Little Rancheria Caribou in the Yukon: Evaluation of Winter Habitat Quality and Habitat Use

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This report includes material from on-going studies by British Columbia Ministry of Water, Land and Air Protection (MWLAP). The MWLAP studies will be reported more fully from that agency in the future. Data gathered from caribou radio-collared by the British Columbia Ministry of Environment Lands and Parks (2001/02 FRBC Project #SBA02802 Liard Plains Caribou) is the property of the British Columbia Ministry of Water, Land and Air Protection. Permission to use the information or data must be obtained from the British Columbia Ministry of Water, Land and Air Protection, Smithers, BC.

DEDICATION

We dedicate this work to
Glen Stockman
Who loved these caribou
just because they were there

Little Rancheria Caribou in the Yukon: Evaluation of Winter Habitat Quality and Habitat Use

Summary

We studied caribou from the Little Rancheria Herd (LRH) from 1990 to 2000 as part of an evaluation of ungulate habitat use in the Liard Basin. Studies on caribou conducted early in the period focused on validating published patterns of distribution and range use. During our study, caribou concentrated in the central "core" part of the winter range. We observed consistent fall movement patterns from the south to the winter range through a migration corridor paralleling the Little Rancheria River. We also established the winter range outer periphery based on the distribution of historic and recent caribou track sign. Collectively, these observations were integrated into 3 broad zones on the Yukon winter range.

We incorporated new data on caribou distribution and movement patterns from a study initiated by the British Columbia Ministry of Water, Land and Air Protection. Caribou preferred habitats with the highest cover of lichens: O*pen pine/lichen*, *Pine/bearberry, and Black spruce* habitat types. Caribou avoided *Pine/feathermoss* habitat types.

The more detailed habitat and animal assessments confirmed the patterns seen during the early reconnaissance work. Over our study period the Yukon core wintering areas represented, by far, the greatest concentration of wintering caribou within the total winter range (including British Columbia).

We used this information to develop a computer model to predict habitat quality for the Yukon LRH range to help guide future management activities within the range of these caribou.

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Introduction

The Little Rancheria Herd (LRH) of woodland caribou (*Rangifer tarandus caribou*) and their winter range in the Yukon are facing the same dilemma as many other herds in North America: How do resource managers balance the interests of the economy and the environment in the pursuit of sustainable resource management?

Caribou rely on slow-growing lichens, found primarily in the same mature and old forest types that are most valuable for timber extraction. Caribou are also sensitive to the resulting habitat fragmentation and the associated loss of access to food and security cover (Smith et al. 2000). These have often been consequences of increased industrial activity associated with timber harvest and oil and gas exploration and development (Dyer 1999, James 1999). The Little Rancheria area is not exempt from the pressures associated with industrial development. The LRH winter range is bisected by the Alaska Highway and a proposed natural gas pipeline, and supports a number of forestry-related access routes. Habitat and disturbance impacts are frequently compounded as anthropogenic corridors facilitate access by human hunters and by predators with the possibility of changing local caribou population dynamics.

This herd is an important source of food and hunting opportunities for First Nation, resident, and non-resident hunters of southeastern Yukon and northern British Columbia (Sun-Comeau 2001, Yukon Environment unpublished data). Diaries from early explorers suggest that caribou occupied this region for many hundreds of years (Pyke 1896) and are likely to have sustained local Kaska First Nations for millennia.

Between 1990 and 1993, the Yukon Territorial Government undertook an investigation of possible timber harvest effects on moose in the Liard Basin (Florkiewicz and Henry 1993). Because this area partially overlapped the LRH winter range, data were also gathered on these caribou. In 1995, the territorial and federal governments agreed to a 1-year deferral of timber harvesting in the LRH range to give managers time to assemble information about this caribou range and to develop management guidelines to safeguard caribou habitats prior to timber harvest on this winter range. In 1996, managers from both federal and territorial governments agreed to interim management guidelines that would permit timber harvesting in upland pine forests on glacial moraine sites that were readily accessible from the Alaska highway. Specific sites and harvest configurations were permitted with the understanding that more detailed assessments of the caribou and their habitat use would be made.

This report is a synthesis of information gathered between 1990 and 2000 and provides an assessment of caribou distribution, habitat quality, and habitat use within the Yukon portion of the LRH winter range. The information is provided to guide sound management recommendations for the LRH caribou winter range. Specific objectives were:

1. To evaluate available land classification schemes in their ability to describe the landscape and habitats important to caribou.
2. To quantitatively assess caribou habitat use within the LRH winter range, including spatial patterns and timing of use.
3. To develop a landscape model for the Little Rancheria caribou that integrates both animal use and habitat quality.

Study Population and Area

Study Population

The LRH is 1 of 23 discrete woodland caribou populations in the Yukon (Figure 1). It was first described as a distinct population by Bergerud (1978) but Kaska hunters of southeastern Yukon, who have maintained a close association with these caribou for many generations, likely understood this long before his assessment. In 1999, this population totalled approximately 1000 caribou (Marshall 1999). The LRH is typical of the northern mountain caribou ecotype common within northern British Columbia and Yukon ecosystems. They occupy alpine and subalpine ranges in the Cassiar Mountains of northern British Columbia from spring (April/May) through fall (usually early to mid-October) when they move to either of 2 loosely connected forested winter ranges in the Liard River Basin. At least a few caribou occasionally summer in locations typically considered to be winter range (E. Van Dyke, trapper, personal communication; G. and R. Stockman, trappers, personal communication).

Key findings from studies prior to this work included the definition of migration routes and winter range use over 2 seasons through the Foothills Pipelines' Alaska Highway Pipeline corridor project along British Columbia/Yukon border (Eccles 1983). Farnell and McDonald (1990) also identified distinct winter ranges in Yukon and in British Columbia based on a census survey and a small sample of radio-collared caribou.

In addition to the LRH, the Yukon portion of the range also supports, in part, caribou from the adjacent Horseranch Herd (HH). This herd has about 800 animals (Marshall 1999). Radio-collar data collected between 1996 and 2001 by the British Columbia Ministry of Water Land and Air Protection (MWLAP) showed that a few HH caribou were using LRH winter ranges in both Yukon and British Columbia (R. Marshall and M.

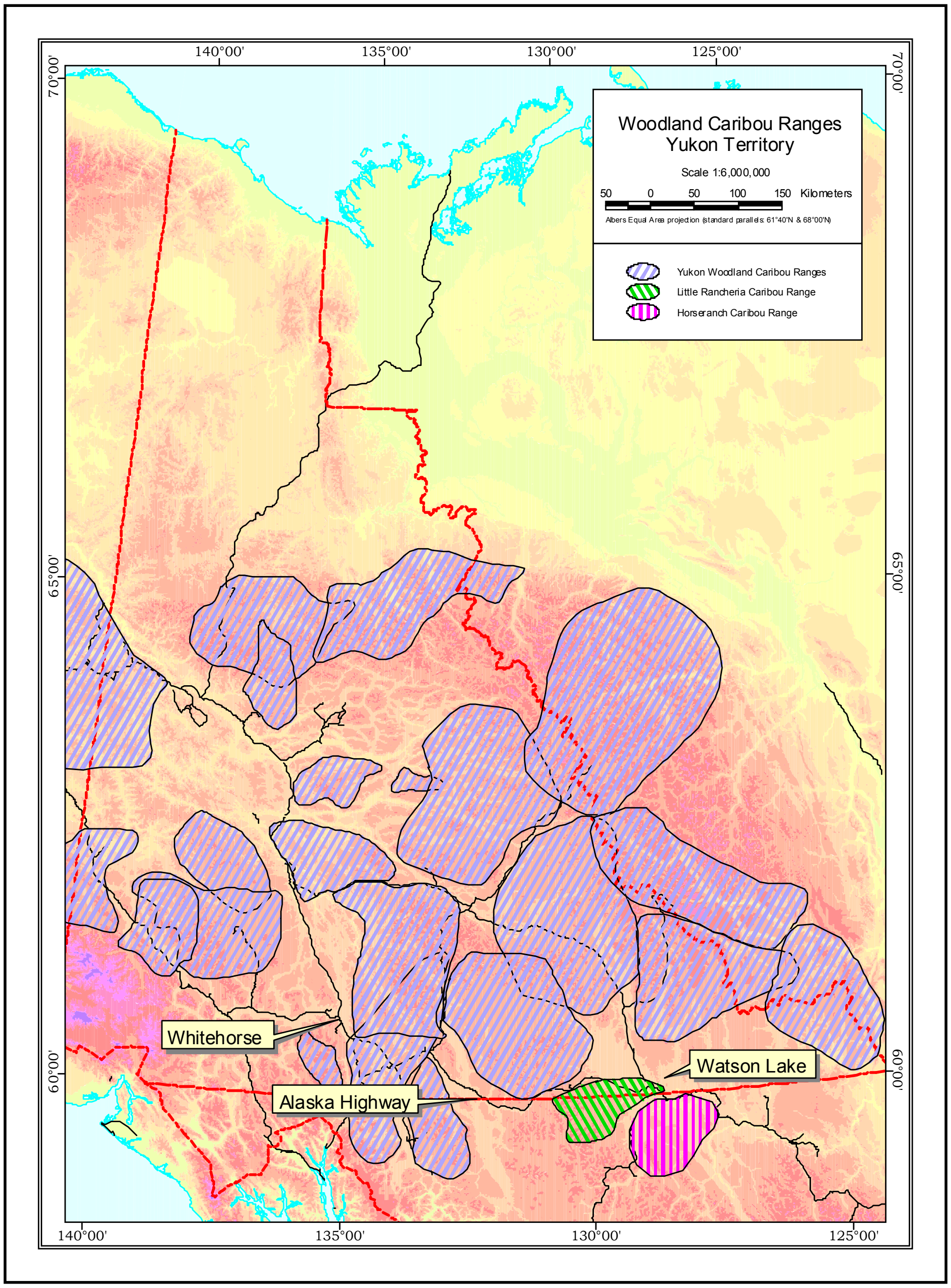


Figure 1. Little Rancheria and Horseranch Herds relative to the other Yukon caribou ranges.

Williams, MWLAP biologists, personal communication), which had not been demonstrated in any of the earlier studies (R. Farnell, Yukon Environment, personal communication).

In 2001, Kaska elders and trappers shared their knowledge of summer and winter caribou ranges in their traditional territory (Sun-Comeau 2001). Current caribou ranges and those prior to 1942 (before the construction of the Alaska Highway) were very similar, strongly suggesting that caribou have used these same summer and winter ranges for more than 60 years.

Study Area

The study area is within the Liard Basin Ecoregion of the Boreal Cordillera Ecozone (Ecological Stratification Working Group 1995). The area is topographically complex and is characterized by subdued relief and large tracts of continuous conifer forests. The western portions of the range are primarily gentle rolling morainal hummocks. The eastern side is dominated by complex terrain with numerous eskers and kettle lakes, resulting in a high degree of terrain diversity. This region receives some of the highest levels of winter precipitation in Yukon (Wahl et al. 1987).

The range of the LRH is near the communities of Upper Liard and Watson Lake in southeast Yukon and Lower Post in British Columbia, south to the Dease River and along the Little Rancheria River into the Cassiar Mountains of British Columbia. This report focuses on the 1389 km^2 of LRH winter range that lies within the Yukon (about 12% of the 12,100 km^2 annual range of the herd; Figure 2).

The landscape within the LRH winter range is highly stratified geomorphically and vegetatively. These biophysical conditions are not widely distributed over the southern Yukon. The Liard River basin was strongly affected by glaciofluvial processes during the late- and post-glacial periods (approximately 12,000 to 8,000 years ago). Enormous volumes of glacial melt water flowed over portions of the Liard Basin, creating outwash plains and channels within a predominantly morainal landscape (Rostad et al. 1977) and removing much of the fine silt and clay from portions of the landscape. The resultant coarse-textured soils drain rapidly and are nutrient poor. Prominent esker ridges and ice-stagnant terrain, with many small kettle lakes and depressions are characteristic of this landscape. Morainal hummocks and plateaus rise above the glaciofluvial features. Reid (1975) provides a detailed account of the glacial history for the area. There are characteristic forest communities associated with the landform and soil conditions found within the study area. Low nutrient soils inhibit growth of both dense forest cover and understory

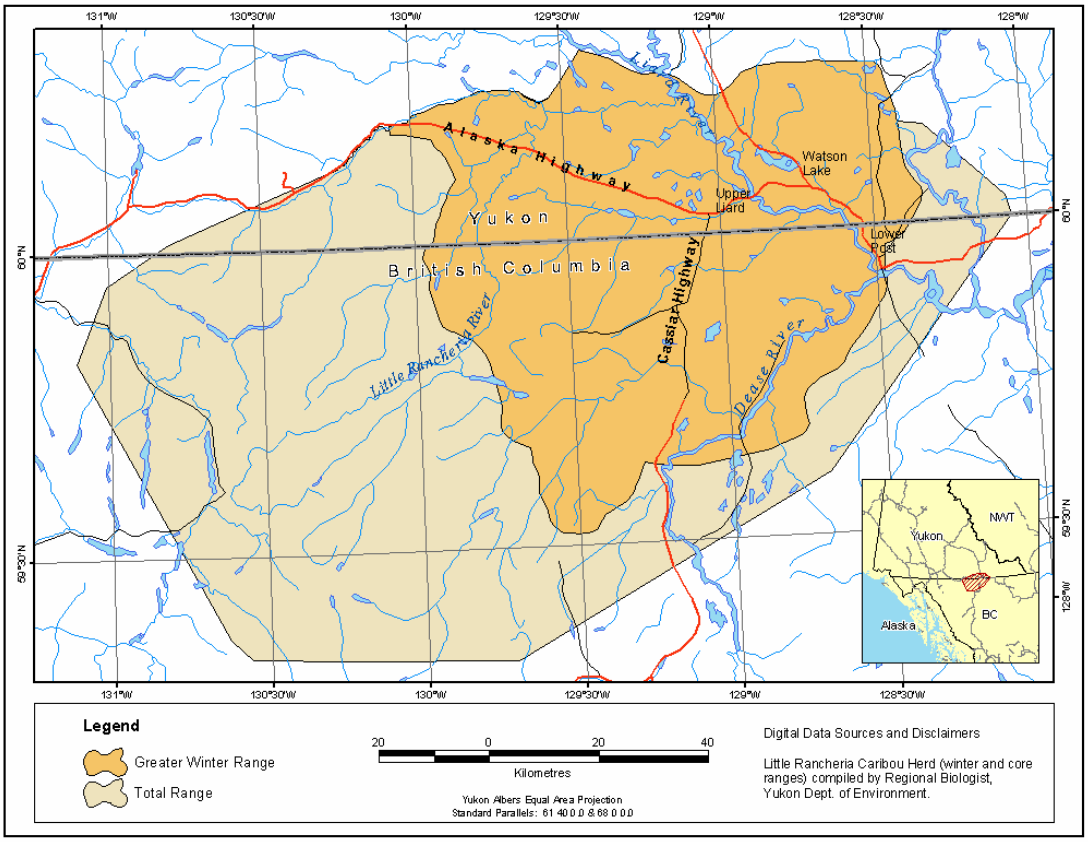


Figure 2. Total and winter ranges of the Little Rancheria herd of woodland caribou, Yukon and British Columbia.

vegetation. The complex glaciofluvial terrain found in the central and eastern portion of the caribou range supports predominantly open canopy lodgepole pine (*Pinus contorta*) forests with a lichen understory. Extensive stands of even-aged, closed-canopy lodgepole pine and alder (*Alnus* spp.) forests, with a ground cover of abundant feathermoss rather than lichens, occur on the morainal hummocks common to the western portion of the study area. Many of the abandoned meltwater channels and depressions have poorly drained and/or organic soils (organic and gleysolic morainal soils) that support various classes of forested and non-forested wetlands with variable lichen cover. In depressions between the major morainal hummocks these soils support black spruce (*Picea mariana*) and white spruce (*P. glauca*) forest communities. These depressions and channels through the upland areas provide landscape-level travel corridors within the caribou winter range.

Fire Patterns

Fire patterns, including measures of fire size, frequency, and intensity, appear to be related to glacial history Applied Ecosystem Management (1998) described the fire history of the LRH range. The pine forests on glaciofluvial soils have had a complex fire history; parts of the LRH range have burned up to 6 times over the last 250–300 years. Many of the forested stands within the winter range have been exposed to repeated low intensity fires. Often, living trees have scars from successive fire events, most likely caused by burning ground fuels rather than the forest canopy. The pre-1800 forests were structurally and floristically similar to present day forests with little evidence of conversion to spruce dominated forest types. Fire in these forests appears to maintain rather than initiate stands. This behaviour, uncharacteristic of boreal forests, is more commonly associated with the interior montane and parkland Douglas Fir-Ponderosa Pine/Bunchgrass ecosystems of Alberta and British Columbia (British Columbia Ministry of Forests 1995). In contrast, the closed-canopy pine/feathermoss stands growing on morainal sites common on the west end of the LRH range have experienced, almost exclusively, stand-replacing crown fires.

Because of the interaction between surficial geology and fire, much of the forest cover on this landscape can be considered relatively static. Well-drained low nutrient glaciofluvial sites are unlikely to support large quantities of fuels, nor will they support more than sparse pine forests. Sites that currently support open-canopy pine/lichen forests are unlikely to become closed-canopy pine stands with an alder/feathermoss understory in the foreseeable future. Nor are they likely to succeed into spruce dominated stands, largely due to the low capacity for soils to hold nutrients and moisture.

Methods

Woodland Caribou Data

Reconnaissance surveys and caribou management zones

Our objectives in conducting reconnaissance surveys were to determine the timing of the fall migration into the winter range, to delineate winter range boundaries, and to identify high use areas and movement corridors within the winter range. Caribou locations were recorded on 1:50,000 scale maps together with information on caribou group size and survey date. We recorded caribou winter locations between 1990 and 1994 opportunistically during aerial moose surveys (Florkiewicz and Henry 1993). In the winter of 1994–1995 we conducted systematic low-level (e. g., 150 m above ground level) tracking flights at biweekly intervals. Additional surveys were flown in October and November 1995, and March 1996. Each animal or group of animals was recorded as a single point and digitized in ArcView 3.1 GIS (geographic information system; ESRI, Redlands, CA). We used tracks, trails, and feeding areas to define the bounds of seasonal ranges but did not use these observations in the analysis. In 1996, the reconnaissance survey information, in conjunction with previously published work, was used to define 3 caribou management zones. The 3 zones were a central core range that included the most heavily used areas, a migration corridor that included most of the early-winter trails into the main winter range, and an extended winter range as the outer boundary of less intensively used areas (Figure 3). These zones provided the basis for our subsequent analyses.

VHF Radio-collars

Between 1996 and 2001, 40 LRH caribou and 40 HH caribou were captured using a helicopter and hand fired net gun and were fitted with conventional VHF (Very High Frequency) radio-collars. Additional details regarding the caribou captures can be found in the summary of the study looking at the ecology of caribou, moose and wolves (2001/02 FRBC Project

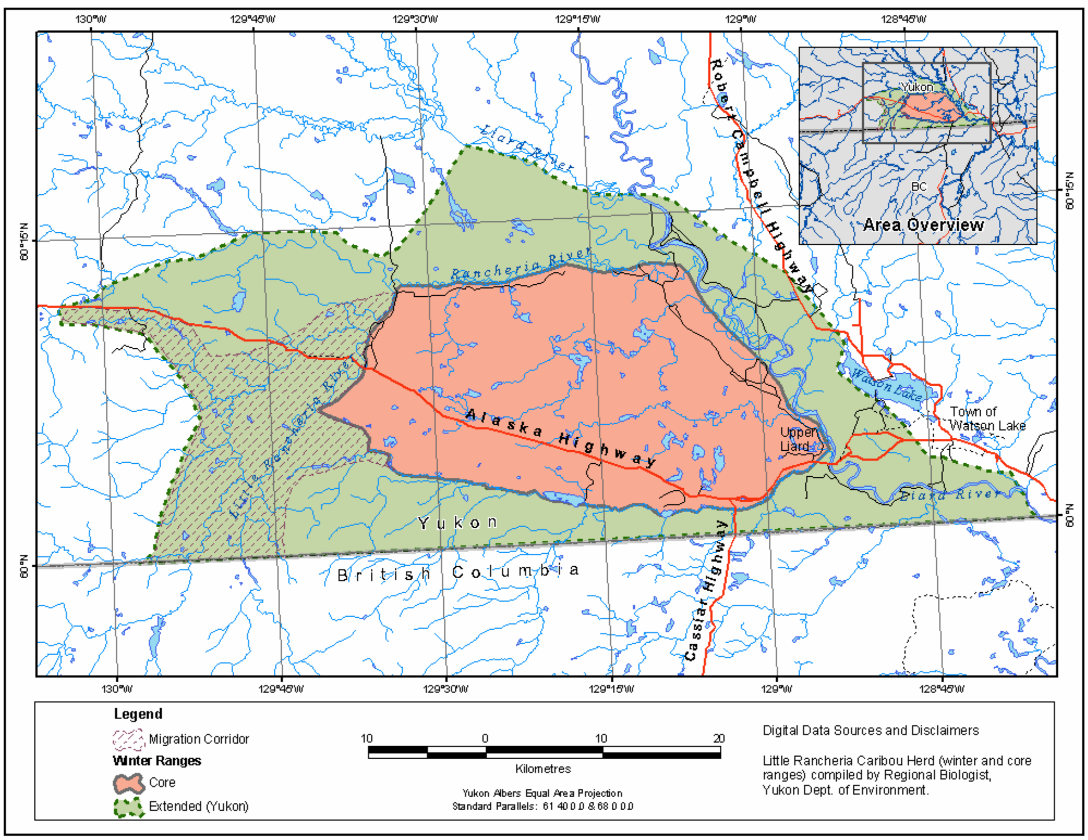


Figure 3. Yukon range and management zones for the Little Rancheria caribou herd in the Yukon.

#SBA02802: Liard Plains Caribou) from the British Columbia Ministry of Water Land and Air Protection.Winter locations of radio-collared caribou were collected from a fixed-wing aircraft at 10- to14-day intervals between October and 30 April of each year from 1996 to 1999. Caribou locations were recorded from the aircraft's global positioning system (GPS) along with group size and composition (males, females, and young). Each location was treated as a single data point, regardless of the number of caribou associated with the collared animal.

Based on local knowledge, reconnaissance flights, and pre-1990 radio-collar data (Farnell and McDonald 1990), differential use of some portions of the winter range was readily apparent. We sought to quantify these observations and determine range estimates and habitat preferences by monitoring the VHF radio-collared caribou.

GPS Radio-collars

Seven adult female caribou were captured and fitted with GPS collars as part of the broader MWLAP study. Four of these animals provided detailed location and movement information for the Yukon winter range during 1997–1999 but the other 3 remained in British Columbia. Locations were collected at 4-hour intervals and were differentially corrected using data from a GPS base station at Dease Lake, British Columbia, a linear distance of approximately 200 km. The locations are considered to be accurate to within at least 10 m (Rempel et al. 1997). We considered 100-m accuracy to be sufficient for the objectives of this study.

Landscape and Habitat Classification Data

We used 3 primary habitat/landscape classifications for this project: 1) Yukon Forest Inventory's Forest Cover (FC), 2) Broad Ecosystem Inventory (BEI) and 3) Surficial Geology (SG) mapping. We applied the southeast Yukon ecosystem classification (Zoladeski et al. 1996) to the FC maps to derive a fourth classification scheme, Ecosystem Units (EU). The ecosystem classification was particularly appropriate because much of the original ecosystem sampling was done within and surrounding our study area. The classifications covered different geographic extents and were compiled at different levels of resolution (Figures 4 *a* – *d*). FC (and the derived EU) classifications were mapped at 1:50,000 scale; the SG and BEI were mapped at 1:125,000 scale. We considered that coverage of the critical core range was essentially complete for each classification type and therefore suitable for this evaluation.

Yukon Forest Cover

The FC database (DIAND Forest Resources 1995) is the principal source of spatial vegetation information in the

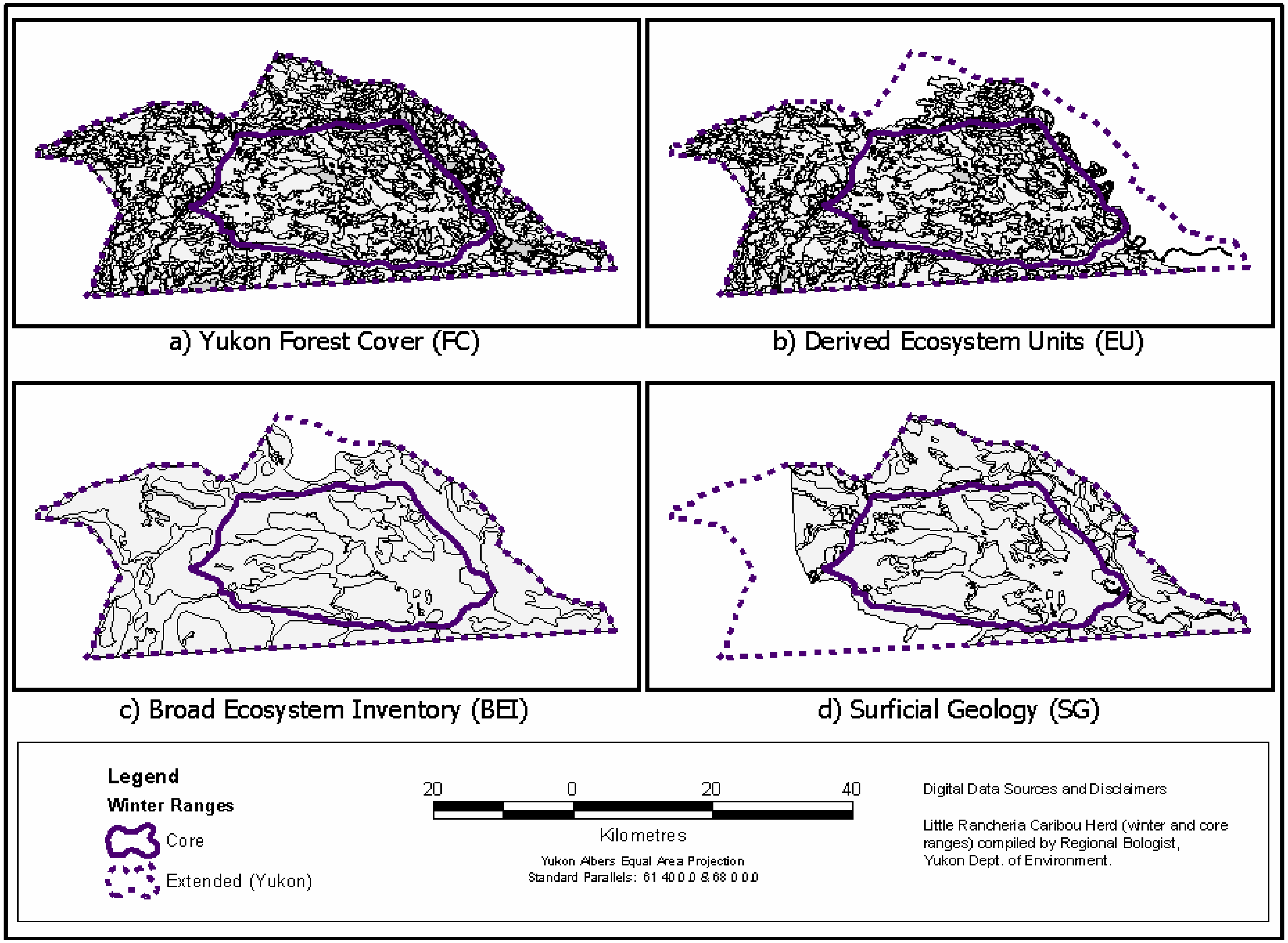


Figure 4. Spatial extent of polygon coverage for the Little Rancheria caribou study area: a) Yukon forest cover (FC), b) derived ecosystem units (EU), c) Broad Ecosystem Inventory (BEI), d) surficial geology (SG).

southern Yukon. FC mapping is based on dominant tree species. Tree species composition, height, canopy closure, age, site class, disturbance history, and related attributes are contained within the database but information on forest canopy/understory associations was not gathered. The forest cover polygons used in this analysis were originally identified by the Department of Indian Affairs and Northern Development (DIAND) for Forest Management Units YO3P1, YO3P2, YO3Q1, and YO3Q2 (DIAND Forest Resources 1995).

Broad Ecosystem Inventory

The BEI is an ecologically based framework developed to support resource management and land use planning in British Columbia (Resource Inventory Committee 1998). This classification was designed to fit into the hierarchical British Columbia Ecoregion and Biogeoclimatic Ecosystem Classification scheme, which is based largely on the predicted climax vegetative community rather than the current vegetative condition (Meidinger and Pojar 1991, Demarchi 1996). An ArcInfo Workstation 7.2 GIS (ESRI, Redlands, CA) was used to create a BEI coverage for the Yukon that would match with and provide a seamless coverage with British Columbia (Applied Ecosystem Management Ltd. 1999). We used only the Yukon portion for our assessment.

Within the BEI, the Broad Ecosystem Unit is an area of the landscape that supports a distinct type of dominant vegetative cover, or distinct non-vegetated cover such as lakes or rock outcrops (Appendix 1). These units are based on an amalgamation of vegetation, terrain (surficial material), topography, and soil characteristics; the vegetation defines each unit and, for forests and grasslands, incorporates any associated successional stages. This approach emphasizes those site characteristics that determine the function and distribution of plant communities in the landscape (Resource Inventory Committee 1998).

Surficial Geology

The SG mapping covered approximately 75% of the total study area and 100% of the core area and represented the 4 primary classes of surface materials: morainal, glaciofluvial, organic, and fluvial (Rostad et al. 1977). The pattern and distribution of these classes appear to have an important influence of the vegetative patterns within the LRH winter range. No additional soil attributes were evaluated.

Derived Ecosystem Units

We reinterpreted the FC map using the vegetation types (V-types) described in the Ecosystem Classification Field Guide for southeast Yukon (Zoladeski et al. 1996). Each polygon was reinterpreted and assigned a primary V-type by an experienced air photo interpreter (see McKenna 1996). FC characteristics within these units were determined through interpretation of 1:40,000 air photographs acquired in 1992. If an FC polygon had more than 1 identifiable primary V-type, new polygons were drawn to match the V-type boundaries. Where a complex of V-types was identified within a polygon, the type dominant by area was used in the analysis. Non-forested cover types were identified as shrub, lake, river, wetland, or *not sufficiently regenerated* (disturbed, logged, or burned). Phases of individual primary V-types were identified (Rosie 1995) but not used in our analysis.

Vegetative Characteristics of Key Caribou Habitats

To better understand vegetative characteristics of habitats within the caribou range, we did detailed plot sampling in the summers of 1991 and 1995. In 1991, we grouped dominant FC classes based on dominant tree species and forest canopy closure (Florkiewicz and Henry 1993). Within each of the dominant FC types we selected up to 5 random polygons for intensive ground sampling. FC maps and air photos were used to locate the polygons on the ground. Along a line through the longest axis of the polygon we sampled 10–20 locations at random co-ordinates. We gathered information on vegetative characteristics at each location by placing 2 rectangular 10 m^2 sample units to estimate cover percent for herbaceous vegetation and 1 square 100 m^2 unit for shrub stem and twig counts. In 1995, further vegetation measurements were conducted specifically within the core winter range of the LRH. Sampling locations were centred in known caribou use areas; air photo interpretation was used to delineate short transects that traversed a variety of V-types. The sampling procedure followed the large diameter plot-sampling format outlined by Zoladeski et al. (1996). The data gathered in these sampling rounds provided understory vegetative composition that was generally lacking from traditional forest mensuration data.

Data Analyses

Caribou range use

To evaluate visibility bias among the 3 types of location information, caribou locations from reconnaissance surveys were compared with both VHF and GPS radio-collared caribou locations using a Chi-squared analysis. Broad canopy cover classes could be distinguished from the forest cover database and were used to assess differences.

Caribou range use at the landscape scale was determined using probabilistic range estimates (55% to 95% in 10% increments) by the adaptive kernel method (Worton 1989, 1995) using the Animal Movement Analyst (Hooge and Eichenlaub 1997), an extension for ArcView GIS, to the full dataset of VHF radio-collared caribou. This method took advantage of the large number and relative density of caribou locations distributed across the winter range of the LRH. We used the adaptive kernel density estimator to determine a weighted winter range selection with a limited bias (Seaman and Powell 1996) as the minimum convex polygon approach to mapping animal ranges does not take into account the relative density of locations (White and Garrott 1990).

Habitat Associations

Habitat associations for each VHF radio-collar location within the winter range were evaluated as both point and buffered point (polygon) locations (Rettie and McLoughlin 1999) using an ArcInfo GIS workstation. First, caribou locations were treated as points to compare use of the 4 broad cover types in areas covered by all 4 classification schemes. Habitat attributes of the polygon in which each caribou location was recorded were used to identify characteristics potentially selected by caribou. The use of unbuffered point locations erroneously assumes that there is no telemetry or mapping error (Carrel et al. 1997). Although this assumption is false, the error as a result of this assumption is small if the habitat units are very large polygons or if adjacent polygons have similar habitat features. When the location, as either a point or buffered point, is clearly within a polygon, the analysis is relatively uncomplicated.

We used the EU coverage to further explore differences in mapping related to points or polygons because of the finer-grained resolution of this coverage. We evaluated habitat characteristics from point locations (habitat attributes of a single polygon) and from buffered points (habitat attributes of multiple polygons). We applied buffers around each location to try to incorporate error associated with representing an animal's true location (Nams 1989, Rettie and McLoughlin 1999). We contrasted the proportion of habitat within buffers (radii: 100, 200, 300, and 500 m) with the true proportion of each habitat within the study area. We felt that these radii reflected realistic values for positional error, given the inaccuracies in plotting caribou locations and habitat polygon boundaries.

We used locations of only VHF radio-collared caribou to avoid the potential bias introduced from the disproportionate contribution of many locations of the few GPS-collared animals. Failure to do this could result in a higher probability of Type 1 statistical error (finding a difference when none exists; Machlis et al. 1985). To ensure statistical rigour, we filtered data so that there were at least 5 locations for each animal/season combination. Filtering reduced the sample from 38 (available in the study area) to 26 caribou for the habitat selection analysis. Habitat classes with fewer than 5 locations over the winter period were also removed from the assessment. Because most of the radio-collared animals were adult females (21 of the 26), our study should be considered largely as an assessment of habitat selection by adult female caribou.

Statistical treatment of the data

We evaluated habitat use by LRH caribou within the Yukon winter range. We documented population-level resource selection using 2 of 3 typical experimental designs (Thomas and Taylor 1990, Manly et al. 2002:6). Briefly, Design Type I studies evaluate resource selection where each location contributes a single observation: individual animals are not differentiated from groups. For this design, resource availability is measured as the entire study area. Typically, reconnaissance type studies employ this design (see: Neu et al. 1974). Design Type II studies differ in that selection occurs for the individual animal rather than the sum of all animals while habitat availability remains at the level of the study area. Conventional studies of radio-collared individuals are an example of this design. Design Type III studies focus on individual animals to determine habitat use and, frequently, habitat availability (e.g. Aebischer et al. 1993). This type uses a smaller area, relevant to the individual animal, such as a home range or an area of seasonal range use. Our location frequency (e.g. 5 locations per animal per season) was not sufficient to incorporate a Type III design in this study. Sampling protocols are also critical to the study design and ultimately the assumptions and final conclusion of resource selection studies (Manly et al 2002:4). Resource selection may be detected by comparing 2 of 3 possible sets of resource units (used, unused, or available). Our study incorporated sampling protocol A (SP-A: Manly et al. 2002) where we sampled resource use and censused resource availability.

Resource selection in Design Type I studies—

Assessments based on the full dataset of VHF radio-collared caribou and contrasts among the reconnaissance, VHF, and a GPS radio-collared caribou were done using Design Type 1 criterion. Each group or individual location was treated as a single point and contrasted with the availability of habitats over the entire range. Standard Chi-squared analyses were used to contrast use and availability (Neu et al. 1974).

Resource selection in Design Type II studies—

To evaluate patterns of habitat selection in the extended and core wintering areas, we used a Type II study design; most of the criteria or assumptions needed for meaningful analysis were satisfied (see Manly et al. 2002:12 –14). It is difficult to evaluate whether all variables that influence the probability of selection were correctly identified, however maintaining the assessment within a single season should reduce potential errors related to this assumption.

Caribou locations were overlaid with each of the FC, EU, BEI, and SG coverages in a GIS. We used a log-likelihood Chi-square test (Manly et al. 2002) to determine if selection was occurring within each classification. Where significant selection was identified, we determined patterns of habitat selection using a Resource Selection Index (RSI) following the method of Neu et al. (1974) as modified by Manly et al. (2002). Available habitat was defined as the core wintering area and the individual animal was the sample unit. Each location was considered a subsample of the primary sample unit (Manly et al. 2002).

We applied a more robust method of determining habitat selection for only the EU coverage over the core and the entire LRH winter range. Because the RSI is a ratio, we combined the attributes of the portions of the polygons that occurred within a specified radius of an animal location rather than the attributes of the single polygon in which the point was located. In this way, the animal location was treated as "fuzzy" or integral with the errors associated with imprecise maps, telemetry locations, or both. We did this by using a Resource Selection Function (RSF) as adapted by Arthur et al. (1996).

We evaluated different buffer radii to assess the potential bias introduced by incorporating telemetry error (Hoskinson 1976, Nams 1989) and mapping error. While errors of up to 300 m are possible in the FC maps, a 100 m buffer radius was chosen because we observed that differing buffer radii (100, 200, 300, and 500 m) had little influence on the relative proportion of habitat types used by caribou.

The RSI (w_i) is the ratio of the amount of resource used by the animals to the amount available either at the level of the population or of the individual animal.

For design Type II studies it is defined as:

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

where u_{i+} = number of type i resource units used by all animals
π_i = proportion of available resource units in category i
u_{++} = total number of units u sed by all sampled animals.

The measure is the ratio of proportion of habitat used by the sample of animals to what is available to the population. The equation was modified for proportional habitat use instead of absolute frequencies for each animal and each habitat type (Rettie and Messier 2000, Manly et al. 2002):

$$w_i = u_i / a_i$$

where u_i = area of habitat i
a_i = proportion of available resource units in category I.

Bonferroni confidence intervals for the above indices were calculated using 100(1–α)% family of confidence intervals with $\alpha = 0.05$. However, we conducted simultaneous tests and so 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. 2002).

We examined the effect of year on habitat selection using a MANOVA (Multivariate Analysis of Variance) on standardized resource selection index (b_i) values for the difference between each habitat pair. Habitat selection for 12 caribou with greater than 5 observations in each winter (1996–1997, 1997–1998) were contrasted (Arthur et al. 1996). Multiple comparisons were made with post-hoc *t*-tests to evaluate differences among habitat types. No experiment-wise error adjustments were made for this test.

The selection ratios were then standardized as an index (Manly et al. 2002:51) for each of the habitat types using the naming conventions of Arthur et al. (1996):

$$b_i = w_i / (\sum_{i=1}^{I} w_i)$$

The standardized RSI estimates the relative probability of an animal selecting a habitat type if all other habitats are equally available. It has the advantage of being insensitive to the inclusion of unused habitat types that are considered available (Manly et al. 2002:55).

We tested for differences in caribou selection for sequential pairs of habitat classes using a paired-sample *t*-test (Arthur et al. 1996) on b_i values. Post-hoc multiple comparisons were adjusted using Holm's modification of the Bonferroni approach (Arthur et al. 1996, Rettie and Messier 2000). This increased the *p*-value for each test to maintain the experiment-wise alpha level of 0.05 over all comparisons. A detailed example of the RSI and RSF and the associated documentation is presented in Appendix 2.

Habitat Quality Model

We constructed a habitat quality map for the LRH winter range in the Yukon by ranking each EU according to its value to caribou based largely on the abundance of lichen in the understory. However, we also incorporated our assessment of habitat use by caribou and the EU position on the landscape (e.g. glaciofluvial versus morainal). We assessed the habitat quality as being of low, medium, or high value to caribou from these criteria. Subsequently, we buffered each medium and high value polygon by 250 m to minimize the influence of boundary errors. For this model, each watercourse was also buffered by 250 m to recognize their importance as landscape-level migration corridors.

Results

Caribou range use and movement patterns

Canopy cover and visual bias

The number and quality of animal locations varied greatly among the 3 location methods (Table 1). A contingency table analysis determined that the results from the 3 types of location information were not independent of habitat type based on open-, moderate-, or closed-canopy cover characteristics (Table 2) (core range $\chi 24 = 126$, $p < 0.005$; winter range $\chi 24=291$, $p < 0.005$). Due to the lack of independence, the data types were treated separately in the habitat selection assessments.

In aerial reconnaissance surveys we found significant selection for open-canopy forest habitats and avoidance of moderate- to closed-canopy forest over both the core and the entire 1389 km^2 winter range (Table 2). This differed from similar assessments of the VHF and GPS radio-collared caribou. No discrimination in canopy cover was seen for GPS radio-collared caribou whereas the VHF collared animals demonstrated selection for moderate-canopied forests over the entire winter range and avoided dense-canopied forests over both the core and the entire winter range (Table 2). No selection was evident for open-canopied forests by this sample of VHF collared caribou.

Table 1. Descriptive statistics for caribou locations (VHF, GPS, and reconnaissance) within the Yukon winter range (November 1–April 30) 1996–1999.

	Winter Range			Core Winter Range		
Parameters	VHF	GPS	Recon.	VHF	GPS	Recon.
Number of collared animals	54	4	–	44	4	–
Mean number of locations per animal	10	468	–	9.4	360	–
Standard deviation of locations	8.7	318	–	7.7	325	–
Minimum number of locations	1	134	–	1	77	–
Maximum number of locations per	30	868	–	28	781	–
Total number of locations	540	1871	246	414	1439	225

Note: this information includes all animals, not just those actually used in the habitat selection analysis.

Table 2: Comparison of canopy closure index (open, moderate, closed) between reconnaissance locations and VHF and GPS radio-collared caribou within the winter range and core winter range. Summary of utilization-availability analysis (Neu et al. 1974) using Bonferroni confidence interval $(1-\alpha/(2*I))$ where $\alpha = 0.05$ and $I = 3$. Note: all observations were incorporated into this analysis. Where "Conclusion" is blank, caribou were located in habitats in proportion to their availability.

a) Reconnaissance locations

Canopy Closure (%)	Winter range				Core winter range			
	Habitat Available	Number of Observations	Habitat Used	Conclusion	Habitat Available	Number of Observations	Habitat Used	Conclusion
Open (0–20)	0.579	196	0.797	Select	0.490	182	0.809	Select
Moderate (30–40)	0.291	44	0.179	Avoid	0.304	37	0.164	Avoid
Closed (50–100)	0.130	6	0.024	Avoid	0.205	6	0.027	Avoid

b) VHF radio-collared caribou

Canopy Closure (%)	Winter range				Core winter range			
	Habitat Available	Number of Observations	Habitat Used	Conclusion	Habitat Available	Number of Observations	Habitat Used	Conclusion
Open (0–20)	0.579	310	0.559		0.490	224	0.538	
Moderate (30–40)	0.291	192	0.346	Select	0.304	149	0.358	
Closed (50–100)	0.130	53	0.095	Avoid	0.205	43	0.103	Avoid

c) GPS radio-collared caribou

Canopy Closure (%)	Winter range				Core winter range			
	Habitat Available	Number of Observations	Habitat Used	Conclusion	Habitat Available	Number of Observations	Habitat Used	Conclusion
Open (0–20)	0.579	356	0.555		0.490	244	0.503	
Moderate (30–40)	0.291	200	0.312		0.304	156	0.322	
Closed (50–100)	0.130	86	0.134		0.205	85	0.175	

Seasonal Movement Patterns

We found that aerial reconnaissance surveys and local information consistently recorded caribou return dates within the first 2 weeks of October (Table 3). These dates were generally earlier in the season than was determined from either VHF or GPS radio-collared caribou. Once fall migration was initiated, caribou movement into the winter range occurred within 1–2 weeks. Caribou returning to the winter range followed key landscape features such as stream and river courses and associated wetlands (Figure 5). However, we observed a fall movement pattern associated with cover, where caribou made use of closed-canopy forest stands situated along highway corridors as they travelled to key highway crossing points.

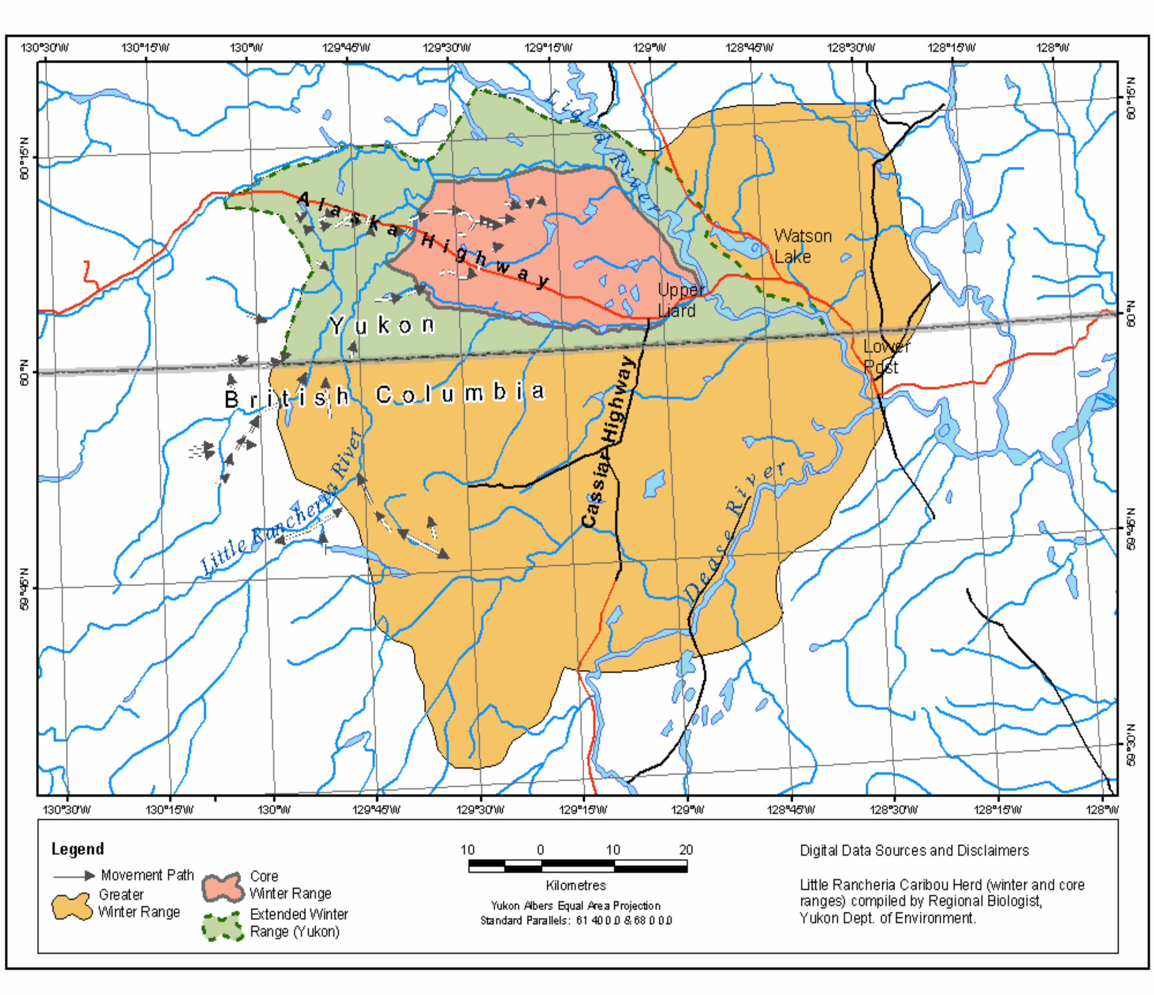


Figure 5. Fall caribou movement patterns into the winter range for Little Rancheria caribou based on tracking flights.

Table 3. Earliest and latest observation of caribou within the Little Rancheria winter range as defined by the earliest recorded entry date and the last recorded departure date.

Ending Year	Source: Reconnaissance/Local Information		VHF		GPS	
	Enter	Leave	Enter	Leave	Enter	Leave
1995		April 13				
1996	October 15*	March 29				
1997	October 10		November 5	April, 4	**	May 9
1998	October 1		October 17	April 16	November 23	April 22
1999	October 7		October 25	April 24	February 28	May 30
2000	October 8		November 3***			

*Observations of caribou entering between 1995 and 1999 were provided by Linda and Scott Goodwin and were recorded near the Northern Beaver Post

**The first GPS observation day was January 20 1997

***Collared caribou entered the range between November 3 and November 22

Caribou used the winter range in strongly traditional patterns based on sightings (Figure 6) and track sign. We consistently noted a concentration of sign within the core area, particularly in open pine forest types and along the creek, river, and lake corridors. Caribou used the winter range outside the core area, specifically near the winter range boundary with much lower intensity. Track sign noted early in the season was often lost or not refreshed following subsequent snowfalls.

Over the study period 414 of the 540 VHF radio-collar locations (76.7%) concentrated in the Yukon core winter range (Figure 7). VHF radio-collared caribou tended to leave the winter range throughout April (Table 3), which agreed with the pattern noted reconnaissance surveys and local observations. However, local information identified movement out of the winter range that continued into May, a pattern not evident from the other information sources.

Range use determined from GPS radio-collared animals (n=4) differed from that determined by reconnaissance flights and the VHF radio-collared caribou. The GPS-collared caribou used the core winter range to some extent, but 2 of them spent large periods of the winter in the extended winter range (Figure 8). The departure of GPS-collared animals from the winter range was recorded in detail due to the high recording frequency of these collars (Figure 9). These individual caribou arrived on the winter range later and departed later than the VHF radio-collared caribou (Table 3).

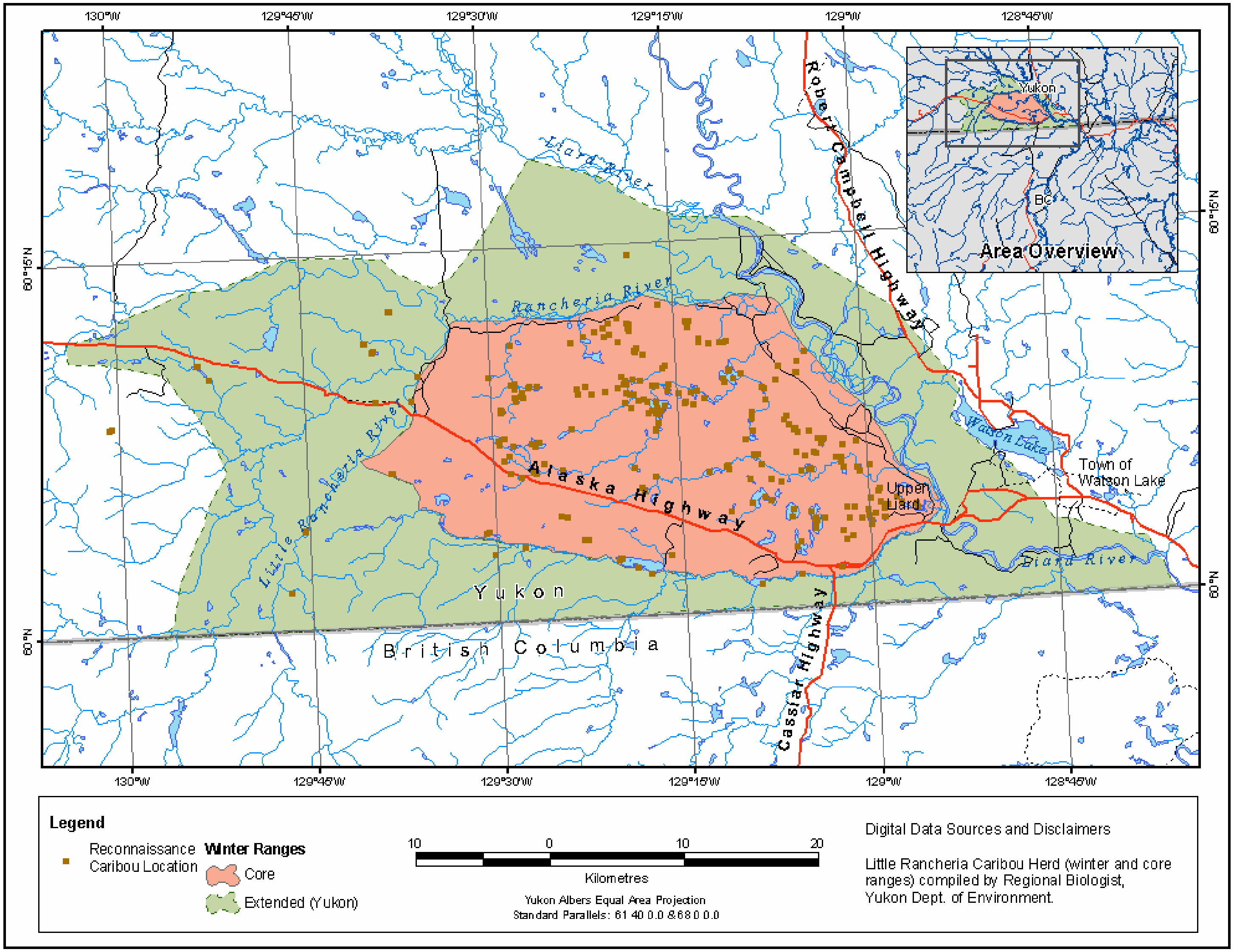


Figure 6. Distribution of reconnaissance caribou locations within the Yukon Little Rancheria caribou winter range (1990–1996).

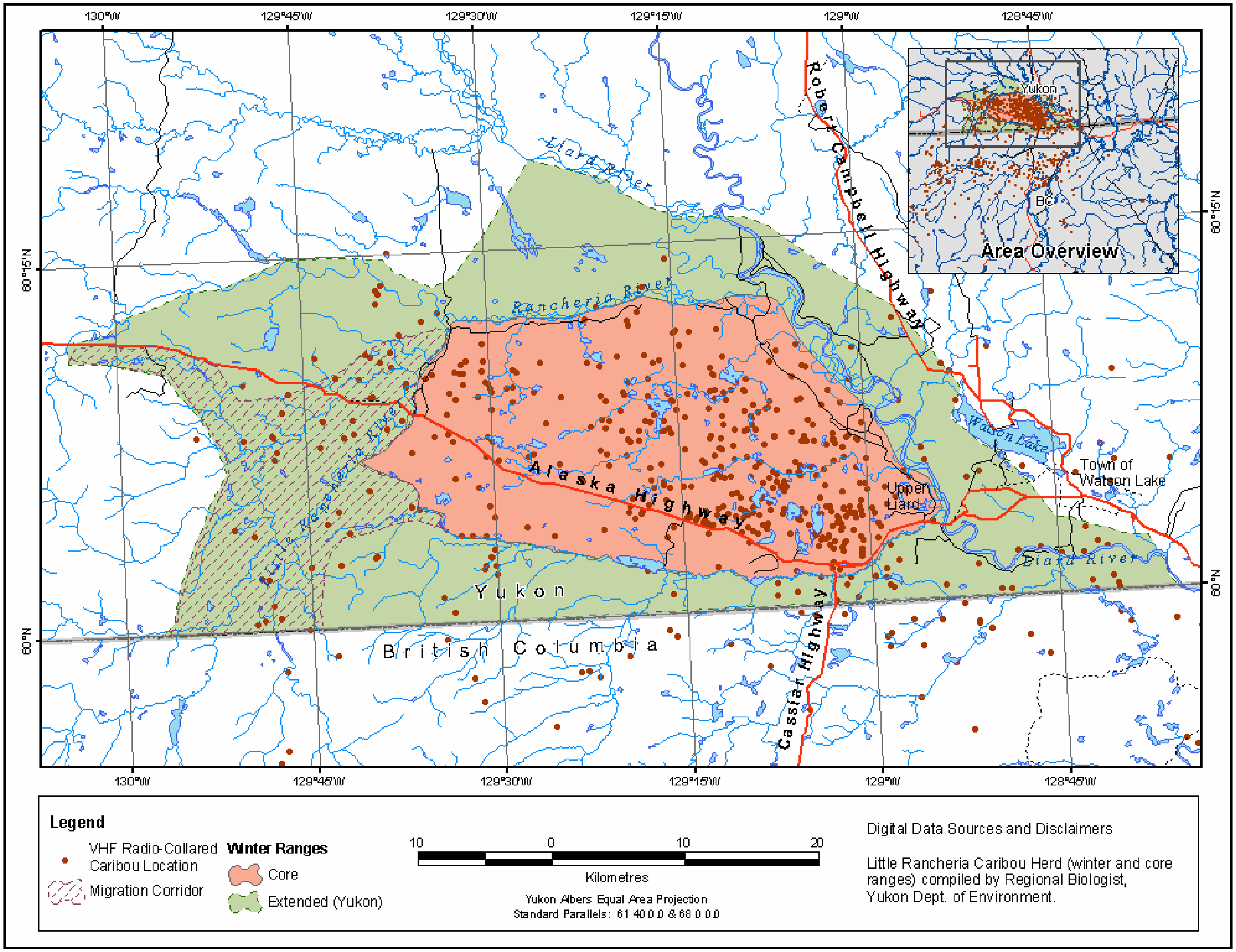


Figure 7. Distribution of VHF radio-collared caribou locations within the Yukon Little Rancheria herd winter range (1996–1999).

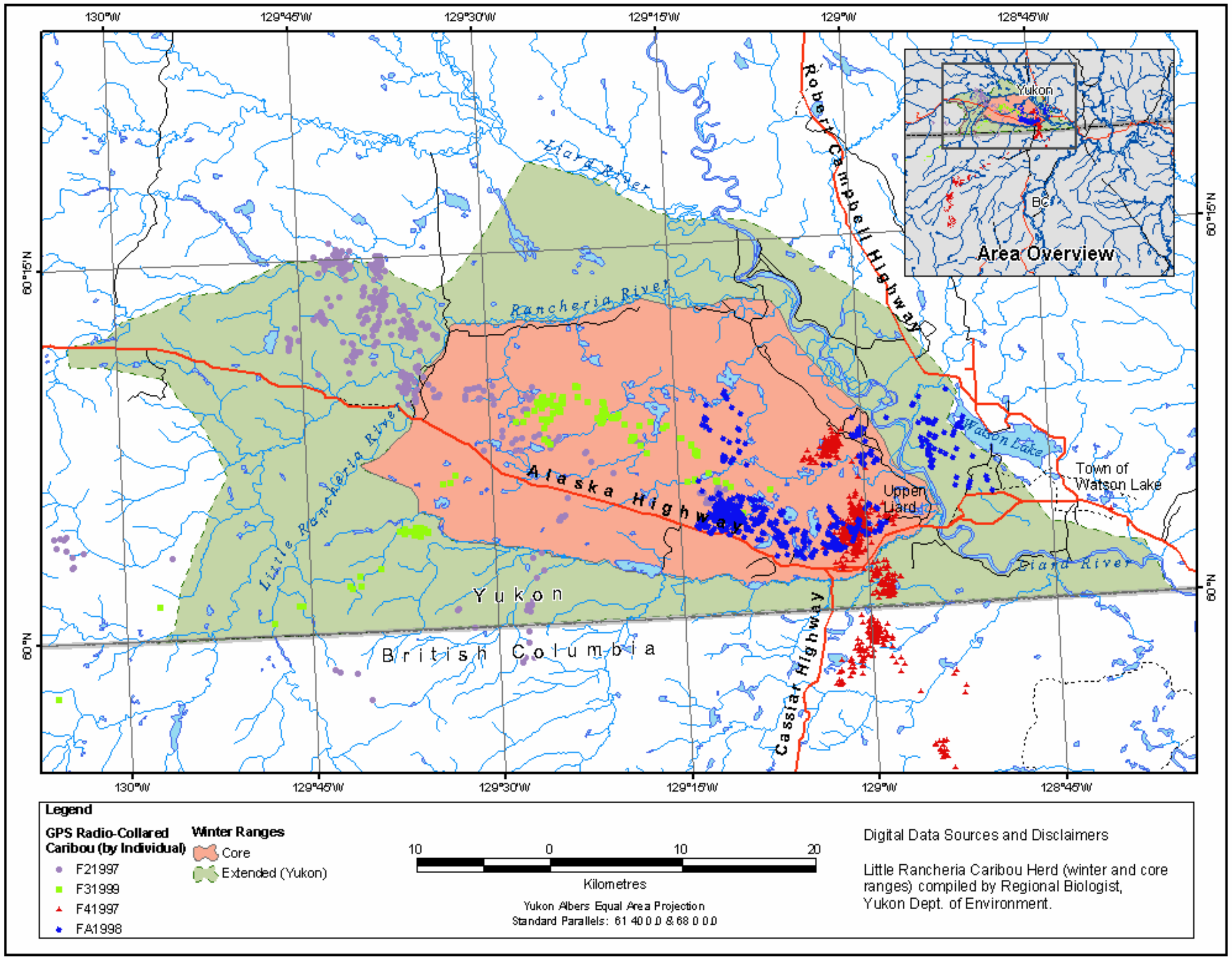


Figure 8. Distribution of 4 GPS radio-collared caribou locations within the Yukon Little Rancheria herd winter range.

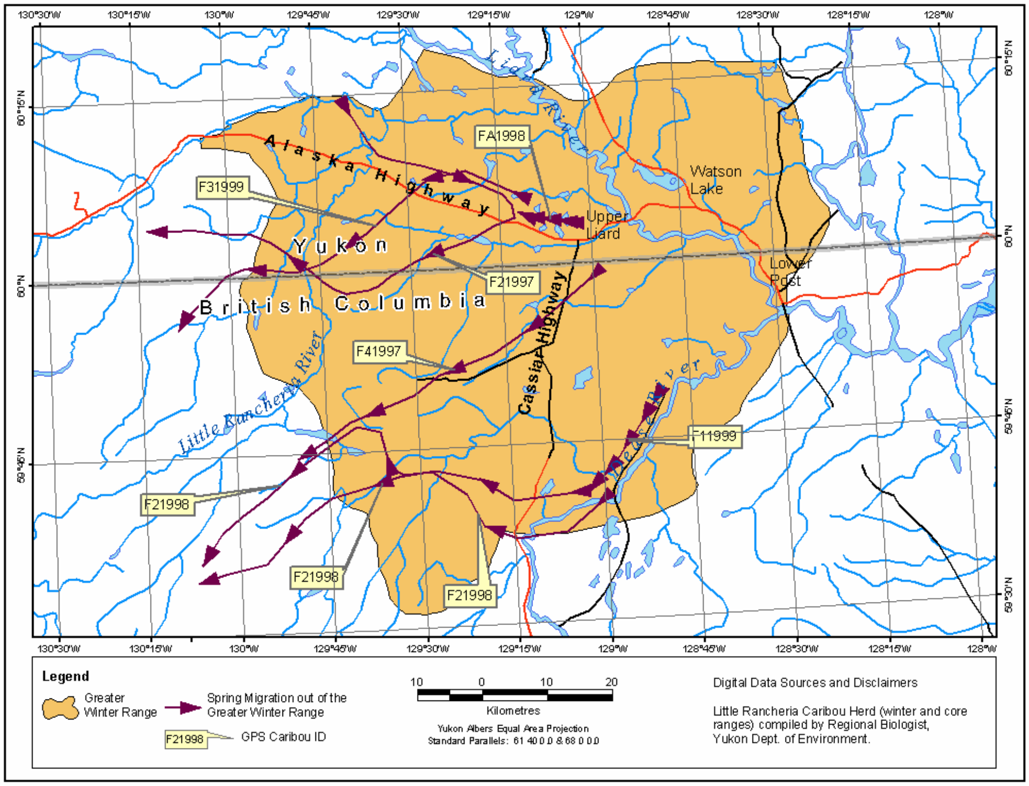


Figure 9. Spring movements of GPS radio-collared caribou out of the Little Rancheria caribou winter range (1997–1999).

Home range analysis

The 95% adaptive kernel estimate for the total size of the LRH winter range was 1,292 km^2 (Table 4). We derived this estimate using location data from only the VHF radio-collared caribou, over the entire Yukon and British Columbia winter range. In the 4 winters covered by this study, caribou concentrated into the relatively discrete 1389-km^2 Yukon winter range (Figure 10). We found no statistical difference in winter range use among years based on the distribution of VHF radio-collared caribou (ANOVA, $F_{2, 86}=0.05$, $p=0.95$, $F_{crit}=3.10$).

Table 4. Adaptive kernel winter home range analysis for VHF radio-collared Rancheria herd caribou. Probability distribution of VHF radio-collared caribou and relative proportions of area.

Probability	Cumulative area (km^2)
55%	194.6
65%	263.4
75%	346.7
85%	530.7
95%	1292.3

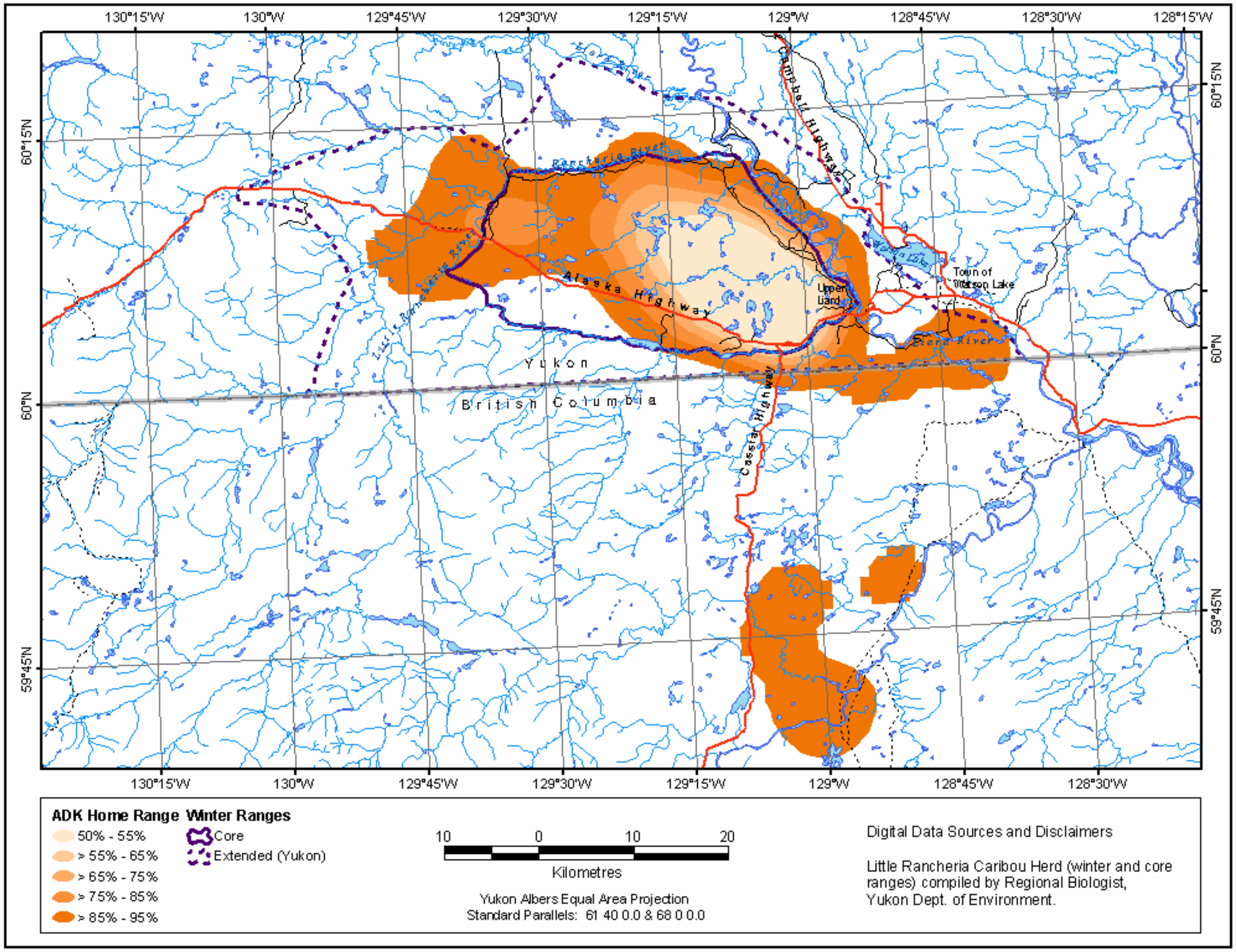


Figure 10. Adaptive kernel home range for all VHF radio-collared caribou on the Yukon and British Columbia winter ranges.

Table 5. Reclassification of Southeast Yukon V-type assessments (Zoladeski et al. 1996, McKenna 1996) into related ecological units.

Reclassification		Material/ Terrain Unit	Landscape Position	Ecosystem Classification V-Type	Moisture/ Nutrient Class**
Community	**Code**				
Poplar Riparian	PR	Fluvial	Lowland	V7 (Open Balsam Poplar – Spruce)	6
Spruce Riparian	SR			V13 (Closed Spruce)	4
Spruce Riparian	SR			V17.1 (Open White Spruce, Alluvial)	6
Poplar Riparian	PR			V26 (Closed Balsam Poplar – Spruce)	6
Poplar Riparian	PR			V31 (Open Balsam Poplar – Spruce)	6
Pine/Lichen	PL	Glaciofluvial	Upland	V21.2 (Open Pine – Spruce Lichen)	2
Pine/Lichen	PL			V22.1 (Open Pine – Lichen)	1
Pine/Bearberry	PB			V33 (Open Pine – Trembling Aspen)	2
Black Spruce/Labrador Tea	BL		Lowland	V12 (Closed Black Spruce)	5
Spruce/Feathermoss	SF	Glaciofluvial/ Morainal Transition	Upland	V14 (Closed Pine – Spruce)	1
Pine/Feathermoss	PFo			V21 (Open Pine – Spruce Lichen, no mod)	2
Pine/Feathermoss	PFo			V21.1 (Open Pine – Spruce Lichen, Moss)	2
Pine/Feathermoss	PFo			V22.2 (Open Pine – Lichen, Moss)	4
Mixed-wood/Feathermoss	MF			V25 (Closed Aspen – Spruce – Pine)	5
Pine/Bearberry	PB			V28 (Closed Pine – Aspen)	2
Mixed-wood/Feathermoss	MF			V30 (Open Aspen – Spruce – Pine)	5
Young seral stage of upland conifer	NA			V111 (Pine – Med/Tall Shrub, Fire Regen)	NA
Pine/Feathermoss	PFc	Morainal	Upland	V15 (Closed Pine)	4
Spruce/Labrador Tea	SL			V17.2 (Open White Spruce, Sloping)	5
Spruce/Labrador Tea	SL			V20 (Open White/Black Spruce)	5
Spruce/Birch	SB			V27 (Closed Paper Birch – Spruce) RARE	2
Mixed-wood/Feathermoss	MF			V29 (Closed Spruce – Aspen)	5
Spruce/Birch	SB			V32 (Open Paper Birch – Spruce (Pine))	2
Mixed-wood/Feathermoss	MF			V34 (Open White Spruce – Paper Birch (Aspen))	5
Black Spruce/Labrador Tea	BL		Lowland	V18 (Open Black Spruce)	5
Black Spruce/Labrador Tea	BL			V35 (Open Black Spruce – Aspen)	5
Black Spruce/Labrador Tea	BL			V35.1, 35.2 (moss, lichen phases)	5
Black Spruce Bog	BB	Organic	Lowland	V19 (Open Black Spruce, Organic)	7
Tamarack Fen	TF			V23 (Open Tamarack – Spruce)	8

**Moisture-Nutrient Class created from approximation of Zoladeski et al. (1996).

Land and Habitat Classifications

The SG and BEI classification schemes were sufficiently generalized that they could be used for analysis in their original form. The FC classification was used in the analysis based on leading tree species and modified based on canopy cover class for conifer forest types. However, the derived EU coverage required additional treatment and generalization. Based on Rosie (1995) 35 different V-types were initially identified using this classification: too many to assess caribou-habitat relationships. We grouped structurally or ecologically similar V-types to derive EUs based on our prior experience in the region and by a systematic examination of moisture/nutrient classes (Table 5, Zoladeski et al. 1996). Preliminary descriptions of the vegetated EUs are reported in Appendix 3

Distribution of land cover classes over caribou range

Pine or pine-dominant forest was the predominant cover type in both the core and the extended winter ranges in all 3 vegetation-based classifications. Pine-dominated forest classes comprised 48.8% of the core range and 42.1% of the extended winter range (Figure 11*a*). The EU coverage represented both the core and extended winter range as pine-dominated (67.0% and 45.1% respectively (Figure 11*b*) and was higher than any of the other schemes. The BEI coverage identified only 34.2% of the core and 28.8% of the extended range as pine dominated (Figure 11*c*). However, in the BEI, spruce classes are considered climax communities but may be dominated by pine in their current successional stage. If these spruce/lodgepole pine classes are included in the BEI assessment, pine forests dominate both the core and the extended winter range habitats (84.3% of the core and 75.1% of the extended winter range). The ability of these coverages to represent the abundant lichen component typical of high quality caribou range varied considerably. The EU classification explicitly differentiates the lichen understory component as an ecological indicator. Lichen-dominated cover types (*Pine/Bearberry, Pine/Lichen*) constituted 28.5% of the core area and 12.5% of the extended winter range based on this classification. Other classes that could potentially support caribou foraging habitat, based on lichen in the understory, are the *Black Spruce, Wetland,* and *Open Pine/Feathermoss* EUs, which made up an additional 25.8% of the core and 28.0% of the extended winter range.

The FC differentiates between open- and closed-canopy classes (similar to the EU classification); 30.1% of the core range and 34.6% of the extended range were identified as open pine. Clearly defining additional high quality habitat for caribou is difficult due to the abundance of mixed conifer types and the lack of detail in descriptions of understory plant composition. If the spruce types are included without further interpretation of the understory vegetation, most of the forested land within the core and extended winter ranges would be identified as caribou habitat. The BEI coverage suffers from this same lack of resolution in understory vegetation.

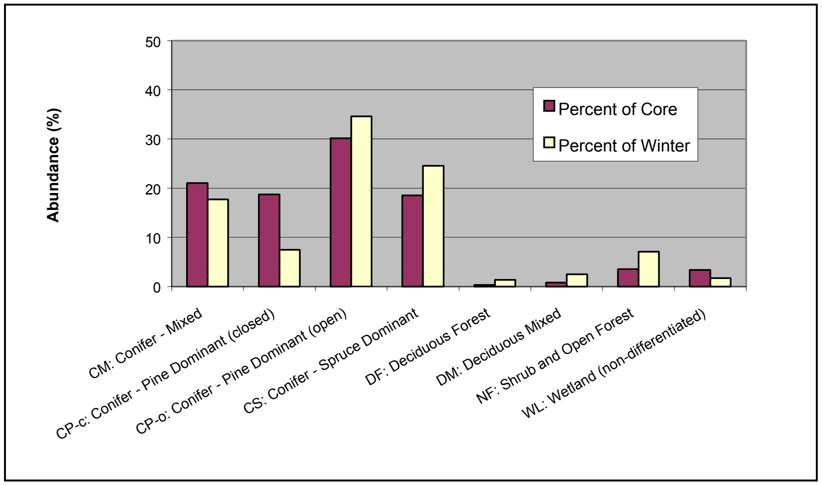
The SG classification identified that the core range supported 36.0% glaciofluvial parent materials, which are frequently associated with important lichen producing habitats (Figure 11*d*). Organic soil types, which also support important lichen foraging and movement areas, cover an additional 15.5% of the range, for a total of 51.5% of the core identified as potentially important caribou range.

When coverages were overlaid there were surprisingly few consistent or clear relationships among them. For example, the *Pine/Lichen* EU was associated with a number of different habitat units among each of the FC, BEI, and SG coverages. Although 67.2% of the *Pine/Lichen* EUs were associated with glaciofluvial parent materials, they were also related to morainal (17.6%) and organic parent materials (9.5%). The relationship was even less distinct within glaciofluvial parent materials of the SG. Only 35.6% of the area in glaciofluvial parent material was associated with a *Pine/Lichen* EU. These soils also supported the related *Pine/Bearberry* EU (21.7%), and closed canopy *Pine/Feathermoss* (16.2%) and *Black Spruce/Ledum* (8.5%). These latter EUs are more frequently associated with morainal and organic soil types. Similarly, intersecting the *Pine/Lichen* EU with the BEI coverage demonstrated strong correspondence with the BEI *Lodgepole Pine* class (59.2%) but was also associated with *Boreal White Spruce/Lodgepole Pine* (20.0%) and *Poplar Riparian* (9.5%). As above, the converse relationship was also less clear where *Pine/Lichen* EUs represented only 33.8% of the *Lodgepole Pine* class.

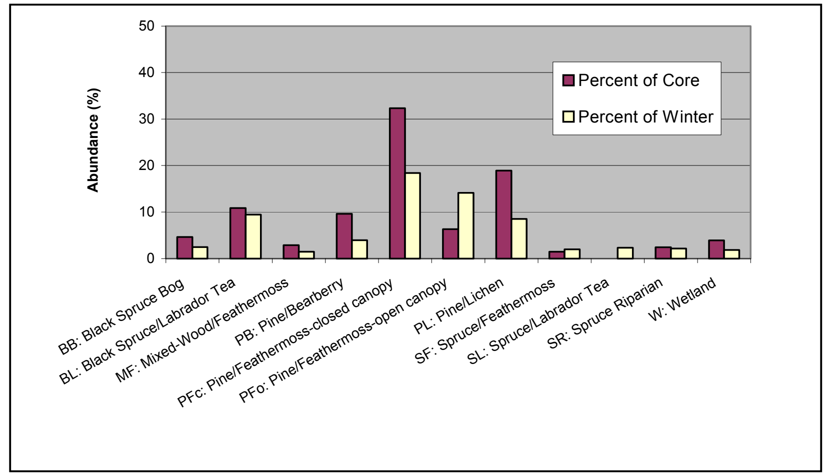
Vegetative Characteristics of Key Caribou Habitats

Intensive ground sampling confirmed that groundcover in habitats frequented by caribou typically supported a high proportion of understory lichen (Table 6, Table 7). *Pine/Lichen*, *Pine/Bearberry* and open-canopy *Pine/Feathermoss* EUs contained the highest proportion of ground lichens and the lowest proportion of moss. Black spruce sites situated on both organic and mineral soils supported high moss ground cover but also supported between 9% and 23% lichen ground cover. There appeared to be an association between the amount of canopy cover and the dominance of either lichen or moss. High lichen and low moss cover were associated with relatively open canopy upland habitats (Appendix 4).

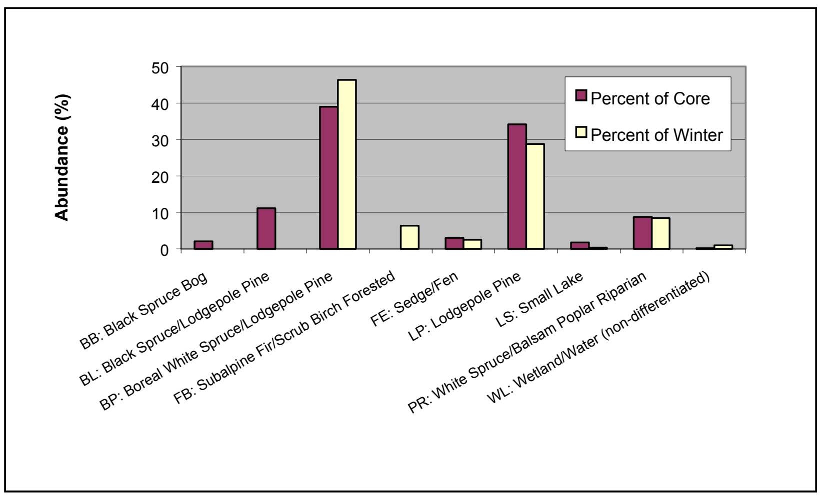
Figure 11. Relative abundance of simplified habitat coverages on the little Rancheria caribou herd winter range.



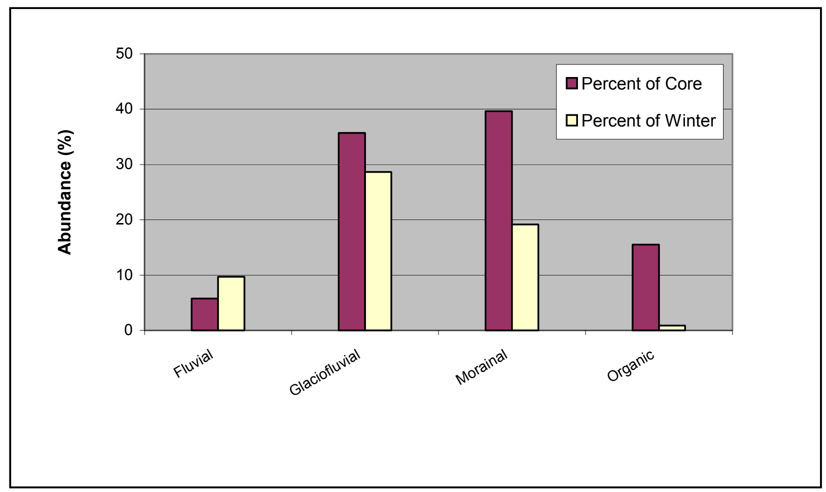
a) Forest cover units.



b) Derived ecosystem units.



c) Broad ecosystem units.



d) Surficial geology.

Table 6. Mean percent ground cover for lichen, moss, grass and litter determined by plot sampling on winter range of the Little Rancheria caribou herd, July–August 1991.

Reclassified Community Name	Code	No. Plots	Mean Percent Cover					
			Canopy	Lichen	Moss	Grasses	Litter	Bare
Black Spruce Bog	BB	40	10	9	70	1	0	0
Black Spruce/Ledum	BL	40	10	9	70	1	0	0
Pine/Feathermoss closed	PFc	100	41	2	40	0	42	0
Pine/Feathermoss open	Pfo	20	30	27	37	0	19	0
Pine Lichen	PL	119	15	41	16	1	28	1
Poplar/Riparian	PR	20	13	0	13	2	46	10
Spruce/Birch	SB	20	44	2	34	0	57	0
Spruce/Feathermoss	SF	40	46	0	52	1	24	0
Spruce/Ledum	SL	19	30	3	70	0	11	0
Spruce/Riparian	SR	106	47	2	66	0	5	0

Table 7. Mean percent ground cover for lichen, moss, and litter determined by plot sampling (after Zoladeski et al. 1995) on winter range of the Little Rancheria caribou herd, July–August 1995.

Reclassified Community Name	Code	No. Plots	Mean Percent Cover						
			Canopy	Lichen	Moss	Conifer Litter	Deciduous Litter	Wood	Bare
Black Spruce Bog	BB	11	31	14	73	4	2	7	0
Black Spruce/Ledum	BL	5	47	23	64	3	2	9	0
Mixed Wood/Feathermoss	MF	3	50	4	34	8	47	7	0
Pine/Bearberry	PB	4	36	32	17	25	21	6	1
Pine/Feathermoss closed	PFc	17	55	13	41	22	10	14	0
Pine/Feathermoss open	PFo	17	38	16	50	16	7	10	1
Pine Lichen	PL	31	32	52	6	28	9	5	0
Spruce/Birch	SB	1	50	2	45	10	15	12	0
Spruce/Feathermoss	SF	2	63	13	53	18	8	10	0
Spruce/Riparian	SR	2	65	4	75	6	4	12	0

Caribou habitat use and resource selection

Location/habitat associations

No significant difference was found in habitat selection by individual VHF radio-collared caribou among years (MANOVA; Wilks Lambda = 0.536, $F_{7,\ 16}$ = 2.66, p = 0.123) thus data from the different years were pooled for further assessments.

We found significant overall selection was occurring for at least some attributes within each of the 4 landcover classification schemes within the core wintering area (Table 8; see also Appendix 2).

Forest Cover

When we modified the FC classification to account for canopy cover in pine stands we found that within the core range caribou avoided closed-canopy pine forest types (Table 9, Table10). The absence of selection within the *Open Pine Forest* cover type is likely due to high levels of both use and availability of this type. Caribou were located in this type more frequently than in any other. The analysis also indicated avoidance of the *Open Shrub* and *Deciduous Mixed* classes (Table 9, Table 10). These differences may not be an accurate reflection of animal selection patterns but may be related to mapping resolution and classification of habitats that are limited in extent but widely distributed.

Broad Ecosystem Inventory

When caribou locations were intersected with the BEI scheme, we found significant selection for *Black Spruce Bog* and *Lodgepole Pine* and avoidance of *Boreal White Spruce/Pine* and *White Spruce/Poplar/Riparian*. Caribou appeared to neither select nor avoid the other habitats described in this scheme (Table 11). Caribou use of the entire winter range was similar to that of the core (Table 12), except that *Black Spruce/Ledum* and *Small Lake* communities were also selected as winter habitat.

Table 8. Log-likelihood analysis of overall habitat use among different landcover classification schemes by Little Rancheria caribou within the core winter range. Observations pooled for the years 1996–1999.

Landscape classification method	Number of individuals in test (n)	χ_{L1}^2	χ_{L2}^2	D	Is selection taking place?
Forest Cover	26	**85.41** (233.99,200)	**115.62** (242.65,208)	**30.23** (15.51,8)	Yes
BEI	26	**197.99** (179.58,150)	**244.80** (185.15,156)	**46.81** (12.59,6)	Yes
Surficial Geology	25	**268.96** (92.81,72)	**304.69** (96.22,75)	**35.74** (7.81,3)	Yes
Derived Ecosystem Units	24	**209.20** (206.87, 175)	**247.09** (214.48,182)	**37.9** (14.07,7)	Yes

Note: The critical Chi square value is in (*,df) where df is degrees of freedom. Test statistic is in bold.

See Appendix 2 for details on formulae and test procedure. After Manly et al. (2002:64).

Surficial Geology

We found significant selection for glaciofluvial soil parent materials and avoidance of morainal types within the core wintering area (Table 13).

Table 9. Bonferroni confidence intervals for probabilities of selection of Yukon forest cover (FC) by Little Rancheria caribou within the core winter range. Observations for the years 1996–1999 were combined. This analysis used 26 caribou, none with fewer than 6 observations per habitat type.

Forest Cover	Observed	w_i**	Se(w_i)	*Bonferroni Confidence Limits* Lower	Upper	Decision**
Mixed Conifer (CM)	100	1.25	0.313	0.394	2.106	
Closed Pine (PC)	33	0.382	0.15	0	0.792	Avoid
Open Pine (PO)	123	1.132	0.246	0.459	1.805	
Spruce (CS)	79	1.184	0.264	0.462	1.906	
Shrub Open (NF)	2	0.121	0.109	0	0.419	Avoid
Water Open (OW)	20	1.779	0.495	0.425	3.133	
Wetland (WL)	16	1.192	0.489	0	2.529	

Deciduous communities were infrequent forest cover types in the core winter range
*Terminology as outlined in methods and in Appendix 2
**Where "Decision" is blank neither preference nor avoidance was evident

Table 10. Bonferroni confidence intervals for probabilities of selection of Yukon forest cover (FC) by Little Rancheria caribou within the entire winter range. Observations for the years 1996–1999 were combined. This analysis used 32 caribou, none with fewer than 6 observations per habitat type.

Forest Cover	Observed	w_i	Se(w_i)	*Bonferroni Confidence Limits* Lower	Upper	Decision
Mixed Conifer (CM)	128	1.306	0.293	0.505	2.107	
Closed Pine (PC)	42	0.567	0.201	0.017	1.117	
Open Pine (PO)	179	1.135	0.214	0.55	1.72	
Spruce (CS)	110	0.915	0.204	0.357	1.473	
Deciduous Mixed* (DM)	2	0.191	0.15	0	0.601	Avoid
Shrub Open (NF)	10	0.409	0.119	0	0.734	Avoid
Water Open (OW)	23	1.592	0.402	0.493	2.691	
Wetland (WL)	17	1.337	0.523	0	2.767	

* Deciduous communities were infrequent in the winter range forest cover

Table 11. Bonferroni confidence intervals for probabilities of selection for habitat use using broad ecosystem inventory (BEI) within the core winter range. Observations for years 1996–1999 were combined. The analysis used 26 individual caribou, none with fewer than 6 observations per habitat type.

Broad Ecosystem Unit	Observed	w_i	se(w_i)	*Bonferroni Confidence Limits* Lower	Upper	Decision
Black Spruce Bog (BB)	23	3.37	0.64	1.64	5.11	Select
Black Spruce/Lodgepole Pine (BL)	45	1.01	0.15	0.59	1.44	
Boreal White Spruce/Lodgepole Pine(BP)	105	0.66	0.08	0.46	0.87	Avoid
Sedge/Fen (FE)	7	0.57	0.27	0.00	1.29	
Lodgepole Pine (LP)	172	1.39	0.09	1.16	1.63	Select
Small Lake (LS)	9	1.52	0.45	0.29	2.74	
White Spruce/Balsam Poplar Riparian(PR)	12	0.44	0.13	0.07	0.80	Avoid
Wetland/Water (WL)	0	0.00	0.00	0.00	0.00	

Table 12. Bonferroni confidence intervals for probabilities of selection for habitat use using the broad ecosystem inventory (BEI) within the extended winter range. Observations for years 1996–1999 were combined. This analysis used 32 individual caribou, none with fewer than 6 observations per habitat type.

Broad Ecosystem Unit	Observed	w_i	se(w_i)	*Bonferroni Confidence Limits* Lower	Upper	Decision
Black Spruce Bog (BB)	24	6.202	0.94	3.64	8.77	Select
Black Spruce/Lodgepole Pine (BL)	45	1.543	0.18	1.05	2.03	Select
Boreal White Spruce/Lodgepole Pine(BP)	162	0.627	0.10	0.35	0.91	Avoid
Sedge/Fen (FE)	12	0.700	0.25	0.00	1.38	
Lodgepole Pine (LP)	237	1.452	0.14	1.07	1.83	Select
Small Lake (LS)	10	2.245	0.36	1.26	3.23	Select
White Spruce/Balsam Poplar Riparian(PR)	19	0.498	0.13	0.14	0.86	Avoid
Wetland/Water (WL)	1	0.252	1.34	0.00	3.90	

Table 13. Bonferroni confidence intervals probabilities of selection for habitat use by Little Rancheria caribou using the surficial geology (SG) coverage within the core winter range. Observations for years 1996–1999 were combined. Locations from 25 caribou were used in this analysis.

Surficial Geology	Observed	w_i	se(w_i)	*Bonferroni Confidence Limits* Lower	Upper	
Fluvial	9	0.67	0.20	0.14	1.21	
Glaciofluvial	161	1.53	0.10	1.25	1.82	Select
Morainal	78	0.52	0.09	0.28	0.76	Avoid
Organic	54	1.12	0.11	0.82	1.41	

Ecosystem Unit Classification

We found that caribou avoided the *Open-* and *Closed-canopy Pine/Feathermoss* EUs within the core wintering area (Table 14). We expanded this analysis to the mapped extent of the LRH winter range, and found that the pattern of avoidance of the *Pine/Feathermoss* EUs remained, but also that caribou were selecting for *Pine/Lichen* and the *Pine/Bearberry* EUs (Table 15). Most other cover types were used in proportion to their availability.

Table 14. Bonferroni confidence intervals of probabilities of selection of derived ecosystem cover (EU) by Little Rancheria caribou within the core winter range. Observations for years 1996–1999 were combined. The analysis used 26 individual caribou, none with fewer than 6 observations per habitat type.

Derived Ecosystem Units				*Bonferroni Confidence Limits*		
	Observed	w_i	se(w_i)	Lower	Upper	Decision
Black Spruce Bog (BB)	23	1.460	0.279	0.697	2.223	
Black Spruce/Ledum (BL)	40	1.210	0.16	0.772	1.648	
Pine Bearberry (PB)	52	1.649	0.242	0.987	2.311	
Pine Feathermoss closed (PFc)	70	0.584	0.086	0.349	0.819	Avoid
Pine Feathermoss open (Pfo)	12	0.560	0.147	0.158	0.962	Avoid
Pine Lichen (PL)	70	1.144	0.107	0.851	1.437	
Wetland (W)	15	1.284	0.315	0.423	2.145	
Water (WAT)	18	1.493	0.343	0.555	2.431	

Table 15. Bonferroni confidence intervals for probabilities of selection of derived ecosystem cover (EU) by Little Rancheria caribou within the extended winter range. Observations for years 1996–1999 were combined. This analysis used 30 individual caribou, none with fewer than 6 observations per habitat type.

Derived Ecosystem Units				*Bonferroni Confidence Limits*		
	Observed	w_i	se(w_i)	Lower	Upper	Decision
Black Spruce Bog (BB)	26	1.518	0.267	0.788	2.248	
Black Spruce/Ledum (BL)	48	0.876	0.114	0.564	1.188	
Pine Bearberry (PB)	67	2.256	0.272	1.512	3.000	Select
Pine Feathermoss closed (PFc)	93	0.671	0.075	0.466	0.876	Avoid
Pine Feathermoss open (Pfo)	25	0.452	0.076	0.244	0.660	Avoid
Pine Lichen (PL)	89	1.377	0.126	1.032	1.722	Select
Wetland (W)	15	1.179	0.301	0.356	2.002	
Water (WAT)	20	1.223	0.263	0.504	1.942	

Statistical treatment and resource selection

Our assessment of selection, using pairwise comparisons of habitat resource preference within the core range with unadjusted p-values, determined that most habitat types in the winter range were preferred over both *Open*- and *Closed-canopy Pine/Feathermoss* EUs. No relationships were identified in the core range when habitats were compared with each other using the more rigorous Holm's modification for these assessments (Table16). Some consider the Holm's modification to be statistically essential when doing multiple comparisons in a Bonferroni analysis because it accounts for the total number of contrasts in assigning the appropriate pairwise test significance (Arthur et al. 1996). However, others have suggested that it may be too rigorous and that the unadjusted differences are appropriate for this type of habitat assessment (J. Rettie, Ontario Ministry of Natural Resources, personal communication). We present both analyses for the core and extended winter range to illustrate where the key differences occur.

Over the entire winter range, we found significant selection for the *Pine/Lichen* and *Pine/Bearberry* EUs over the *Open*- and *Closed-canopy Pine/Feathermoss* EUs (Table 15).

This relationship stood up even with the more rigorous Holm's modification. Using the unadjusted p-values, caribou also selected the *Pine/Bearberry* and *Pine/Lichen* EUs over *Black Spruce/Ledum* EU. This analysis further identified preference for *Pine/Bearberry* over *Water* and *Wetland* EUs. *Black Spruce/Ledum* and *Black Spruce/Bog* EUs were also selected over the *Open*- and *Closed-canopy Pine* EUs (Table 17).

Table 16. Paired-sample *t*-test for significant differences using selection indices (b_i values) for 26 individual Little Rancheria caribou in the core winter range from 1996 to 1999 (all years combined

		Habitat V-Type Code (see Table 1)							
		PB	BB	PL	WAT	BL	W	PFc	PFo
	Mean b_i	0.184	0.151	0.135	0.141	0.130	0.126	0.072	0.060
PB	0.184							+	+
BB	0.151							+	+
PL	0.135							+	+
WAT	0.141								+
BL	0.130							+	+
W	0.126								
PFc	0.072	-	-	-		-			
PFo	0.060	-	-	-	-	-			

++ Significantly greater using Holm's Procedure
+ Significantly greater using unadjusted p-values
-- Significantly less using Holm's Procedure
Significantly less using unadjusted p-values

Table 17. Paired-sample *t*-test for significant differences using selection indices (b_i values) for 30 individual Little Rancheria caribou in the entire winter range from 1996 to 1999 (all years combined).

		Habitat V-Type Code (see Table 1)							
		PB	BB	PL	WAT	BL	W	PFc	PFo
	Mean b_i	0.157	0.100	0.229	0.082	0.052	0.154	0.108	0.119
PB	0.157			+	+	+	+	++	++
BB	0.100							+	+
PL	0.228	-				+		++	++
WAT	0.082	-							+
BL	0.052	-		-				+	+
W	0.154	-							
PFc	0.108	--	-	--		-			
PFo	0.119	--	-	--	-	-			

Habitat Quality Modelling

Habitats of varying qualities were distributed over both the core and extended range (Figure 12). We identified high quality caribou habitats as the lichen dominant *Pine/Lichen* and *Pine/Bearberry* EUs (Table 18). We included habitats with moderate to substantial lichen understory that also function as movement corridors due to their position on the landscape. Specifically, these included the *Black Spruce/Bog* and *Black Spruce/Ledum* EUs. Habitats ranked as having medium value to caribou had moderate but variable quantities of lichen and were strategically situated on the landscape (Table 18). Collectively, the high- and medium-quality habitat types comprised 54.3% of the core and 40.5% of the extended range. These habitats were incorporated into the model and boundaries buffered by 250 m to safeguard against mapping boundary errors and to provide a buffer from human activity in adjacent low quality habitats.

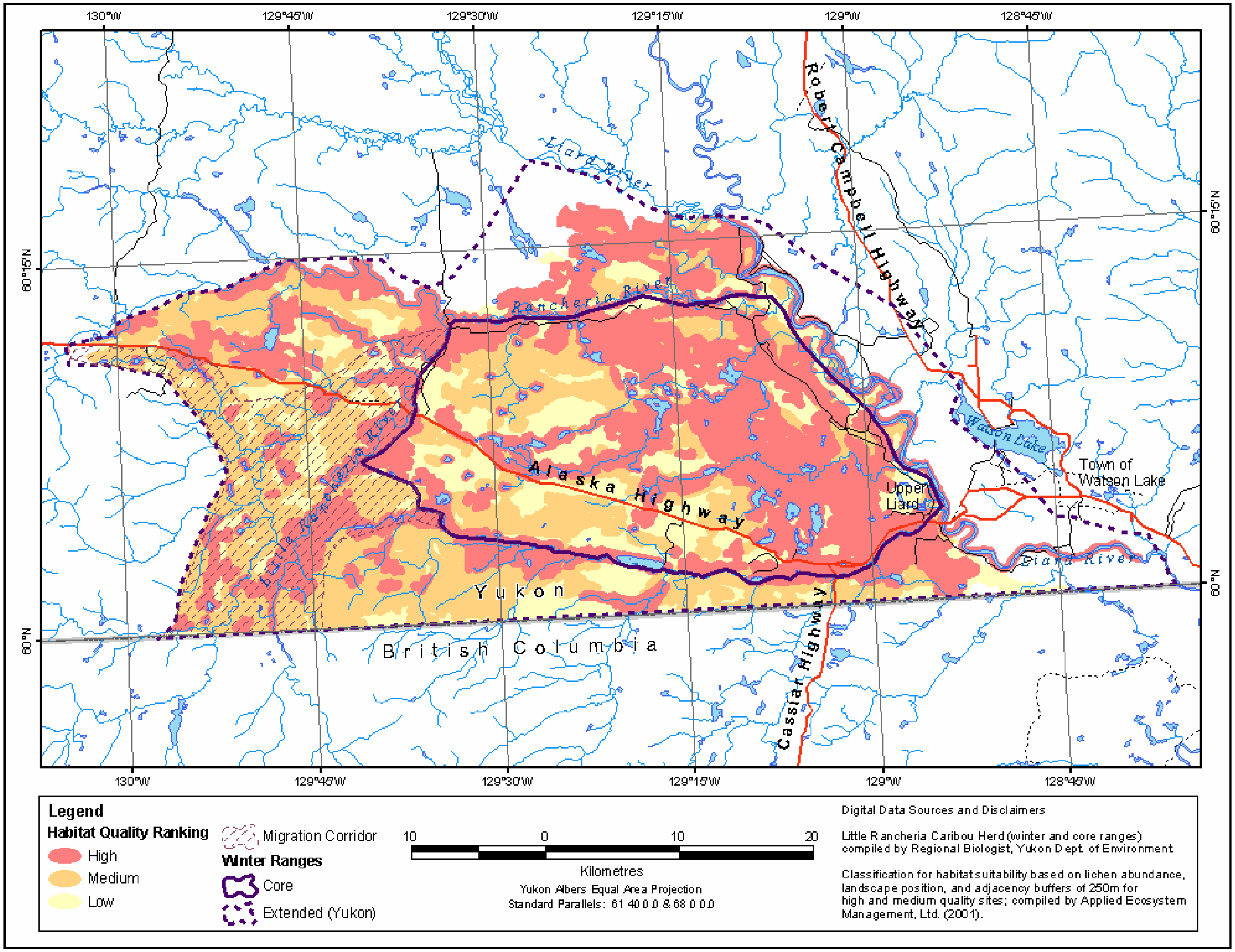


Figure 12. Habitat suitability map for the Yukon Little Rancheria caribou winter range.

Table 18: Habitat ranking attributed to derived ecosystem unit types based on lichen abundance and landscape position.

Ecosystem Unit Code	Definition	Habitat Rank
PB	Pine/Bearberry	H
PL	Pine/Lichen	H
BB	Black Spruce/Bog	H
BL	Black Spruce/Ledum	H
PFo	Pine Forest/open canopy	M
WET	Wetlands	M
WAT	Water	M
AF	Alpine Fir	L
MF	Mixed-wood/Feathermoss	L
NSR	Not Sufficiently restocked	L
PFc	Pine Forest/closed canopy	L
PR	Poplar/Riparian	L
SB	Spruce/Birch	L
SF	Spruce/Feathermoss	L
SL	Spruce/Labrador Tea	L
SR	Spruce/Riparian	L
TF	Tamarack Fen	L
NP	Non Productive (burns)	L
Blank	Undefined	NA
C	Cultivated	NA

Discussion

Importance of the Yukon LRH winter range

Our study found a strong association between LRH caribou and the Yukon portion of its winter range through all 10 years covered by this study. This range use pattern was noted historically through local knowledge (Sun-Comeau 2001) and from previous studies (Bergerud 1980, Eccles 1983, Farnell and McDonald 1990). Variation in the pattern of winter range use has been found for caribou of the same ecotype in British Columbia (Wood and Terry 1999) and for the boreal ecotype of woodland caribou in Labrador (T. Jung, Yukon Environment, personal communication). Similar variation between an alternate winter range in British Columbia was not observed over the term of this study. This type of landscape scale selection may be associated with suitable lichen growth and the relative accessibility of this forage associated with snow depth.

Terrestrial lichen abundance is of key importance to caribou of the mountain/ terrestrial ecotype (Cichowski 1989, Edmonds 1991). Diet studies from caribou ranges in the Yukon, including the LRH range, determined that lichens from the genera *Cladina* and *Cladonia* are the primary winter forage (Farnell and McDonald

1989, 1990; Farnell et al. 1991). Preferred lichen species made up over 70% of the winter diet for LRH caribou (Farnell and McDonald 1990) and is consistent with assessments of dietary lichen intake on other high quality caribou ranges (Schaefer and Pruitt 1991). Lichen-bearing habitats within the core range of the LRH range appear to be regionally significant. Sampling within many of the open-canopy lodgepole pine stands found terrestrial lichens averaged 30–40% of the ground cover and ranged up to 95% on some sites (Rosie 1995). Frid (1996) found that the choice of cratering areas for caribou in the Carcross herd of southcentral Yukon is highly correlated with the cover for key lichen forage species; sites required 11–24% lichen cover before caribou made use of them. Cichowski (1989) similarly determined that relative lichen abundance influenced caribou crater site selection.

Snow depth is likely important in determining suitable caribou wintering areas in Yukon and elsewhere (Brown and Theberge 1990, Rominger et al. 1994). For mountain/terrestrial caribou, such as the LRH, snow accumulations in alpine habitats are thought to push post-rutting caribou onto traditional winter ranges (Bloomfield 1980, Wood and Terry 1999) where winter accumulations are lower than surrounding habitats. In Yukon, Farnell and McDonald (1989, 1990) and O'Donoghue (1996) reported that caribou winter ranges, including the LRH range, tend to have lower snow accumulations than surrounding parts of the caribou range. In southeastern British Columbia, snow depth determined whether caribou could access arboreal lichens in the upper branches of mature trees (Rominger et al. 1994); this constraint may be unique to the mountain/arboreal caribou ecotype (but see: Brown and Theberge 1990). Once within a winter range, it is much more likely that forage abundance and local variations in the landscape that influence forage are determinants of caribou winter range use. Palidwor and Schindler (1995) also considered that woodland caribou might vary sites they select based on suitable vegetation and secondarily on snow.

Landscape classification and caribou habitat

The lack of a comprehensive, ecologically based, and spatially referenced landscape classification scheme is a major impediment to the analysis and understanding of wildlife/habitat associations in the Yukon. We created the EU system as a hybrid of the detailed—but aspatial— Yukon Forest Ecosystem Classification (Zoladeski et al. 1996), and the spatial FC polygons. The strength of our methodology was that the Forest Ecosystem Classification is based on combinations of soil and canopy and understory vegetation, so our description of the landscape was based on ecological relationships. The major limitations to our approach were that the FC information was dated, polygons were periodically larger than the variation in landform features and, in approximately 5%–10% of the cases, the airphoto interpretation was incorrect. Overall, the EU coverage provided the greatest level of detail and the most meaningful ecological description of caribou habitat compared to individual coverages for SG, FC, or BEI.

The 4 land classifications we evaluated were consistent in identifying some patterns of caribou habitat use. All methods agreed that caribou avoid or are indifferent to alluvial forests (lowland white spruce); various classes of pine forest, which were treated as a single type in the FC coverage, were either selected or avoided. These patterns could be refined using canopy cover classes but that would not meaningfully separate differences in lichen understory composition among pine stands. This is one of the most important attributes of caribou habitat and is essential to properly manage caribou winter ranges.

Where attributes of the soil genetic material strongly influenced the associated vegetation communities there was general agreement among the SG, BEI and EU classifications. Although the SG classification reflected the presence or absence of lichen in the forest understory, coarse resolution due to large polygon size limited its utility in identifying more finely distributed elements of the landscape. The BEI mapping scheme was better than the FC and SG classifications because it used ecological descriptions for understory, canopy, soil, and slope/aspect positions. However, the mapping resolution was coarse and suffered from the same polygon size limitation as the SG classification. While suitable for landscape level planning and management, it has limited use in the assessment of finer scale ecological relationships.

We found that EU typing was most useful in describing the landscape relative to caribou habitat on this range. Finer scale mapping could improve the utility of the classification methods evaluated in the present study. More importantly, developing an ecological mapping system for Yukon or updating the forest inventory using the Forest Ecosystem Classification or an equivalent ecologically based system would enable resource managers to better manage multiple resources on the landscape.

Caribou winter range: The inter-relationship between landscape, fire, and forest communities

Many forestry-wildlife habitat management plans focus on the concept of seral stage management (Mladenoff and Pastor 1993, Hannon et al. 1996, Haufler et al. 1996, Hervieux et al. 1996, Eng 1998, Parminter 1998). Many forestry-wildlife studies are actually based on this premise (e.g. Van Horne 1982, McGarigal and Fraser 1984, Westworth and Telfer 1993, Jung et al. 1999).

Such a management strategy assumes that most forests will undergo similar patterns of succession and that successional stages shift across the landscape over time (i.e., most sites have the same potential to create suitable habitat). If this were true, then providing a representative range of inter-connected forest communities in different stages of structural development should, in theory, ensure habitat requirements for species dependent on specific stages of forest succession. We feel that this concept does not apply to the LRH winter range.

The surficial geology (Rostad et al. 1977) and fire history (Applied Ecosystem Management Ltd. 1998) for the LRH winter range area have influenced patterns of vegetation and forest development. These patterns appear to persist through time beyond what might be predicted from the fire regime. Cichowski (1989) noted a relationship between habitats that support abundant terrestrial lichens and soil genetic material. Coarse textured glacial till and glaciofluvial sand and gravel deposits typically supported the highest cover of terrestrial lichens. Reid (1975) noted similar relationships between glacial terraces, south aspect pits (kettles), south slope habitats, meltwater channels and the dominance of lichen-bearing habitats in parts of the LRH winter range.

Pine/lichen communities in the LRH winter range appear to have a long-term persistence on the landscape. Fire patterns over the last 2 centuries have been affected by the shape of the ground following the retreat of the last ice age (Applied Ecosystem Management Ltd. 1998). The current seral stages in the LRH range may be more related to the topographic variation and soil nutrient status than to fire history. Brulisauer et al. (1996) examined post-fire successional patterns of lodgepole pine communities and established that differences in understory vegetation communities were associated with soil moisture. Between 100 and 200 years post-fire, dry sites supported an understory high in fruticose lichens (*Cladina* spp./*Cladonia* spp.), while wetter sites supported pine communities with high feathermoss (*Pleurozium* spp., *Hylocomium* spp.) and foliose lichen (*Peltigera* spp.) components. For sites similar to the LRH winter range, Brulisauer et al. (1996) determined that ground cover on wetter sites changed little beyond the 200-year period, whereas the cover of *Cladina* on dry sites continued to increase for at least 300 years. Lichen cover and biomass peaked 60–100 years after fire on forested winter ranges of barren ground caribou, but peak use was not until 100–150 years after burning (Thomas et al. 1996). These findings suggest that pine/lichen communities in LRH range are stable in the long term, and that after a large fire they will likely return as pine communities. It follows that woodland caribou may need forested ranges far older than those typically found in forests where commercial timber rotations dictate forest age class.

Scotter (1971) and Klein (1982) concluded that the long-term benefits of fire to caribou ranges outweigh both the short- and long-term costs. They go on to suggest that caribou in boreal forests are *fire-influenced* rather than *fire-adapted*. Being *influenced* is the long-term expression of fire on the ecosystem rather than the reliance on the relatively shorter-term early successional stages that typically follow fire or other forest disturbances.

We suggest that in the LRH core winter range, fire has combined with the complex morphology and glacial history of the area to maintain a high value caribou range.

While commonly viewed as fire-driven mid-seral stage communities, our studies suggest some lodgepole pine communities may be late-seral communities maintained by fire. Where fire does initiate large-scale forest renewal, soil conditions are such that these sites will likely return to the same complexes supporting high quality lichen forage for caribou. Our view of long term stability in these complexes is supported by local information on the presence of caribou in the same area for many human generations (Sun-Comeau 2001).

Use and value of caribou management zones

Core winter range

The combined information from multiple data sources provided strong evidence that LRH caribou use a core wintering area that is consistent from year to year. At any one time more than half of the radio-collared caribou were found to winter within this part of the range. The range analysis results (see Figure 10) underscore the consistent use, year after year, of the core, particularly its eastern end near the community of Upper Liard. Local information and research on the soil/vegetation associations concur that the range is of particularly high quality and that important pine/lichen habitats are stable over the long term. No other portion of the herd's winter range in Yukon or British Columbia is used to the same extent as this well-defined core. Concentrated use of core or key winter ranges has also been documented for ecologically similar caribou herds in British Columbia (Stevenson and Hatler 1985, Armleder and Stevenson 1996), other parts of the Yukon (Rob Florkiewicz, unpublished data), and elsewhere (e.g. Labrador; Thomas Jung, Yukon Environment, personal communication). Many local resource management plans acknowledge concentration of caribou on winter ranges and identify the need for protection (B.C. LUCO 2000*a*, B.C. LUCO 2000*b*).

The extended winter range

Use of the extended winter range has varied within seasons and between years. Farnell and McDonald (1990) identified a more balanced use of the British Columbia portion of the LRH winter range than was observed in this study. Prior to the construction of the Alaska Highway caribou used parts of the winter range east of the present day location of the community of Watson Lake (Sun-Comeau 2001). Between 1998 and 2001, caribou were also occasionally reported north and east of Watson Lake. In the final year of our study we also noted that adjacent HH caribou wintered in the range of the LRH caribou, including the Yukon portion. Although the use of the core range appears consistent, patterns in the surrounding extended winter range appear to be more variable. As caribou range use patterns shift on the landscape, future monitoring will need to update and incorporate new caribou range use patterns.

The extended winter range may appear to be less important to caribou because of its apparently lower level of current use. However, a substantial extended range serves a number of critical functions:

Provides alternate range: The expanded range supports some areas of high and medium quality pine/lichen that can serve as alternate range when disturbances such as periodic fires may remove important feeding habitats.

Allows selective feeding over the landscape: Routine feeding activity results in compaction and hardening of snow, rendering local feeding sites unavailable for the balance of the winter. Feeding activity also reduces the availability of lichens through removal and trampling. Because lichens regenerate slowly, caribou require a large area where they are able to meet their winter food needs.

Facilitates predator avoidance: Constant movement and travelling over large wintering areas are important adaptations to avoid predators. Caribou may select habitats that are little used by other ungulates such as moose (Bergerud and Paige 1987, Seip 1992). If caribou are confined on reduced winter ranges "ecological compression" can increase local caribou densities (Dzus 2001). This may reduce their ability to use "space" to avoid predators and therefore increases the efficiency of predators and thereby, the natural mortality of caribou (Bergerud et al. 1984, Bergerud 1992).

Loss of habitat within the winter range can be expected to affect caribou movement rates and concentrate range use into unbroken habitat. In the case of timber harvest, Smith et al. (2000) determined caribou avoided recently harvested areas by an average distance of 1.2 km. If relatively little of the land base is harvested at any time, caribou are more apt to adjust if alternative areas are substantial.

Habitat management should allow caribou to shift their range use over time, to space out from predators, and to move via connected corridors among patches of winter feeding habitat.

Migration Corridor

The major LRH migration routes from alpine post-rut habitats to the Yukon winter range have been known since the late 1970s (Eccles

1983, Farnell and McDonald 1990; present report) and likely much earlier by trappers and First Nations hunters. LRH caribou also spend significant time foraging in parts of the migration corridor, generally in suitable pine/lichen communities. Steventon (1996) noted similar functions of the migration corridor for the Entiako caribou herd in British Columbia.

Timing of caribou arrival on the winter range has been attributed to the accumulation of snow in alpine rutting and post-rutting areas (Bloomfield 1980, Wood and Terry 1999). The relative consistency of caribou arrivals in the Yukon winter range within the first 2 weeks of October suggests that other factors, such as learned behaviours or other environmental cues may influence the timing of fall migration.

Movement corridors have been identified in caribou management plans as key landscape features to conserve (Cichowski and Banner 1993, Steventon 1996). In migratory species, cover is essential to ensuring that animals are not unduly exposed to predation. Loss of contiguous canopy cover or habitat fragmentation is 1 consequence of human development on caribou winter ranges. Increased predation on caribou associated with habitat fragmentation has been demonstrated in Alberta (James and Stuart-Smith 2000).

We observed that caribou movement patterns were influenced by the Alaska Highway right-of-way. Caribou travelled the forested margin parallel to the highway and crossed at specific, possibly traditional, locations. Linear corridors in caribou range have been considered "semi-permeable" barriers to caribou movement (James 1999); caribou tend to avoid corridors with high levels of human activity (Cumming and Hyer 1998). Timber harvest near the highway could increase the effective width and barrier effect of the road. Forests near the Alaska Highway should be managed to limit these effects by providing unbroken forest cover on both sides of the highway.

Key habitats for woodland caribou

Selection for the *Pine/Lichen* EU and glaciofluvial genetic material was pronounced in the EU and BEI assessments, as was avoidance of the *Closed-canopy Pine/Feathermoss* EU and morainal soil types. Our findings were similar to those shown for the same caribou ecotype in British Columbia by Cichowski (1989) and Cichowski and Banner (1993). They found that wetter sites on morainal soils were dominated by mosses (*Pleurozium schreberi, Ptilium crista-castrensis*) and generally had less than 1% lichen cover. Drier sites of coarser textured tills and glaciofluvial sand and gravel typically supported between 30% and 50% lichen ground cover (*Cladina* spp., *Cladonia* spp., *Stereocaulon* spp.). Similar to our findings, these drier sites represented the best caribou habitats.

Pairwise comparisons defined similar significant patterns of habitat selection. Ecosystem units dominated by lichen understory (*Pine/Bearberry* and *Pine/Lichen*) were highly selected by caribou. In contrast, *Pine/Feathermoss* habitats with abundant moss and little lichen cover were avoided. Preference for black spruce habitats over *Pine/Feathermoss* habitats appeared consistent based on the presence of some preferred lichen species. Spruce habitats supported lichen abundance intermediate to open- and closed-canopy pine forests.

Ecosystem components that support connectivity on the landscape are essential to ensuring that landscapes remain intact for wide ranging large ungulates (Noss and Harris 1986, Noss 1995). Topographic variability on the LRH Yukon winter range provides ideal natural movement corridors, particularly the connections between the British Columbia winter range and the alpine summer habitats. These corridors are dominated by *Black Spruce/Ledum* and *Black Spruce/Bog* habitat types, and total about 15% of the winter range. Although our assessment did not identify statistically significant use of these areas, snow tracking identified them as movement corridors into and within the winter range

The lack of apparent use may be related to caribou spending more time foraging in adjacent habitats with greater lichen cover and spending less time in habitats used more for movement. It is likely that black spruce EUs are used for foraging and help caribou to meet nutritional requirements (Schaefer and Pruitt 1991, Bradshaw et al. 1995, Rettie and Messier 1998). In other systems, they are the most productive lichen-bearing habitats available to caribou. Recognition of the caribou winter range not only as a foraging area but also as an intact landscape with well-connected habitat components is critical to managing for the future range use and persistence of caribou.

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Appendix 1: BEI habitat classes determined for the Little Rancheria Caribou range (source: Resource Inventory Committee 1988).

Code	Habitat Class	Description
BB	Black Spruce Bog	A bog wetland class that typically is a sparse to open treed organic wetland, with a peat moss dominated understory, black spruce and sometimes, tamarack.
BC	Sphagnum Bog	A bog wetland class that typically is an unforested wetland, dominated by sphagnum mosses and herbaceous plants, found on poorly drained organic sites.
BL	Black Spruce/Lodgepole Pine	Typically an open coniferous forest with shrub, moss or terrestrial lichen understories, on gently sloping dry or wet sites, usually with lodgepole pine communities that progress to a black spruce climax.
BP	BorealWhite Spruce/Lodgepole Pine	Typically a dense, boreal coniferous forest that includes plant communities that succeed through lodgepole pine seral forests to a white spruce climax.
FB	Subalpine Fir/Scrub Birch Forested	Typically a northern, subalpine, open forested habitat characterized by stands of subalpine fir and white spruce with a dense shrub understory of willows and scrub birch.
FE	Sedge Fen	A fen wetland class is typically an unforested wetland, dominated by sedges, found on poorly drained organic sites.
LL	Large Lake	Typically a fresh deepwater habitat that includes permanently flooded lakes, usually found in a topographical depression, lacking emergent vegetation except along shorelines and usually with a size of greater that 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.
PR	White Spruce/Balsam Poplar/ Riparian	Typically a dense, deciduous, mixed or coniferous forest, with thick shrub understories, found on or in association with fluvial sites; includes plant communities which succeed through deciduous forests to a white (or hybrid white) spruce climax.
OW	Shallow Open Water	A shallow open water wetland class that typically is comprised of permanent shallow open water and that lacks extensive emergent plant cover; water is usually less than 2 m in depth, with submerged and floating aquatic plants present.
WL	Wetland	Used for any wetland habitat class that cannot be recognized at small mapping scales.

Appendix 2: Sample computations for Resource Preference Index (after Manly et al. 2002, Rettie and Messier 2000, Arthur et al. 1996).

Log-likelihood Chi square tests

The first step in any selection analysis is to estimate whether or not selection is taking place. To do this we applied log-likelihood Chi-squared tests (Manly et al. 2002:53). Below is the χ^2 equation for Design Type I study where individuals are not identified. Note that expected frequencies should be 5 or more (Manly et al. 2002). Because this report is following statistical techniques using Manly's Selection Index we use the log-likelihood Chi-square test instead of the standard Chi-square test. The log-likelihood Chi-squared test will also give the same numerical results as the traditional method of calculating the Chi-squared test.

Design Type I

(Eq. 1)

$$\chi_L^2 = 2\sum_{i=1}^{1} u_i \log_e\{u_i/(u_+\Pi_i)\}$$

Where Π_i = proportion of the population of available resource units
u_i = number of units in category I in a sample of used units
u_+ = size of a sample of used resource units
Degrees of freedom is ((I–1)*(n–1)).

$$\chi_{L1}^2 = 2\,\Sigma\,2\sum_{j=1}^{n}\sum_{i=1}^{I} uij\ \log_e\{uij/(ui_+u_{+j}/u_{++})\}$$

Degrees of freedom is (I–1)*(n–1).

$$\chi_{L2}^2 = 2\,\Sigma\,2\sum_{j=1}^{n}\sum_{i=1}^{I} uij\ \log_e\{uij/(\Pi i\ u_{+j})\}$$

Degrees of freedom is n*(I–1).

The difference "D" between $\chi_{L1}^{\ 2} - \chi_{L2}^2$ (with I–1 degrees of freedom) is a measure of the extent to which animals are on average using resources in proportion to availability, irrespective of whether they are selecting the same or not (Manly et al. 2002).

Where u_{ij} = number of category I resource units used by animal j
u_{i+} = number of category I resource units used by all sampled animals
u_{+j} = number of resource units used by animal j
u_{++} = total number of units used by all sampled animals

Resource Selection Index

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 or to the individual animal. For Design Type II studies it is defined as:

(Eq. 2)

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

Where: u_{i+} = number of type *i* resource units used by all animals
π_i = proportion of available resource units in category i
u_{++} = total number of units used by all sampled animals

and the measure is the ratio of proportion of habitat used by the sample of animals to what is available to the population.

Following Manly et al. (2002) and Rettie and Messier (2000) the equation was modified for proportional habitat use instead of absolute frequencies to give

(Eq. 3)

$w_i = \pi_j / \pi_i$

Where π_j = area of habitat *i* covered by animal *j*
π_i = proportion of available resource units in category I

Variance, as used to estimate the confidence limits of the RSI (Tables 9, 10) is calculated by the equation

$$var(w_i) = \{ \sum_{j=1}^{n} (u_{ij} / \Pi_i - w_i u_{+j})^2 / (n-1)\} \{(n/u_{++})^2\}$$

Where: u_{ij} = number of type *i* resource units used by animal *j*
u_{+j} = total number of units used by animal *j*
Π_i = proportion of the population of available resource units
n = number of animals in the comparison

Degrees of freedom is ((I–1)*(n–1)).

The Bonferroni confidence intervals are calculated using 100(1– α)% family of confidence intervals with $\alpha = 0.05$. However when doing simultaneous tests we calculate the upper tail of the standard normal distribution to be $\alpha/(2I)$, where I is the number of habitat types. By doing this one can maintain a 1/20 or 5% probability of finding evidence of selection when in fact there is none (Type 1 error). The Bonferroni confidence interval has the effect of widening the confidence interval to reduce the chance of committing a Type I error.

For example, if we had 3 animals (Animal 1, Animal 2, and Animal 3) each with 5 locations and 4 habitat classes (A, B, C, D) the resulting table for the calculated RSI, using equation 2, would look like this.

Table 2.1: Example of calculations of the Resource Selection Index (RSI).

	Habitat A	Habitat B	Habitat C	Habitat D
Animal 1	(.162) **1.62**	(.125) **1.25**	(.399) **1.995**	(.315) **.525**
Animal 2	(.2) **2**	(.3) **3**	(.5) **2.5**	(0) **0**
Animal 3	(.364) **3.64**	(.1) **1**	(.436) **2.18**	(.1) **.167**
Habitat Available (Π_i)	.1	.1	.2	.6
Average w_i	2.42	1.75	2.23	0.23

*Note that value in parentheses indicate the proportion of area and the bolded numbers after are the calculated RSI – w_i

Below is an example of how to calculate the compositions of habitats used by each animal. The calculations for Animal 1 are shown below (note the area is in metres squared). This table shows all 5 relocations for Animal 1.

Table 2.2: Sample showing the calculation of the proportion of total habitat within 100 m of each location of a single radio-collared caribou.

Animal 1	Habitat A	Habitat B	Habitat C	Habitat D	Total Area (m^2)
Point 1	(6000) **0.038**	(500) **0.003**	(200) **0.001**	(24715) **0.157**	31415
Point 2	(9424) **0.06**	(9423) **0.06**	(12568) **0.08**	(0) **0**	31415
Point 3	(4712) **0.03**	(3141) **0.02**	(14147) **0.09**	(9415) **0.06**	31415
Point 4	(1570) **0.01**	(500) **0.003**	(20000) **0.127**	(9345) **0.059**	31415
Point 5	(3769) **0.024**	(6000) **0.038**	(15707) **0.1**	(5939) **0.059**	31415
Proportion of habitat i	0.162	0.125	0.399	0.315	157075

*Note that values in parentheses represent the area (in m2) used in habitat I by animal j; the bolded numbers are the calculated π for each point. The total π values are given in the last row as total.

The set of resource selection indices such as that given in Table 1.1 are called Resource Selection Function. This estimate is the probability that a resource would be selected when compared to the probability for selecting other resource types (Arthur et al. 1996). If habitat were being selected at random then you would expect the average of w_i for habitat i across animals (1 to 3) to be close to 1. If w_i is significantly different from 1 then resource i is being using less or more than it is available. In our example we see that the average w_i values for habitats A, B, C, and D are 2.42, 1.75, 2.23, and 0.23 respectively.

Standardized Resource Selection Index

The standardized RSI estimates the probability of an animal-selecting habitat if all other habitats were equally available. The equation is (Manly et al. 2002):

(Eq. 4)

$$b_i = w_i / (\sum_{i=1}^{l} w_j)$$

Where b_i = Manly's Standardized Selection Index
w_i = Selection Index for habitat I (see Eq. 2)
w_j = In the context of equation 3 this is the sum of w_i for habitats i..l for animal j

The set of these values sum to 1 and are calculated independently for each individual.

Table 2.3: A sample calculation using the previous scenario of 3 animals and 4 habitats. Proportional habitat use by animal is indicated in bold.

	Habitat A	Habitat B	Habitat C	Habitat D	Sum
Animal 1	(1.62) **.301**	(1.25) **.232**	(1.995) **.370**	(.525) **.097**	5.39
Animal 2	(2) **.267**	(3) **.4**	(2.5) **.333**	(0) **0**	7.5
Animal 3	(3.64) **.521**	(1) **.143**	(2.18) **.312**	(.167) **.024**	6.987

One can see that if an animal were using all habitats randomly or in proportion to their occurrence on the landscape the calculated b_i values should be equal to 1/H or 1 divided by the number of habitats. In this example significant deviation from 0.25 may indicate that animals are not using the habitat type randomly.

Appendix 3: Reclassified Community Descriptions from V-Typing assessment (after Zoladeski et al. 1996).

Position/ Material	Reclassified Community	Community Name	Description
Alluvial sites, active flooding	PR	Poplar Riparian	Active zones of deposition and flooding on alluvial sites. Balsam poplar is the dominant tree species. Rich, moist sites.
Alluvial sites, stable phase	SR	Spruce Riparian	Stable benches or erosion bends on alluvial sites. Large white spruce forests with complex structure are typical. High cover of horsetails a good indicator. Rich, moist sites
Lowland sites with variable mineral soils	BL	Black Spruce/Labrador Tea	Black spruce growing in lowland positions on mineral soils. Various moss species with Labrador tea as dominant low shrub. Lichen cover can be high but sporadic, related to micro-topography. Permafrost is prevalent. Poor, wet sites.
Upland sites on glaciofluvial soils	PL	Pine/Lichen	Open canopy, lodgepole pine with abundant terrestrial lichen cover growing on coarse textured soils. Flat benches and complex terrain are the dominant terrain features. Complex fire history. Dry, poor sites.
Upland sites on transitional glaciofluvial/morainal soils	PB	Pine/Bearberry	Variable canopy lodgepole pine forests with bearberry and moss ground cover. Sporadic shrub cover of buffaloberry and willow. Dry, poor sites.
Upland sites on morainal or transitional glaciofluvial/morainal soils	Pfo PFc	Pine/Feathermoss (open phase) Pine/Feathermoss (closed phase)	Variable canopy lodgepole pine forests growing on morainal or transitional sites with feathermoss ground cover. Two phases are recognized, open and closed canopy. Open PF has drier understory conditions with a mix of lichen and moss. Closed PF has a cool, moist understory with a thick feathermoss carpet. Both phases have a sporadic shrub understory of alder and willow. Generally moist, poor sites; slightly drier sites will have a greater abundance of terrestrial lichen.
Upland sites on morainal or transitional glaciofluvial/morainal soils	SF	Spruce/Feathermoss	Closed canopy white spruce forests with variable ground cover of feathermoss. Sparse shrub understory. Stand replacing fires are dominant disturbance regime. Dry, poor sites.
Upland sites on morainal or transitional glaciofluvial/morainal soils	MF	Mixed-wood/Feathermoss	Boreal mixed-wood forest communities with variable tree canopy and understory; Spruce, aspen, pine and birch may all be present. Feathermoss usually dominant ground cover but bearberry can be important Low lichen cover is characteristic. Moist, moderate sites.
Upland sites on morainal or transitional glaciofluvial/morainal soils	SL	Spruce/Labrador Tea	Open canopy white spruce forest with Labrador tea understory. Cool aspects or moist hollows are the most common sites. Moist, moderate sites.
Upland sites on colluvial or morainal soils	SB	Spruce/Birch	Open canopy white spruce – paper birch forests growing on sloping, colluvial materials. Dry, moderate sites.
Lowland, organic soils	BB	Black Spruce Bog	Open canopy black spruce growing under bog conditions. Cold, saturated, acidic organic soils with isolated hydrology. Sphagnum and other mosses dominate. Lichen may be prominent on hummocks but distribution is sporadic. Wet, poor sites.
Lowland, organic soils	TF	Tamarck Fen	Open canopy tamarack and black spruce on wet, moderate sites. Fen conditions are more productive than BB sites. TF distribution is probably limited within study area.

Appendix 4: Vegetation plot sampling summary for the Little Rancheria caribou winter range 1991.

Forest cover polygon	Forest cover map	Habitat type	Plots sampled	Canopy (%)	Percent Cover									
					Mosses	Shrub	Grasses	Lichen	Litter	Bare	Forbs	Water	Log	No. Plots
77	Y03Q1	Aspen	20	44	34	23	0	2	57	0	2	0	1	120
933	Y03P2	Aspen	18	22	10	15	5	4	64	0	5	0	1	103
370	Y03Q1	Black Spruce	20	7	78	13	1	6	0	0	4	0	1	102
392	Y03Q1	Black Spruce	20	10	66	17	2	10	1	0	4	3	3	105
405	Y03Q1	Black Spruce	20	45	76	9	0	5	11	0	1	0	6	109
560	Y03Q2	Black Spruce	20	48	40	20	0	0	30	0	7	0	8	105
736	Y03Q2	Black Spruce	20	10	75	22	1	9	0	0	4	0	2	112
372	Y03Q1	Dense Pine	20	67	57	15	0	1	28	1	2	0	8	112
390	Y03Q1	Dense Pine	20	53	77	9	0	7	7	0	6	0	4	111
412	Y03Q1	Dense Pine	40	6	8	3	1	0	64	0	4	0	3	84
84	Y03Q1	Dense Pine	20	68	51	7	0	4	45	0	0	0	3	110
1020	Y03Q2	Riparian Spruce	26	33	67	15	1	5	0	0	11	0	1	100
1055	Y03Q1	Riparian Spruce	20	59	52	22	0	0	12	1	8	0	9	104
1070	Y03Q2	Riparian Spruce	20	49	74	8	0	3	2	0	2	0	15	103
332	Y03Q1	Riparian Spruce	20	49	79	14	0	1	10	0	5	0	5	114
404	Y03Q1	Riparian Spruce	20	46	57	7	0	2	1	0	4	0	4	73
1002	Y03Q2	Open Pine	20	9	3	6	0	53	34	0	1	0	1	98
1032	Y03Q2	Open Pine	20	12	5	16	2	42	31	0	2	0	0	98
1041	Y03Q2	Open Pine	20	30	37	14	0	27	19	0	3	0	5	105
125	Y03Q2	Open Pine	20	24	40	7	1	37	13	0	3	0	2	102
351	Y03Q1	Open Pine	20	25	23	7	1	28	29	1	16	0	2	107
442	Y03Q2	Open Pine	20	4	8	10	0	52	25	0	1	0	1	96
997	Y03Q2	Open Pine	20	13	16	16	2	31	35	4	1	0	0	107
848	Y03Q2	Poplar	20	13	13	7	2	0	46	10	5	0	2	85
1106	Y03Q2	Upland Spruce	20	15	69	11	0	17	6	0	1	0	2	105
409	Y03Q1	Upland Spruce	20	63	89	5	1	1	6	0	5	0	2	109
735	Y03Q2	Upland Spruce	20	43	64	15	2	1	18	0	1	0	8	109
764	Y03Q2	Upland Spruce	12	32	60	7	0	1	17	0	2	0	3	90
96	Y03Q2	Upland Spruce	20	29	65	9	0	22	3	0	3	0	4	106

Appendix *5: Sampling data from habitat plots, Little Rancheria caribou core winter range: 1995.*

Forest Cover Map ID	Polygon ID	Plot reference number	Latitude	Longitude	Canopy cover	Percent Cover								
						Moss	Lichen	Confer litter	Deciduous litter	Wood	Organic soil	Mineral soil	Stones	Plot total
Y03P1	104	60	600930	1294330	60	20	20	25	15	20	0	0	0	100
Y03P1	108	120	600949	1294117	45	30	5	15	44	6	0	1	0	101
Y03P1	105	133	600916	1294256	50	37	3	8	50	2	0	0.5	0	101
Y03P1	131	22	600835	1294000	55	0.5	50	35	0	10	0	0	0	96
Y03P1	131	21	600820	1294020	55	15	20	30	25	10	0	0	0.5	101
Y03P1	131	20	600815	1294010	55	20	20	45	5	10	0	0.5	0	101
Y03P1	109	119	600941	1294137	20	30	33	3	7	12	0	0	15	100
Y03P1	150	59	601028	1293320	35	10	60	23	2	5	0	0.5	0	101
Y03P1	131	118	600929	1293827	25	63	20	6	2	4	2	2	1	100
Y03P1	151	110	600919	1293238	35	80	6	6	1	5	0.5	0	0	99
Y03P1	150	111	600852	1293255	45	35	29	23	3	10	0	0.5	0.5	101
Y03P1	132	113	600905	1293819	25	10	54	20	15	2	0	0.5	0	102
Y03P1	149	112	600822	1293316	40	40	15	15	15	15	0	0	0.5	101
Y03P1	131	117	600917	1293823	50	47	10	10	5	25	0	1	2	100
Y03P2	946	58	601022	1293400	55	40	20	10	15	15	0	0.5	0	101
Y03P2	944	35	601030	1293550	65	65	5	10	5	15	0	0	0	100
Y03P2	946	36	601030	1293530	55	53	20	15	2	10	0	0	0.5	101
Y03Q1	411	43	600430	1292420	55	30	40	20	1	9	0	0.5	0.5	101
Y03Q1	381	29	600248	1291539	55	75	8	5	7	5	0	0.5	0	101
Y03Q1	437	30	600242	1291524	65	10	20	45	10	14	0	0.5	1	101
Y03Q1	391	28	600230	1291559	30	45	45	1	4	5	0	0	0	100
Y03Q1	492	3	600135	1290650	15	0	0	65	35	0	1	0	0	101
Y03Q1	351	5	600212	1290045	20	0	80	19	0	1	0	0	0	100
Y03Q1	412	45	600500	1292420	50	50	10	15	15	10	0	0	0.5	101
Y03Q1	84	46	600715	1293320	60	40	10	25	15	10	0	0	0	100
Y03Q1	84	47	600710	1293400	60	40	20	25	10	5	0	0	0	100
Y03Q1	376	1	600145	1290620	30		0.1	29	70	0	1	0	0	100
Y03Q1	91	49	600705	1293230	35	20	40	15	15	10	0	0	0	100
Y03Q1	492	2	600135	1290640	20	2	2	40	53	0	5	0	0	102
Y03Q1	417	42	600545	1292855	35	65	10	2	3	8	0	0.5	0	89
Y03Q1	381	17	600530	1292340	50	70	10	1	4	14	0	1	0	100

Appendix 5: continued

Forest Cover Map ID	Polygon ID	Plot reference number	Latitude	Longitude	Canopy cover	Percent Cover								
						Moss	Lichen	Confer litter	Deciduous litter	Wood	Organic soil	Mineral soil	Stones	Plot total
Y03Q1	381	10	600640	1293050	70	5	20	60	0	15	0	0	1	101
Y03Q1	91	11	600600	1285950	50	8	40	50	0.5	2	0	0	0	101
Y03Q1	91	12	600620	1290000	15	0	75	25	0	0.5	0	0	0	101
Y03Q1	91	13	600618	1285910	30	0	40	40	0	1	0	0	0	81
Y03Q1	376	14	600215	1290600	50	0	70	28	0	2	0	0	0	100
Y03Q1	491	23	600126	1293000	45	80	5	7	0.5	8	0	0	0	101
Y03Q1	571	16	600230	1290600	55	0.5	40	50	0	10	0	0	0	101
Y03Q1	491	24	600120	1293000	65	85	7	2	0	6	0	0	0	100
Y03Q1	518	18	600538	1292350	30	85	5	1	1	8	0	0	0	100
Y03Q1	381	9	600620	1293100	45	40	15	40	0.5	5	0	0	0	101
Y03Q1	351	7	600218	1290030	30	1	70	25	0	5	0	0	0	101
Y03Q1	351	6	600223	1290045	25	1	70	25	0.5	3	0	0	0	100
Y03Q1	372	4	600142	1290730	60	80	1	8	1	10	0	0	0	100
Y03Q1	518	19	600538	1292350	55	75	20	1	0.5	5	0	0	0	102
Y03Q1	372	15	600212	1290640	60	70	5	5	5	15	0	0	0	100
Y03Q1	87	48	600700	1293350	35	2	35	35	25	3	0	0.5	0	101
Y03Q1	378	105	600310	1291130	50	41	8	5	25	20	0	1	0.5	101
Y03Q1	474	104	600258	1291231	25	48	10	25	4	12	0	1	0	100
Y03Q1	638	50	600820	1291810	15	80	10	2	2	6	0	0	0	100
Y03Q1	26	51	600820	1291720	25	1	84	10	0.5	5	0	0.5	0	101
Y03Q1	21	52	600850	1291730	25	3	67	20	0.5	10	0	0.5	0	101
Y03Q1	372	102	600314	1291313	45	64	10	15	1	10	0	0.5	0	101
Y03Q1	390	103	600247	1291321	40	64	10	15	1	10	0	0.5	0	101
Y03Q1	449	136	600205	1292028	25	64	15	8	3	10	0	0.5	0	101
Y03Q1	21	53	600900	1291735	50	25	40	15	10	10	0	0.5	0	101
Y03Q1	26	54	600830	1291510	40	5	5	10	70	10	0	0	0	100
Y03Q1	32	55	600810	1291530	50	65	10	5	2	18	0.5	0.5	0	101
Y03Q1	31	56	600755	1291600	55	78	10	1	1	10	0	0	0	100
Y03Q1	26	57	600735	1291700	35	5	80	10	0.5	5	0	0.5	0	101
Y03Q1	372	101	600312	1291321	35	2	49	40	0.5	8	0	0	1	101
Y03Q1	381	132	600358	1201459	30	36	25	15	12	10	0	1	0	99
Y03Q1	338	116	600344	1285956	35	28	34	20	10	8	0	0.5	0	101

Appendix 5: continued.

Forest Cover Map ID	Polygon ID	Plot reference number	Latitude	Longitude	Canopy cover	Percent Cover								
						Moss	Lichen	Confer litter	Deciduous litter	Wood	Organic soil	Mineral soil	Stones	Plot total
Y03Q1	78	125	600930	1290504	30	2	35	52	4	6	0	1	0	100
Y03Q1	81	124	600956	1290527	20	1	79	15	0	5	0	0.5	0	101
Y03Q1	81	123	600949	1290521	25	5	80	8	0.5	7	0	0.5	0	101
Y03Q1	82	122	600907	1290508	50	45	2	10	15	12	0	0	0	84
Y03Q1	381	130	600352	1291403	40	40	20	19	9	11	0	1	0	100
Y03Q1	83	121	600856	1290523	30	7	53	30	5	5	0	0	0	100
Y03Q1	381	106	600449	1292008	38	17	22	25	20	14	0	1	1	100
Y03Q1	409	134	600234	1292004	30	72	2	12	10	4	0	1	0	101
Y03Q1	402	107	600503	1291947	40	2	5	33	10	50	0	0.5	0.5	101
Y03Q1	342	115	600336	1285930	50	43	5	30	15	7	0	0.5	0.5	101
Y03Q1	341	114	600342	1285935	25	1	64	30	1	4	0	0.5	0.5	101
Y03Q1	404	109	600452	1291909	20	60	2	20	3	15	0	0	0.5	101
Y03Q1	403	108	600453	1291910	35	30	15	25	14	15	0	1	0.5	101
Y03Q1	381	135	600242	1291943	35	60	10	11	4	15	0	0.5	0	101
Y03Q1	381	131	600359	1291436	55	38	5	22	12	22	0	1	0	100
Y03Q2	954	27	601130	1292940	50	15	20	30	30	5	0	0	0	100
Y03Q2	969	39	601150	1292248	50	83	13	1	1	2	0	0	0	100
Y03Q2	1016	126	601205	1291434	25	7	50	30	10	3	0	0.5	0	101
Y03Q2	1009	127	601104	1291458	40	65	4	8	13	11	0	1	0	102
Y03Q2	1009	128	601123	1291423	35	9	39	35	3	12	0	1	1	100
Y03Q2	995	129	601153	1291439	65	64	0.5	10	7	18	0	0.5	0	100
Y03Q2	405	44	600445	1292430	40	75	10	3	2	10	0	0.5	0	101
Y03Q2	961	25	601118	1292820	65	90	5	1	0.5	4	0	0	0	101
Y03Q2	971	40	601130	1292500	10	94	0	0.5	1	2	0	0	0	98
Y03Q2	953	26	601130	1292900	50	0	78	20	0	2	0	0	0	100
Y03Q2	969	38	601140	1292250	20	75	18	1	1	5	0.5	0	0	101
Y03Q2	998	37	301135	1292150	50	63	20	10	5	2	0	0	0	100
Y03Q2	997	34	601140	1292050	60	60	5	7	20	8	0	0.5	0.5	101
Y03Q2	997	33	601130	1292100	10	1	77	20	0.5	2	0	0.5	0	101
Y03Q2	997	32	601145	1291950	35	10	50	30	8	2	0	1	0	101
Y03Q2	997	31	601150	1291935	25	0.5	94	5	0.5	1	0	0.5	0	102
Y03Q2	971	41	601140	1292520	5	40	15	2	3	40	0	0	0	100