). Northern caribou live in the northern and west-central areas of British Columbia and in west-central Alberta. They generally inhabit mountainous areas in the summer and low elevation pine forests or windswept alpine areas during winter; however, the proportion of time spent in low elevation forests versus windswept alpine areas varies between individuals, populations and years (Cichowski 1993, Wood 1996). In winter, northern caribou appear to forage primarily on terrestrial lichens in relatively young stands (Johnson 2000, Cichowski 1993), but they also use arboreal lichens depending on snow conditions and lichen abundance (Johnson 2000, Poole *et al*. 2000). The use of arboreal lichen diminishes in northern boreal ecosystems and away from Englemann Spruce – Sub-alpine Fir forests (Farnell 1990, Florkiewecz *et al.* in prep). Snow depth and density can affect the availability of caribou winter forage. Deep snow may prevent cratering for terrestrial lichens, while crusted snow may provide a platform on which to reach arboreal lichens. Yearly variations in snow depth and density are suggested by Himmer (2000) to reflect the observed changes in patterns of caribou winter range use .

The estimated population of caribou in 1996 in British Columbia was 14,000 – 17,000 animals (Siep and Cichowski 1996) and is believed to be substantially reduced from historic populations (Bergurud 1978 from Siep and Cichowski 1996). Caribou have been eliminated from about 15% of their historic provincial range and some currently occupied habitats have experienced population declines (Siep and Cichowski 1996). In May 2002, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) upgraded the designation of the Northern Mountain Caribou Population (including the Telkwa Caribou Herd) to a species of "Special Concern". This designation was increased from "Not at Risk" due to increasing pressure resulting from human activities such as forestry, roads, and development in the range of this population. Provincial Tracking Lists of the British Columbia Conservation Data Centre designate Northern Woodland Caribou as a Blue listed species that is particularly sensitive to human activities. The Northern Woodland Caribou population currently appears stable; although wildlife managers are actively managing the populationsto prevent deterioration.

The Telkwa Mountains caribou herd (Telkwa herd) represents a valuable resource due to its proximity to urban centres and because of the importance in maintaining genetically viable populations of caribou in the face of encroaching urban developments and habitat fragmentation. The Bulkley Forest District Land and Resources Management Plan (Bulkley Valley Community Resources Board [BVCRB] 1996) provided direction through a public planning process to develop a "comprehensive plan to enhance and sustain a viable caribou population" (BVCRB 1996:68) within the Telkwa planning unit. Due to evidence in the mid 1990's that the Telkwa herd was in danger of extirpation, the management plan was to include both augmentation of the herd by transplanting animals and management of both industrial and recreational activities to protect habitat and animals.

Caribou were relocated over several years, and a number of caribou were collared with VHF radio collars. Caribou were monitored on an approximately bi-monthly schedule and a telemetry location database maintained. This report has been produced as a summary of the recovery program and a review of population distribution, age and sex survival, seasonal movements, habitat use, and home range analysis.

Goal and Objectives

The goal of this project is to complete a summary report for all available information on the Telkwa Caribou Herd Recovery Program and to analyse seasonal habitat selection and evaluate Home ranges. Specific objectives to achieve this are:

1. To review and summarize background information and existing information on the Telkwa Caribou herd and Recovery program;
2. To identify seasons for the Telkwa caribou herd and quantify seasonal home ranges;

3. To evaluate resource selection at a landscape scale;
4. To compare seasonal habitat selection between years and try to correlate annual seasonal selections with climatic conditions;
5. To compare seasonal habitat selection with other herds that are in the Skeena Region;
6. To make landscape management recommendations that ensure the integrity of habitats required by caribou and to make recommendations for the direction of future projects to fill in information gaps for the Telkwa Caribou Herd.

SUMMARY OF THE TELKWA CARIBOU HERD RECOVERY PLAN

Introduction

The following sections outline the work completed to date on the development and implementation of the Telkwa Mountains Caribou Herd Recovery Plan. This summary describes the rationale behind the recovery plan, and the various projects and management initiatives that that have initiated since 1997.

Maintaining the distribution and abundance of indigenous species of wildlife falls within the mandate of the Wildlife Branch of the Ministry of Water, Land and Air Protection (WLAP), who initiated the Telkwa Caribou Herd Recovery Plan (TCHRP) in 1997 after it was evident that the Telkwa caribou herd was in serious danger of extirpation (TCHRP 1998). The goal of the TCHRP is to work toward a genetically viable population of caribou in the Telkwa Mountains. Specific objectives that were outlined at the beginning of the TCHRP to achieve this goal included:

1. Augment the existing population by transplanting caribou into the area from the Sustut/Chase herd;
2. Identify seasonal movements, distribution and habitat requirements by monitoring radio collared animals, using fixed winged aircraft to relocate collared animals;
3. Implementing access control measures within the recovery area to minimize disturbance of animals;
4. Ensuring species timber harvesting guidelines within the recovery area;
5. Monitoring base population numbers and calf recruitment;
6. Determining timing and causes of mortalities by monitoring animals fitted with motion sensitive radio collars; and
7. Conducting lichen abundance surveys for management of winter foraging habitat.

The Telkwa herd represents a particularly valuable resource to the residents of British Columbia for several reasons. The Telkwa Mountains comprise prime woodland caribou and goat habitat only 15km from the major transportation corridor of Highway 16 and close to the urban centres of Smithers, Telkwa, and Houston. The proximity of caribou and goats to these centres makes these wildlife and their habitats extremely valuable for recreational use. A large and increasing proportion of the economy in the Bulkley Valley is derived from tourism and a self-sustaining caribou population in the Telkwa Mountains would enhance the image of the Bulkley Valley as a destination with high natural beauty and wildlife values (Theberge and Oosenbrug 1977, TCHRP 1997). Harvest for native sustenance requirements could be considered if the Telkwa herd increases sufficiently in size where some harvest could be sustained and the Telkwa herd also provides an opportunity to increase understanding of factors that influence population processes in small, isolated caribou populations. Protecting the Telkwa herd is also important because residents of the Bulkley Valley have indicated, through a pubic planning process, that they feel it is important to maintain a caribou population in the Telkwa Mountains.

The TCHRP proposed management actions designed to 1) reverse recent declines in size of the Telkwa herd by augmenting the population with caribou from another caribou population, 2) increase understanding of factors influencing population growth rates by frequent monitoring of radio-collared caribou, and 3) protect caribou habitat by modifying industrial activities and reducing potential disturbance to caribou arising from increasing human access into and recreational use of the Telkwa Mountains (TCHRP 1998).

In the fall of 1997, WLAP assembled a Telkwa Caribou Recovery Team consisting of wildlife biologists and managers responsible for completion of the TCHRP and identification of a Telkwa Caribou Herd Recovery Project Area (TCHPA). The team developed a transplant plan (Skeena Wildlife Program 1997) that outlined the strategy and implications of transplanting caribou from another herd into the Telkwa range. The transplant plan evaluated potential risks of introducing parasites or diseases, alteration of the genetic composition of the existing herd, increased competition with existing wildlife or livestock, and potential damage to habitat. It was concluded that potential risks of transplanting caribou were outweighed by the risk of extirpation of the Telkwa herd. Between the fall of 1997 and early 1999, caribou were transplanted from the Sustut-Chase herd to the Telkwa Mountains.

An intensive consultation process (Bulkley Consensus 1996) was initiated to gain public and stakeholder input to the development of designated zones for the purpose of managing caribou habitat for industrial and recreational activities. A recreational access management plan (RAMP) was conducted to complete the task of designing the zone definitions and locations. Consistent with the Bulkley RAMP document, public and stakeholder input from the consultation process was incorporated into a plan to manage recreational access into the Telkwa Mountains through the designation of zones. A Telkwa Caribou Standing Committee was convened to create objectives and associated guidelines for harvesting in the TCHRP area. These harvesting guidelines are interim until the completion of a higher-level plan that directs activities within the herd range.

Other projects were co-ordinated alongside the Recovery Plan. A post-graduate student was hired to monitor the calving success and level of predation on the Telkwa herd (vic Stronen 2000). Lichen abundance surveys were conducted in 1996 (Houwers 1996) in predominantly sub-alpine forests and in 1999-2000 in valley bottom to sub-alpine forests (Roberts 2000 and 2001).

Historical Population Surveys

Based on historic reports and the distribution of cast antlers, caribou were once widely distributed throughout most mountainous areas surrounding the Bulkley Valley. Elders of the Wet'suwet'en First Nation report that Smithers is built in an area that was formerly used by caribou for calving and that caribou migrated seasonally across the Bulkley Valley and through the Hazelton Mountains (M. George, pers. comm.. from TCHFP 1998). Caribou using the alpine areas around Smithers may have formed a part of a larger herd whose range extended south into Tweedsmuir Park. Movement of caribou from the Tweedsmuir Park area to the Bulkley Valley have been greatly reduced in the last fifty years. There is evidence that the Babine Mountains, located northeast of Smithers, had historically supported caribou until the twentieth century. It was suspected that caribou from the Telkwa herd had migrated to the Babine range during the spring and the fall during years of high population numbers (Marshall 1984).

The earliest recorded estimate of the size of the Telkwa herd was obtained in 1949 from a horseback survey (Cox unpubl. report n.d.) that provided the basis for an estimate of 60 caribou. Figure 1 outlines the results of population surveys from the 1949 survey to the population count in 2001 (Cox 1966, Bustard 1977, Hodson 1980,van Drimmelen 1986, unpublished data). After a population high of 271 animals in 1965, there was a huge population decline that nearly resulted in the extirpation of the herd by 1967. Numbers slowly increased at an approximate annual rate of 3% (van Drimmelen 1985 and 1986) and in 1984 there was a minimum count of 68 animals. Instead of the population numbers continuing to increase, in 1993, there were only 11 caribou found. The numbers of animals continued to decline from 1993 to June of 1997 when total counts of 6 adult caribou and no calves were found. Twelve caribou were transplanted into the Telkwa Mountains from the Sustut-Chase caribou herd in 1997 and another twenty in the fall/winter of 1998-1999. Since the recovery program began in 1997, the Telkwa caribou herd has generally been increasing.

The dramatic decline in numbers in the mid 1960's could be correlated to an increase in the amount of forestry and mineral exploration activities in central British Columbia that led to increased activity of helicopters in the area. It was reported that hunters were utilizing helicopters to access caribou and goat populations. A complete closure on hunting was implemented for the Telkwa caribou in 1973; however, despite this closure, the population levels have not returned to pre-1965 levels. Other factors that could impede population growth for the Telkwa herd are high mortality rates of adult caribou, poor recruitment of calves due to predation, movements of caribou out of the area, and range abandonment due to disturbance from human activities (TCHRP 1998).

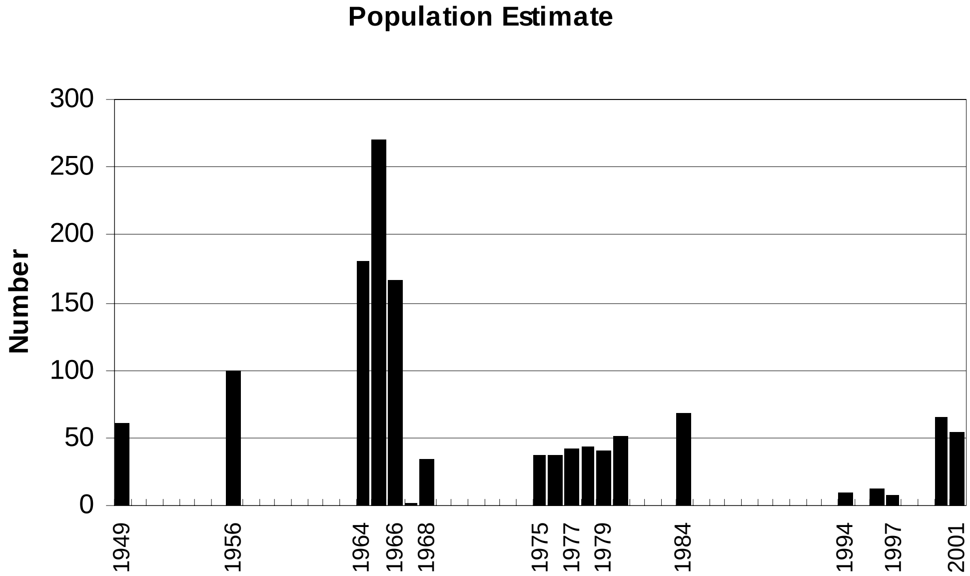

Figure 1. Population estimates of the Telkwa caribou herd from surveys 1949 to 2001.

Population Augmentation and Monitoring

A total of 32 caribou (28 females and 4 males) were transplanted from the Sustut-Chase caribou herd between 1997 and 1999. The caribou were fitted with VHF radio collars and coloured ear tags and released in the Telkwa Mountains. The transplanted caribou have been monitored with approximately bi-monthly to weekly fixed-wing telemetry flights. During the summer of 1999, six calves were captured shortly after birth and fitted with radio collars. Calves were monitored daily throughout the summer until the end of August, weekly through September and October, and as part of the regular telemetry schedule after October. Three GPS collars were fitted onto adult animals during 2001 and the first location downloads were in early 2002.

Recreational Access Management Plan Process

An implementation requirement of the Bulkley Land and Resource Management Plan (LRMP) was for the Bulkley District of the Ministry of Forests (MOF) to co-ordinate public input into a Recreational Access Management Plan (RAMP). The Bulkley RAMP process clarified where recreation values are secondary to the resource values identified in the LRMP, and where management of recreation may be required to protect the resource. Input from public and stakeholders through a public consultation process was incorporated into a plan to manage recreational access into the Telkwa Mountains through designation of zones (Appendix B). The zones incorporate available information on seasonal movements and distribution of the Telkwa herd, habitat capability mapping, and results from a lichen abundance survey (Houwers 1996). The zones reflect recommendations for areas where forest practices will be modified in consideration of caribou values, and access and hunting restrictions will be implemented as part of an overall access management plan (TCHRP 1998).

Interim Harvesting Guidelines for the TCHRP Area

The TCHRPA overlaps portions of five landscape units in the Morice Forest District and one landscape unit in the Bulkley Forest District. The licensees in both forest districts were invited to participate in the establishment of interim harvesting guidelines that would minimize the impact on caribou and caribou habitat, while practicing good forest management in the TCHRPA. Key habitat and disturbance issues identified for management were:

1. Maintaining suitable lichen producing range and important habitat quality;
2. Minimizing habitat fragmentation;
3. Managing human access;
4. Maintaining habitat separation from predators.

Key Caribou Habitats were identified for the entire TCHRPA. These areas were considered to be important forested habitats based on delineation of slopes providing likely movement corridors, delineation of good caribou habitat based on Biophysical Classification for Ungulate Capability mapping, delineation of moderate to high arboreal lichen areas, and delineation of areas of known previous and current high caribou use. The harvesting guidelines for the TCHRPA are based on the ecological characteristics of the habitat in each biogeoclimatic zone and the importance of each key forested caribou habitat.

Current Population Status

Fall surveys are used to determine population estimates and status of the herd through ratios of numbers of calves to 100 cows and numbers of bulls to 100 cows. By the fall of 2000, the caribou population was estimated to be approximately 65 animals. This number had fallen to an estimated 55 animals in the fall of 2001. Although by the fall of 2001 the calf production appeared to be good with pregnancy rates comparable to other herds (TCHRP progress report 2001), the actual number of calves (6) was considered low because of the small population size and calf survival. At the current rate, however, the calf to cow ratio should meet replacement needs. The bull to cow ratio of approximately 30 bulls to 100 cows, is approximately half of the value that is considered sufficient to ensure that all cows would be bred; however, this low ratio has not appeared to deter the success of most of the cows becoming pregnant.

In general, annual mortalities appeared to be low. A total of eleven adult mortalities had been documented between 1997 and the fall of 2001. The causes of mortality were capture related mortalities, accidental injury, and suspected wolverine, bear and wolf predation. Most of the calf mortalities occurred between June and October. Monitoring of calf survival has indicated that the most likely causes of calf mortality are abandonment and subsequent starvation and predation.

Related Projects

In 1999, a graduate project (vic Stronen 2000) began examining the causes of mortality and calf survival in the Telkwa herd. Due to low sample sizes and low mortality, the main causes of calf mortality in the Telkwa Mountains could not be determined. This graduate project also examined habitat selection for females with calves versus females without calves compared to habitat use throughout the year. vic Stronen (2000) found that females tended to use higher elevations on moderate slopes with warm aspects and that forested habitats selected were generally greater than 250 years old. Analysis of elevation use of reproductive caribou cows versus barren cows in 1999 was compared using ANOVA for the calving season and against elevations used all year. There was significant difference in elevation use between calving season and use all year. It should be noted that this analysis was completed on one year’s data following relocation of transplanted animals that may not be representative of use (Audet 1996). Habitat selection was assessed for all locations for all seasons, due to lack of number of locations for each season and assessed selection based on a comparison of ranks (Johnson 1980). Grouping seasonal habitat use points across seasons and years is only rigorous if there is similar selection for each season and year. The reason for grouping data points for this selection was due to a small number of data points. These results must be interpreted with caution due to the low level of sensitivity of the analysis and the grouping of locations across years and seasons.

Lichen abundance surveys were conducted in high elevation/sub-alpine forests in 1996 (Houwers 1996) and in forested ecosystems throughout the Telkwa herd range in 1999-2000 (Roberts 2001). Arboreal and terrestrial lichen abundances were quantified and correlations to forest stand or habitat variables analysed. Roberts (2001) observed that most high arboreal lichen sites were associated with edge habitats along wetlands and ridges and that arboreal lichen abundance was positively correlated to stand age. Both Houwers and Roberts found that arboreal lichens occurred across the landscape, but that stands with moderate to high levels of lichen abundance had a patchy distribution. Terrestrial lichen abundance in the alpine and sub-alpine habitats were not studied extensively, and for forested sites, there was overall, low abundance of terrestrial lichens within the Telkwa mountain range.

STUDY AREA

Location and General Description

The Telkwa Mountain range is located in west-central British Columbia (BC), approximately 50 km south of Smithers and east of the Coast mountain range (Figure 2). The Telkwa range is characterized by ranges of relatively high relief, rugged, glacially sculptured peaks, separated by broad floored U-shaped valleys (van Drimmelin 1985). There is a close interspersion of vast, open plateaus and rolling windswept alpine tundra covered with alpine sedges, grasses and lichens as well as steep, rugged slopes (van Drimmelen 1985). The highest peak in the Telkwa's is approximately 2300 m and is covered by glaciers.

Ecological Classification

To describe the study area, two types of broad ecological land classification schemes were used in this project, Broad Ecosystem Inventory (BEI) and biogeoclimatic (BEC) classification. BEI classification is a 1:250,000 scale terrestrial ecosystem classification and mapping system that classifies ecosystem types by vegetation communities at a large scale (Resources Inventory Committee 1998). Appendix A contains a list and general description of the BEI types that were found within the study area. BEC classification is based on a hierarchy from the regional to the site-specific level using a combination of the climate, geology and vegetation of an area (Meidinger and Pojar 1991). For this project, the BEC system was used to the subzone level only (e.g. ESSFmc).

The TCHRPA is located in the Bulkley Range ecoregion. The biogeoclimatic (BEC) zones that comprise most of the forested habitat in the TCHRPA are the sub-boreal spruce (SBS) and the Engelmann spruce – sub-alpine fir (ESSF) zones. There is also a large component of alpine tundra (AT) and sub-alpine or parkland forest. The Interior cedar hemlock (ICH) also occurs in the study area, but to a lesser extent. There are two SBS subzones in the study area; sub-boreal spruce moist cold subzone, Babine variant (SBSmc2) and the sub-boreal spruce dry cool subzone (SBSdk). The ESSF subzones that comprise the study area are: moist cold subzone (ESSFmc), moist cool (ESSFmk), moist very cold (ESSFmv3), wet, very cold (ESSFwv) and parkland (designated with a p following the subzone name). The SBSdk lies below the SBSmc2 and is less predominant in the TCHRPA than the SBSmc2. The ESSFmc is the predominant forested subzone in the study area.

The ESSFmc characterizes most of the ESSF zone in this area. Climax forests of the ESSFmc are dominated by sub-alpine fir with lesser components of hybrid white spruce and lodgepole pine. The subzone extends from approximately 1200m to 1800m in elevation and has a shorter, cooler and moister growing season than the lower elevation SBSmc2 and a longer, colder and snowier winter (Banner *et al*. 1993).

Between the ESSF subzones and the AT is the parkland subzone. The parkland subzone is a transitional area between the forested timber below and the open, treeless expanse of the alpine above. The elevation at which continuous forested ESSFmc grades into ESSFmc parkland and then into AT depends on topography and climatic conditions. This transition is generally a gradual one; however, there are areas where abrupt transitions do occur (Houwers 1996). The AT zone is characterized in the Telkwa range by vast, open plateaus. Sedges, grasses, lichens and other low-lying vegetation dominate this environment.

The SBSmc2 lies below the ESSFmc and is characterized by a climax forest of hybrid spruce (*Picea engelmannii x glauca*) and subalpine fir (*Abies lasiocarpa*). Black spruce (*Picea mariana*) also occurs in climax forests in wetland areas or areas with cold air ponding. There are also extensive seral stands of lodgepole pine (*Pinus contorta*) that have formed due to frequent wildfires in this subzone. The SBSmc2 ranges from approximately 850m to 1350m. The upper elevation at which the SBSmc2 grades into the ESSF ranges from 900m to1350m and is determined by local topography and climatic conditions. The SBSmc2 is characterized by severe, snowy winters and relatively warm, and moist, short summers (Banner *et al*. 1993).

Figure 2. Telkwa Caribou Herd Recovery Project Area.

The SBSdk (dry cool subzone) ranges from approximately 500m to 750m elevation and lies along the valley floors. The zonal site series of the SBSdk is characterized by hybrid white spruce (P. engelmannii x glauca) with some lodgepole pine (P. contorta) and trembling aspen (Populus tremuloides). In the study area, the SBSdk has been highly disturbed from human activity (agriculture, settlement, logging, burning) and wildfire has affected all parts of the SBSdk at some time. Much of this site series is in early to mid seral associations (Banner et al. 1993).

METHODS

Data Review

Caribou telemetry locations were recorded from aerial and ground surveys. The locations were generally located with Geographic Positioning System (GPS) equipment, and locations were recorded to degrees, minutes, and seconds. Date, age, sex, population and habitat information was also recorded. The information was entered into a regional database (RELOCATE) and Geographic Information System (GIS). The database reviewed for this report consisted of ArcInfo® geographic and attribute files. A review of the database was required to determine the appropriate home range estimate and habitat selection analysis techniques. The geographic variables were reviewed for accuracy and level of precision by examining the data. Data quality was reviewed for age and sex criteria, and general information. Individual caribou locations were also reviewed to determine location recording errors, and the level of outlier effect.

Digital Habitat Information

Digital habitat information was obtained from the Ministry of Sustainable Resource Management GIS section and included 1:250,000 scale BEI mapping, 1:20,000 scale BEC mapping, and 1:20,000 Forest Cover information. As well, 1:20,000 Digital Elevation Model (DEM) mapping obtained from Terrestrial Resources Inventory Mapping (TRIM) was used to create slope and aspect mapping at a 50 m grid cell resolution.

Exploratory Data Analysis

Scatter plots of the data were examined to refine the dates for the definitions of caribou seasons. The aim was to enclose localized seasonal movements related to calving and rutting (fall) seasons and define dates from these. Animals were excluded from the analysis if there were fewer than half of the mean number of radio-locations for that season and year. This was done to avoid biases to particular periods within a season and year. Animals with very few points would only have data points that were representative of a small portion of the season/year. Each season and year was analysed separately for habitat selection of BEI, BEC, aspect and slope classes. Locations for each season and year were examined to see if the data could be lumped between years for analysis of BEI types.

Home Range Analysis

Estimating Home Range

Two methods of home range estimation were used for the report. The MCP method was used to delineate the study area and to allow for comparisons to other caribou studies (Grinder and Krausman 2001, Mohr 1947, White and Garrott 1990). The kernel method was used for comparing home range estimates between seasons and sexes. The kernel method was selected because it does not overestimate home range size and is not significantly biased by outlier effects, as is the MCP method (Gallerani *et al.* 1997). The kernel method takes advantage of the number and the relative density of radiolocations distributed across the Telkwa caribou range. The kernel density estimator was used to determine a weighted range selection based on probability density estimates with a limited bias (Seaman and Powell 1996). To limit bias or area overestimation, kernel density estimators use least square cross validation (LSCV) and recommends a sample size greater than 100 locations (Seaman and Powell 1996). The LSCV is a smoothing factor in the determination of bivariate normal kernel distribution.

Both the kernel density and MCP home range estimates were produced using the *Animal Movement* extension for ArcView® GIS (ver. 2.04) (Hooge and Eichenlaub 1997). To determine whether telemetry locations could be pooled across years and seasons a literature review provided the following techniques:

- Wilks Lambda test to determine if significantly different habitat selection was occurring across years (Florkiewicz *et al*. in prep);
- ANOVAs and Student t test to determine difference between seasons and years (Grinder and Krausman 2001)
- Assume pooling can occur if the collared sample is representative of the population (Apps and Kinley 2000). This would apply to recovery programs where the proportion of collared individuals is a high proportion of the population.

ANOVAs were selected to test seasonal and sex differences of individual caribou kernel home ranges.

Home range estimates were based on the assumptions that the relocation data were statistically independent samples that are representative of the population. Autocorrelation of telemetry locations occurs when the sampling interval is too narrow and negatively bias the home range estimate (i.e. the telemetry locations are not independent) (Hansteen et al. 1997). Autocorrelation was tested for seasonal and sex home range estimates using the Swihart and Slade ratio (1985), and the *Animal Movement* extension for ArcView® GIS (ver. 2.04) (Hooge and Eichenlaub 1997). Recent literature on autocorrelation suggests that the bias to the home range estimate by reducing samples to achieve statistical independence outweighs the bias of autocorrelation (Hooge and Eichenlaub N.D., Otis and White 1999).

Evaluation of Seasonal Range Use, by Sex and Reproduction Criteria

Caribou are species that generally use different seasonal ranges. They may also use habitats selectively in the range depending on their sex and reproductive status (e.g. females with a calf). The telemetry database was evaluated to determine whether adequate sample sizes existed by season, sex, and reproductive status for home range estimation.

Comparison of Seasonal Home Range Locations

We mapped 50% and 95% kernel home range locations for all seasons and compared the seasonal locations for all years together and the home range locations to the Recovery management zones.

Study Design

Generally, for studies using radio telemetry to determine resource selection, the study design will determine an appropriate sampling interval to provide sufficient seasonal sampling while reducing autocorrelation. For the Telkwa Caribou Recovery Program, the main intent was to monitor population growth and age/sex survival (TCHRP 1998). Habitat selection analysis was not a component of the initial study design. After reviewing the telemetry locations the following study designs could be applied for habitat selection analysis:

> *Design Type I* – The number of radiolocations for all individuals collectively in each habitat type gives a measure of selection. Reconnaissance type studies employ this design type (see Neu *et al*. 1974); and
>
> *Design Type II* – The number of radiolocations for animal x in each habitat type gives a measure of selection for animal x. Most studies of radio-collared individuals generally fall within this design type (Thomas and Taylor 1990).

Both designs use the entire study area to quantify habitat availability. A *Design Type II* analysis was selected for the post-hoc data analysis as it allow for a more robust analysis and it is easily incorporated into home range estimation.

Habitat Selection

We used a *Design Type II* analysis to look at population level resource selection. Following the assumptions outlined in Manly *et al*. (1993), habitat availability was defined as the entire study area and the location of the individual animals was used to determine the selection of resource units. We compared patterns of habitat selection for the female Telkwa caribou during the winter, spring, calving, summer and fall. Since forest harvesting was suspended in a large portion of the study area for most of the sampling period, the availability of resources was considered to be the same throughout the study.

Resource Selection in Design Type II Studies

Using ArcView® GIS, the locations for radio-collared caribou were overlaid with the classification schemes to provide a biogeoclimatic (BEC) subzone derivation, a BEI unit for each location, aspect and slope information. We used a log-likelihood Chi Square test (Manly *et al.*1993) to determine whether overall selection was occurring within each classification. Where significant selection was identified, we determined patterns of habitat selection using Bonferonni Confidence intervals following the method of Manly *et al*. (1993). Available habitat was defined as the 100% minimum convex polygon using the remaining data points after 5% of the outliers were removed. Individual animals were defined as the sampling unit, with each location considered a sub-sample of the primary sample unit (Manly *et al*. 1993).

Rettie and McLoughlin (1999) outlined potential biases that occur in habitat selection studies and sources of error associated with mapping and telemetry locations. We opted to determine habitat selection for the derived ecosystem type (BEI, BEC, slope and aspect) as an area determined by a circular buffer around each point location. This method is more robust with regards to integrating the location with some of the errors associated with mapping and telemetry location. The use of buffers does reduce our ability to detect selection (Rettie and McLoughlin 1999); however, based on the scale of our land classification schemes (BEI and BEC), this may not be a large factor.

We evaluated the ability of different buffer widths (200 and 500 m radius) to incorporate the potential bias introduced by incorporating telemetry error (Hoskinson 1976, Nams 1989) on habitat mosaics. We used Arcview GIS 3.2a® *Buffer Wizard* extension to create buffers around each point location. Areas (ha) for classes of each habitat type (BEI, BEC, slope and aspect) were calculated for each buffer polygon. We used a chi square goodness of fit test to compare whether the results for habitat use were significantly different for locations buffered by a 200 m or a 500 m radius. We chose a 200 m buffer radius after we found that most tests were not significantly different and that there was little difference between buffer widths on the relative proportions of habitat types used by caribou. A smaller buffer allowed for a tighter fit around a telemetry point and quicker data analysis.

The Resource Selection Index (RSI) is the ratio of the amount of resource used by the animals to the amount available either at the level of the population (i.e. study area) or to the individual animal. For *Design Type II* studies it is defined as:

$$w_i = u_{i+} / (\pi_i \, u_{++}).$$

Where: $\mathbf{w_i}$ = the ratio of the proportion of habitat used by the sample of animals to what is available to the population

$\mathbf{u_{i+}}$ = number of type i resource units used by all animals

$\boldsymbol{\pi_i}$ = proportion of available resource units in category i

$\mathbf{u_{++}}$ = total number of units used by all sampled animals

Bonferroni confidence intervals for the above indices were calculated using 100(1-α)% confidence intervals with $\alpha = 0.05$. Simultaneous tests were conducted, therefore we calculated the upper tail of the standard normal distribution to be $\alpha/(2I)$, where I is the total number of habitat types used. This maintains a low probability (1/20 or 5%) of finding selection when in fact there is none (type I error) (Manly *et al.* 1993).

Exploration of Winter Home Range Forest Cover Composition

Winter home ranges (50%, 75%, and 95% kernels) were assessed against forest cover attributes (stand age and leading species), summarized and graphed. The following were summarized and compared: 1.) forested versus non-forested and alpine forest, 2.) non-forested habitat types, 3.) forested habitat by leading species and 4.) mature – old forest (stands greater than 141 years) by leading species. These results are descriptive and a complete statistical analysis was not completed due to time constraints.

Snow Depth Data

Snow depth data was summarized from the Ministry of Sustainable Resource Management Historic Water survey website for the (http://srmwww.gov.bc.ca\aib\wat\rtc\archive\asp_archive.htm) snow station located on Hudson Bay Mountain (snow station 4A03 in the Northwest region). This snow station is located at 1480m in the high elevation ESSFmc forest and is likely to be similar to the snow conditions found in the TCHRPA. Snow depth information was compared with winter habitat use, but due to time constraints, a complete analysis was not completed and the results are compared qualitatively.

RESULTS

Data Exploration

Locations were subdivided into five seasons (Table 1) based on examination of specific movements of animals at the beginning of the calving and the fall (rut) season.

Animals were excluded from the analysis if there were fewer than half of the mean number of radiolocations for that season and year. This was done with an effort to avoid biases in particular periods within a season and year. We would have preferred to use only animals that had a minimum of 5 locations per season for each year; however, this would have excluded a large number of animals from most years and seasons and only the winter season and the calving season of 1999 would have had enough data points for analysis. Rather, we chose to continue with the analysis but provide a cautionary note regarding the strength of interpretation. Habitat selection was analysed for locations grouped by season within years to assess habitat selection between years.

Table 1. Dates defined for the five seasons used in habitat selection analysis for the Telkwa caribou.

Season	Season Code	Dates	Years Analysed
Winter	1	November 1 – April 15	1997-98, 1998-99, 1999-00, 2000-01, 2001-02
Spring	2	April 16 – May 24	1998, 1999, 2000, 2001
Calving	3	May 25 – June 24	1998, 1999, 2000, 2001
Summer	4	June 25 – September 15	1998, 1999, 2000, 2001
Fall (Rut)	5	September 15 – October 31	1998, 1999, 2000, 2001

Telemetry Location Database Review

In reviewing the telemetry location database, there were significant issues related to the data quality of the information collected. Population information such as group size, collared caribou with calf, sex classification, and animal status (alive, dead, or unknown) were only recorded for a minority of the records and was not collected using a standard methodology. The result of the inconsistent data collection is an inability to provide rigorous age and sex survival rates for comparison to other caribou herds.

Locations were recorded with a non-corrected GPS during the aerial telemetry sessions and it is estimated that the average error polygon was approximately 120 m (Carrel *et al.* 1997). This error can be mitigated for, however, in habitat selection analysis by using the appropriate scale of resource mapping (e.g. BEC, or BEI classification mapping).

The number of collared individuals varied over the years, with the time period of 1997 to 2002 being the most consistent (Figure 3) and the telemetry locations from the winter of 1997 to the winter of 2002 selected for analysis. Female caribou were selected for collars at a greater proportion than males (Figure 4). This is a common bias in radio telemetry studies due to the relative importance of females for population demographics. However, the number of collared males was further reduced due to mortalities for the Telkwa caribou. Based on the available collar information, home range estimates were restricted to females.

Home Range Estimation

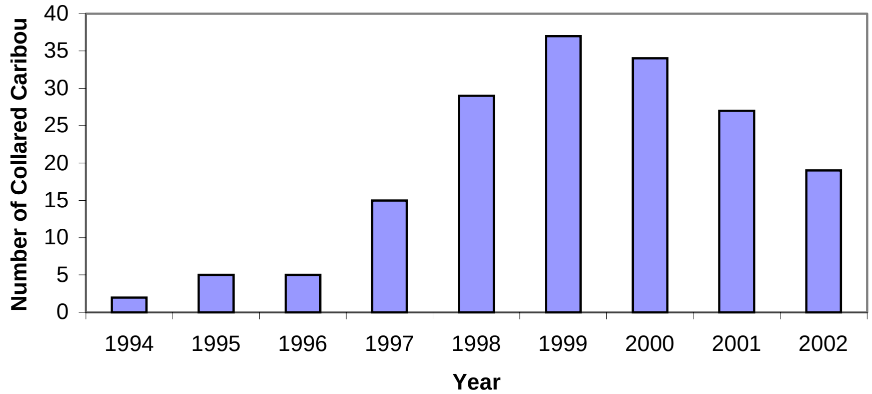

Figure 3. Number of collared caribou from 1994 to 2002.

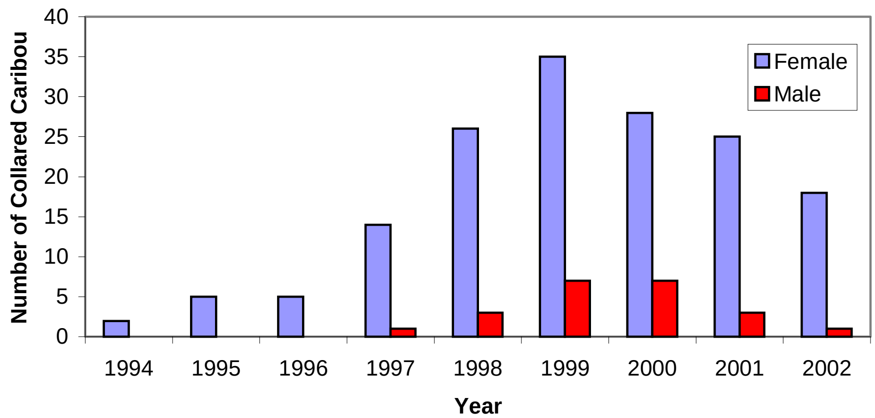

Figure 4. Comparison of the number of male and female caribou collared from 1994 to 2002.

Individual female caribou home range sizes were tested for differences between years, and seasons using ANOVAs (Table 2). The sizes of home ranges for all seasons and between years were not significant except for calving and spring seasons. This is likely primarily due to varying sampling intensity across years for individual samples. For example, in 2001, collared caribou were located for the calving season but individual samples were too small to create kernels. The same issue occurred in evaluating the Rut season as only 2 years had sufficient individual samples to estimate kernels. The number of animals in each season and year that had sufficient points to create kernels was limited, which resulted in low power in determining whether there was actually significant differences between years, or whether significance, or lack of, was attributed to low sample size.

Table 2. Telkwa caribou home range evaluation between seasons

Season	Years	df	F value	Probability Value
Between Years	1998-2002	4	0.872	0.48
Spring	1998-2000	2	9.941	0.01*
Calving	1998-2000	2	3.148	0.01*
Summer	1998-2001	3	1.040	0.38
Rut	2000-2001	1	0.201	0.65
Winter	1998-2002	4	2.102	0.08

* Significantly different home range sizes between years.

The 50% probability kernel home ranges pooled across years, showed similar sizes between seasons, while the 95% home ranges varied greatly between seasons (Table 3).

Home range estimation for female caribou reproductive status was also reviewed (e.g. collared female with calf). Initially, it was expected that reproductive status could be tracked across seasons, but inconsistent data reporting has restricted the information to only the calving season. During the calving period from 1998 – 2001, female caribou were classified into three groups: *Calf Present, Calf Lost* and *No Calf* (Table 4).

An ANOVA was used to test for differences in home range size estimates between reproductive status. There was no significance difference between the classes (ANOVA, P=0.11). Females who had lost a calf (*Calf Lost*), or did not have a calf (*No Calf*) had overall kernel home ranges considerably larger than females with a calf (*Calf Present*) (Table 5).

Sample size and sample intervals were evaluated for the calving season, and a bias in observations was identified. In comparing the sample size by the reproductive status, a significant difference was identified for *Calf Present* females (ANOVA *P*=0.01). Females with calves were located 222 times, while *Calf Lost* caribou and *No Calf* caribou were only located 94 times each for the same time period. To reduce the chance of autocorrelation in the data, the dataset was reduced by randomly selecting only one record for each week of calving for each reproductive status. After applying this dataset record reduction, a difference was found to exist between reproductive status (ANOVA *P*=0.02).

Table 3. 50% and 95% kernel home ranges for female caribou for each season pooled across years.

Season	50% Kernel (ha)	95% Kernel (ha)
Spring	7,981	38,438
Calving	4,211	36,971
Summer	7,078	89,790
Rut	4,586	23,804
Winter	6,099	37,124

Table 4. Reproductive status of collard female caribou.

Reproductive Status	Criteria
Calf Present	Collared female was observed with a calf throughout the calving season
Calf Lost	Collared female was observed with or assumed, due to presence of udder, to have had a calf during the early portion of the calving season but was observed later to be without a calf; and
No Calf	Collared female was not observed to have a calf throughout the calving season

Table 5. Kernel home range areas for collared female caribou during the calving season.

Probability Contour	Reproductive Status		
	Calf Present (ha)	Calf Lost (ha)	No Calf (ha)
50% Kernel	2,485	5,065	15,206
75 % Kernel	5,581	9,950	31,151
95% Kernel	17,587	53,993	160,358

Comparison of Seasonal Home Range Locations

The winter kernel home range map (Figure 5) shows that the 50% kernel winter range and the 75% kernel were almost entirely within the *Core Re-introduction* area. The 95% kernel was much larger and included an area south of the *Core* area in the *Non-motorized* and the *Winter Motorized* zones as well as north, overlapping the *Integrated Use* zone. Caribou located outside of the 95% kernel were scattered, with a small, localized group of locations along the Bulkley River adjacent to the Coffin Lake area and south towards the junction with the Morice River. These locations are outside of the current management zones. When 50% kernel home ranges were examined for each year (Figure 6), all years except 1997/98 were found to have similar home ranges centred on the *Core Re-introduction* area. The animals during the winter of 1997/98 were located further south than the other years, while a portion of the animals in 1996/97 wintered near Mooseskin Johnny Lakes. During the winter of 2001/02, animals were more dispersed, using lower elevation forests than in other years.

The overall spring kernels are very similar to the winter kernels, except that the spring kernels are slightly larger and there is more area in the lower elevation *Integrated Use* area in the spring than was observed in the winter (Figure 7). Animals were found in similar locations in the springs of 1998 and 1999 (Figure 8). In the spring of 2000, animals were located at slightly higher elevation habitats and in 2001, caribou were more dispersed than in other years, using more of both lower elevation habitats and higher elevation habitats.

The 50% and 75% home range kernels of all female caribou during the calving season were very similar to the spring and winter home ranges in size and extent (Figure 9). A portion of the 95% kernel home range extended to the west of the 50% kernel home range. shows that the 50% kernel home range areas were all centred in the *Core Re-introduction* zone. Females with *Calf Present* were located entirely in this zone in a relatively small area. The 95% kernel for *Calf Present* females shows two areas; one that surrounds the 50% kernel that extends through the sub-alpine, and a second area located near Emerson Ridge. Females classified as *Calf Lost* had a core range twice the size of those classified as *Calf Present*

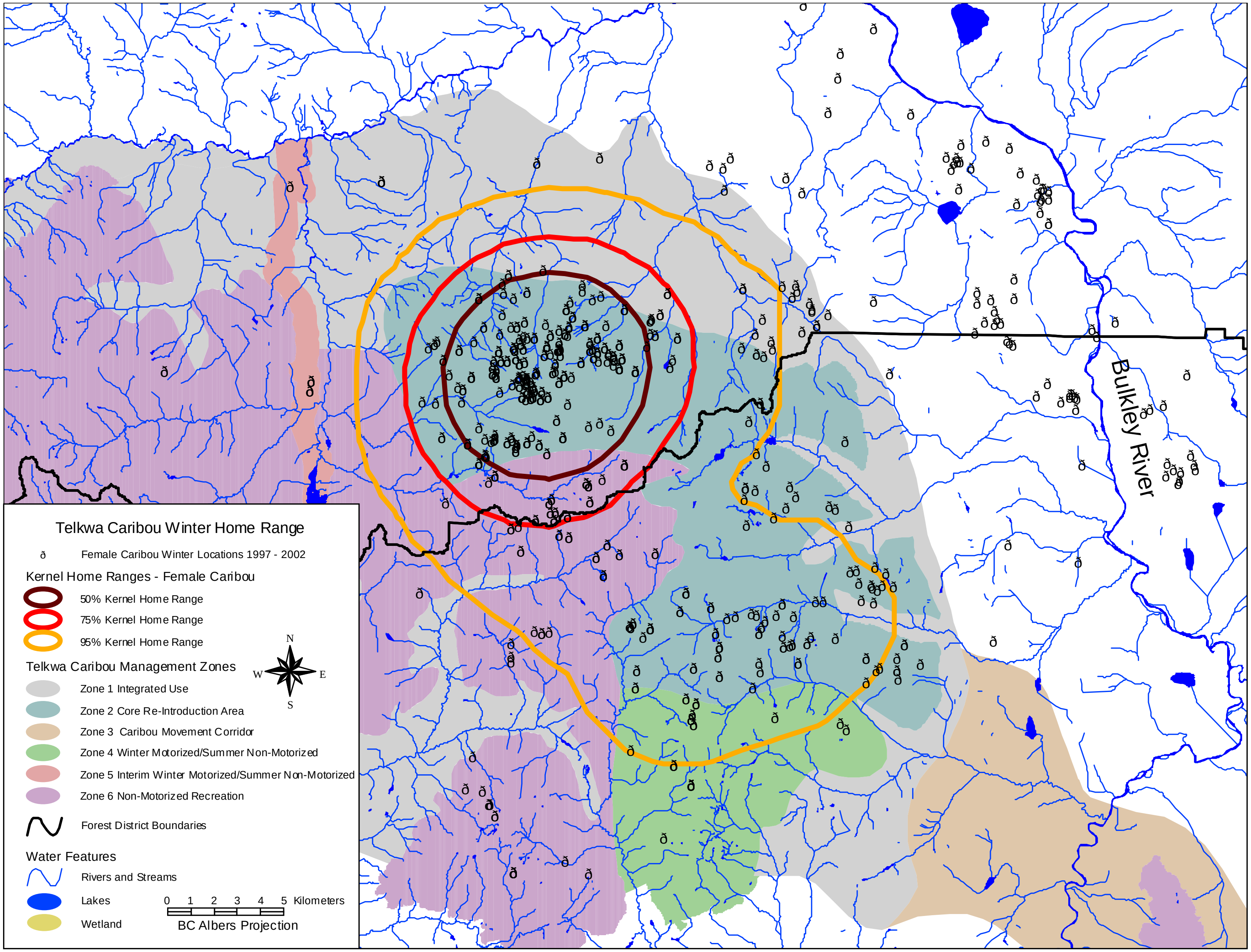

Figure 5. Female caribou winter kernel winter home ranges for years 1997/98 to 2001/02.

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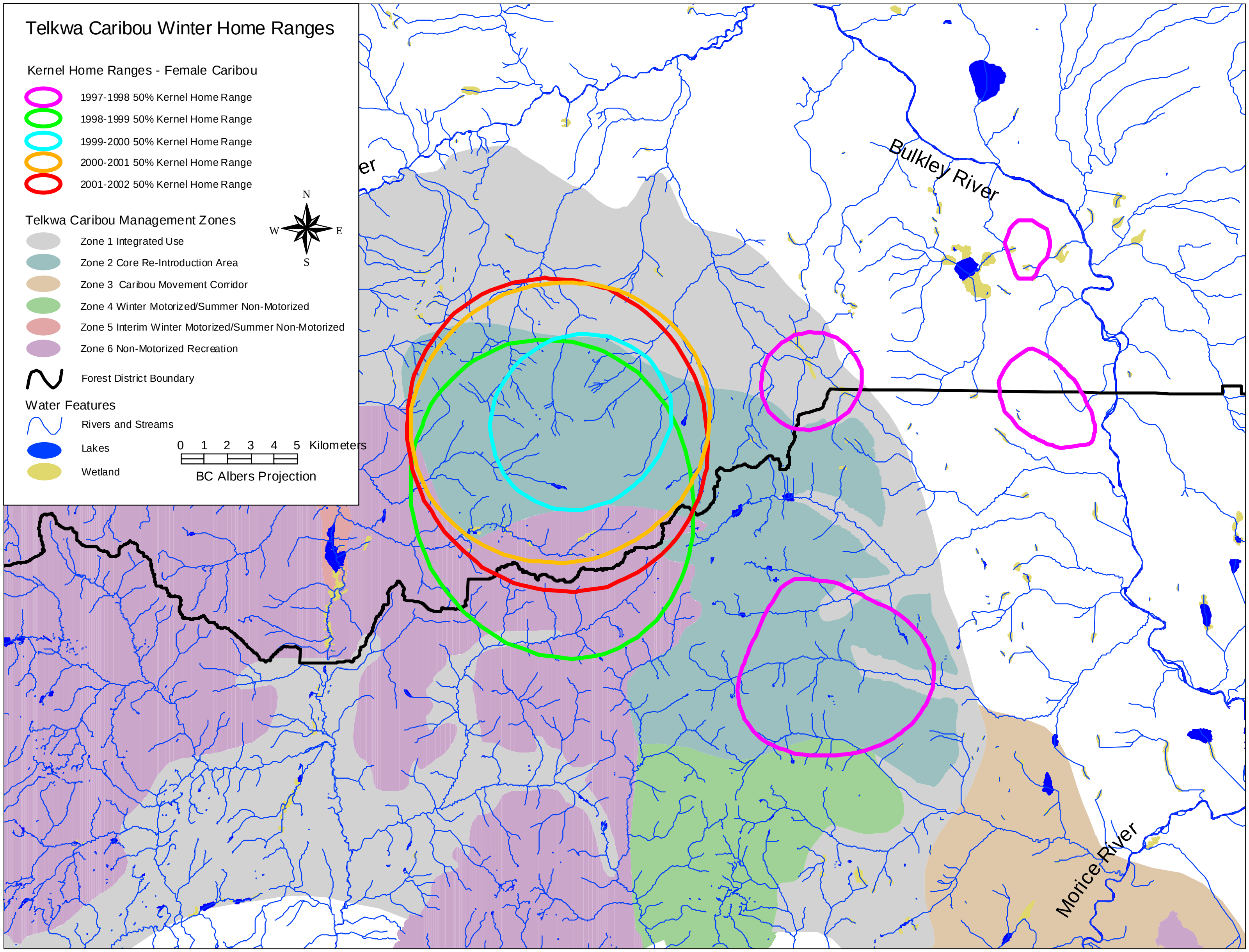

Figure 6. Female caribou 50% kernel winter home ranges for years 1997/98 to 2001/02.

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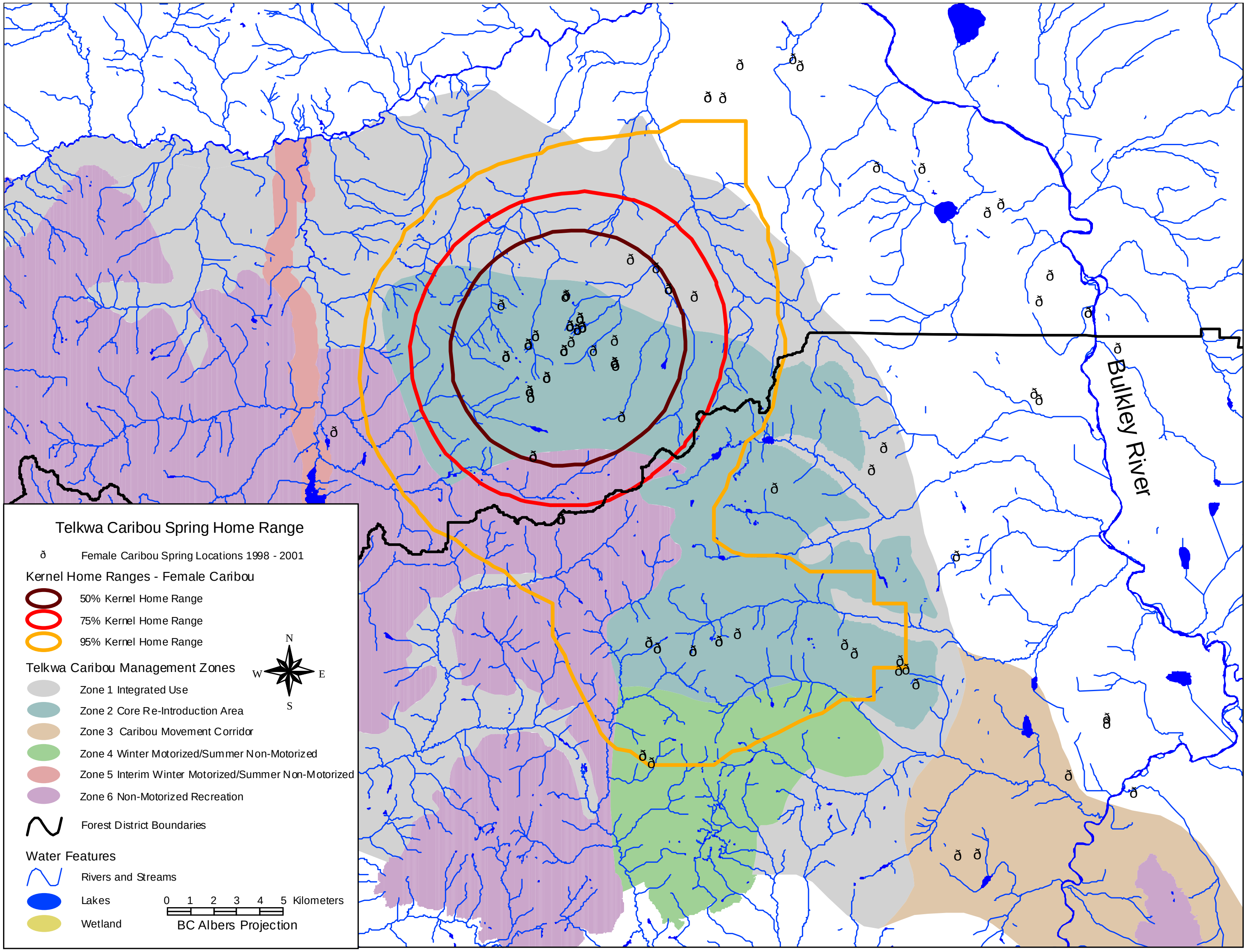

Figure 7. Female caribou spring kernel home ranges for years 1998 to 2001.

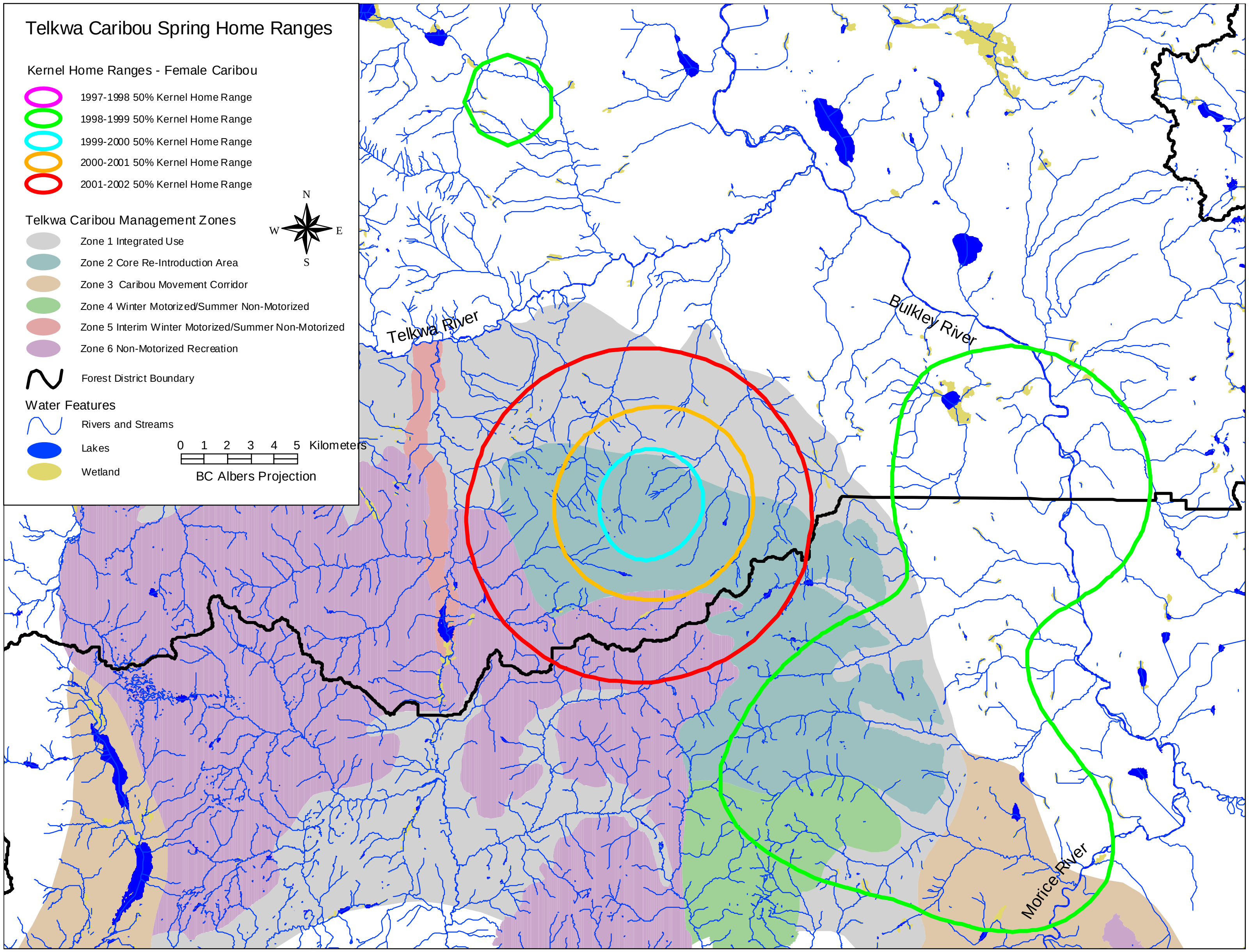

Figure 8. Female caribou 50% kernel spring home ranges for years 1998 to 2001.

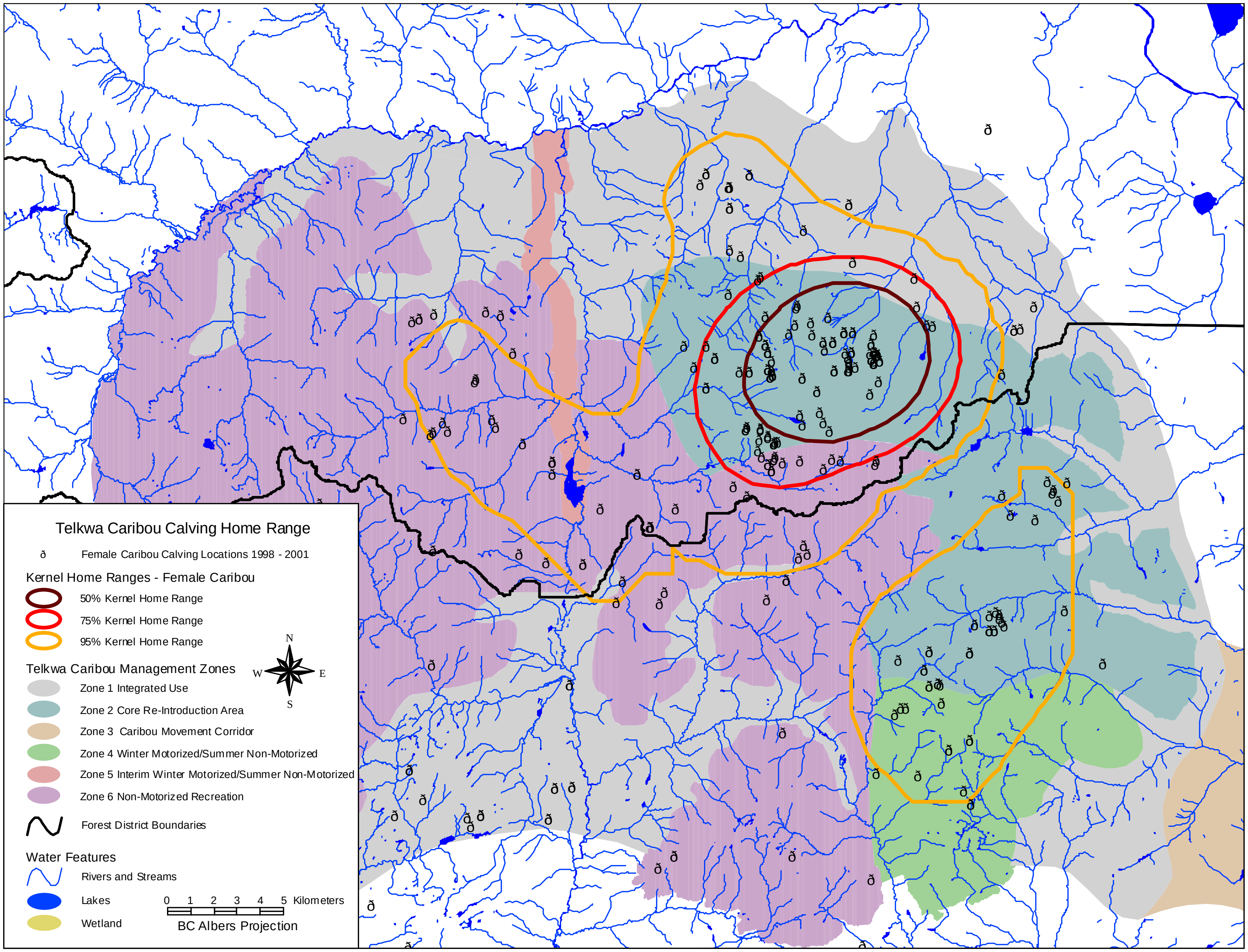

Figure 9. Female caribou calving kernel home ranges for years 1998 to 2001.

females, but inclusive of their range. The 95% kernel for the *Calf Lost* females was much more extensive than *Calf Present* females and included habitats south of Burnie Lake and along the south portion Houston Tommy Creek. *Barren* females 50% kernel home ranges included the area used by *Calf Present* females as well as habitats in the *Integrated Use* zone and the *Non-Motorized Recreation* zone. The 95% kernel for these females was very large and included almost all of the Recovery zones as well as locations outside of any zones. The 50% kernel home ranges for the female caribou during the calving period were very similar in size and extent for 1998 to 2000, but much larger for 2001 (Figure 11).

The 50% kernel summer home range was similar in size to the 50% kernel spring home range, however, the 75% and the 95% kernel summer home ranges were much larger than any other season (Figure 12). The 50% kernel home range was mostly in the *Core Re-introduction* area in the summer, with a small portion extending south into the *Non-Motorized Recreation* zone. The 95% kernel summer range utilized portions of almost all of the Recovery plan zones and was almost entirely encompassed by the habitat protection zones. There was a small portion that encircled locations south of Morice Lake. The yearly 50% kernel home ranges for the female caribou in the summer were almost identical for 1999 to 2000 in size and extent, with the 2001 home range slightly larger (Figure 13).

Rut kernel home ranges were the smallest of all seasons (Figure 14). The 50% kernel and the 75% kernel home ranges were almost entirely located in the *Core Re-introduction* zone in the sub-alpine and alpine above Goathorn and Cabinet Creeks and near Hunter's Basin. The 95% kernel home range was also centred around these locations. There was a second portion of 95% kernel home range that was located along the southern portion of the Telkwa Mountains overlooking Houston Tommy Creek. The 50% kernel fall home range polygons were very similar in size and position between years (Figure 15).

Habitat Selection

Habitat selection analysis was confined to investigating patterns of use at the level of BEI and BEC subzones due to concerns about the lack of precision of the relocations. The large scale and coarse level of resolution of mapping of the BEI and BEC subzone classification allows for compensation for some of the telemetry location error, however; mapping at these large scales results in a loss of information for identifying more detailed habitat elements. The use of buffers instead of point locations reduces the ability to detect fine scale habitat use patterns, however, using buffers reduces the probability of drawing incorrect conclusions regarding relative preferences among habitat types (Rettie and McLoughlin 1999).

Slope was divided into four categories (Table 6) and aspect into three categories (Table 7). Slope class 1 (0-10%) was regarded as flat, class 2 (11-30%) was relatively gentle terrain, easily traversed, class 3 (31-50%) was moderately steep terrain, but accessible for ungulates, and slope class 4 (51%+) was largely inaccessible and difficult to traverse. Aspect was converted into categorical classes as a method for dealing with its circular distribution. The categories chosen were warm (135.5° to 285°) and cool (285.5° to 135°) and flat (any aspect, less than 10% slope). These categories were selected based on the aspect categories used in the Telkwa Range Pilot Predictive Ecosystem Mapping project (A. Banner, *pers. comm.* 2000). Due to time constraints, selection was not assessed within the various aspect classes, although further analysis of both slope and aspect categories is recommended, especially within the winter home ranges.

Table 6. Slope classes for evaluation of caribou habitat selection.

Slope (%)	Slope Class
0-10	1
11-30	2
31-50	3
51+	4

Table 7. Aspect classes for evaluation of caribou habitat selection.

Aspect Class	Aspect (degree)	Qualifier
Cool	285° – 135°	For slope > 10%
Warm	135° – 285°	
Flat	Any	For slope ≤ 10%

Caribou were not utilizing resources in the same way in the winter of 1997 and 2000, the summer of 1998, and the calving season of 1999. In all other seasons and years, female caribou were utilizing BEI resources in a similar manner. There was significant selection occurring by at least some of the animals in all of the seasons and years except for the spring of 1998 and 2001. Analyses of years and seasons indicated that the selection was significantly large, while the

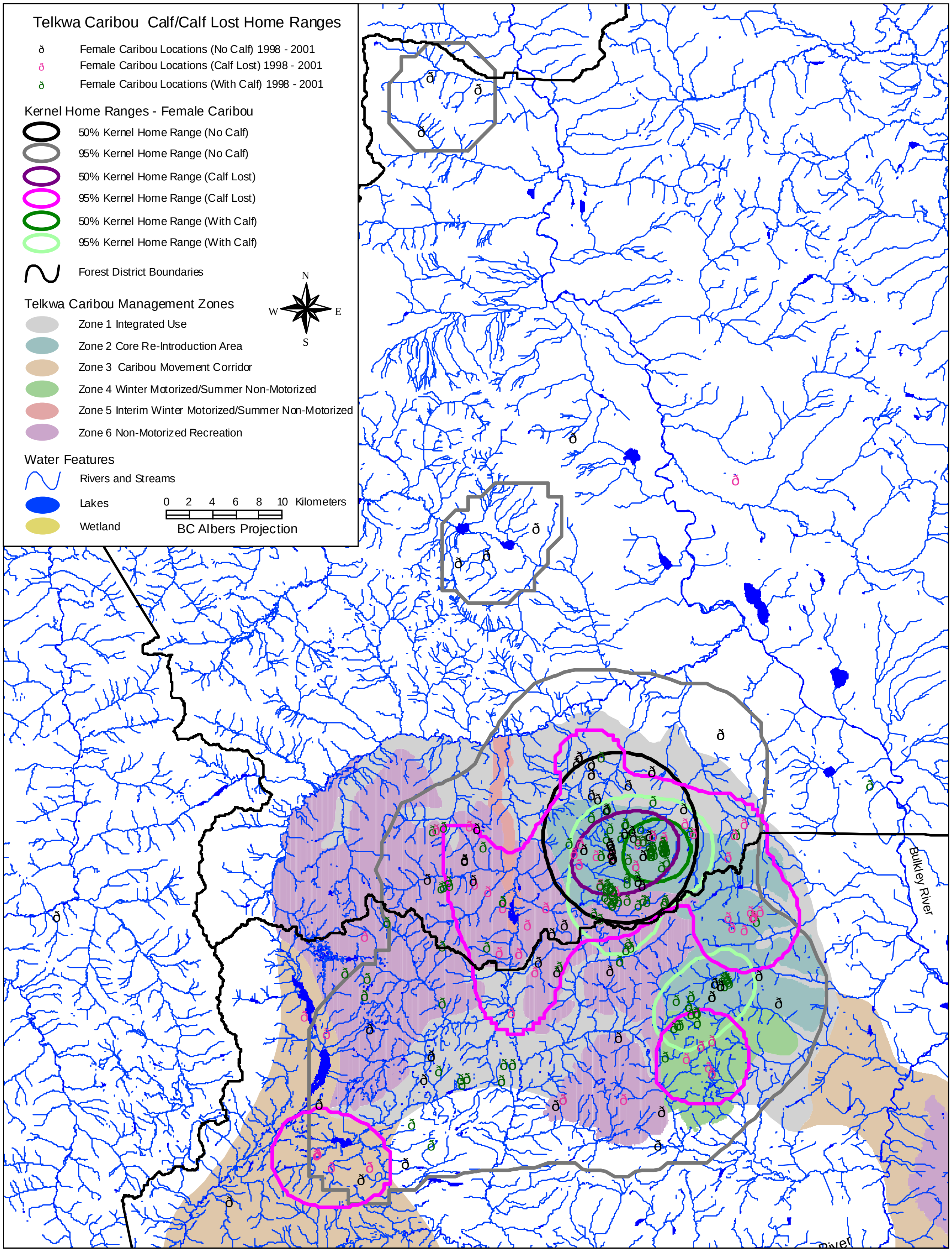

Figure 10. Female caribou calving season home ranges for *Calf Present, Lost Calf* and *Barren* status caribou for years 1998 to 2001.

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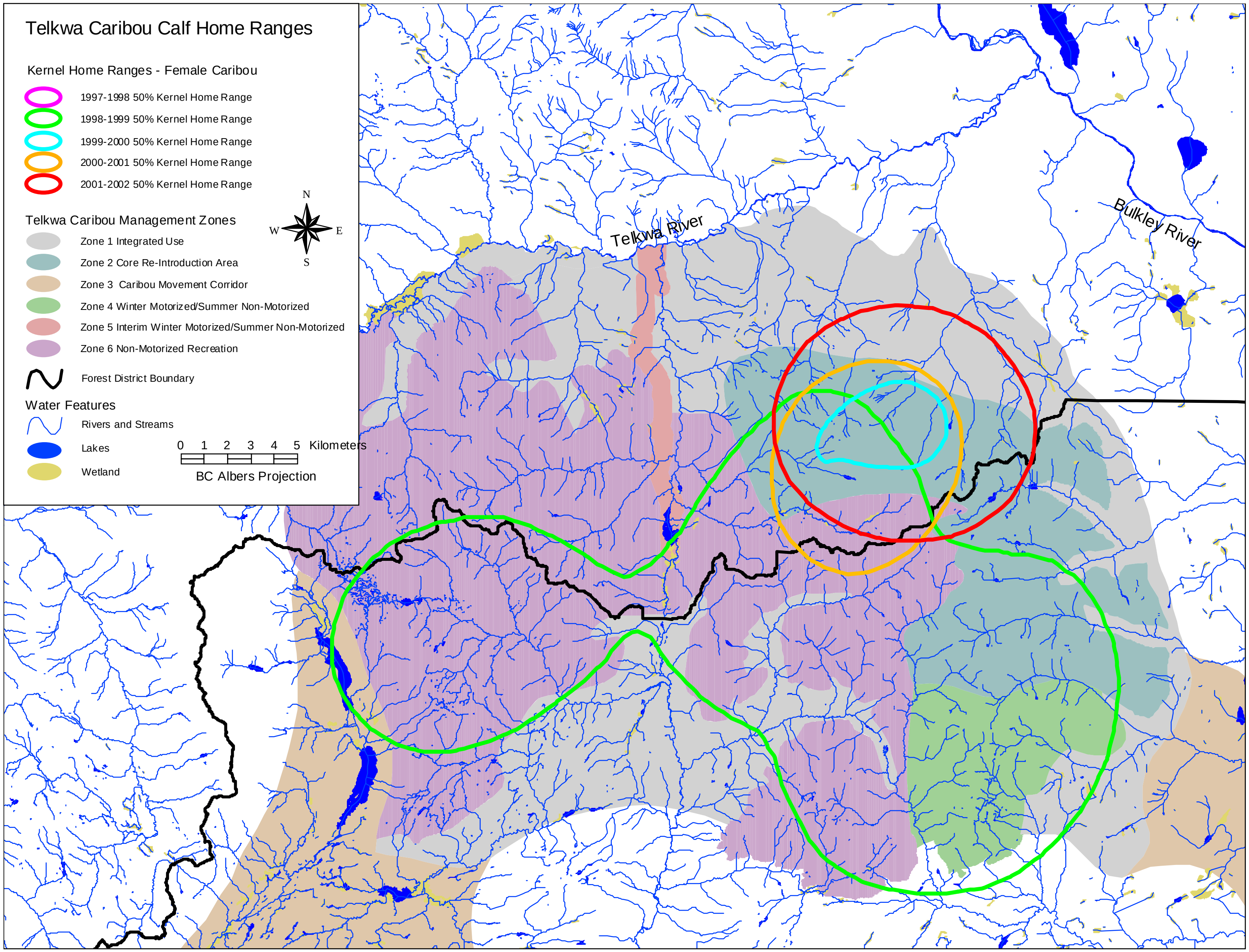

Figure 11. Female caribou 50% kernel calving home ranges for years 1998 to 2001.

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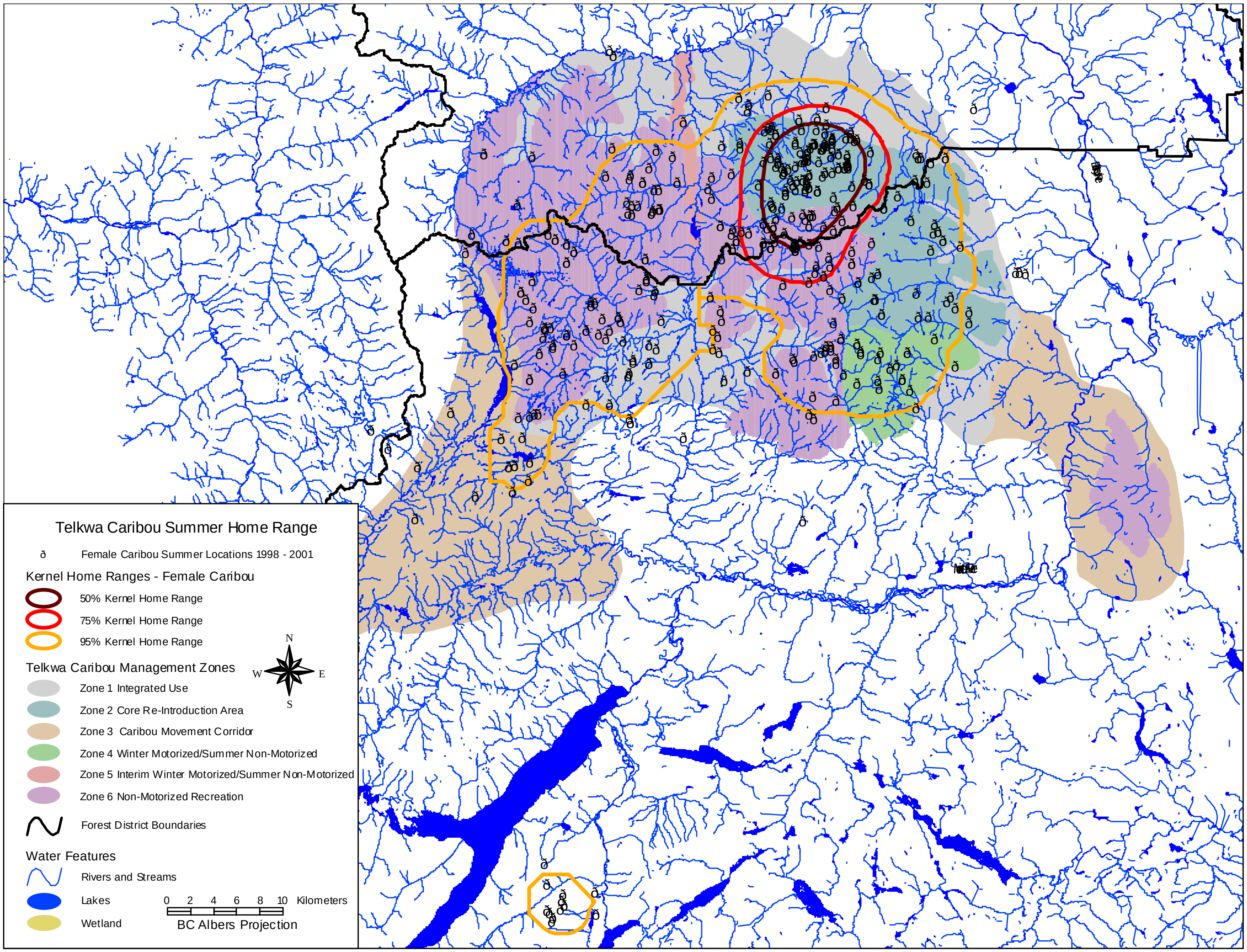

Figure 12. Female caribou summer kernel home ranges for years 1998 to 2001.

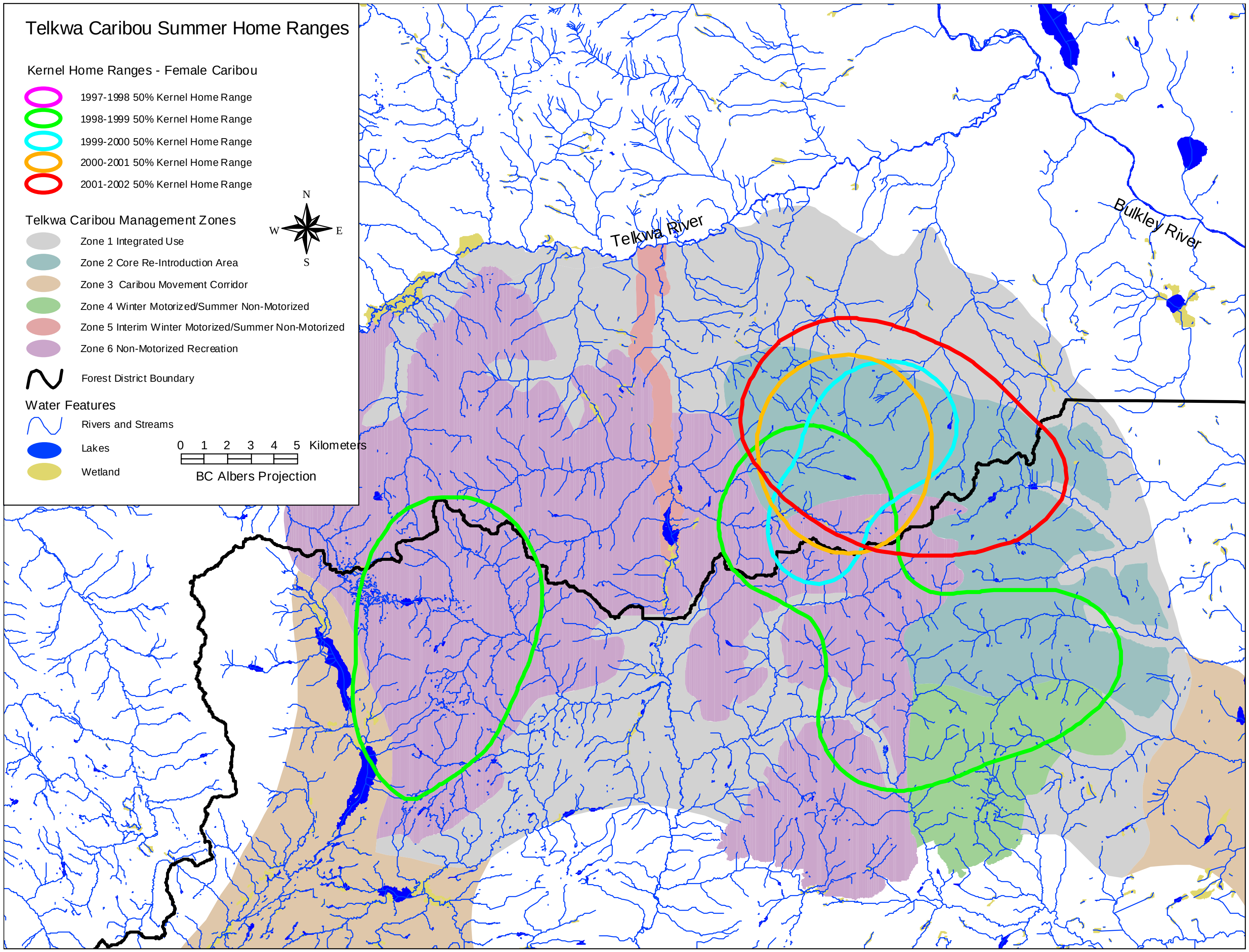

Figure 13. Female caribou 50% kernel summer home ranges for years 1998 to 2001.

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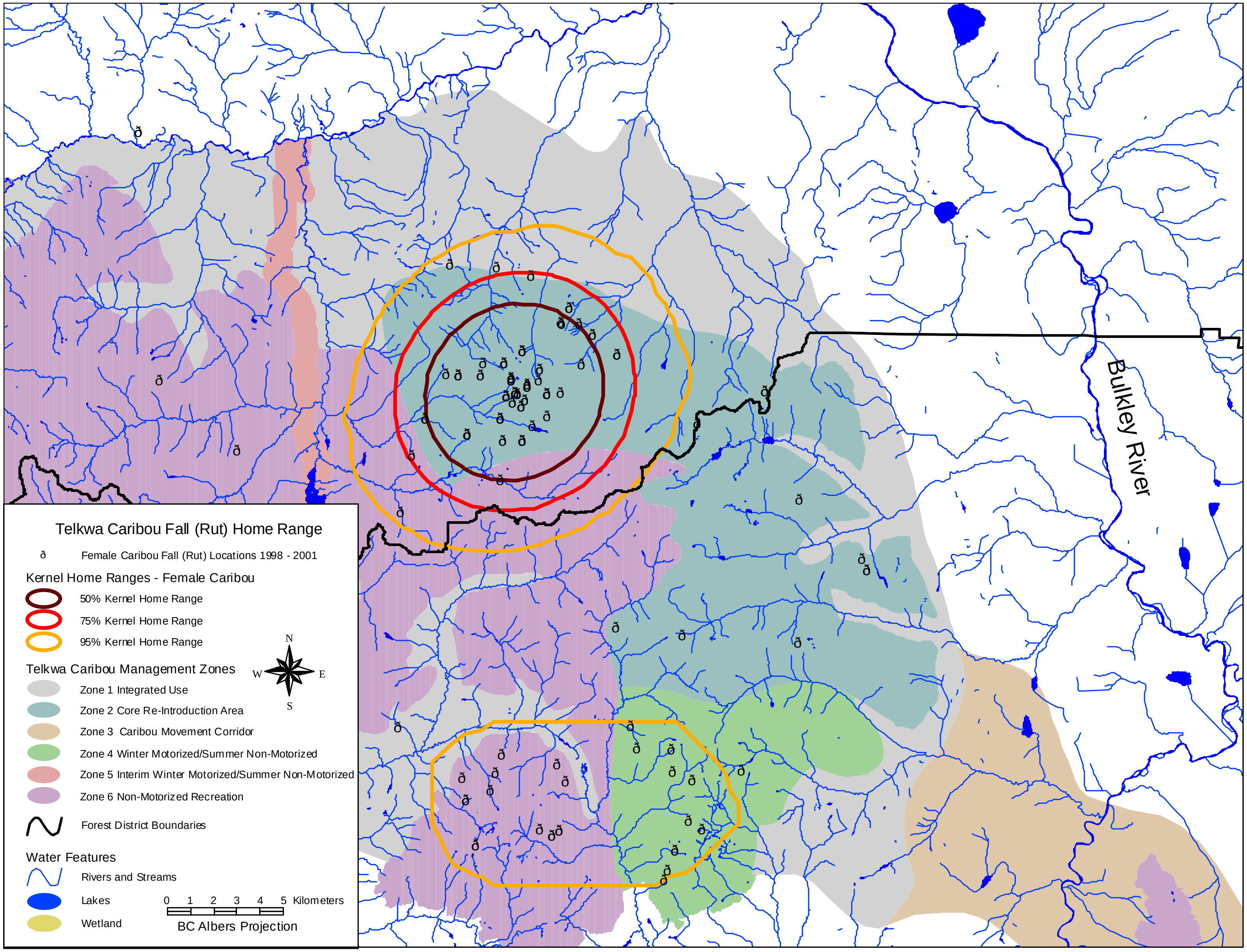

Figure 14. Female caribou fall (rut) kernel home ranges for years 1998 to 2001.

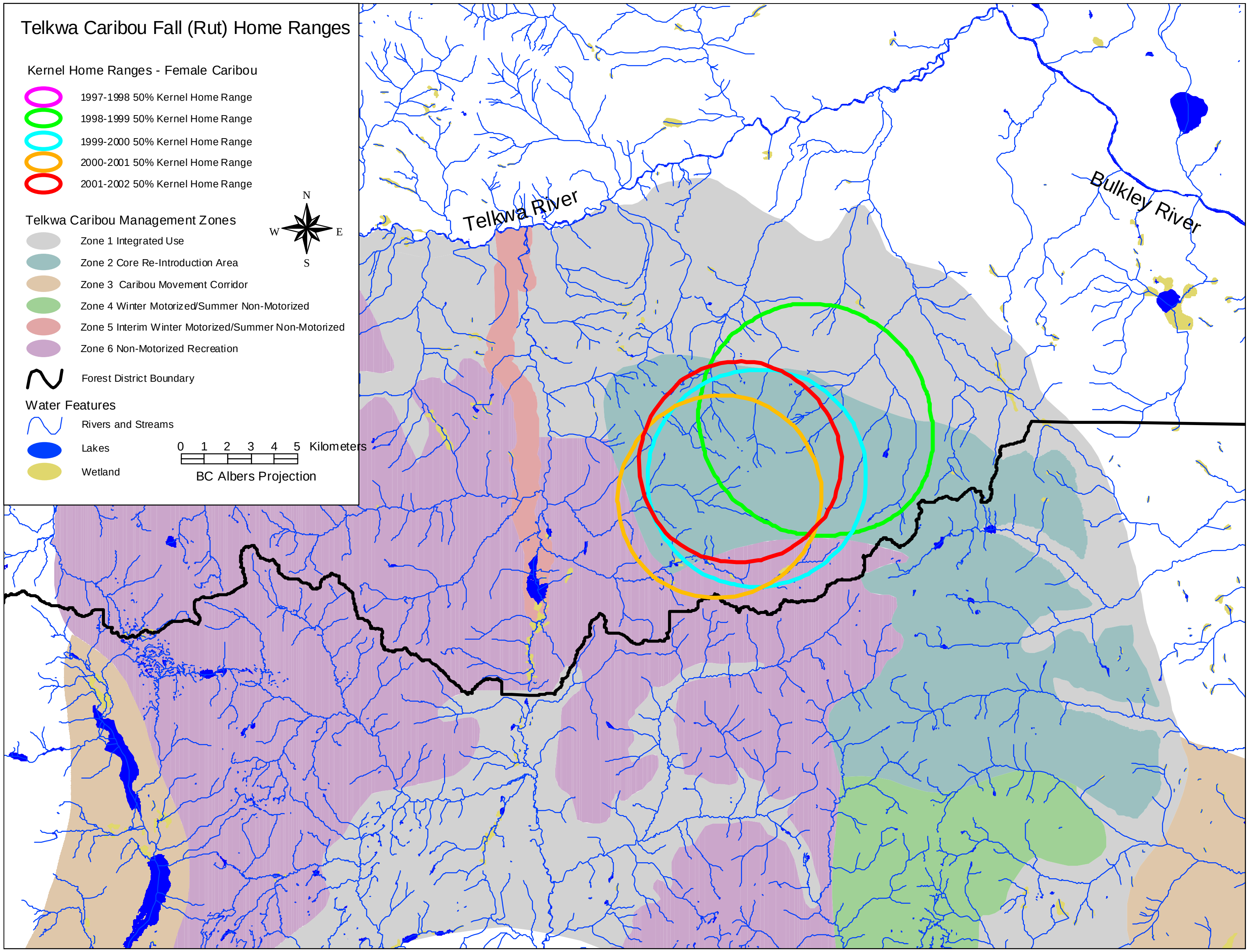

Figure 15. Female caribou 50% kernel fall (rut) home ranges for years 1998 to 2001.

winter results indicated a very large selection occurring. The summers of 1999 and 2000 also resulted in very large test statistics indicating a very high extent of selection overall. Appendix C, Tables C-1 and C-2 show the calculated statistics for the analyses of BEI selection.

Table 8 outlines the selection of BEI units by caribou in the study area. During all winters, caribou selected high elevation alpine type habitats alpine meadow (AM), alpine tundra (AT), and alpine unvegetated (AU) habitats and selected or used other habitats in the sub-alpine or high elevation forests. Avalanche track (AV) habitats and Engelmann spruce – sub-alpine fir dry forested (EF) habitats were selected in the winters of 1997 to 1999 but were used equivocally in 2000 and 2001. Engelmann spruce – sub-alpine fir dry parkland (FP) habitats were selected for in the winters of 1997, 1998 and 2001, selected against in 1999 and used in proportion to their availability in 2000. Sub-alpine shrub/grassland (SU) habitats and hybrid white spruce – black cottonwood riparian (WR) habitats were selected in 1997 and rock (RO) habitats were selected in 1998. Caribou either appeared neutral to or selected against all other habitats during the winter.

There was less consistency across years in habitat selection for the spring, summer, and fall seasons. Caribou selected AM and AT habitats in the spring of 1999 and 2000, AU habitats in the spring of 2000 and 2001, EF habitats in 2001, and WR habitats in 1999. Caribou either appeared neutral to or selected against all other habitats during the spring.

In summer, caribou tended to select for habitats in the alpine, sub-alpine, or high elevation forests over most other habitat types. Caribou were less selective in summer than in other seasons, appearing to use more habitat types in proportion to their availability than in other seasons. Caribou either selected for or appeared neutral to alpine habitat types: e.g. AM, AT, AU, AV, FP habitats, and EF habitats from 1998 to 2001. Most other habitats were significantly avoided except for a few habitats that caribou appeared

Table 8. Selection of Broad Ecosystem Inventory (BEI) polygons by female caribou within the study area.

Season	Year	Broad Ecosystem Inventory Units[1]																						
		AM	**AT**	**AU**	**AV**	**CF**	**CS**	**EF**	**EW**	**FP**	**FR**	**GL**	**HP**	**LP**	**MF**	**RO**	**SF**	**SL**	**SM**	**SU**	**WB**	**WL**	**WP**	**WR**
Winter	97/98	+	+	+	+	+	–	+	–	+	–	–	–	–	–	–	–	–	–	+	–	–	–	+
	98/99	+	+	+	+	•	–	+	–	+	•	–	•	–	•	+	–	–	•	–	•	–	•	–
	99/00	+	+	+	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	00/01	+	+	+	•	–	•	•	•	•	–	–	–	–	–	•	–	–	–	–	–	–	–	–
	01/02	+	+	+	•	–	•	•	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Spring	1998	•	•	•	•	•	–	•	•	–	–	–	–	–	–	–	•	•	•	–	–	•	–	•
	1999	+	+	–	–	•	–	•	–	–	•	–	–	–	–	–	–	–	–	–	–	–	–	+
	2000	+	+	+	–	–	–	•	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	2001	•	•	+	–	–	•	+	•	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Summer	1998	•	•	•	•	–	–	•	•	•	•	–	–	–	–	–	–	–	–	–	•	–	•	–
	1999	+	+	+	•	–	–	+	•	•	–	–	–	–	–	•	–	–	•	–	•	–	•	–
	2000	•	+	+	•	–	•	•	•	+	–	•	–	–	–	•	–	–	•	–	•	–	•	–
	2001	•	+	+	•	–	•	+	•	•	–	•	–	–	–	•	–	–	•	•	•	–	•	–
Fall	1998	•	•	•	–	–	–	•	•	•	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	1999	•	+	+	–	–	–	•	•	•	–	–	–	–	–	•	–	–	–	–	–	–	–	–
	2000	•	+	+	–	–	–	+	•	+	–	•	–	–	–	•	–	–	–	–	•	–	–	–
	2001	•	+	•	•	–	•	•	•	•	–	–	–	–	–	•	–	–	–	–	–	–	•	–

[1] BEI codes and descriptions are in Appendix A

• no significant selection occurring

+ animals significantly selecting for the habitat

– animals significantly avoiding the habitat

neutral to.

In the fall, caribou selected or appeared neutral to AT and AU habitats, appeared neutral to AM habitats, and avoided AV habitats for most years. The only other habitats that were selected for during the fall were the EF habitats and the FP habitats in 2000. Caribou appeared neutral to the sub-alpine fir – mountain hemlock wet forest (EW) habitats for all years. Caribou either appeared neutral to or significantly avoided all other BEI types from 1998 to 2001.

There were fewer BEI habitats used during the calving season than in other seasons (Table 9). In all years but 1999, the sample size for females classified as *Calf Lost* was too low for an analysis of habitat selection. *Calf Lost* females were grouped with *Calf Present* females and habitat selection was compared to the habitat selection results of *Calf Present* females and *No Calf* females (Table 8). Females classified as *Calf Lost* were assumed to behave similarly to successfully reproductive (*Calf Present*) females for the first portion of the calving season. Although there was only enough data during one year to do this comparison (1999), it appears that females that successfully calved (*Calf Present*) and females classified as *Calf Lost* did not use habitats in the same proportion. Caribou classified as *No Calf* selected for EF habitats for all years, whereas *Calf Present* females selected for the EF type only in 1999 and appeared neutral to it in other years. When *Calf Lost* females were grouped with *Calf Present*, there was significant selection for the EF type in all years. Grouping these females resulted in more habitats being selected than for *Calf Present* females on their own. Females classified as *Calf Present* selected for EF habitats in 1999 and AU habitats in 1999 and 2001 and appeared neutral or avoided other habitats. Grouped females (*Calf Present* and *Calf Lost*) selected EF habitats in all years, FP and AV habitats in 1999, AM and AU habitats in 1999 and 2000, and AM habitats in 1998 to 2000. Both *Calf Present* and grouped females avoided cultivated fields (CF), coastal western hemlock – subalpine fir (CS), FR, RO, SF, SL, WL habitats for all years. Females classified as *No Calf* appeared neutral to alpine types AM, AT, and AU for most years and generally avoided AV habitats except in 1999 when selection by caribou appeared to be neutral. Other than the EF habitats, *No Calf* females only selected for the AU habitat type in one year (1999), and avoided fewer habitats than other females during calving season. Habitats that were avoided every year were: CF, RO, SF, SL, and WL habitats.

Table 9. Selection of Broad Ecosystem Inventory (BEI) polygons by female caribou during the calving season within the study area.

Year	Status	Broad Ecosystem Inventory Units[1]																
		AM	AT	AU	AV	CF	CS	EF	EW	FP	FR	RO	SF	SL	SM	WB	WL	WP
1999	CL[2]	•	+	+	–	•	–	+	•	+	–	–	–	–	–	•	–	–
1998	NC[2]	•	•	•	–	–	–	+	–	•	•	–	–	–	–	–	–	•
1999	NC	•	•	+	•	–	–	+	–	•	–	–	–	–	–	–	–	–
2000	NC	•	•	•	–	–	–	+	•	•	–	–	–	–	•	–	•	–
2001	NC	•	•	•	–	–	•	+	•	–	–	–	–	–	–	–	–	–
1998	CP	–	•	•	–	–	–	•	•	•	–	–	–	–	•	–	–	•
1999	CP	•	•	+	•	–	–	+	–	•	–	–	–	–	–	–	–	–
2000	CP	•	•	•	•	–	–	•	–	•	–	–	–	–	•	•	–	–
2001	CP	–	–	+	–	–	–	•	–	–	–	–	–	–	–	–	–	–
1998	CP-L[2]	•	+	•	•	–	–	+	•	•	–	–	–	–	•	–	–	•
1999	CP-L	+	+	+	+	–	–	+	–	+	–	–	–	–	–	–	–	–
2000	CP-L	+	+	+	•	–	–	+	–	•	–	–	–	–	•	•	–	–
2001	CP-L	–	–	•	–	–	–	+	–	–	–	–	–	–	–	•	–	–

[1] BEI codes and descriptions are in Appendix A

[2] CL = *Calf Lost*, CP = *Calf Present*, NC = *No Calf*, CP-L = *Calf Present* plus *Calf Lost*.

• no significant selection occurring

+ animals significantly selecting for the habitat

– animals significantly avoiding the habitat

The results for the selection of BEC subzones by female caribou for each season indicated that in the winter of 1997 and 2000, the spring of 1998 and 2000, and the summer and fall of 2000, animals were using resources significantly different from one another. Selection of habitats was occurring overall for all seasons and all years by at least some of the animals. The magnitude of selection was significant for all years and seasons, however, the magnitude for all winters, except 1997, was very large, indicating that selection for resources was very high during this season. The summer season of 1999 and 2000 and calving in 1999 also indicated a high degree of selection for specific biogeoclimatic subzones. Appendix C, Tables C-3 and C-4 show the calculated statistics for the analyses of BEC selection.

Table 10. Selection for Biogeoclimatic subzones (BEC) polygons by female within the study area.

		Biogeoclimatic Subzones											
Season	**Year**	**AT**	**ESSFmc**	**ESSFmcp**	**ESSFmk**	**ESSFmkp**	**ESSFmv3**	**ESSFwv**	**ESSFwvp**	**ICHmc1**	**ICHmc2**	**SBSdk**	**SBSmc2**
Winter	1997-98	•	•	•	–	–	–	–	–	–	–	•	–
	1998-99	+	•	+	–	•	–	–	–	–	–	–	–
	1999-00	+	–	+	–	–	–	–	–	–	–	–	–
	2000-01	+	+	+	–	–	–	•	–	•	•	–	–
	2001-02	+	–	+	–	–	–	•	–	•	•	–	–
Spring	1998	•	•	•	•	–	–	–	–	–	–	•	•
	1999	+	–	+	–	–	–	–	–	–	–	–	–
	2000	+	–	+	–	–	•	–	–	–	–	–	–
	2001	+	•	+	–	–	–	•	–	•	–	–	–
Calving	1998	+	•	+	•	•	–	–	–	–	–	–	–
	1999	+	•	+	•	•	–	•	–	•	–	–	–
	2000	+	•	+	•	•	–	•	•	•	–	–	–
	2001	+	+	+	•	•	–	•	–	–	•	–	–
Summer	1998	+	•	+	•	•	–	–	–	–	–	–	–
	1999	+	•	+	•	–	–	–	–	–	–	–	–
	2000	+	+	+	•	•	–	–	–	–	–	–	–
	2001	+	+	•	–	–	–	•	–	•	–	–	–
Fall	1998	+	•	+	–	–	–	–	–	–	–	–	–
	1999	+	•	+	–	–	–	•	–	–	–	–	–
	2000	+	•	+	•	•	–	•	•	–	–	–	–
	2001	+	•	+	–	–	–	•	•	–	–	–	–

• no significant selection occurring
+ animals significantly selecting for the habitat
– animals significantly avoiding the habitat

Caribou selected the AT and ESSFmcp subzones for most years and across all seasons (Table 10). In winter, caribou did not consistently use the ESSFmc between years. In 2000, caribou selected for the ESSFmc, in 1997 and 1998 they appeared neutral to it, while in 1999 and 2001 caribou avoided the ESSFmc. Females either avoided or appeared neutral to the ESSFmc in the spring between 1998 and 2001, while in the summers of 2000 and 2001 select the ESSFmc. Caribou during the calving season in 2001 selected the ESSFmc and appeared neutral to the ESSFmc for all fall seasons. In the winters of 2000 and 2001, caribou appeared neutral to the ESSFwv, the ICHmc1 and the ICHmc2 subzones, while in all other years they avoid these types. For most years, the ESSFmv3, ESSFwvp, ICHmc1, ICHmc2, SBSdk and the SBSmc2 subzones are avoided for all seasons. The ESSFmk and ESSFmkp are mostly avoided for all years and seasons except for the calving season. During the calving season, these habitats appear to be neutral for caribou use. Female caribou mostly avoided the ESSFwv, with the exception of the calving and fall seasons for some years, when it appears to be neutral.

When the caribou were grouped into non-reproductive (*No Calf*) and reproductive (*Calf Present*) females, there was no significant selection for any habitats except for the AT in 1999 for *Calf Present* females (Table 11). Females classified as *Calf Present* avoided more habitats than *No Calf* females and there was a difference in the BEC zones that appeared neutral and that were avoided between the two groups for some years.

Table 11. Selection for Biogeoclimatic subzones (BEC) polygons by female caribou during the calving season within the study area.

		Biogeoclimatic Subzones											
Year	**Status**	**AT**	**ESSFmc**	**ESSFmcp**	**ESSFmk**	**ESSFmkp**	**ESSFmv3**	**ESSFwv**	**ESSFwvp**	**ICHmc1**	**ICHmc2**	**SBSdk**	**SBSmc2**
1998	NC[1]	•	•	•	–	•	–	–	–	–	–	–	–
1999	NC	•	•	•	•	–	–	–	–	–	–	–	–
2000	NC	•	•	•	•	–	–	–	–	–	–	–	–
2001	NC	•	•	•	–	–	–	•	–	•	–	–	•
1998	CP[1]	•	•	•	•	•	–	–	–	–	–	–	–
1999	CP	+	•	•	•	–	–	–	–	–	–	–	–
2000	CP	•	•	•	–	•	–	–	–	–	–	–	–
2001	CP	•	•	•	–	–	–	–	–	–	–	–	–

[1] CP = *Calf Present*, NC = *No Calf*.

• no significant selection occurring

+ animals significantly selecting for the habitat

– animals significantly avoiding the habitat

Analysis of slope categories indicated that except for the winter of 1997, all animals were using slope resources in a similar way. Slope classes were not selected significantly for the spring and fall of 1998, 1999, and 2001, the fall of 2000, and the winter and calving seasons of 2001. All other seasons indicated that there was significant selection occurring by some animals. The measure of the extent to which animals are on average using resources in proportion to the availability, irrespective of whether they are selecting the same resources or not, is examined by the third test statistic calculated. There was no significant difference in use versus availability for slope classes for the winter of 1997, the spring of 1998, and non-reproductive females in the 2000 calving season. All other years and seasons indicated that selection was significantly large. The winter seasons of 1997 to 2000, the calving season of 1999, and the summer seasons of 1999 and 2000 indicated the highest level of selection occurring for slope classes. Appendix C, Tables C-5 and C-6, show the calculated statistics for the analyses of slope selection.

Analyses of slope classes indicated that the 0% to 10% class was used less than available for most seasons and years (Table 12). It appeared that the most selected for slope classes were the 10% to 31% and 31% to 50% classes. Slopes that were greater than 50% were selected for in some seasons and some years, but never during the rut.

Caribou were grouped into non-reproductive (*No Calf*) and reproductive (*Calf Present*) females, and it was found that in all years except 2000, both groups selected all slope classes except 0% – 10% (Table 13). During 2000, the females classified as *No Calf* were neutral for any slope classes greater than 0% – 10%. Both groups also appeared to avoid slopes in the 0% – 10% slope category in all years except 1998 when the *Calf Present* females were neutral to that slope category.

Animals used aspect classes similarly in all seasons and years except for the winter of 1997 and 2000 (Appendix C: Tables C-7 and C-8). There was no significant selection for aspect classes for fall seasons 1998 to 2001, for spring 1998, for non-reproductive females in 1998 and 2000, for females that lost calves in 1999, and for females of all calving types in 2001. There was no significant difference in use versus availability of aspect classes for the spring of 1998. All other seasons and years showed significant difference in use versus availability. The extent of the selection indicated that the most significant selection was occurring in the winters of 1998 to 2000, the summers of 1999 and 2000, and in the calving season in 1999 for females that lost a calf (*Calf Lost*), and in 2000 and 2001 for all females.

Assessment of Winter Home Range and Forest Cover Data

The composition of the 50% and the 95% home range kernels for all winters from 1997/98 to 2001/02 were summarized by forested/non-forested, ecosystem types within the non-forested, forested type by leading species, and forested type by age class. The combination of leading species and age class was also reviewed for mature-old forest (age greater than 141 years) and the three leading species (lodgepole pine, subalpine fir and hybrid white spruce). Statistical analysis was not completed, due to time and budget constraints, although the observed trends are discussed.

Figure 16 outlines the results of the analysis of the 50% and 95% kernel home ranges for forested, non-forested and alpine forested habitats. The 95% kernel home range contained substantially more non-forested habitat than forested habitat in all years, except the winter of 1999/00. Generally, the 50% kernel home ranges did not contain the same proportion of non-forested to forested habitat for all winters as the 95% kernel home ranges. For the winter of 1997-98, however, the 50% kernel home range had approximately the same proportions of habitat types in the 95% kernel home range. The 50% kernel home range for the winter of 1998-99 had almost twice the amount of non-forested as forested habitat, however, when the forested alpine and the forested are combined, the amount of total forested to non-forested was similar. The 95% kernel home range for 1998-99, had significantly more forested than non-forested habitat. For the winter of 1999-00, both the 50% and the 95% kernel home range areas had more non-forested habitat than forested habitat. The

Table 12. Selection of slope classes by female caribou within the study area.

Season	Year	Slope (%)			
		0-10	11-30	31-50	51+
Winter	97/98	•	•	•	•
	98/99	–	+	+	+
	99/00	–	+	+	+
	00/01	–	+	+	•
	01/02	–	+	+	•
Spring	1998	•	•	•	•
	1999	–	+	+	•
	2000	–	+	•	–
	2001	–	+	+	+
Calving	1998	–	+	+	–
	1999	–	+	+	+
	2000	–	+	+	•
	2001	–	+	+	•
Summer	1998	–	•	+	+
	1999	–	•	+	+
	2000	–	+	+	•
	2001	–	+	+	•
Fall	1998	–	•	+	•
	1999	–	+	•	–
	2000	–	+	•	•
	2001	–	+	•	•

• no significant selection occurring
+ animals significantly selecting for the habitat
– animals significantly avoiding the habitat

Table 13. Selection of slope classes by female during the calving season within the study area.

Year	Status	Slope (%)			
		0-10	11-30	31-50	51+
1998	CP[1]	•	•	•	•
1999	CP	–	+	+	+
2000	CP	–	•	•	•
2001	CP	–	+	+	+
1998	NC1	–	•	+	•
1999	NC	–	+	+	+
2000	NC	–	+	+	+
2001	NC	–	+	+	+

[1] CP = *Calf Present*, NC = *No Calf*.
• no significant selection occurring
+ animals significantly selecting for the habitat
– animals significantly avoiding the habitat

winters of 2000-01 and 2001-02 had similar 50% and 95% kernel home range sizes. For the 50% kernel home ranges the total forested habitats (alpine forest + forested) was greater than non-forested habitats. There was substantially more forested habitat than non-forested habitat in the 95% kernel home range. Caution should be taken when comparing the 2001-02 results to other years as the winter data only included locations until February. As snow and environmental conditions change later in the winter, animals may utilize different habitat types, or proportion of habitat types, and this is not reflected in these results.

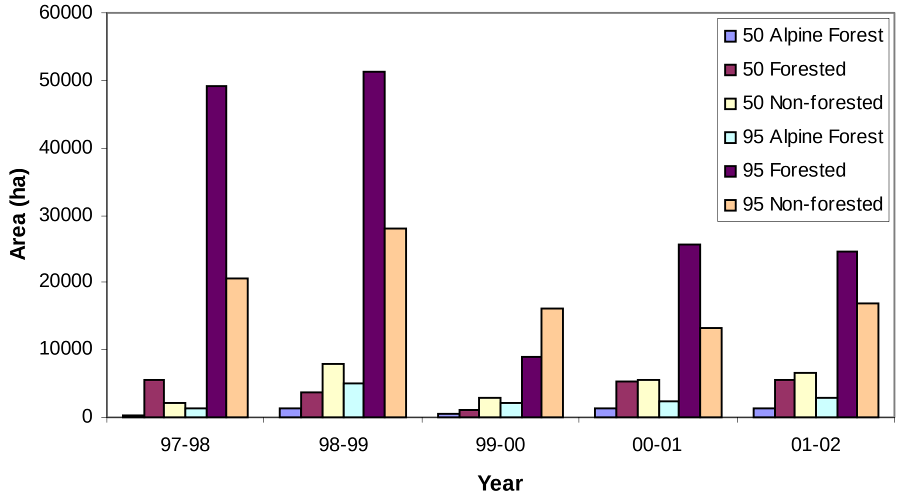

Figure 16. Area of 50% and 95% kernel winter home range in forested, alpine forest and non-forested types by winter season.

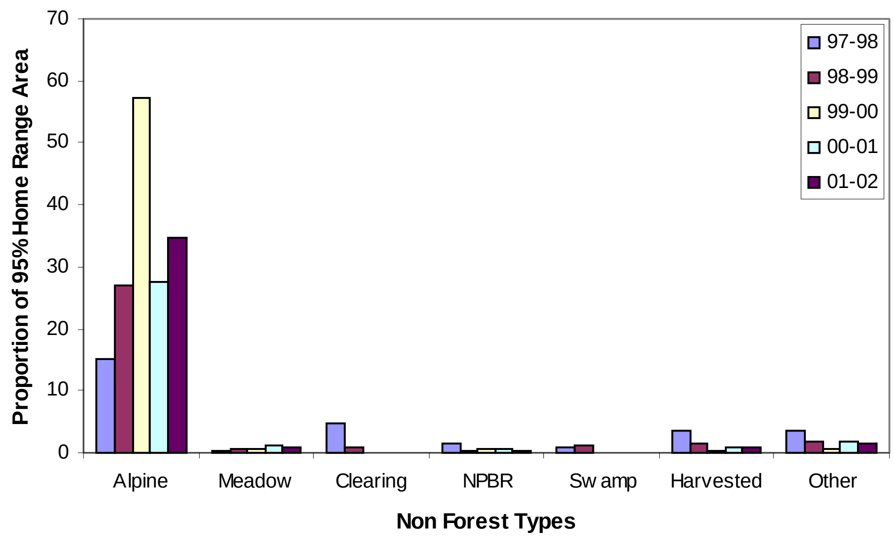

Figure 17. Proportion of 95% kernel winter home range in non-forested ecosystem types.

The non-forested and forested habitats were examined as the proportion of the total 95% winter home ranges and the results summarized in Figure 17. The majority of the non-forested habitat was composed of alpine habitat types for all years. For the winter of 1999-00, the home range size was much smaller than other winters and the majority of the home range was alpine habitat. Non-forested habitat in the winter of 1997-98 was mostly alpine, however; almost 14% of the total 95% kernel home range area was in non-forested types other than alpine. This could potentially be an effect of locating newly transplanted animals. For all other years, caribou utilized non-forested types, other than alpine, to a very small extent.

Figure 18 summarizes the leading tree species found in the 95% kernel home range for all winters. Results of the data exploration by leading species show that, for all years, subalpine fir forests were the dominant type in the winter home range area For all years, there was also a minor, component of lodgepole pine and spruce within the 95% kernal winter home range. The winter of 1997-98 had the widest range of forested types. For all winters, there was a minor (<1%) proportion of whitebark pine, which is common in high elevation subalpine forests.

The distribution of forest age classes found in the 95% kernel winter home range is shown in Figure 19. Forests between 141 and 250 years accounted for a large proportion of the forested types that were within the 95% kernel home range for all years. The distribution of other age class stands in was similar between years, except that stands between 21 and 40, and 41 and 60 years were much lower.

Leading tree species in stands older than 141 years for the 95% kernel winter home ranges are summarized in Figure 20. For all winters, between 22% and 35% of the total 95% kernel winter home range was subalpine fir forests, while 2% to 7% were. hybrid spruce and 1% to 4% were lodgepole pine leading stands.

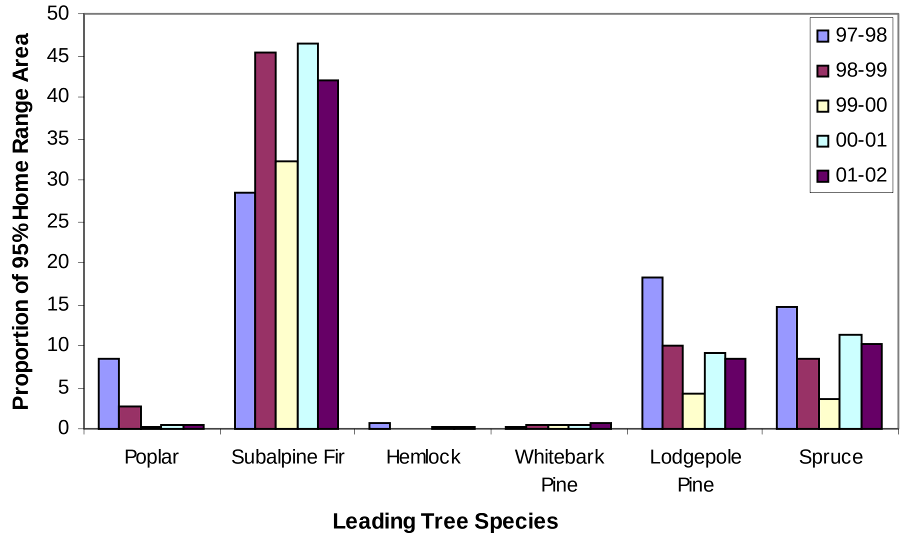

Figure 18. Proportion of 95% kernel winter home range of forested ecosystem types by leading species.

Assessment of Snow Depth Data

Snow data was summarized for the winters 1997-98 to 2001-02 and for the associated spring and calving months that had snow packs (Figure 21). The average line was obtained from snow depth data from 1995 to 2002.

Most years had starting snow depths close to the average, except 1999-00 and 2000-01, which started lower. As the winter progressed, snow depths accumulated to approximately March, then dropped as the snow began to melt. Interesting trends noted in the data include a higher than average snow depth for the 2001-02 winter for the entire winter. The 1997-98 winter showed a rapid snowmelt, with all of the snow gone by late May. Both 1998-99 and 2000-01 winters had snow depths close to or lower than the average until early May, when their snow depths were higher than the average.

Snow Levels and Habitat Use

Habitat use was compared in an exploratory manner to snow pack level and duration and no obvious were found. Caribou tended to select fewer habitats but use more habitats in proportion to their availability during the low snow pack spring of 1998 in comparison to the other years. Even though the snow pack of 1999 and 2001 had similar levels and timing of melt, BEI habitat use was not similar for either spring or calving females. Low

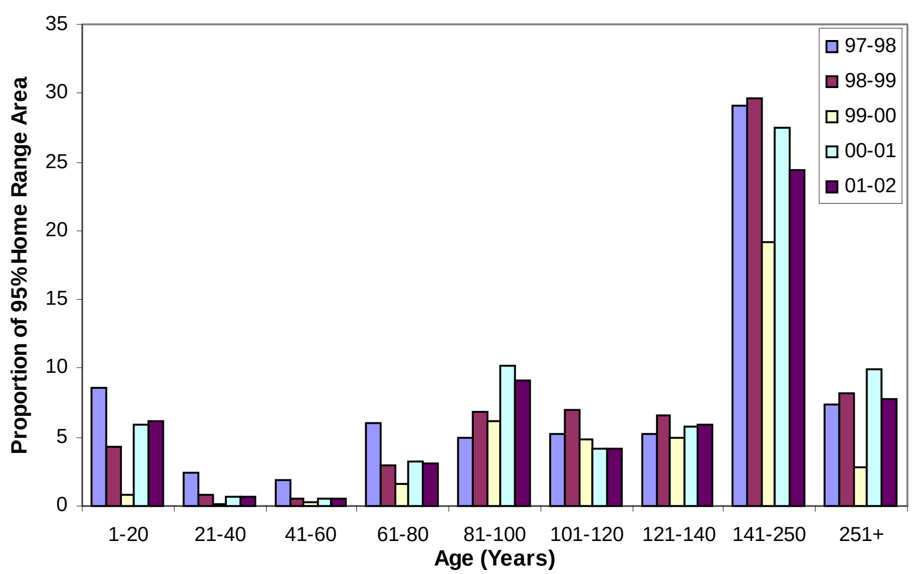

Figure 19. Proportion area of 95% kernel winter home range of forested ecosystem types by age classes.

elevation habitats were not significantly selected for any of the years for the group of caribou analysed. Individual animals and years were not assessed for habitat use and movements by weather data due to time and budget constraints.

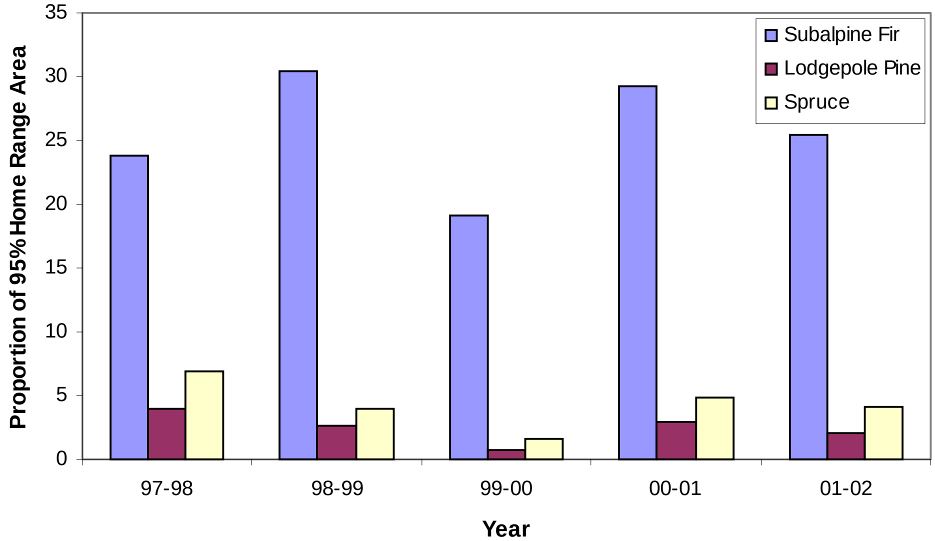

Figure 20. Proportion of 95% kernel winter home range of lodgepole pine, hybrid white spruce, and subalpine fir leading species older than 141 years.

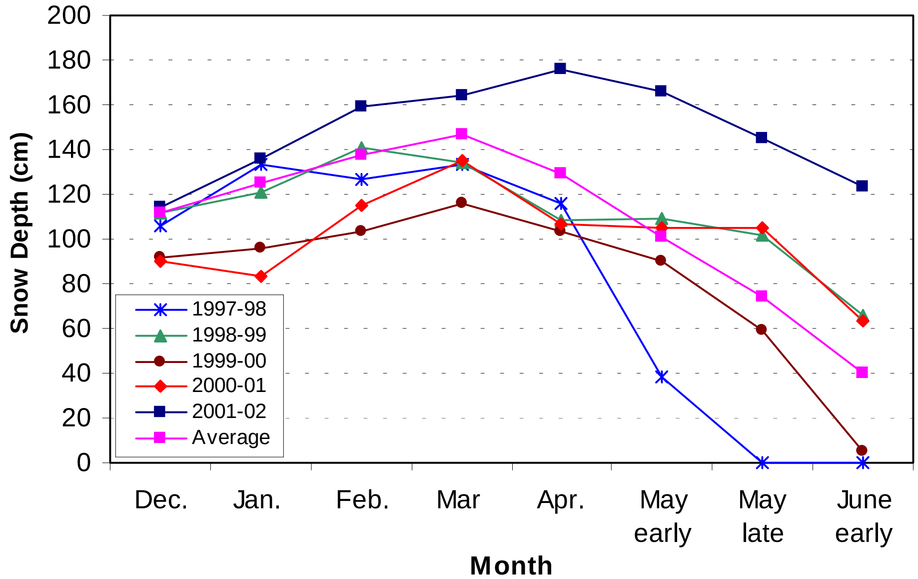

Figure 21. Snow depths for winter months measured from the Hudson Bay Mountain snow station (elevation 1480m) for 1999-98 to 2001-02.

DISCUSSION

This study underscores the importance of the Telkwa mountain range as a core area for the Telkwa caribou herd for all seasons of use. The kernel home range analysis of the VHF radio-collared caribou, from the winter of 1997/98 to 2001/02 and all seasons between, illustrated the preference for the core re-introduction habitat zone during most seasons.

As with many caribou herds that inhabit mountainous areas (e.g. Poole *et al.* 2000, Seip 1996, and Cichowski 1993), caribou in the Telkwa Mountains typically wintered in the alpine and sub-alpine habitats found in the Telkwa Mountain range. The Telkwa caribou are classified as a part of the northern woodland ecotype (Stevenson 1991) and exhibit behaviours similar with those described for other northern caribou ecotype herds in west-central British Columbia with the exception that they do not select for low elevation pine forests for terrestrial lichens. This exception may be due to a lack of this type of habitat in the core range. Telkwa caribou did not show distinctive trends for seasonal migrations; however, some animals moved to lower elevation forests in the spring or late winter of some years. There were some caribou in some years that did use lower elevation habitats; however, these were not selected as a whole by the herd.

It has been proposed (Bergerud *et al* 1990; Rettie and Messier 2000) that caribou may select habitats for predator avoidance at broad scales, and then select habitats for forage at finer scales, within these broader habitats that are relatively free of predation risk. The presence of moose in the lower elevation ranges of the Telkwa caribou may provide an alternate prey species for wolves as outlined in Seip (1996 and 1992). Caribou are thought to avoid predators, in part, by spatially separating themselves from alternate prey (Seip 1992). The avoidance of lower elevation habitats by the Telkwa caribou may be linked in part to this higher risk of predation.

Other factors that likely affect the movements and habitats used by caribou are human activities (i.e. forestry, agriculture, roads and recreation) that result in increased access to caribou habitat and possible disturbance to caribou. Activities (i.e. snowmobiles, exploration, aircraft, all terrain vehicles, hiking traffic) in the high elevation sites can also result in stressing and harassing caribou. This could lead to displacement from habitats and may result in increased mortality, decreased reproductive success, increased predation, and altered habitat use. Caribou are most sensitive to harassment during calving and rutting periods and during these times depend on alpine habitat to space themselves away from predators and other caribou (Webster 1997). vic Stronen (2000) suggested that caribou attempted to space away from snowmobile activity in the winter, often moving to ridges. Extensive snowmobile activity in high value winter habitats can also lead to increased access into an area by predators and can lead to packed snow which is more energetically costly to crater for terrestrial forage lichens (Fancy and White 1985).

The length and timing of the winter season was similar for the Little Rancheria herd (Rancheria herd) and the Telkwa herd; however, the 95% kernel winter home range (pooled across years) of the Telkwa herd was 37,124 ha, which was larger than the pooled 95% kernel winter home range of 21,170 ha observed for the Rancheria herd (Florikiewicz *et al*. *in prep*.). Cichowski (1993) calculated the Tweedsmuir – Entiako caribou herd home range sizes based on the minimum convex polygon (MCP) method and reported an average winter home range size of 5,270 ha and an average summer home range size of 2,460 ha. Estimation of home range by the MCP method does not indicate how intensively different parts of an animals range are used and the estimate of the home range size is strongly related to the outermost points (Gallerani Lawson and Rodgers 1997). A direct comparison cannot be made between the home range sizes of the Telkwa herd and the Tweedsmuir – Entiako herd because of the different methods that were used to calculate home ranges and the timing of the winter seasons were not biologically the same. A general statement could be made that the winter home range of the Telkwa herd appears to be substantially larger than the winter home range of the Tweedsmuir – Entiako caribou herd. Potential reasons for the Telkwa herd to have a larger winter home range size than that of the Tweedsmuir – Entiako herd are that the winter habitat for the Telkwa herd may not be as good, requiring the animals to venture further to forage in the winter. Another reason may be that the Telkwa herd may have to move more between terrestrial cratering sites and arboreal forests when foraging strategies change, whereas in the Tweedsmuir – Entiako winter range, the terrestrial cratering habitats and the arboreal forests are often found in complexes together (Cichowski 1993).

In the Charlotte Aplands caribou transplant project (Young *et al.* 2001), it was found that for the first season after transplant, collared juvenile caribou remained in the area where they were relocated and adult caribou migrated back to their original range (less than 100 km). Transplanted caribou from BC to Idaho in the 1990s were noted to wander considerably more than accounted for by home ranges and average activity radii (Audet 1996). These long-range exploratory movements post-transplant were reduced by releasing animals near other caribou, but did not entirely eliminate them. As within the Charlotte Apland caribou, many of the transplanted animals returned to the relocated release site and remained there for at least some time. Animal locations for the Telkwa caribou include locations soon after transplant. The influence of reporting on habitat selection of newly transplanted animals is unmeasured due to the lack of information prior to transplant; however, it is likely that there is an influence. It can be noted that some animals did wander considerable distances after the transplant, however, the nature of the timing and length of this behaviour was not known. Based on the location data, the greatest range of forested types and ages was observed during the first year and season after most of the animals were transplanted.

Both the Tweedsmuir – Entiako and the Rancheria herds migrate to summer and winter ranges, whereas the Telkwa herd does not appear to migrate to separate winter and summer grounds. The Takla Lake caribou (Poole *et al.* 2001) are also non-migratory northern caribou that are considered to be an isolated population. Poole *et al.* (2001) states that like many types of isolated populations, the animals have adapted to the food, topography and cover types that are available to them. It appears that the Telkwa herd is exhibiting similar habitat use patterns and can also be considered isolated. The Telkwa caribou utilize the rolling plateau habitats of the alpine and subalpine over most other habitats, however, unlike the Tweedsmuir – Entiako herd, there are no extensive low elevation habitats that are abundant with terrestrial lichens for the Telkwa caribou to winter in.

The average 50% kernel spring home range of 7,981 ha for the Telkwa herd, was the largest of all of the average seasonal home ranges and was almost twice the size of both the average calving (4,211 ha) and fall (rut) (4,586 ha) home ranges. Both the fall and the calving time periods were defined based on behavioural changes and not on specific weather changes or changes in forage availability. The caribou tended to group up for the rut and generally did not make large movements during this time period. During the calving season, females that calved did not group up as in the rut, however, these caribou were not very mobile. Females that were non-reproductive used more habitat types, used more forested habitats and had significantly larger home ranges than females that calved. Unlike the high elevation habitats used for calving in the Tweedsmuir – Entiako herd, where females utilized inhospitable ridges amidst rocky terrain, the Telkwa Mountains do not have an abundance of these types of habitats; therefore, calving females in the Telkwa herd tended to use the high elevation plateaus that were available to them. According to vic Stronen (2000), there were a couple of females that calved on the top of the rocky ridge above Hunter's Basin, suggesting that the lack of availability of these types of habitats, did not limit their use.

Caribou that had lost or aborted calves at some time during the calving period used more habitat types and larger home ranges (50% kernel = 5,065 ha) than reproductive females (50% kernel = 2,485 ha), but fewer habitats and smaller home ranges than females that did not calve (50% kernel = 15,206 ha). Females that calved exhibited less mobility than females that did not calve and have fewer locations outside of any of the 50%, 75% and 95% kernel home ranges. Depending on the circumstances of the loss of the calf, these females may have become more mobile after the calf loss, perhaps moving to areas of better forage opportunities and away from females that had calves. Females that did not produce calves had very large home range sizes, even in comparison to all other seasons.

In northern BC, Bergerud and Page (1987) suggested that the dispersion of calving caribou from valley bottom habitat into the mountains was an anti-predator tactic. Females with calves migrated, whereas non-productive females and males remained at low elevation habitat and were found to suffer higher mortality rates than those at higher elevations. Cichowski (1993) found that caribou in northern Tweedsmuir Park were widely dispersed during calving, but only 30% were found above treeline and 50% were at low elevations. Females that had calved in lower elevation habitats suffered a higher mortality from predation than did females at higher elevations. Most females in the Telkwa herd calved in alpine and sub-alpine habitats, however, there were some animals that were located at lower elevations with calves. Cichowski (1993) and Barten *et al*. (2001) proposed that there is a trade-off between superior forage quality at lower elevations and reduced predation risk in the higher elevation habitat. Depending on the distribution of predators and forage in the environment, caribou might minimize the ratio of predation risk to forage availability.

The 95% kernel home range for summer was more than twice the size of the next largest 95% kernel for any season. In summer, the Telkwa caribou spread out and ranged over the entire recovery area and outside of the recovery area. It is critical in the summer for caribou to get enough energy in their diet to sustain them during the summer and to gain enough energy stores to survive the winter (Mark Williams, *pers. comm*. 2000). In the summer, predator movement is not hindered by snow and they are able to access most or all portions of the caribou's range. Moose also tend to use more habitats and are found in most habitats, from valley bottom to sub-alpine. Caribou disperse into smaller post-calving groups during the summer, presumably as an anti-predator tactic and to access areas of high forage potential.

Habitat Selection

The abundance of terrestrial lichens in the wintering area of northern woodland caribou has been documented as being very important for some herds (e.g. Cichowski 1993, Florikiewicz *et al*. *in prep.*). Poole *et al.* (2001) found that like other northern caribou (e.g. Johnson 2001), Takla Lake caribou foraged on terrestrial lichens when in alpine areas during the winter. When in forested habitats, however, the Takla Lake herd most likely foraged on arboreal lichens because of the lack of terrestrial lichens and abundance of arboreal lichens in habitats that were used. During winter, the Tweedsmuir – Entiako caribou herd (Cichowski 1993, Price 1987) and the Rancheria herd (Florikiewicz *et al*. *in prep.*) appear to select pine dominated ecosystems on coarser textured tills and glacio-fluvial sand and gravel. These types of sites typically supported between 30% to 50% lichen ground cover and represented the best habitats for wintering caribou. The Telkwa caribou herd range is located in a more temperate area that receives more rainfall and precipitation than the wintering range of both the Tweedsmuir – Entiako caribou herd and the Rancheria herd, and there are less forested dry habitat types that support abundant lichen growth (Roberts 2001).

During the winter Telkwa caribou were using alpine habitats, and for some years, high elevation forested types greater than the proportion available. Because Telkwa caribou were selecting non-forested alpine habitat during all winters, there was strong evidence to suggest that terrestrial lichens were utilized for forage for at least a portion of the winter. For years that forested habitats were used during the winter, Engelmann – spruce/subalpine forests were selected for and hemlock, cedar and riparian forests appear to have been avoided. Based on this information, it is likely that the Telkwa caribou were foraging similar to the Takla Lake caribou in winter, e.g. terrestrial lichens in alpine habitats and arboreal lichens in forested habitats. Cratering sites in the alpine could potentially be windswept locations, enabling the caribou to dig through relatively shallow snow, or they could be used early in the winter season before the snow accumulation are too deep to crater through. Later in the winter season, conditions of deeper snow pack and often days of freeze – thaw, can result in either a snow pack too deep to crater for terrestrial lichens, or a thick crust on top of the snow, making cratering difficult. Under these conditions, caribou may use forested habitats and forage on arboreal lichens. The added lift of a deep winter snowpack facilitates access to arboreal lichens, as does a thick crust on the snow surface. Animals may move between the high elevation forest and the alpine habitats to access both types of forage under changing weather conditions. During winter, in west-central Alberta, caribou selected spruce dominated stands in old forests (Szkorupa 2002) during periods when snow conditions were deeper or generally harder.

Some studies have shown that, in winter, caribou tend to select habitats on relatively gentle slopes of less than 30% (Cichowski 1993), while Edmonds and Smith (1991) found that throughout the calving season cow – calf pairs were found primarily on moderate to steep slopes. Our results showed that during the winter and calving seasons, the female Telkwa caribou generally selected slopes ranging from 11% to 50% in most years and greater than 51% in some years. This may be due to the lack of gentle slopes in the higher elevation areas where the caribou were found. Caribou may not be necessarily be avoiding gentle terrain as implied by our results, but may be avoiding low elevation habitat, which is where most of the gentle terrain is located.

The selection of aspect types (cool, warm, flat) was not analysed in this study; however, vic Stronen (2000) presented results that state that calving females were selecting cool slopes in summer season. vic Stronen (2000) defined cool habitats differently than we did; however, if females are selecting for north facing slopes, there may be some benefit, either as an anti-predator strategy as vic Stronen (2000) suggested, or as a foraging strategy. North facing slopes tend to shed snow slower than south facing slopes. This may lead to late lying snow patches; however, it could also lead to rich seepage slopes that have abundant and lush herbaceous vegetation. Use of aspect types may also be linked to thermal cooling.

Management Implications

Analysis of habitat selection and use by female caribou located between early winter 1997 and January 2002 can be considered to be representative of the Telkwa caribou herd. Seasons of use other than winter should be interpreted with caution due to the biases in the data collection, however, results from these analyses should not be disregarded. Another cautionary note for the interpretation of this analysis for future herd management is that this information is representative of the habitat use of a herd in the short term after relocating animals and that as the herd grows, more habitats that were not identified as selected may become important to an expanding herd. As well, to determine which habitats should be maintained, we need to know which habitats caribou typically use, but also their requirements during critical periods (such as harsh winters), which may limit survival and reproduction. Snow conditions can have a negative impact on caribou populations, especially if sufficient habitat for foraging is not available (Adamczewski *et al.* 1986, Szkoropa 2002). Caribou employ two main foraging strategies in the winter: they either crater for terrestrial lichens and forbs, or forage on arboreal lichens. Although caribou are adapted to cratering, very deep or hard snow may force caribou to switch to feeding on arboreal lichens (Rominger and Oldemeyer 1989).

Telkwa Mountain caribou likely forage on both terrestrial and arboreal lichens in winter. When in spruce – fir forests it is likely that arboreal lichens were predominantly fed on. Arboreal lichens are most abundant in old – growth forests (greater than 250 years) and along wetlands and other established edge habitats, such as along ridges. When these types of habitats are harvested, arboreal lichens are entirely eliminated and the return interval for good levels of lichens to return is more than 90 years, and at least 140 years for higher elevation forests with a shorter growing season. Protection of habitat above 1200 m elevation in the range of the Telkwa caribou herd would maintain most of its current core winter habitat; below this elevation, habitats that support high abundances of terrestrial and arboreal lichens should be maintained according to the current interim harvesting guidelines until higher level planning occurs.

Terrestrial lichens are slow to recover after forest harvesting activities that cause soil disturbance and typically peak in abundance on sub-mesic to dry sites that are 70 to 130 years old. It is recommended that sites identified as potentially good terrestrial lichen sites be managed to maintain a portion of the potential area as high value. This habitat is most likely quite infrequent on the landscape and sites that are identified should be maintained within a larger complex of mature to old forest.

Forest harvesting patterns can fragment the landscape and in general creates good habitat for moose. This can potentially lead to higher risk of predation in areas that are utilized by caribou. Until the caribou population is at a level that is stable and healthy, there should be no additional pressures made on the herd with regards to predation. To achieve this, forestry activities should not proceed in areas that are high use areas in any season, or in areas that could potentially be high use areas should the herd return to target levels. Areas that have a high potential for arboreal lichen production should be considered high value within the Telkwa herd range. Other forested types that are or will likely be highly suitable habitat for caribou are high elevation forests (greater than 1200 m) that are greater than 140 years old, dominated by subalpine fir, lodgepole pine or spruce. Other forested types that must be considered for management are low to mid elevation pine forests and wetlands at mid to high elevations.

FUTURE WORK

This report provides information on habitat selection and home range location and size at a coarse landscape scale. The following is a list of recommendations for further analysis not done in this project, changes to telemetry location methodologies to increase location precision, and project ideas to complement habitat selection and home range studies:

1. Calculate Bonferonni confidence intervals of aspect classes to determine selection.
2. Habitat selection analysis of finer scale forest cover and ecosystem information.
3. Conduct a multivariate analysis of habitat attributes to determine interactions of variables.
4. If the goal for future telemetry locations is to conduct habitat selection analysis, then telemetry data collection methodology should be refined to reflect this goal. GPS collar locations can be used as well as VHF locations that are more precise and capture more information (i.e. habitat description and mapping on a finer scale). A recommended methodology for collecting further VHF telemetry locations to be used in habitat selection analysis is provided in Appendix D.
5. Site visits and habitat plots of accurately marked telemetry locations should be done to complement GIS analysis and better quantify habitat types for specific attributes (such as forage quality, snow depth and crustiness, escape terrain).
6. Conduct a winter (and possibly calving) food habit and diet quality analysis. This information can provide valuable information regarding the timing and intensity of use of certain habitat types and the importance of forage types.
7. Use the available VHF and GPS telemetry data to test the validity of existing habitat suitability models.
8. Conduct a habitat supply analysis of potential caribou habitats and predicted forest harvesting scenarios within the Telkwa Caribou Herd Recovery Area.

CONCLUSION AND MANAGEMENT RECOMMENDATIONS

After reviewing the results of habitat use and home range locations of the current Telkwa caribou herd, we are providing some recommendations that are consistent with the direction of the Bulkley LRMP, the objectives of the Telkwa Caribou Recovery Plan, and the mandate of WLAP. Recommendations consider the population requirements and possible management approaches for herds of similar ecotypes in British Columbia.

1. Adjust the borders of the core recovery area to better fit the areas of high use. This is especially intended to incorporate the high elevation forest that is used, but that is currently in the integrated use zone.
2. Continue to monitor the herd, but with the new intent to collect information in a methodology suitable for conducting habitat selection analysis.

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APPENDIX A: BROAD ECOSYSTEM UNITS IN THE STUDY AREA

Symbol	Name	Description
AG	Alpine Grassland	Typically a high elevation, northern, grassland habitat, characterized by lush bunchgrass growth, with forbs, sedges and terrestrial lichens.
AM	Alpine Meadow	Typically a high elevation, herbaceous community, dominated by moisture-loving herbs and sedges, on wetter sites in alpine areas.
AT	Alpine Tundra	Typically a high elevation, open to dense herbaceous or dwarf shrubland habitat, characterized by cold resistant vegetation consisting of low dwarf shrubs, graminoids, hardy forbs, and lichens.
AU	Alpine Unvegetated	Typically a high elevation habitat dominated by rock outcrops, talus, steep cliffs and other areas with sparse vegetation of grass, lichens and low shrubs.
AV	Avalanche Track	Typically a shrubland dominated by alders, or other shrubs where periodic snow and rock slides have prevented coniferous forest establishment and where moisture is plentiful for much of the growing season; lower areas may support rich herbaceous growth.
CF	Cultivated Field	Typically a mixture of farmlands where man's influence has resulted in long-term soil and/or vegetation changes because of agricultural practices of plowing fertilization, and non-native crop production.
CS	Coastal Western Hemlock - Subalpine Fir	Typically a northern coastal, cold habitat, characterized by dense coniferous forests of western hemlock, subalpine fir and spruce with dense shrub and moss layers.
DF	Interior Douglas-fir	Typically a dense coniferous forest, with grass-dominated understories, that includes plant communities that progress directly to a Douglas-fir climax.
EF	Engelmann Spruce - Subalpine Fir Dry Forested	Typically a dense coniferous forest, with shrub-dominated understories, that includes plant communities that may progress through seral lodgepole pine to a varied climax of Engelmann spruce and subalpine fir.
EW	Subalpine Fir - Mountain Hemlock Wet Forested	Typically a dense coniferous forest, with shrub-dominated understories, that includes plant communities that progress directly to a mixed climax of subalpine fir and mountain hemlock, sometimes amabilis fir.
FP	Engelmann Spruce - Subalpine Fir Dry Parkland	Typically a high elevation mosaic of stunted-tree clumps and herb or dwarf shrub dominated openings, occurring above the closed forest and below the alpine.
FR	Amabilis Fir - Western Redcedar	Typically a dense coniferous forest of low elevations, with fern - or shrub-dominated understories, that includes plant communities that may contain western redcedar as a long-lived seral species, leading to a mixed western hemlock and amabilis fir climax.
GL	Glacier	Permanent icefield or glacier, with no vegetation.
HP	Mountain Hemlock Parkland	Typically a high elevation, sparse to open mosaic of stunted tree Clumps and herbaceous or mountain-heather dominated openings, that proceeds after disturbance directly to a climax species mix, dominated by mountain hemlock.
LL	Large Lake	Typically a fresh deepwater habitat that includes permanently flooded lakes, usually found in a topographic depression, lacking emergent vegetation except along shorelines, and usually with a size of greater than 60 hectares.
LP	Lodgepole Pine	Typically an open lodgepole pine forest with shrub, moss or terrestrial lichen understories on level, nutrient-poor, coarse-textured soils.
LS	Small Lake	Typically a fresh deepwater habitat that includes permanently flooded lakes (and sometimes reservoirs), usually 8 to 60 ha in size in a topographic depression, with most of the water less than 7 m in depth.
MF	Mountain Hemlock - Amabilis Fir	Typically a high elevation dense coniferous forest with shrub-dominated understories, that proceeds after disturbance directly to a climax species mix of mountain hemlock and amabilis fir, sometimes with yellow-cedar.

Symbol	Name	Description
MI	Mine	An underground or open pit mine site with associated infrastructure such as tailings ponds, processing facilities, etc.
RO	Rock	Typically a mixture of nonalpine steep bedrock cliffs, escarpments and outcroppings with little soil development and relatively low vegetative cover.
SF	White spruce - Subalpine Fir	Typically a dense, coniferous subboreal forest, with dense shrub-moss dominated understories that include communities that progress directly to a white spruce and subalpine fir climax, sometimes with lodgepole pine or trembling aspen.
SL	White Spruce - Lodgepole Pine	Typically a dense, subboreal coniferous forest that includes plant communities that succeed through lodgepole pine seral forests to a white spruce climax.
SM	Subalpine Meadow	Typically a high elevation herbaceous habitat, dominated by moisture-loving herbaceous species, on wetter sites in subalpine forest areas.
SR	Sitka Spruce - Black Cottonwood Riparian	Typically a dense coniferous forest, with fern - or shrub - dominated understories, that may progress through plant communities with redalder, black cottonwood or bigleaf maple to a coniferous mixture of Sitka spruce and western hemlock; found on or in association with fluvial sites.
SU	Subalpine Shrub/Grassland	Typically high elevation, northern habitat, characterized by dense shrubs and bunchgrasses intermixed and dominated by scrub birch, willows and Altai fescue.
UR	Urban	Typically a mixture of man-influenced habitats that includes residential areas, urban areas and commercial/industrial areas, but excludes major agriculture lands.
WB	Whitebark Pine Parkland	Typically a subalpine habitat of open, whitebark pine forests, intermixed with lush bunchgrasses, other perennial grasses and forbs, on droughty sites.
WL	Wetland	Used for any wetland habitat class which cannot be recognized at small mapping scales.
WP	Subalpine Fir - Mountain Hemlock Wet Parkland	Typically a high-elevation mosaic of tree clumps and subalpine meadows or tundra, occurring above the closed forest and below the alpine.
WR	Hybrid White Spruce - Black Cottonwood Riparian	Typically a dense deciduous, mixed, or coniferous forest, with shrub-dominated understories, found on or in association with fluvial sites, that includes plant communities that succeed slowly through black cottonwood to potential white spruce climax.

APPENDIX B: TELKWA CARIBOU HABITAT ZONES

Zone 1. Integrated Use.

Areas within Zone 1 consist of caribou habitat in which industrial activity is expected to occur, consistent with direction provided by the Bulkley LRMP. Caribou habitat areas were mapped using information from Biophysical Classification for Wildlife ungulate Capability Mapping, 1996 lichen transect surveys, radio-telemetry locations of Telkwa herd caribou, and locations of collared caribou sightings. Primary industrial activity will be forest harvesting and silviculture activities that are modified for caribou objectives in this zone. Mineral exploration and extraction activities are expected to play a lesser role.

Higher elevation boundaries for Zone 1 were determined from the best approximation of forest harvest operability lines. Habitat capability, caribou distribution data and natural physical barriers formed lower zone boundaries. The upper Mooseskin Johnny Lake area was not included in Zone 1, as forest harvesting is not slated for that area during the next five year time period. Future forest harvesting strategies for this area will depend on values incorporated in the Landscape Unit Planning process (maintaining visual quality, habitat connectivity, and protection of wetlands around Mooseskin Johnny Lake).

Management within Zone 1 areas will involve adoption of forest harvesting strategies that integrate caribou values with management of public access through forest road and block deactivation planning. Area or specific road closures will be legislated through the Forest Practices Code (soon to be objectives of the results based code) of British Columbia Act or the Wildlife Act where necessary.

Zone 2. Core Re-Introduction Area

Area designation was based on historic and current use by Telkwa herd and delineation of the area rated to have the highest capability for caribou.

<u>All access</u> will be restricted within this zone on a voluntary basis, especially during the first critical years of caribou recovery, when it is important to minimize the potential for disturbance to cause recently introduced caribou to leave the recovery area.

Zone 3. Caribou Movement Corridor to Morice Mountain.

To maintain the potential for genetic interchange between Telkwa herd animals and caribou in Tweedsmuir Park, and to allow caribou to access habitat within their historic range, caribou must be allowed to move between the Telkwa Mountains and areas to the south, including Morice Mountain and Tweedsmuir Park. In the Morice Mountain corridor, current and future harvest plans will be reviewed to ensure that cutting plans are designed to maintain habitat connectivity, permitting movement and security cover between harvest blocks and lowland valley development. A corridor to Morice Mountain was identified because there were confirmed sightings of caribou on Morice Mountain in both 1996 and 1997. The Tweedsmuir corridor was removed from the initial draft of the Telkwa Caribou Recovery Zone map because of a lack of proposed forest harvest plans for that area.

Zone 4. Winter Motorized/Summer Non-Motorized.

Zone 4 was identified to permit continued recreational snowmobile use, recognizing the importance of that area to the Houston snowmobile club, and consistent with the intent of the Recovery Plan to provide public recreational opportunities so long as they are consistent with habitat protection measures that will ensure sufficient habitat exists to sustain a viable caribou herd. The boundaries of this area were determined through discussion and negotiation with representatives of the Smithers Snowmobile Club and Houston Snowmobile Association.

BCE staff felt that winter snowmobile use could continue on a trial basis given available information and caribou distribution that shows Telkwa herd mainly use this area in early spring and over the summer. Therefore this area is designated non-motorized for summer periods.

Management actions in the Recovery Plan call for frequent monitoring of translocated caribou to determine annual movements, distribution and habitat use. That data will be used in future considerations of the importance of this zone to Telkwa herd and whether winter motorized use is compatible with caribou winter range requirements.

Zone 5. Interim Winter Motorized/Summer Non-Motorized.

This zone (Meat Cache Trail) was designated, and the boundaries determined after discussion and negotiation with representatives of the Smithers Snowmobile Club and Houston Snowmobile Associations. This designation is in place for one year, to be evaluated at the end of the 1997/98 snow-mobiling season. BCE was willing to consider continued motorized access to this area on a trial basis because most motorized use of the area occurs over a relatively short period of time in the spring (March -May) before caribou move up into higher elevation area to calf, and because there exists natural physical barriers to motorized access to the areas (Emerson Ridge) currently used as late-winter range by the Telkwa herd.

This zone extends to the height of land on the east at which there is a natural, physical barrier to snow-machines onto Emerson Ridge. The northwestern boundary has been extended up into a corridor through the "Meat Cache" area. The area to the west of the corridor is non-motorized and snowmobile access is prohibited. The area to the east is the "Core" introduction area and snowmobile access is also prohibited in that area. This corridor ends at the height of land prior to "the small lake". The small lake is in the "Core" area and motorized access is not permitted.

These restrictions will be communicated to the public through signs placed at the trailhead by the parking lot, and at the natural topographic funnel at "the top of the meat cache, before the hole". Additional signs will be located as necessary along the boundaries of the corridor area.

This zone also includes Morice Mountain. Members of the Houston Snowmobile Association will monitor caribou activity on Morice Mountain, and have agreed to refrain from using Morice Mountain if caribou are present.

Zone 6. Non-Motorized Recreation

Zone 6 consists of caribou habitat located above forest harvest operability lines. The intent is to restrict all motorized use within those areas to minimize potential direct and indirect impacts on Telkwa herd, and to maintain the opportunity for caribou to use all areas of potential winter range.

APPENDIX C: HABITAT SELECTION RESULTS

Table C-1. Chi-Square results for habitat use for Broad Ecosystem Inventory (BEI) units by female caribou within the study area.

Year	Season	n[a]	I[b]	X^2_{L1} (df_{L1})[c]	Animals using Resources Differently?	X^2_{L2} (df_{L2})[c]	Overall Selection ?	X^2_{L1}-X^2_{L2} (df_{L1-L2})	Significant difference: use vs. availability?
1997-98	Winter	11	13	295.59 (120)	Yes	580.00 (132)	Yes	-284.4 (12)	Yes
1998	Spring	10	12	79.34 (99)	No	119.97 (110)	No	-40.63 (11)	Yes
1998	Summer	8	14	135.98 (91)	Yes	346.47 (104)	Yes	-210.49 (13)	Yes
1998	Fall	8	6	18.96 (35)	No	85.87 (40)	Yes	-66.92 (5)	Yes
1998-99	Winter	28	18	244.08 (459)	No	1445.98 (476)	Yes	-1201.9 (17)	Yes
1999	Spring	24	9	110.38 (184)	No	395.38 (192)	Yes	-285.01 (8)	Yes
1999	Summer	24	14	220.59 (299)	No	1041.65 (312)	Yes	-821.06 (13)	Yes
1999	Fall	29	10	78.53 (252)	No	338.39 (261)	Yes	-259.86 (9)	Yes
1999-00	Winter	26	10	192.81 (225)	No	2689.52 (234)	Yes	-2496.71 (9)	Yes
2000	Spring	27	6	72.93 (130)	No	487.95 (135)	Yes	-415.03 (5)	Yes
2000	Summer	29	15	256.75 (392)	No	1162.78 (406)	Yes	-906.04 (14)	Yes
2000	Fall	27	10	29.32 (234)	No	250.96 (243)	No	-221.64 (9)	Yes
2000-01	Winter	24	13	506.35 (276)	Yes	1890.09 (288)	Yes	-1383.74 (12)	Yes
2001	Spring	24	10	80.96 (207)	No	193.95 (216)	No	-112.98 (9)	Yes
2001	Summer	20	16	186.48 (285)	No	606.45 (300)	Yes	-419.98 (15)	Yes
2001	Fall	15	11	127.50 (140)	No	564.94 (150)	Yes	-437.44 (10)	Yes
2001-02	Winter	19	10	136.93 (162)	No	889.02 (171)	Yes	-752.09 (9)	Yes

[a] n= the number of animals used in the analysis
[b] I= the number of habitats used in the analysis
[c] degrees of freedom: df_{L1} = (n-1)(I-1), df_{L2} = n(I-1), df_{L1-L2} = $|df_{L1} – df_{L2}|$

TableC-2. Chi-Square results for overall habitat use for Broad Ecosystem Inventory (BEI) units by female caribou within the study area during the calving season.

Year	Status[1]	n[a]	I[b]	X^2_{L1}	(df_{L1})[c]	Animals using Resources Differently?	X^2_{L2}	(df_{L2})[c]	Overall Selection?	X^2_{L1}-X^2_{L2}	(df_{L1-L2})[c]	Significant difference: use vs. availability?
1998	NC	4	7	19.08	(18)	No	101.16	(24)	Yes	-82.08	(6)	Yes
	CP	4	7	22.22	(18)	No	105.90	(24)	Yes	-83.68	(6)	Yes
	CP-L	17	8	33.45	(5)	No	142.82	(119)	Yes	-109.38	(7)	Yes
1999	CL	7	10	60.41	(54)	No	327.67	(63)	Yes	-267.26	(9)	Yes
	NC	10	8	39.67	(63)	No	104.55	(70)	Yes	-64.88	(7)	Yes
	CP	10	7	98.37	(54)	Yes	800.95	(60)	Yes	-702.58	(6)	Yes
	CP-L	17	11	196.02	(160)	Yes	1128.62	(170)	Yes	-932.60	(10)	Yes
2000	NC	9	10	57.51	(72)	No	152.79	(81)	Yes	-95.28	(9)	Yes
	CP	10	14	83.93	(117)	No	356.85	(130)	Yes	-272.92	(13)	Yes
	CP-L	12	11	114.78	(160)	No	440.71	(120)	Yes	-325.93	(10)	Yes
2001	NC	12	7	51.54	(66)	No	124.28	(72)	Yes	-72.74	(6)	Yes
	CP	9	4	29.91	(24)	No	88.21	(27)	Yes	-58.30	(3)	Yes
	CP-L	7	5	45.26	(44)	No	119.78	(28)	Yes	-74.52	(4)	Yes

[1] CP = *Calf Present*, NC = *No Calf*, CP-L = *Calf Present* and *Calf Lost*
[a] n= the number of animals used in the analysis
[b] I= the number of habitats used in the analysis
[c] degrees of freedom: df_{L1} = (n-1)(I-1), df_{L2} = n(I-1), df_{L1-L2} = $|df_{L1} – df_{L2}|$

Table C-3. Chi-Square results for habitat use for Biogeoclimatic subzones (BEC) by female caribou within the study area.

Year	Season	n[a]	I[b]	X^2_{L1} (df_{L1})[c]	Animals using Resources Differently?	X^2_{L2} (df_{L2})[c]	Overall Selection?	X^2_{L1}-X^2_{L2} (df_{L1-L2})	Significant difference: use vs. availability?
1997-98	Winter	11	5	247.42 (40)	Yes	393.60 (44)	Yes	146.18 (4)	Yes
1998	Spring	10	6	65.18 (45)	Yes	87.73 (50)	Yes	22.55 (5)	Yes
1998	Calving	10	6	33.83 (45)	No	168.00 (50)	Yes	134.17 (5)	Yes
1998	Summer	8	7	47.19 (42)	No	223.32 (48)	Yes	176.13 (6)	Yes
1998	Fall	8	3	15.24 (14)	No	69.30 (16)	Yes	54.06 (2)	Yes
1998-99	Winter	27	9	149.81 (208)	No	876.28 (216)	Yes	726.47 (8)	Yes
1999	Spring	24	4	34.90 (69)	No	247.18 (72)	Yes	212.28 (3)	Yes
1999	Calving	27	4	297.90 (78)	Yes	1335.28 (28)	Yes	1037.38 (3)	Yes
1999	Summer	24	8	169.24 (161)	Yes	900.04 (168)	Yes	730.80 (7)	Yes
1999	Fall	29	5	56.79 (112)	Yes	305.02 (116)	Yes	248.23 (4)	Yes
1999-00	Winter	26	5	99.62 (100)	No	2104.80 (104)	Yes	193.01 (4)	Yes
2000	Spring	27	5	67.14 (104)	Yes	464.16 (108)	Yes	397.02 (4)	Yes
2000	Calving	26	6	136.64 (125)	No	409.84 (130)	Yes	273.20 (5)	Yes
2000	Summer	29	9	151.19 (119)	No	835.60 (232)	Yes	684.41 (8)	Yes
2000	Fall	27	8	98.45 (224)	No	467.28 (189)	Yes	368.83 (7)	Yes
2000-01	Winter	24	8	336.00 (161)	Yes	1409.12 (168)	Yes	1073.12 (7)	Yes
2001	Spring	24	7	61.68 (138)	No	184.66 (144)	Yes	122.98 (6)	Yes
2001	Calving	24	6	87.52 (115)	No	209.60 (120)	Yes	122.08 (5)	Yes
2001	Summer	20	8	109.44 (133)	No	466.60 (140)	Yes	357.16 (7)	Yes
2001	Fall	15	5	65.17 (56)	No	140.00 (60)	Yes	74.83 (4)	Yes
2001-02	Winter	19	8	85.29 (126)	No	605.04 (133)	Yes	519.75 (7)	Yes

[a] n= the number of animals used in the analysis
[b] I= the number of habitats used in the analysis
[c] degrees of freedom: df_{L1} = (n-1)(I-1), df_{L2} = n(I-1), df_{L1-L2} = |df_{L1} – df_{L2}|

Table C-4. Chi-Square results for overall habitat use for Biogeoclimatic subzone (BEC) by female caribou within the study area during the calving season.

Year	Status[1]	n[a]	I[b]	X^2_{L1} (df_{L1})[c]	Animals using Resources Differently?	X^2_{L2} (df_{L2})[c]	Overall Selection?	X^2_{L1}-X^2_{L2} (df_{L1-L2})[c]	Significant difference: use vs. availability?
1998	NC	4	5	7.34 (12)	No	62.62 (16)	Yes	55.28 (4)	Yes
	CP-L	6	5	18.95 (20)	No	105.38 (24)	Yes	86.43 (4)	Yes
1999	NC	10	5	105.58 (36)	Yes	418.80 (40)	Yes	313.22 (4)	Yes
	CP-L	17	6	187.04 (80)	No	906.60 (85)	Yes	719.56 (5)	Yes
2000	NC	9	5	44.56 (32)	Yes	110.52 (36)	Yes	65.96 (4)	Yes
	CP-L	17	4	76.86 (48)	Yes	299.40 (51)	Yes	222.54 (3)	Yes
2001	NC	12	6	45.80 (55)	No	103.18 (60)	Yes	57.38 (5)	Yes
	CP-L	12	4	31.22 (33)	No	96.44 (36)	Yes	65.22 (3)	Yes

[1] NC = *No Calf*, CP-L = *Calf Present* and *Calf Lost*
[a] n= the number of animals used in the analysis
[b] I= the number of habitats used in the analysis
[c] degrees of freedom: df_{L1} = (n-1)(I-1), df_{L2} = n(I-1), df_{L1-L2} = |df_{L1} – df_{L2}|

Table C-5. Chi-Square results for overall habitat use for slope classes by female caribou within the study area.

Year	**Season**	**n[a]**	**I[b]**	**X^2_{L1} (df_{L1})[c]**	**Animals using Resources Differently?**	**X^2_{L2} (df_{L2})[c]**	**Overall Selection?**	**X^2_{L1}-X^2_{L2} (df_{L1-L2})[c]**	**Significant difference: use vs. availability?**
1997-98	Winter	11	4	71.72 (30)	Yes	76.20 (33)	Yes	4.48 (3)	No
1998	Spring	10	4	10.96 (27)	No	12.97 (30)	No	2.01 (3)	No
1998	Calving	10	4	21.46 (27)	No	45.66 (30)	Yes	24.20 (3)	Yes
1998	Summer	8	4	10.092 (21)	No	57.52 (24)	Yes	47.43 (3)	Yes
1998	Fall	8	4	7.15 (21)	No	16.62 (24)	No	9.47 (3)	Yes
1998-99	Winter	28	4	37.32 (81)	No	166.30 (84)	Yes	128.98 (3)	Yes
1999	Spring	24	4	28.08 (69)	No	86.62 (72)	No	58.54 (3)	Yes
1999	Calving	27	4	89.16 (78)	No	294.80 (81)	Yes	205.64 (3)	Yes
1999	Summer	24	4	55.68 (69)	No	175.66 (72)	Yes	119.98 (3)	Yes
1999	Fall	29	4	19.66 (84)	No	43.66 (87)	No	24.00 (3)	Yes
1999-00	Winter	26	4	45.2 (75)	No	327.00 (78)	Yes	281.80 (3)	Yes
2000	Spring	27	4	31.52 (78)	No	104.86 (81)	Yes	73.34 (3)	Yes
2000	Calving	26	4	61.34 (75)	No	118.60 (78)	Yes	57.26 (3)	Yes
2000	Summer	29	4	32.20 (84)	No	214.60 (87)	Yes	182.40 (3)	Yes
2000	Fall	27	4	32.74 (78)	No	45.74 (81)	No	13.00 (3)	Yes
2000-01	Winter	24	4	57.78 (69)	No	237.60 (72)	Yes	179.82 (3)	Yes
2001	Spring	24	4	18.15 (69)	No	58.64 (72)	No	40.49 (3)	Yes
2001	Calving	24	4	29.88 (69)	No	59.82 (72)	No	29.94 (3)	Yes
2001	Summer	20	4	22.04 (57)	No	97.20 (60)	Yes	75.16 (3)	Yes
2001	Fall	15	4	11.81 (42)	No	26.46 (45)	No	14.65 (3)	Yes
2001-02	Winter	19	4	25.50 (54)	No	71.14 (57)	No	31.50 (3)	Yes

[a] n= the number of animals used in the analysis
[b] I= the number of habitats used in the analysis
[c] degrees of freedom: df_{L1} = (n-1)(I-1), df_{L2} = n(I-1), df_{L1-L2} = $|df_{L1} – df_{L2}|$

Table C-6. Chi-Square results for overall habitat use for slope classes by female caribou within the study area during the calving season.

Year	**Status[1]**	**n[a]**	**I[b]**	**X^2_{L1} (df_{L1})[c]**	**Animals using Resources Differently?**	**X^2_{L2} (df_{L2})[c]**	**Overall Selection?**	**X^2_{L1}-X^2_{L2} (df_{L1-L2})[c]**	**Significant difference: use vs. availability?**
1998	NC	4	4	8.63 (9)	No	17.22 (12)	No	8.59 (3)	Yes
	CP-L	6	4	12.41 (15)	No	28.43 (18)	No	16.02 (3)	Yes
1999	NC	10	4	26.02 (27)	No	80.05 (30)	Yes	54.03 (3)	Yes
	CP-L	17	4	62.41 (48)	No	214.84 (51)	Yes	152.43 (3)	Yes
2000	NC	9	4	14.88 (24)	No	13.46 (27)	No	1.42 (3)	No
	CP-L	17	4	25.10 (48)	No	98.08 (51)	Yes	72.97 (3)	Yes
2001	NC	12	4	13.33 (33)	No	28.59 (36)	No	15.27 (3)	Yes
	CP-L	12	4	16.01 (33)	No	31.23 (36)	No	15.23 (3)	Yes

[1] NC = *No Calf*, CP-L = *Calf Present* and *Calf Lost*
[a] n= the number of animals used in the analysis
[b] I= the number of habitats used in the analysis
[c] degrees of freedom: df_{L1} = (n-1)(I-1), df_{L2} = n(I-1), df_{L1-L2} = $|df_{L1} – df_{L2}|$

Table C-7. Chi-Square results for overall habitat use for aspect classes by female caribou within the study area.

Year	Season	n[a]	I[b]	X^2_{L1} (df_{L1})[c]	Animals using Resources Differently?	X^2_{L2} (df_{L2})[c]	Overall Selection?	X^2_{L1}-X^2_{L2} (df_{L1-L2})[c]	Significant difference: use vs. availability?
1997-98	Winter	11	3	58.77 (20)	Yes	80.39 (22)	Yes	-21.62 (2)	Yes
1998	Spring	10	3	8.83 (18)	No	9.74 (20)	No	-0.91(2)	No
1998	Summer	8	3	6.48 (14)	No	45.62 (16)	Yes	-39.14 (2)	Yes
1998	Fall	8	3	12.16 (14)	No	23.05 (16)	No	-10.89 (2)	Yes
1998-99	Winter	28	3	6.88 (54)	No	158.92 (56)	Yes	-152.04(2)	Yes
1999	Spring	24	3	24.90 (46)	No	85.15 (48)	Yes	-60.25 (2)	Yes
1999	Summer	24	3	50.78 (46)	No	157.85 (48)	Yes	-107.08 (2)	Yes
1999	Fall	29	3	24.64 (56)	No	55.82 (58)	No	-31.18 (2)	Yes
1999-00	Winter	26	3	40.93 (50)	No	333.82 (52)	Yes	-292.89 (2)	Yes
2000	Spring	27	3	16.27 (52)	No	85.15 (54)	Yes	-68.88 (2)	Yes
2000	Summer	29	3	40.43 (56)	No	221.65 (58)	Yes	-181.22 (2)	Yes
2000	Fall	27	3	29.05 (52)	No	42.27 (54)	No	-13.22 (2)	Yes
2000-01	Winter	24	3	69.02 (46)	Yes	288.26 (48)	Yes	-219.23 (2)	Yes
2001	Spring	24	3	29.02 (46)	No	78.12 (48)	Yes	-49.10 (2)	Yes
2001	Summer	20	3	29.75 (38)	No	109.41 (40)	Yes	-79.65 (2)	Yes
2001	Fall	15	3	13.41 (28)	No	29.07 (30)	No	-15.66 (2)	Yes
2001-02	Winter	19	3	20.18 (36)	No	69.04 (38)	Yes	-48.86 (2)	Yes

[a] n= the number of animals used in the analysis
[b] I= the number of habitats used in the analysis
[c] degrees of freedom: $df_{L1} = (n-1)(I-1)$, $df_{L2} = n(I-1)$, $df_{L1-L2} = |df_{L1} – df_{L2}|$

Table C-8. Chi-Square results for overall habitat use for aspect classes (warm, cool, flat) by Telkwa caribou within the available habitat for females during the calving season.

Year	Status[1]	n[a]	I[b]	X^2_{L1} (df_{L1})[c]	Animals using Resources Differently?	X^2_{L2} (df_{L2})[c]	Overall Selection?	X^2_{L1}-X^2_{L2} (df_{L1-L2})[c]	Significant difference: use vs. availability?
1998	NC	4	3	0.77 (6)	No	3.91 (8)	No	-79.63 (2)	Yes
	Yes	4	3	10.46 (6)	No	27.57 (8)	Yes	-58.59 (2)	Yes
	Y+L	6	3	17.46 (10)	No	32.78 (12)	Yes	-60.66 (2)	Yes
1999	No	10	3	70.31 (18)	Yes	116.94 (20)	Yes	-88.62 (2)	Yes
	Yes	10	3	69.85 (18)	Yes	212.76 (20)	Yes	60.11 (2)	Yes
	Lost	7	3	8.56 (12)	No	22.26 (14)	No	-100.84 (2)	Yes
	Y+L	17	3	95.86 (32)	Yes	235.02 (34)	Yes	50.24 (2)	Yes
2000	No	9	3	14.52 (16)	No	21.28 (18)	No	-319.30 (2)	Yes
	Yes	14	3	45.35 (26)	Yes	121.51 (28)	Yes	-39.80 (2)	Yes
	Y+L	17	3	51.15 (32)	Yes	129.90 (34)	Yes	-106.70 (2)	Yes
2001	No	12	3	11.42 (22)	No	31.18 (24)	No	-276.83 (2)	Yes
	Yes	9	3	9.75 (16)	No	26.54 (18)	No	-75.40 (2)	Yes
	Y+L	12	3	13.37 (22)	No	32.56 (24)	No	-208.28 (2)	Yes

[1] NC = *No Calf*, CL = *Calf Lost*, CP = *Calf Present*, CP-L = *Calf Present* and *Calf Lost*
[a] n= the number of animals used in the analysis
[b] I= the number of habitats used in the analysis
[c] degrees of freedom: $df_{L1} = (n-1)(I-1)$, $df_{L2} = n(I-1)$, $df_{L1-L2} = |df_{L1} – df_{L2}|$

ARDEA BIOLOGICAL CONSULTING
2175 Millar Rd. Smithers, BC
Ph. (250) 877-6705♦FAX (250) 877-6805

APPENDIX D: RECOMMENDED PROTOCAL FOR COLLECTING TELEMETRY LOCATIONS FOR HABITAT SELECTION

Equipment Required

1. clip board and extra pencils
2. camera (Polaroid or digital)
3. frequency list (updated)
4. binoculars
5. 1:250 map sheets
6. data forms (1 per animal)

Methodology - Flying

1. Get as accurate a location as possible (i.e. what tree is that animal hiding under).
2. Record as detailed habitat information as possible from the air (dominant tree species, aspect, canopy cover etc.). This will help during the plotting later.
3. Draw a picture of the location while in the air to help you plot the location when you are on the ground.
4. Take a Polaroid/Digital photo of the location with something in the photo for reference i.e. road or distinctive edge of a cut block anything that will help us verify the location if there is uncertainty. Make sure that the flash does not go off because it will reflect in the window. You can usually write notes as the pilot circles to gain elevation and give you a perspective for the photo. Mark the location on the photo and mark the date, time, animal number and frequency on the bottom of the photo

Methodology – Plotting

1. Plot locations as soon after the flight as possible. Make a note on the telemetry form if photos are needed for verification.
2. At your disposal are:
3. Ortho photos and air photos
4. Maps including 1:250,000 and 1:50,000 topographic and 1:20,000 forest cover
5. Plot the locations as follows:
6. Convert Lats\Longs to utms.
7. Using indices select appropriate topographic and forest cover maps and ortho and air photos
8. Plot caribou location on ortho photos (if available) and airphoto.
9. Write corrected coordinates on the back of the aerial telemetry data sheet.
10. Pinhole location on the photo with a needle and write the caribou ID on the back in fine tipped permanent felt pen (i.e. W 10 21/02/98). Note date is DD/MM/YY.
11. Plot corrected coordinates on 1:20,000 forest cover map and record forest cover information from that onto aerial telemetry data sheet.
12. Record 1:20,000 map sheets on back of aerial telemetry data sheet.
13. Describe accuracy of location in comments.