TECHNICAL REPORT

Herd Boundary Refinement for the Chase, Spatsizi, and Frog Caribou Herds in North-central British Columbia: Final Report 2012-2015

HCTF Project #7-394

KRISTA SITTLER, R. SCOTT MCNAY[1], AND LINE GIGUERE[1]

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[1]Wildlife Infometrics Inc., PO Box 308, Mackenzie, BC, V0J 2C0, wild_info@wildlifeinfometrics.com

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INTRODUCTION

Background

Woodland caribou (*Rangifer tarandus caribou*) in British Columbia (BC) occur in 52 herds that have been identified, delineated spatially, and monitored on a somewhat regular basis (McNay and Hamilton 2010). However, there are still interstitial areas within the distribution of caribou in BC where caribou are of an unknown status or considered to be in a "zone of trace occurrence" (ZTO). The most significant ZTO in north-central BC is east of Thutade Lake and along the headwaters of the Finlay River (Heard and Vagt 1998, McNay and Hamilton 2010). There are five previously delineated herds sharing common boundaries with the ZTO: Spatsizi, Frog, Gataga, Finlay, and Chase (Figure 1). The significance of that particular ZTO was revealed after recent surveys during which the number of caribou found using the area exceeded the number of caribou in many of the delineated herds in BC (McNay and Hamilton 2010, McNay 2011). Although caribou have been hunted by First Nations in this area for decades (McKay 1997), the caribou that occur there have not been identified as a specific herd nor have they been associated with any other previously delineated herd; hence, there is little documentation of the range used or of the status of the caribou population in the area.

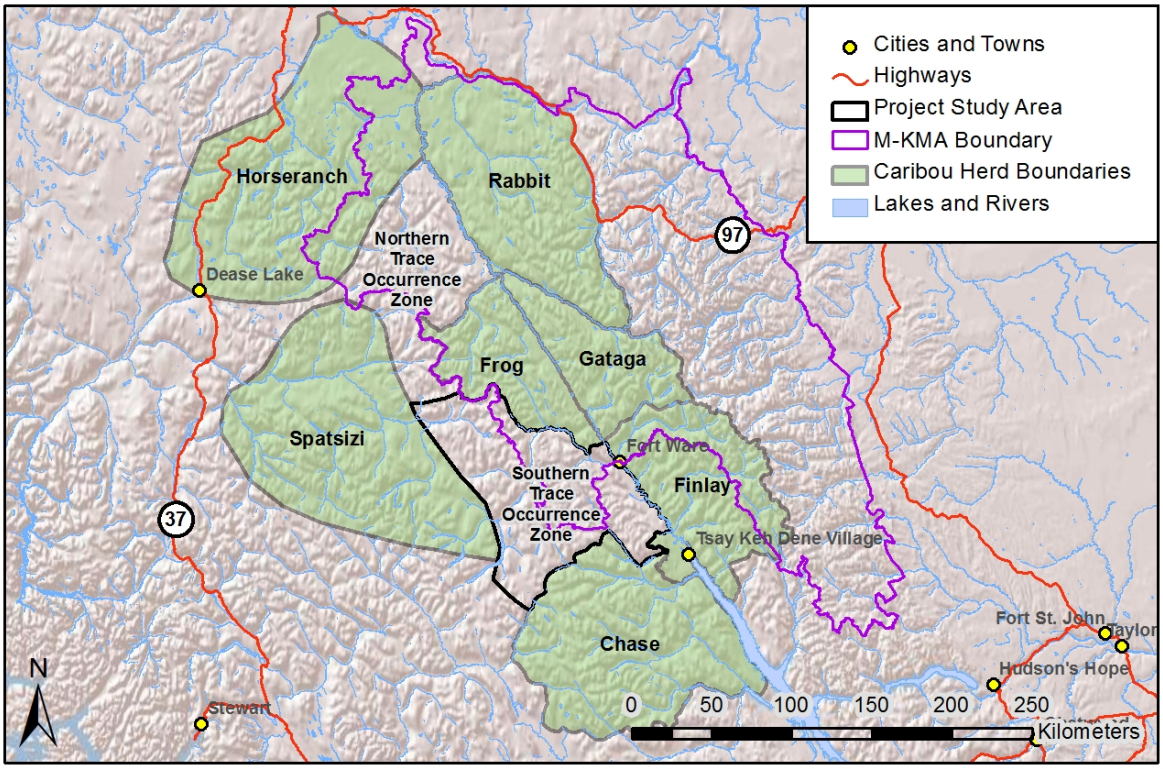

Figure 1. Location of the Thutade - Upper Finlay River study area (i.e., the southern trace occurrence zone) in north-central British Columbia. Purple boundary is the Muskwa-Kechika Management Area.

Reconnaissance-level surveys were conducted in parts of the ZTO in 1990, 1991, 2003, and 2007 (Table 1). Each of those surveys was restricted in extent and associated with

an assessment of potential impacts from a copper/gold mine in the south eastern part of the study area. In 2009 observations of caribou were made coincidentally as part of a Stone's sheep population survey (Pers. Comm.; Conrad Thiessen, BC Ministry of Environment, Fort St. John; February 11, 2011) and as part of an extensive exploratory search for caribou (MacDonald et al. 2009) conducted in the northern and south-western parts of the ZTO. We estimate that a minimum of 250 caribou were likely to have been observed during reconnaissance and directed surveys in the entire ZTO from 1990 through to 2009 (Table 1).

Table 1. Number of caribou observed during aerial surveys conducted from 1990 to 2009, in the vicinity of the Thutade - Upper Finlay River area (i.e., the southern trace occurrence zone) in north-central British Columbia (survey units are shown in Table 2).

Source	Year	Month	Total Caribou	Survey Unit	Comment
MacDonald*	2009	Apr	80	T12	same day; spatially distinct
Thiessen	2009	Feb-Mar	125	north	5 different days; spatially distinct
McNay	2009	Mar	22[a]	C11	Same day; spatially distinct
Turney	2005	Feb	15	T02	same day; estimated from tracks
Turney	2005	Apr	15	T02	3 days; estimated from tracks
Turney	2003	Sep	17	T02	3 days; estimated from tracks
Ritchie	1991	Sep	5	C13	same day; spatially distinct
			48[b]	T02	same day; spatially distinct
			41[b]	west	same day; spatially distinct
Ritchie	1990	Oct	7[b]	C13	same day; spatially distinct
			15	T02	same day; spatially distinct

* Survey was conducted in a directed, extensive manner and should not be considered reconnaissance-level.

[a] not used towards the estimate of total caribou in the "trace occurrence" zone since the unit is wholly within the Chase herd area

[b] used as an estimate of the minimum number of caribou occupying the specific survey unit.

Rationale and Objectives

Since 1999, Government and forest licensees based in the Mackenzie TSA have invested greatly (> $7 million) in the development of information for the purposes of improving conservation of caribou and their habitat in north-central BC. The work has led to large sets of collected data on habitats and habitat use by caribou, moose, and wolves and comprehensive modeling of seasonal range values for caribou (McNay 2011). The study reported here helps close a gap where information on caribou was historically lacking; the gap having been recognized previously as a priority for management action (McNay and Hamilton 2010). The caribou in the study area have been identified as a valued ecosystem component by Tse Keh Nay First Nations (a collaborative planning team consisting of the Tsay Keh Dene, Takla Lake First Nations, and Kwadacha communities). Caribou are also recognized as a species of concern by the Council on the Status of Endangered Wildlife in Canada (COSEWIC, Thomas and Gray 2002).

The objectives of this study are to:

- use data collected from surveys conducted in 2010 and 2012 as well as locations from collared female caribou to refine herd boundaries for the Chase, Spatsizi, Frog and Finlay herds; and,
- make recommendations for protection of caribou habitat through the Forest and Range Practices Act and the Oil and Gas Activities Act.

The short-term results of the project will be a better understanding of caribou distribution, habitat status, and population status in an area where limited information was available and where caribou were previously considered to exist in only trace occurrences.

Results of the project include recommendations for the protection of caribou habitat, and availability of information needed for assessing risks associated with proposed industrial and other human activities as they arise. Outcomes for the TKN First Nations and the BC government include an increased knowledge base of how caribou observed in a "trace occurrence" area contribute to the provincial inventory. Outcomes for Au Rico Gold include a more thorough understanding of the cumulative environmental and socio-economic effects of mining in the Omineca Mountain Region, as well as a more comprehensive understanding of caribou distribution in the area. This will allow for effective follow-up monitoring to accurately assess any effects of mine development on local populations.

STUDY AREA

The study area is in the general vicinity of Thutade Lake and north as far as the upper Finlay River area overlapping the Muskwa-Kechika Management Area. Hence, the study was considered to occur in, and was named as, the Thutade - Upper Finlay River area. The area is situated within the Cassiar Ranges Ecosection and the Southern Boreal Plateau Ecosection of the Boreal Mountains and Plateaus Ecoregion. The delineated caribou herd areas adjacent to the ZTO are: the Frog herd to the north, the Rabbit and Gataga herds to the north-east, the Finlay herd to the east, the Chase herd to the south, and the Spatsizi herd to the west (Figure 1; Heard and Vagt 1998, McNay and Hamilton 2010).

The Cassiar Ranges Ecosection is comprised of rugged mountainous terrain, while the Southern Boreal Plateau Ecosection consists of several deeply incised plateaus with extensive rolling alpine and willow/birch habitats (Demarchi 1996). Biogeoclimatic units in the area are the Spruce-Willow-Birch (SWBmk and mks) in the valley bottoms ranging from approximately 1100 m elevation up to 1300 m where the Alpine-Tundra (ATun) begins and rises to over 2200 m elevation (Meidinger and Pojar 1991). Forest types are dominated by subalpine fir (*Abies lasiocarpa*) at higher elevations but consist of relatively even distribution of subalpine fir, lodgepole pine (*Pinus contorta*), and white spruce (*Picea glauca*) at lower elevations. Large portions of the landscape (greater than 35%) are non-forested alpine areas.

Surrounding Caribou Herds

Chase Herd

The Chase Recovery Plan Area (RPA) is 12,465 km^2, situated in steep mountainous terrain ranging in elevation from 671 to 2466 m, and has four major watersheds including the Ingenika, Osilinka, Swannell and Mesilinka Rivers (Figure 1). It is roughly bounded in the north by the most northerly portion of the Finlay River, in the west by Thutade, Sustut and Driftwood rivers, in the south by Ominicetla Creek, back end of Osilinka River, headwater of Wasi and Flegezand creeks, and in the east by the Williston Reservoir. At low- to mid-elevations, the area is dominated by the BWBSdk1 and SBSmk2 subzone variants, and at mid- to high-elevations the ESSFmv3 subzone variant predominates. The Alpine Tundra (At) prevails above the tree line.

The population was estimated to be between 500-900 caribou in 1996 (Heard and Vagt 1998, Zimmerman *et al*. 2002) but later refined to 475 (McNay et al. 2009; McNay and Hamilton 2010) with a density of 38/1000km^2. Regulated hunting of mature bull caribou occurs in the Chase study area for 12 weeks beginning every August 15th.

Finlay Herd

The Finlay RPA is 8,175 km^2, and is bounded in the north by the Kwadacha River, in the west by the Finlay River and the Finlay Reach of the Williston Reservoir, in the south by the Ospika River and the Ospika Arm of the Williston Reservoir, and in the east by the Rocky Mountains. The central and eastern part of the Akie is dominated by the Northern Rocky Mountains; consequently it is characterized by steep terrain, and has a broad elevation range. It contains several large drainages including the Kwadacha, Akie, and Ospika Rivers. The area is dominated by the BWBS dry cool Stikine variant(BWBSdk1), while at mid- to high-elevations the ESSF moist very cold Graham(ESSFmv4) and the SWB moist cool (SWBmk) variants predominate. The Williston Reservoir shoreline and the lower Ospika River valley bottom are dominated by the SBS moist cool Williston variant (SBSmk2). The AT prevails above the tree line.

In 1996, the Finlay herd was estimated to be 200 to 400 caribou (Heard and Vagt 1998) but in 2010 this was updated to be 26 caribou (McNay and Hamilton 2010) with a density of 3/1000km^2. The herd is considered to be “sensitive” because there are <30 animals (McNay and Hamilton 2010)

Frog Herd

The Frog RPA is 5039, and the caribou here live in rugged country ranging in elevation from about 750m to 220m. The area is located in the upper Kechika River drainage and is characterized by BWBS, SBS and AT above treeline.

Herd and Vagt (1998) speculated that there were about 150 animals in the herd (which included the Gataga herd) in the mid-nineties. This herd is extremely remote and is so far unaffected by roads, agriculture or timber harvest but the area in the past has been and likely in the future will be considered for hard rock mining and bulldozer ripping. In 2010, McNay and Hamilton report the herd to be estimated at 250 with a density of 50/1000km^2.

Spatsizi Herd

The Spatsizi RPA is 15,628 km^2, and the majority of the herd resides within the Spatsizi Wilderness Park in north western British Columbia. The terrain is primarily mountainous, but the rugged relief in many areas of the park gives way to wide open alpine plateaus and wide glacier-shaped valleys favored by caribou. The area boasts many rivers and lakes (Boonstra and Sinclair 1982).

The Spatsizi caribou herd was considered stable in 1996 with an estimated population of 2200 caribou (Heard and Vagt 1998). More recently, on request by the British Columbia Mountain Caribou Recovery Team a two day survey was conducted in October of 2010 and a total of 671 caribou were counted within Spatizi park, but did not encompass the entire range of this heard (Williams and Marshall 2010). These caribou were all observed between 1600m and 2000m. McNay and Hamiliton (2010) estimate the herd to be at 3000 individuals with a density of 192/1000 km^2.

METHODS

Survey Methods

Survey blocks

Priority survey areas were delineated within the southern ZTO, and the study area was stratified into survey units (Figure 2). The units were generally constructed such that groups of mountain ranges that exemplify high-elevation habitat were amalgamated to create individual polygons, often separated by naturally occurring barriers. Boundaries of the units tended to follow rivers or other topographic features resulting in 15 survey units for the southern ZTO; 15 survey units delineated in 2010 (i.e. T1 to T15) and 4 previously delineated survey units (i.e. C12, C13, C14, and F15-Part; Figure 2). The previously delineated survey units were delineated in 2006 as part of the Omineca Northern Caribou project and were included to the southern ZTO since caribou from the Chase and Finlay herds were rarely encountered in these units. Delineation of the study area in this manner allowed us to identify sub-regions of caribou occurrence within the larger ZTO and create a spatial reference for refining the existing herd boundaries. In 2012, 2 additional survey units were added located inside the Frog herd boundary. These extra units were generated from the GPS locations received from satellite collar data downloads and were delineated to include all areas in which we could potentially encounter collared caribou.

Intensive surveys were conducted in the fall of 2010 (11 survey units) and 2012 (10 survey units), and two survey units were surveyed in the fall of 2013.

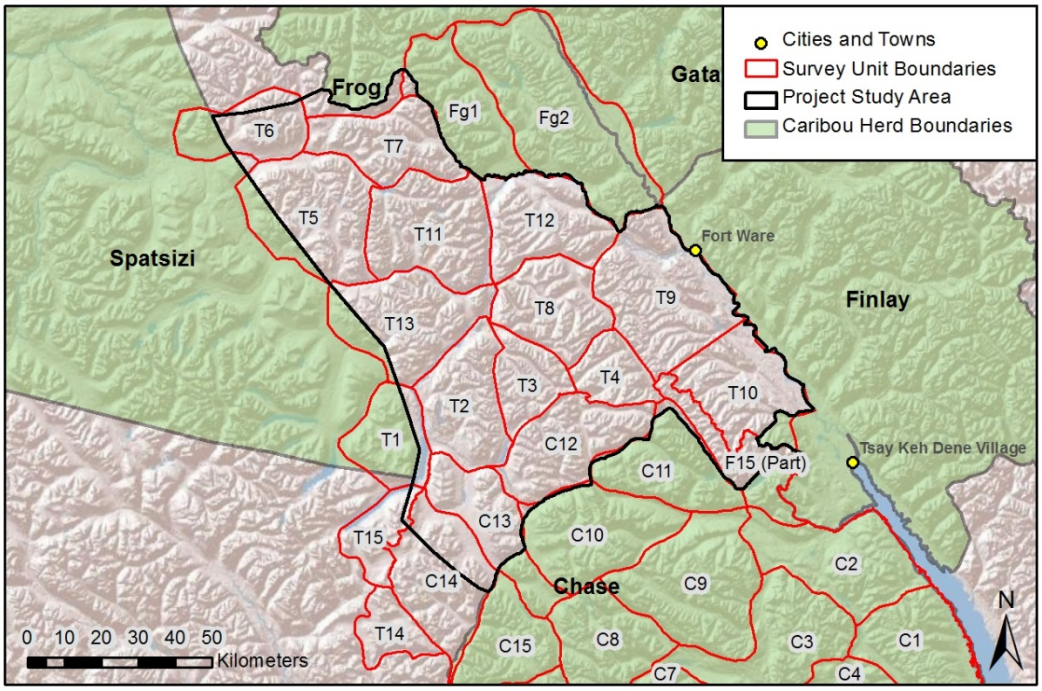

Figure 2. Survey units delineated for the Thutade - Upper Finlay River study area (i.e., the southern trace occurrence zone) and the ones previously delineated when conducting caribou Chase Herd study (C12, C13, C14, and F15), in north-central British Columbia

Survey techniques

Population survey techniques and data collection protocols adhered to BC Resource Inventory Standards Committee guidelines for aerial ungulate inventories British Columbia Ministry of Sustainable Resource Management (BC MSRM 2002). The survey was conducted using a Bell 206 helicopter operated by a pilot who was experienced with flying in rugged mountainous terrain. The crew members accompanying the pilots consisted of one navigator and two observers. To ensure efficient sampling, the navigator directed the pilot to take a direct flight approach towards and through areas delineated as most likely to contain high-value caribou range. This was facilitated using real-time flight tracking based on digital resultant maps of high-elevation winter range that had been previously constructed with modeling methods similar to those described by McNay et al. (2006). In general, the specific range attributes searched included:

- High-elevation winter range characterized by windswept rolling alpine; and,
- High-elevation open subalpine fir forests.

The survey was undertaken according to level-two classifications standards (BC MSRM 2002). During the survey, if multiple groups of animals were encountered in relatively close proximity to each other they were considered separate groups if they were greater than 250 m apart, occurred in different habitats, or displayed different group characteristics or behaviours. Metadata collected for each animal observation included: project name, study area, crew names, survey and census type, date, general location, and general weather conditions. Detailed information for each observation contained: animal identification if marked, species, observation time, group number, group size, gender (if possible), age class, activities, location type, UTM co-ordinates, habitat type,

approximate sinking depth in snow (if present), snow cover, and other marked animals in the group (if present).

The navigator used a laptop computer with ArcView® (Environmental Systems Research Institute, Redlands, California) and DNR Garmin[1] to navigate during the survey and record the flight path. Aircraft speed was held between 60-80 mph depending on relative visibility and the type of terrain encountered. Height-above-ground ranged from 100-300 m depending on openness, tree density, and safety considerations.

Data Management

All data forms were previously approved by the Ministry of Environment and resulting digital data sets were produced in a format, and with appropriate codes, suitable for incorporation into the Wildlife Species Inventory[2] (WSI) database.

Collected data were managed digitally and original data sheets archived for safety purposes. Observations were entered into a relational database (Wildlife Information Management System: WIMS, Terra Cognita Software Systems Inc., Prince George, BC). Digital data have been backed-up, archived for safety against accidental data loss, and provided on digital media to the client.

Animal Collaring

We purchased 30 collars, 15 satellite (SAT) iridium GPS collars (ATS model G2110E) and 15 Very High Frequency (VHF) collars. Our intent was to deploy 1 Sat and 1 VHF collar in each of the 15 southern most survey units in the study area. Over two years, 18 caribou were captured using aerial net gun (see protocol below); 15 were deployed with SAT collars and 3 with VHF collars. The SAT collars were collars were programed to acquire locations at 6-h intervals and SAT collars had a projected 2 year battery life. Details on these activities are provided in a technical report by Rudichuck et al. (2012) and MacDonald and McNay (2013). The following was the protocol used:

Animals were caught using a net-propelled (modified) shotgun, fired from a helicopter while hovering above the animal (Krausman et al. 1985). If possible, the helicopter landed close to the captured animal and immediately shut down. In situations where it is impossible for the helicopter to land and shut down, the crew was dropped-off and the helicopter left the capture site to find a suitable landing place (away from the captured site to avoid extra stress on the caribou). The chase of these animals during capture never exceeded the Resource Inventory Committee (RIC) guidelines for the Live Animal Capture and Handling Guidelines (BC MELP 1998).

Following capture, experienced animal handlers restrained the caribou manually using hobbles and blindfolded it while removing the net. Handling was done as quickly as possible without sudden movements and loud noise. One handler's primary responsibility was maintaining restraint on the caribou, making sure the blindfold stayed

[1] http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html
[2] See http: http://www.env.gov.bc.ca/wildlife/wsi/index.htm

in place, and ensuring that the animal's breathing ability was not compromised. The second handler was responsible for placing the radio-collar and collecting any required biotic samples (e.g., blood and hair), and recording essential information. Biological samples and body measurements were collected when possible (e.g. good capture location, animal responding calmly, favorable weather condition, etc). Hobbles were then removed and the animal was released.

Capture techniques used were designed to minimize stress to the animal at all times, and handling times were under 15 mins. Capture sessions occurred in late March 2012 and 2013 and were timed to avoid disturbing the female caribou during their 3rd trimester.

Mortality Site Investigations

Site investigations were conducted as soon as possible after first receiving mortality download from the GPS collars or a mortality signal from the VHF collars. Site investigations included determination of the time of death as well as cause of death. Time of death, was estimated by downloaded locations as well as subjectively determined by the investigator according to evidence at the site (e.g., a qualitative assessment of relative moisture content of the remains) or by investigating patterns in the radio-telemetry data leading up to the first observation of a mortality signal. When sufficient remains occurred at the site, we conducted partial necropsies, took photos for subsequent inspection, and collected any evidence of the source of mortality. Death was classified as one of four causes: (1) accident/nutrition (including incidents involving vehicles, avalanches, starvation- and disease-related mechanisms), (2) human (including hunting and capture myopathy), (3) predation (including wolf, wolverine, lynx or grizzly bear), or (4) unknown. Kills made by wolverine or lynx are generally recognized by substantial head and/or neck injury and by feeding signs consisting of burrowing into the carcass. Kills made by wolves are generally scattered in a wide area around the site while remains of caribou killed by bears are buried or signs of the hide peeled back. Other evidence at the site, or lack of evidence, was used to help substantiate cause of death such as track patterns, condition of surrounding vegetation, and hair and scat samples were recorded. Malnutrition can be identified by examination of the bone marrow; red, gelatinous bone marrow indicating malnutrition (Cheatum 1949).

Data Analysis

Caribou GPS locations acquired on the day of the capture were removed and the rest of these data were screen for erroneous locations and or any locations that were beyond the realistic movement potential of any animal (D'Eon et al. 2002). For each collared animal (except two that died shortly after being collared), we calculated GPS fix rate as a percentage of the number of acquired fixes relative to the number that should have been taken at 6-h intervals over the time the collar was deployed.

We defined 5 biologically relevant seasons based on life history strategies of behaviours of caribou such as calving, movement rates (m/h): calving, summer, fall, winter, and late winter (Table 2).

Table 2. Dates and biological rationale for defining the seasons of caribou in the Thutade-Upper Finlay study area in north-central British Columbia.

Season	Date Range	Biological Rationale
Calving	1 May−30 Jun	Increased movement, pregnant females disperse and remain in the area with their calves for a few days after calving.
Summer	1 Jul−31 Aug	Females form large groups
Fall	1 Sep−31 Oct	Male and females move to breeding grounds and form mixed sex groups as females come into estrus.
Winter	1 Nov−28 Feb	Post-rut sex specific groups form.
Late Winter	1 Mar−30 Apr	Typically lowest movement and smallest range size.

For each collared caribou, we determined the seasonal movement rates (m/h) by measuring the Euclidean distance between consecutive GPS locations, and then averaged those values for individuals in each season. We defined the annual and seasonal (calving, summer, fall, winter, late winter) range size (km^2) using 95% minimum convex polygons (conservative estimate; Jennrich and Turner 1969) around the GPS locations using the Geospatial Modeling Environment (Spatial Ecology, Version 0.7.2.1, http://www.spatialecology.com/gme/), R(version 2.12, http://www.r-project.org/) and ArcMAP 10 (ESRI 2011, Redlands, California).

We assembled a suite of raster-based Geographical Informations System (GIS) layers at $25m^2$ resolution for topographical attributes and vector based vegetation attributes from using ArcMAP 10 (ESRI 2011, Redlands, California). Topography was characterized by slope (degrees), elevation (m), aspect ($0\text{-}360^0$) and solar loading ($(w/hr)/m^2$) and were all derived from a digital elevation model (DEM). The sources of the vegetation information used were the British Columbia Vegetation Resources Inventory[3], the British Columbia Terrain Resource Information Management program[4], and Baseline Thematic Mapping (BTM; Geographic Data BC 2001)[5]. Forest conditions were characterized by site index (average height of trees at 50 years old), average stand age, percentage canopy closure, tree stem density (number per ha), and the most common (i.e., leading) tree species, and % pine composition in a stand.

We used descriptive statistics to graphically examine the seasonal use of topography (elevation and slope) as well as seasonal movement rates and range sizes. To determine if there was a difference among seasons, we assessed habitat use and movement rates using one-way Analysis of Variance (ANOVA). We tested the assumptions of normality using a Kruskall-Wallis test and equal variances using a Bartlett's test (Zar 1999) and transformed data as necessary. All means were calculated for each individual animal and the averaged across season (SE).

[3] See http://www.for.gov.bc.ca/hts/vri/ accessed 130930
[4] See http://goebc.gov.bc.ca/trim.html accessed 130930
[5]See http://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=43171&recordSet=ISO19115 accessed 130930

Affinity of Adjacent Herds and Seasonal Fidelity

To examine affinity of GPS-collared individuals to the adjacent herds (i.e. Chase, Finlay, Frog and Spatsizi herds) surrounding the ZTO we measured the percent overlap of each animals annual range of the adjacent herd (Rettle and Messier 2001). To assess fidelity of seasonal ranges for individuals with multiple years of data we measure distance between the centroid of their seasonal ranges (Tracz et al. 2010). Calving sites were identified by visually examining GPS-locations of each caribou during the calving season and marking the obvious cluster of locations. Distances between calving sites across consecutive years were measured as an additional metric for fidelity (Schaefer and Mahoney 2013).

Herd Boundary Refinements

The objective was to improve our knowledge about caribou use of ranges within the ZTO as a way to infer connection (or lack thereof) with adjacent, defined herd areas. For example, if we observed linkages then the outcome would be to re-delineate current herd boundaries to encompass the known linkages. If there were no linkages, the outcome would be to delineate a new herd area. We used survey data and the above analyses of the locations of GPS collared caribou to infer affiliations to adjacent herds. For the most part, these affiliations are very obvious, but there was some variation among individuals. We proposed 5 potential outcomes for refinements to the surrounding herds to incorporate caribou in the southern ZTO. After discussions with regional government biologist we developed one final refinement. The herd boundaries were digitized in ArcMap 10 (Esri, Redlands, California) following topographic features such as valley bottoms, rivers, creeks and lakes.

Identifying Designated Areas

We used a Baysian modeling approach to identify seasonal designated areas for high elevations winter range (HEWR), low elevation winter range (LEWR), post-rut, a cavlving summer range (CSR). Baysian Belief Networks (BBN) belong to a deductive (reason based) modelling approach, which consist of nodes and linkages, where nodes represent environmental correlates, disturbance factors, and response conditions (Marcot et al. 2006). All nodes are linked by probabilities. Input nodes (the environmental variables) contain marginal (“prior”) probabilities of their states determined from actual or simulated conditions on the landscape; intermediate nodes (e.g., describing attributes of caribou range) contain tables of conditional probabilities. These probabilities can be based on empirical studies and/or expert judgment. Output nodes (caribou range values) were calculated as posterior probabilities. Some input nodes, which we refer to as “management levers”, can represent environmental correlates that are dynamic either through unmanaged (natural) or managed disturbances. Where feasible, these nodes are the focus of best management practices or general wildlife measures. Management levers can be adjusted, and their effects forecasted, based on simulations to estimate the effects of best management practices during BBN applications. BBNs for seasonal ranges were constructed as influence diagrams, using the modeling shell Netica (version 2.17, Norsys Systems Corp., Vancouver, British Columbia), expanding these into BBN models in which the node states and probabilities were parameterized mostly from expert judgment. For our purposes, the seasonal ranges for caribou we developed were based on the

environmental inputs for the Wolverine and Chase herds (Brumovsky and McNay 2015, McNay et al 2006). Sources for the data inputs are shown in Table 3.

Table 3. Data inputs used by Netica in processing Bayesian Belief Network models of season range value for caribou in the Thutade-Upper Finlay study area in northern British Columbia.

Input	Description	Data Source
Alpine	Alpine forest code	BTM[a]
Aspect	Landscape aspect in degrees	DEM[b]
BGC subzone	Biogeoclimate (BGC)	BGC[c]
Elevation	Elevation in meters above sea level (asl)	DEM
Inventory Type Group	Forest typed based on species composition	User derived - VRI
Lead Tree Species	Dominant tree species in stand	VRI[d]
Non-productive type	Non-productive forest types on the landscape	User derived - VRI
% Comp. Lead Sp.	Percentage of leading species in a stand	VRI
Roughness	Rate of change in topographic slope	DEM
Slope	Landscape slope in degrees	DEM
Solar loading	Global radiation (Wh/m^2)	DEM
Stand Age	Age of a stand at a given age	VRI
Stand % Pine	Percentage of pine in the stand	VRI
Stand Removal	Natural disturbance (set to wildfire)	User-defined
Stocking	Stand stocking level (high/low)	User-defined
Tree Height	Height of dominant species in a stand	VRI

[a] BTM = Baseline Thematic Mapping
[b] DEM = Digitial Elevation Model
[c] BGC = British Columbia Biogeoclimatic Zones
[d] VRI = British Columbia Vegetation Resouce Inventory

In the Bayesian approach to mapping, we combined results from two independent BBNs pine-lichen winter range and black spruce swamp complexes to form LEWR. High elevation winter range was classified as high or low priority based on ruggedness. A ruggedness layer was overlaid on the high elevation winter range results of high ruggedeness were assumed to be of lower priority to caribou, these areas were then confirmed by observations made during the survey flights. In similar way we classified calving/summer range into two classes based on ruggedness.

Smoothing essentially addressed ragged polygon boundaries influenced by surface topography, eliminated small polygons assumed to be of little value to caribou, and filled small voids in polygons of otherwise high likelihood of use. First a 1-cell circular maximum filter was applied to highlight areas of high likelihood of animal use, then a 3-cell circular majority filter was applied to 'clump' concentrations of high-value habitat into rasterized polygons. These rasterized polygons were then converted into vector polygons (shapefiles) and processed to remove small polygons deemed to be of lesser value (<150ha for UWRs, and <400ha for WHAs). As a final step, voids in the polygons that were <250ha in size were filled in to create continuous polygons. All of the spatial processing was performing using ArcGIS Desktop Basic v10.0 with Spatial Analyst (ESRI, Redlands, California, USA).

Validation of Model Performance

We made a final assessment of operational map results by contrasting: 1) the proportion of caribou locations that fell within each designated area. The post rut model did not appear to be a good fit in the Thutade-Upper Finlay study are as there was very little

overlap with known GPS locations and model output. Therefore we identified areas based on the observed GPS locations during the fall and post-rut season.

First Nations Database Info Methods

First Nations have traditionally used this area for hunting caribou (McKay 1997) and retain a rich knowledge of how caribou historically used the area. This knowledge was collected as an activity under the seed funding year and has been archived in a database held by the TKN[6]. TKN shared two records of the data base with us. One community member stated that caribou used to migrate through the area and the other member stated that caribou remained year round in the area. We continue to work with TKN and confirmed further presentation of the project results with community members June 25, 2015.

RESULTS

Survey

In 2010, survey effort was spread over 7 days in late Oct. and encompassed 11 survey units (C11, C12, C13, C15, T1, T2, T3, T4, T8, T12, and T13;Figure 3), four of which could only be partially surveyed because of poor weather (i.e. C11, C15, T4 and T8). The remaining units were not surveyed because of insufficient funds. Caribou were observed in 8 of the 11 survey units (caribou were not observed in C8, C11 and T4). Fresh caribou tracks were observed in T4, but the caribou could not be located. In a previous study, 22 caribou were located in C11, leaving C8 as the only unit having no recorded observations of caribou. In total, 470 caribou were recorded during the survey (Table 4;Figure 4), 60 of which were calves; 13% of the population. The largest group size was 55 animals in T13 on the east edge of the Spatsizi herd. Two hundred and sixteen of the observed caribou where with the ZTO and the remaining where either within the Chase or Spatsizi herd areas (i.e. 13 in C15, 22 in T1, and 232 of the 246 in T13;Figure 4).

In October of 2012, effort was spent in 10 of the survey units (Figure 3); 5 were fully completed (C12, C13, T2, T14, T15), 3 were partially completed (C14, T3, T12), and 2 (Fg1, Fg2) were quickly scrutinized to investigate the potential to encounter caribou. These units were flown over a 5 day period during which the selection was strategically placed on the units with higher potential to encounter caribou. This selection was necessary due to insufficient resources and time, full details of this survey can be found in Rudichuk et al. (2013). During the survey 186 individual caribou in 32 spatially distinct groups were observed (Figure 4). There were 25 calves observed representing an average of 15% across the survey units (Table 4). A total of 143 caribou were located within the ZTO, the largest group encountered consisted of 25 animals (survey unit T12).

In November 2013, effort was spent in 2 survey units (T8 and T11) in one day (Figure 3**Error! Reference source not found.**). One of which, T11 had never been surveyed for caribou before. T8 had been surveyed before (in 2010) but we decided to resurvey

[6] Pers. Comm.; Derek Ingram, Land and Resources Director, Tsay Keh Dene, Prince George, BC; 120716.

this block because there were no caribou detected in the previous survey. We did not have time or funds to properly survey unit T5 but we did fly over the unit and quickly scrutinized the potential to encounter caribou based on available suitable habitat. Six caribou were observed during our survey in unit T8, while zero were observed in unit T11. We considered these two blocks as having very low quality habitat for caribou. The mountains in these blocks were very rugged and more suited to mountain goats.

Caribou densities within survey units in the ZTO ranged from a low of 2/1000km^2 in C14 in 2012 to a high of 127/1000km^2 in in T12 in 2010. Ancillary observations recorded during the survey included: 15 Stone's sheep, 129 mountain goats and 104 moose, 3 wolves and 1 black bear.

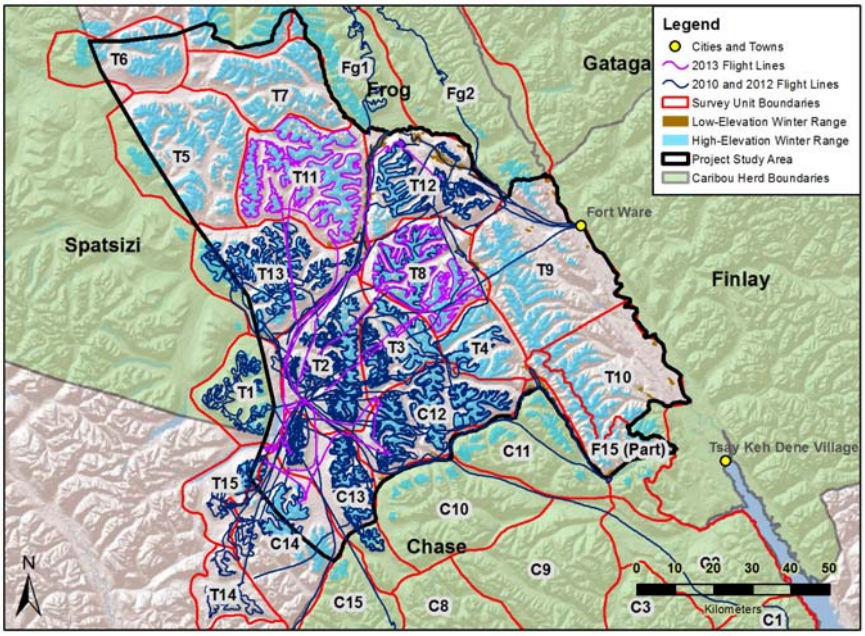

Figure 3. Flight lines during an aerial surveys conducted in and around the Thutade - Upper Finlay River study area (i.e., the southern zone of trace occurrence), in north-central British Columbia, from 2009-2012 (blue lines) and the two blocks surveyed in 2013 (purple lines).

Collared Animals

A total of 30,179 locations have been downloaded from 15 GPS collared caribou in the Upper Finlay-Thudate study area with an average collar fix rate of 95.7 ± 1.5% (

Table 5). Several collars malfunctioned and went on a false mortality while still on a live caribou, this caused the collars to take a fix every 30 min. These malfunctions appeared to reset and correct themselves over time. The 30 min. fixes were dropped for the fix rate analysis for a total of 29,560 pts. Two caribou died shortly after being collared and were dropped from all analyses (C304T and C300T).

Mortality investigations were conducted on 5 collared caribou (4 Sat and 1 Vhf). Upon investigation, one collar had malfunctioned and prematurely released. Three caribou

died of predation, 2 from wolves and 1 likely from a lynx. One caribou died below the high water mark along the banks of the Stikine River and most of the evidence had been washed away only 2 scapulas were found. Interestingly, the collar of this caribou was found unmarred (no chew marks or damage to the pin) approximately 250m up on the bank. We were unable to conclude the cause of death. Two collars have gone on mortality (2013-12-31) but we have not been able to conduct a mortality investigation.

Table 4. Number and density of caribou observed during aerial surveys conducted 2010, 2012 and 2013 in and around the Thutade - Upper Finlay River study area in north-central British Columbia. Survey units are shown in Figure 2.

Year	Survey Unit	Area km^2	Area in ZTO km^2	Total Caribou in Unit	Density #/1000km^2	Total Caribou in Zone	Density in Zone #/1000km^2	Number of Calves	Calves as % of Total
2010	C11^*	679	54	0	NA	0	0	0	0.00
	C12	686	720	16	23	16	23	2	0.13
	C13^	613	455	3	5	3	5	1	0.33
	C15^*	550	0	13	NA	13	NA	0	0.00
	T1^	478	97	22	46	0	0	3	0.14
	T2	732	697	64	87	64	87	16	0.25
	T3	391	391	14	36	14	36	3	0.21
	T4*	333	333	0	NA	0	NA	0	0.00
	T8*	637	637	0	NA	0	NA	0	0.00
	T12	727	724	92	127	92	127	11	0.12
	T13^	875	726	246	281	14	16	24	0.10
	Total	**6701**	**4834**	**470**	**Average 86**	**216**	**Average 42**	**60**	**0.13**
2012	C12	686	686	15	22	15	22	2	0.13
	C13	613	455	8	13	8	18	0	0.00
	C14	809	282	16	20	2	7	1	0.06
	Fg1	115	0	3	26	0	Na	1	0.33
	Fg2	754	0	18	24	0	Na	2	0.11
	T2	732	697	40	55	40	57	7	0.15
	T3	391	391	3	8	3	8	1	0.33
	T12	727	724	75	103	75	104	10	0.13
	T15*	308	23	8	26	0	na	1	0.13
	Total	**5135**	**3258**	**186**	**Average 33**	**143**	**Average 34**	**25**	**0.15**
2013	T11	896		0	0	0	0	0	0.00
	T8	637		6	9.4	6	9	1	0.14

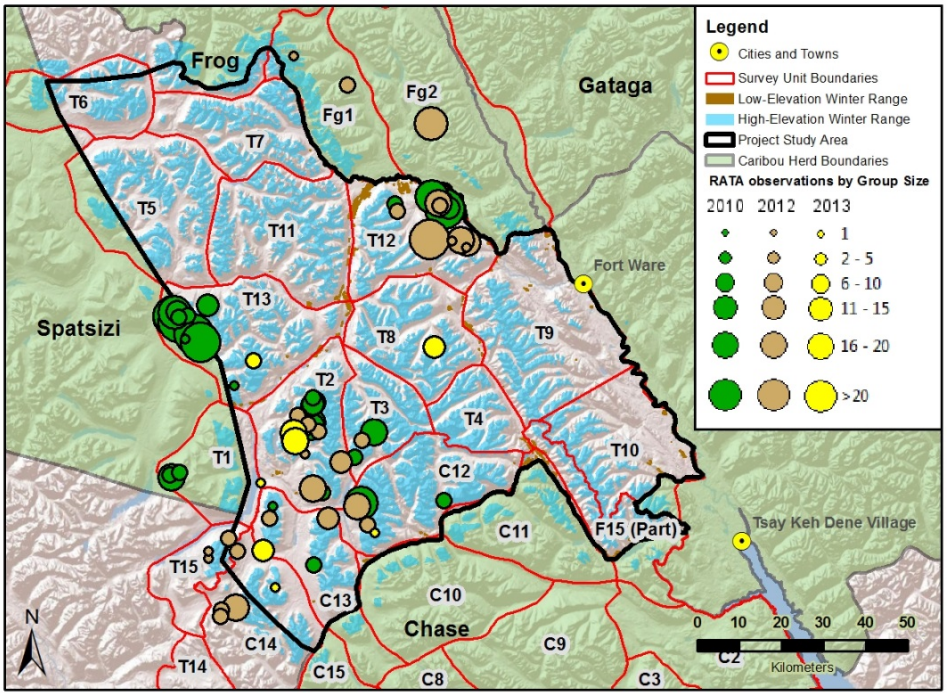

Figure 4. Location of caribou groups identified during aerial surveys and incidental observations during retrieval of collars and other work in the Thutade - Upper Finlay River study area in 2010 (green), 2012 (brown), and 2013 (yellow). Group size is shown by the size of the circle, the larger the circle the more caribou in a group.

Table 5. Fix rate, duration of operation and eventual fate for GPS SAT collars deployed on adult female caribou between 2012 and 2015 in the Thutade-Upper Finlay study area. SAT collars were capable of communicating with Iridium satellites systems (SAT) and were programmed to obtain a fix location four times a day.

Animal	Number of Fixes	Duration	Potential Fixes	Fix Rate	Collar Fate*
C293T	2333	602	2408	96.9	Remote dropped
C294T	2326	602	2408	96.6	Remote dropped
C296T	1854	592	2368	78.3	Remote dropped
C298T	4148	1072	4288	96.7	Active
C295T	2307	592	2368	97.4	Remote dropped
C297T	2302	597	2388	96.4	Mortality
C302T	921	233	932	98.8	Lost
C305T	2139	546	2184	97.9	Lost
C301T	2767	710	2840	97.4	Triggered
C306T	1971	510	2040	96.6	Lost
C300T	24				Mortality
C310T	876	225	900	97.3	Dropped collar
C307T	2793	711	2844	98.2	Active
C303T	2736	712	2848	96.1	Active
C304T	63				Mortality

* 4th mortality occurred on a VHF collared caribou.

Movement

The longest movement between a 6 hour consecutive fix was 16.4 km in July by a caribou in the southern portion of the ZTO traveling east. Seasonally caribou had highest movement rates in the summer and were least active in late winter ($F_{4,58}$ = 15.2, p <0.001; Figure 5).

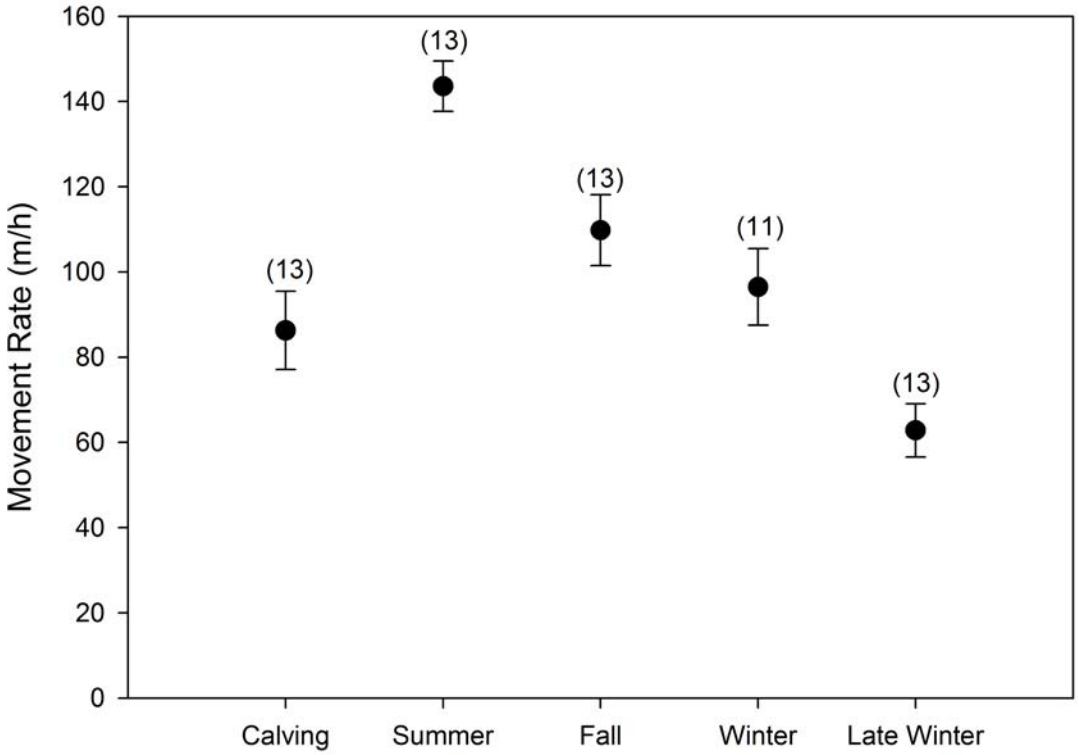

Figure 5. Seasonal movement rates (X±SE) of GPS-collared adult female caribou in the Thutade-Upper Finlay study area between 2012 and 2015. Averages were calculated for each individual and then averaged across individuals in each season. Numbers above the error bars indicate the number of individuals used to calculate the means and standard errors.

Use of Topography

GPS-collared caribou showed variation in their season patterns of use in elevation and slope. Caribou appeared to be lowest in elevation during calving and highest during summer, but due to the high variation among individuals there was no significant difference between seasons ($F_{4,58}$ = 1.50, p = 0.213; Figure 6 A). Although not significant ($F_{4,58}$ = 1.75, p = 0.152), GPS-collared caribou appeared to be using steeper slopes in late winter than any other season. (Figure 6 B).

Annual Range and Fidelity

Annual range size varied considerably by individual ranging from 362 km^2, a caribou collared in the Russel range, to 5073 km^2, a caribou collared in the southern ZTO and moved up in to the Spatsizi herd (Table 6, Figure 7). The percent overlap of the annual

range with the adjacent herds is summarized in Table 6. Five individuals had greater than 50% overlap, three with the Spatsizi and two with the Frog.

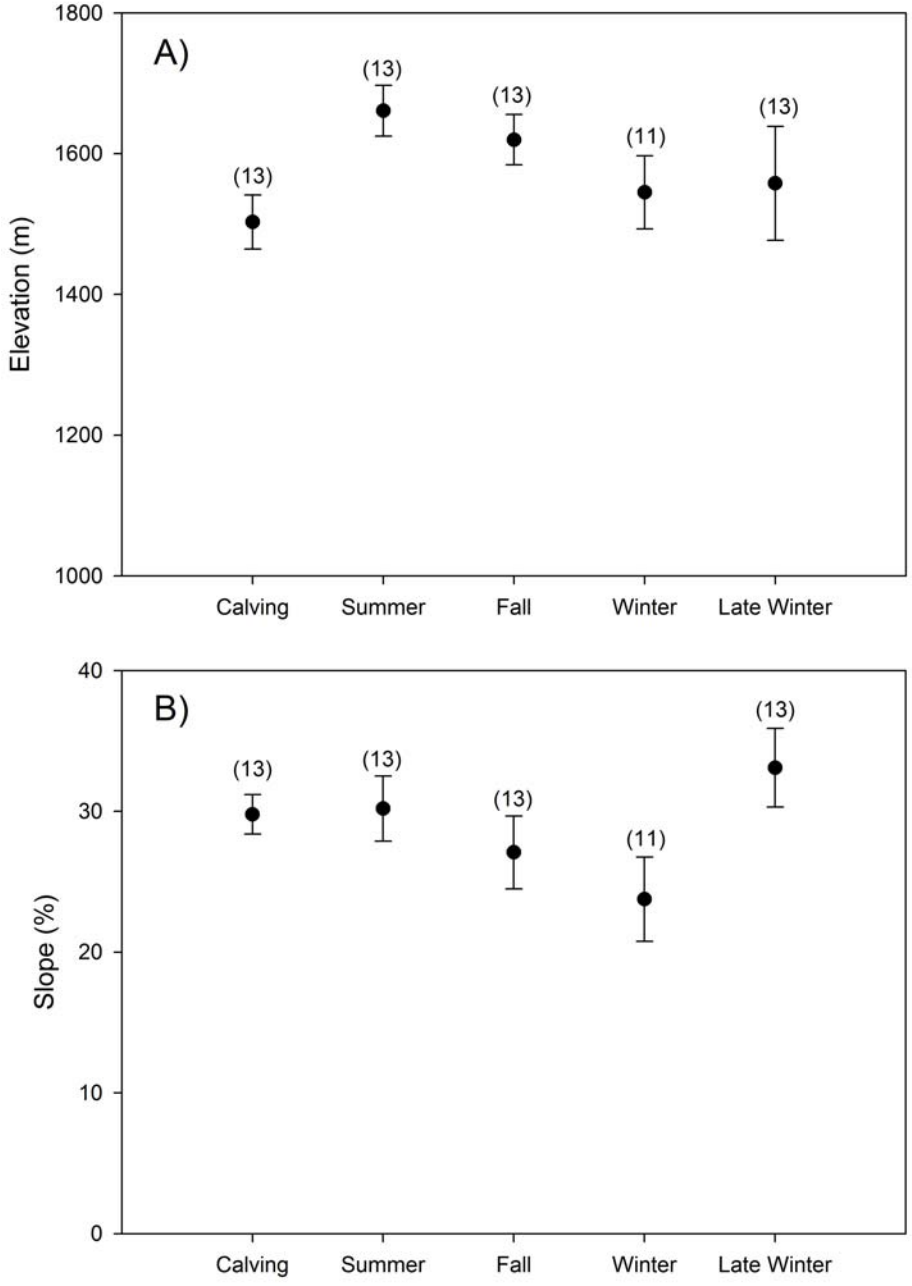

Figure 6. Seasonal use of elevation (A) and slope (B; X±SE) by GPS-collared adult female caribou in the Thutade-Upper Finlay study area between 2012 and 2015. Numbers of individuals averaged for each season are given.

Table 6. Annual range size (km²) and percent overlap with adjacent herd (FG= Frog, FN = Finlay, C= Chase, and S=Spatsizi) for GPS-collared adult female caribou in the Thutade-Upper Finlay study area between 2012 and 2015. Annual range was estimated using minimum convex polygons (MCPs). Overlap was determined by the percent the annual range overlapped with the adjacent herds.

ID	2012			2013			2014		
	Range	Herd	Overlap	Range	Herd	Overlap	Range	Herd	Overlap
C293T	615	FG	37.6	589	FG	39.4			
C294T	723	**FG**	**59.5**	474	FG	12.7			
C296T	2465	C	33.9	864	S	0.9			
C298T				2899	**S**	**71.2**	5073	**S**	**70.3**
C295T	655	C	0.3	178					
C297T	3525	S	41.8	1204	**S**	**100.0**			
C302T				589	C	1.2			
C305T				477	FG	6.3	535	FG	15.1
C301T				1421	S	13.7	628	C	1.8
C306T				590	**FG**	**58.8**	581	**FG**	**50.6**
C310T				157					
C307T				335	FN	14.0	362	FN	6.6
C303T				3755	**S**	**89.5**	3972	**S**	**89.2**

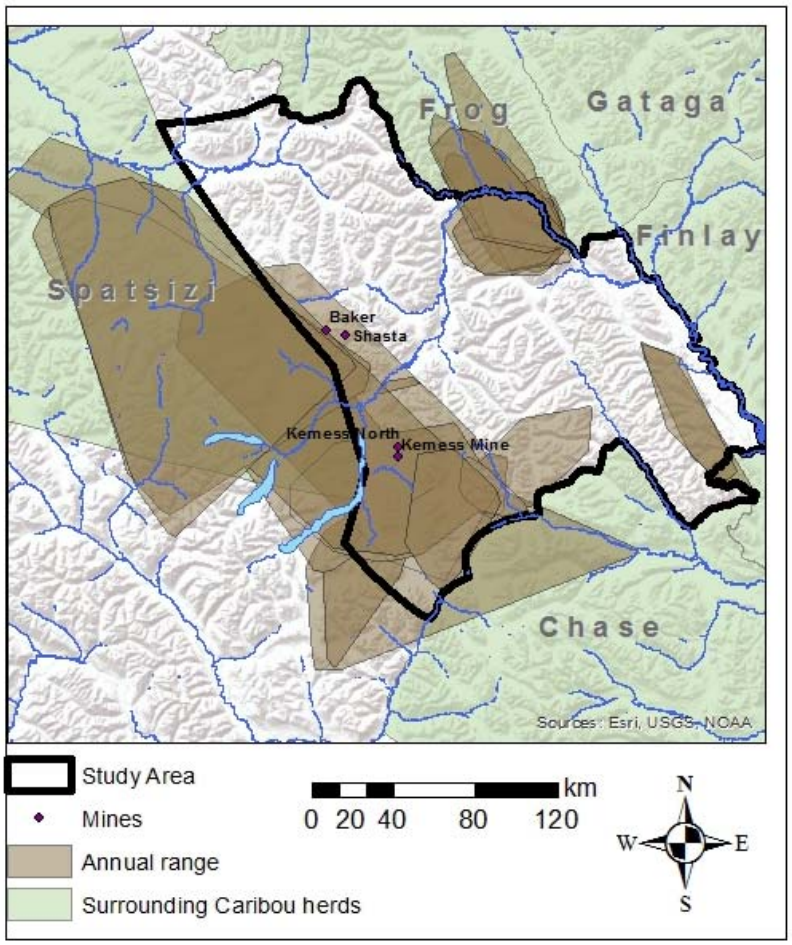

Figure 7. Annual range of 13 GPS-collared female caribou collared in the Thutade-Upper Finlay study area between 2012 and 2015. Annual range was estimated using Minimum Convex Polygons (MCPs)

Seasonal Range and Fidelity

Range size varied among seasons (Figure 8). The largest range size was 1618km^2 and it occurred in winter by an individual that wintered in the Spatsizi herd. The high variation that occurred in winter was likely due to five individuals whom wintered in the Spatsizi herd area and had an average range size of 1238 ± 362 km^2. Late winter was significantly smaller than all of the other season, while calving, summer and fall had similar size ranges ($F_{4,58}$ = 3.63, p = 0.010; Figure 8).

There were 10 individuals with multiple years of data used to examine seasonal fidelity (Table 7). Seven individuals showed strong seasonal fidelity, either returning to the same area every season or not moving far throughout the year. One individual, C298T, showed a more "migratory" behavior (Table 7), this caribou was collared in the ZTO and spent one year here and then moved north into the Spatsizi herd near the Spatsizi River. We had one other caribou do this in her first year of being collared, C297T, but she died on the south side of the Spatsizi River. Six of the ten caribou showed very strong fidelity to their calving sites, calving within 5 km of the previous year (Figure 9). The other 4 caribou calved a distance apart of 11.2-39.26 km (Figure 10).

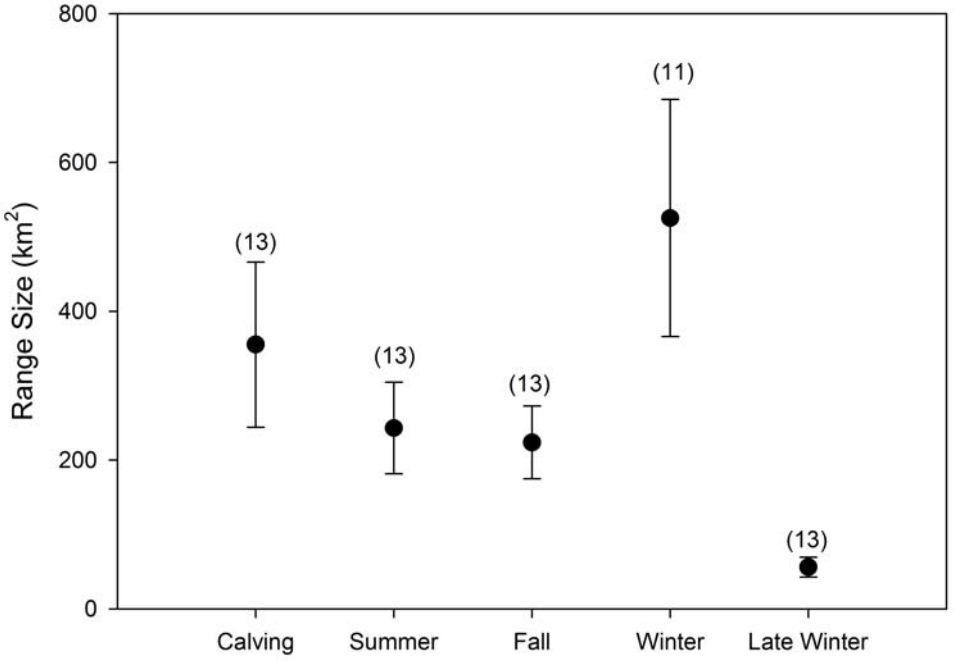

Figure 8. Average seasonal range size (±SE) for GPS-collared adult female caribou in the Thutade-Upper Finlay study area between 2012 and 2015. Annual range was estimated using minimum convex polygons (MCPs) for each individual. Individuals with multiple years of data were averaged. Number of individuals used to calculate means and standard errors are shown above SE.

Table 7. Seasonal range fidelity by years (2012-2013 & 2013-2014). The distance (km) between centroids of the seasonal range across years of each GPS-collared caribou with more than one year of data. Distances larger than 40 km have been bolded.

Animal ID	Summer		Fall		Winter		Late Winter		Calving	
	12/13	13/14	12/13	13/14	12/13	13/14	12/13	13/14	12/13	13/14
C293T	11.0		0.9		4.6		1.52		3.5	
C294T	17.8		7.7		13.9		3.41		22.9	
C296T	11.2		5.2		7.1		24.7		**42.5**	
C298T	17.9	17.3	**67.7**	11.6	**109.8**	36.9	21.7	**119.7**	**59.6**	**55.7**
C295T	2.9		2.4		4.9		0.8		9.8	
C305T		1.9		6.9				5.6		3.3
C301T		2.4		35.2		18.9				4.9
C306T		3.3						3.3		1.1
C307T		0.8		2.5		2.2		4.6		1.9
C303T		8.7		14.4		34.9		**82.7**		29.6

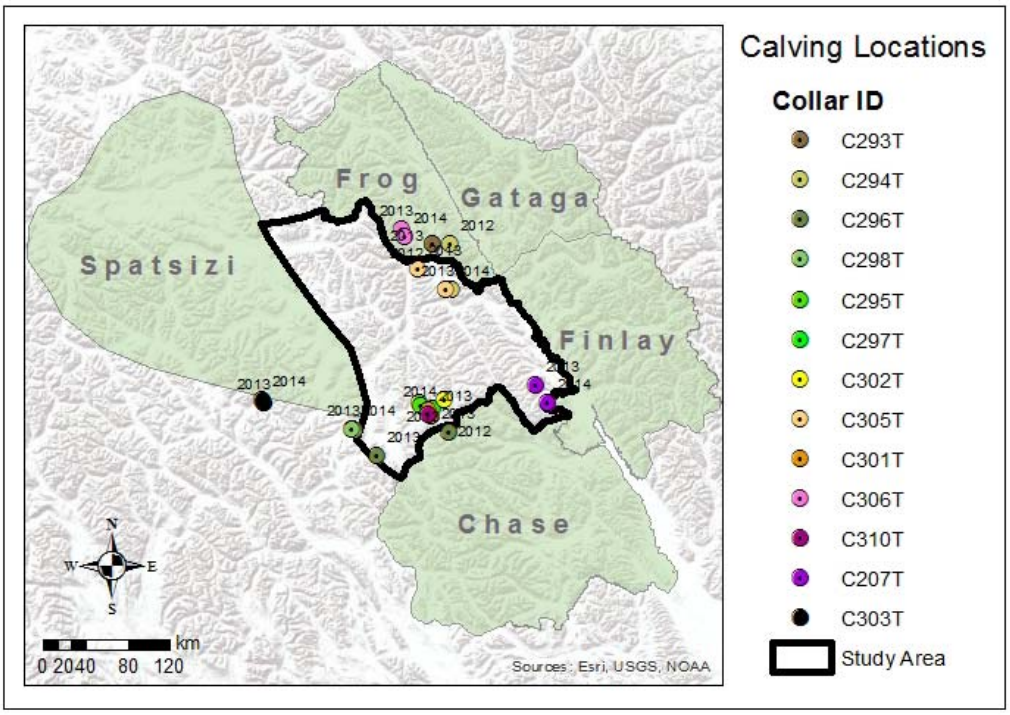

Figure 9. Calving locations of GPS-collared adult female caribou in the Thutade-Upper Finlay between 2012 and 2015. Colors represent different individuals and years are labeled on the map.

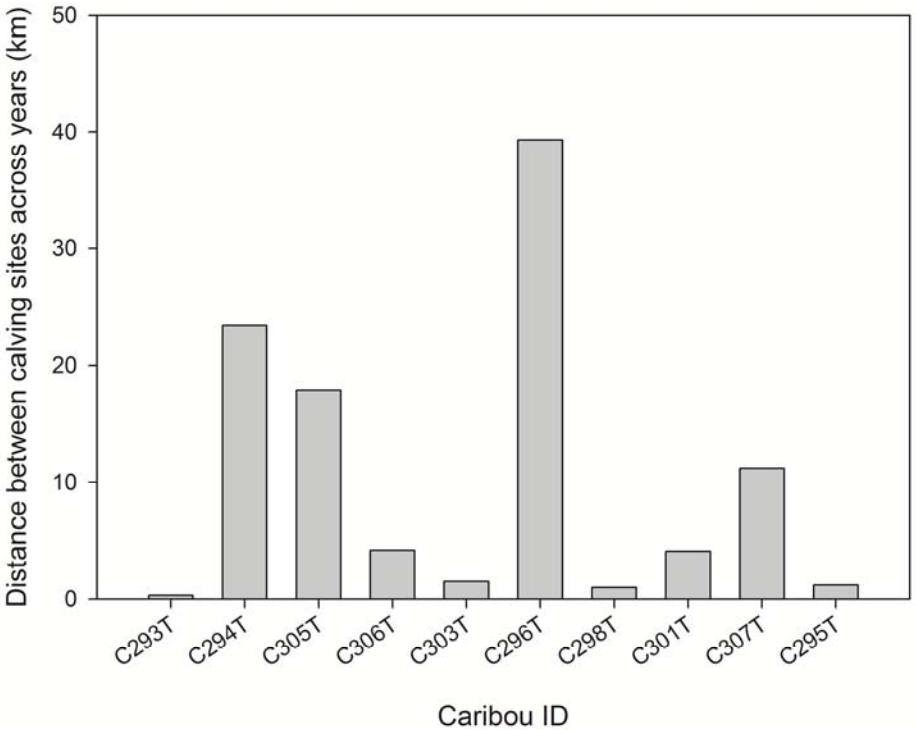

Figure 10. Distance between calving sites in consecutive years by GPS-collared female caribou in the Thutade-Upper Finlay study area. Caribou were collared between 2012 and 2015. Calving sites were determined by visually inspecting data during the calving season (May-Jun) and identifying the cluster where the animal calved.

Final Herd Boundaries

On 16 April 2015 5 scenarios were presented to Wildlife Biologists from the Omineca and Peace Forest, Lands and Natural Resource Operations, unfortunately Biologists from the Skeena could not attend (Appendix B). A consensus was reached on a final herd boundary which will be incorporated into the provincial revised caribou herd boundaries map in the fall of 2015. The caribou that reside in the northern portion of the ZTO are incorporated into the Spatsizi and Frog herds. The caribou in the southern portion of the ZTO will be incorporated into a new herd called Thutade (Figure 11).

The Spatsizi herd area will be increased by 4,121 km^2 to an area of 19,749 km^2 (previously 15,628 km^2). During our survey in 2010, we observed 12 groups of caribou, totaling 246 caribou along the south eastern border of the Spatsizi herd in survey unit T13. We did not survey the area again in 2012. We also had three collared individuals in this area that showed high affinity (high amount of overlap) with the Spatsizi herd (see Table 6, Figure 7). The expansion to the south was to incorporate the locations of one collared individual that calved in that area in two consecutive years (see Figure 9).

The Frog herd has been expanded 2,419 km^2 to the south and the west and now encompasses 7,458 km^2 (previously 5,039 km^2). In the survey in 2010 we observed 87 caribou in 10 different groups and 2012 we observed 11 groups with a total of 94 caribou south and west of the old Frog herd boundary. The four caribou we had collared south of the Frog all had some overlap with the Frog herd.

A new herd called “Thutade” will be created in the southern portion of the ZTO (Figure 11). The Thutade herd northern boundary runs along the southern portion of the Spatsizi and Frog herds and on the east the Finlay River separates the Thutade herd from the Finlay herd. The southern boundary is along the northern portion of the Chase caribou herd. It was a general consensus that the small portion of the Chase herd (714 km^2) north of the Ingenika and a small portion of the Finlay herd (122 km^2; north of the Ingenika and west of the Finlay) should be incorporated in to the Thutade herd. The new Thutade herd is 7,837 km^2. Minimum population numbers based on the 2010 survey was 102 caribou and in 2012 there were a total of 95 caribou counted.

Habitat Modeling within the Zone of Trace Occurrence

The ZTO encompasses 10,017 km^2. Our high elevation winter range model produced 62 polygons for a total area of 3,054 km^2 or 30.5% of the area in the ZTO. These were further classified into high (40 polygons representing 1,733 km^2) and low (20 polygons representing 1,321 km^2) priority high elevation winter range based on ruggedness (Figure 12A), areas with high ruggedness where though to be lower priority for caribou. For low elevation winter range, we identified 55 polygons for a total of 490 km^2 (Figure 12B), representing 4.9% of the ZTO. Sixty one percent of the winter and late winter GPS locations from the 13 collared female caribou were observed within the modeled HEWR and LEWR. The calving and summer range model produced 40 polygons that covered 6,831 km^2. These were classified further into high (31 polygons, 3,960 km^2) and low priority areas (9 polygons, 2,871 km^2). Eighty two percent of the calving and summer locations were observed with the modeled calving and summer range. Our original fall/post rut had poor agreement with the GPS locations <5%. Based on the

GPS locations and survey data we identified 7 polygons for candidates for fall/post-rut caribou habitat areas that represented 1,335 km^2 in the ZTO (Figure 14).

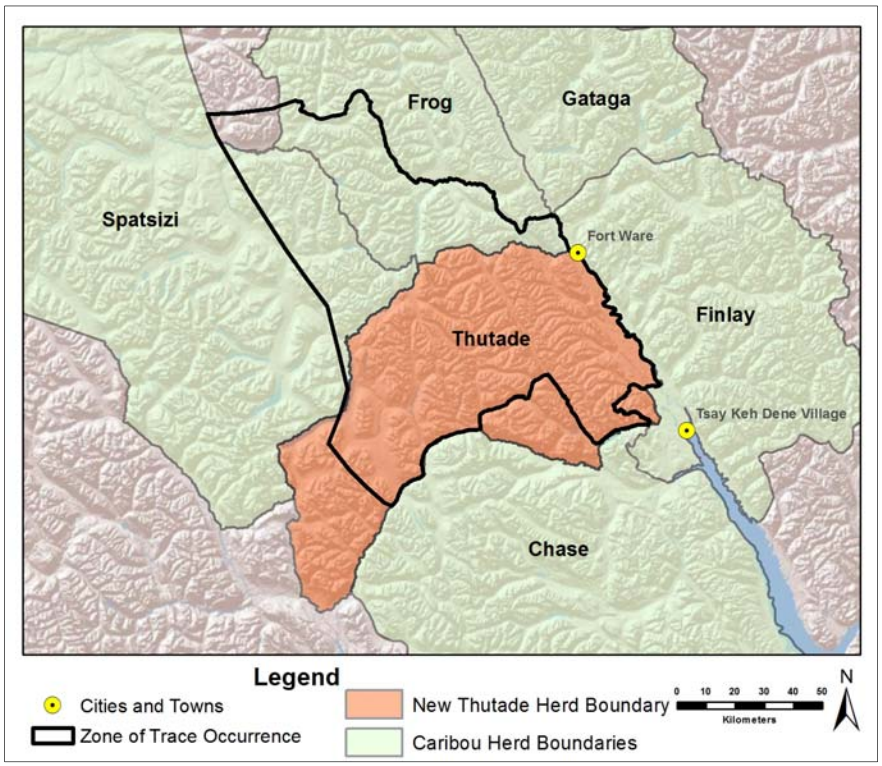

Figure 11. New herd boundary refinements for the caribou that reside in the zone of trace occurrence (ZTO). The Spatsizi and Frog herds have been expanded to incorporate the caribou that live in the northern portion of the ZTO and a new herd "Thutade" has been created in the southern portion.

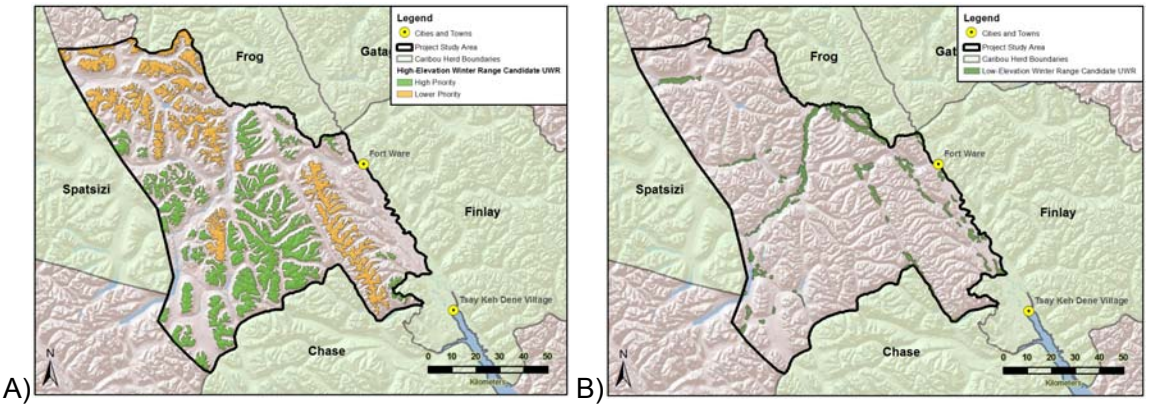

Figure 12. Candidate polygons for A) high elevation caribou winter range and B) low elevation caribou winter range based on habitat modeling in the zone of trace occurrence (ZTO) in the Thutade-Upper Finlay study area of north-central British Columbia. Low priority areas (yellow) where identified as areas of high ruggedness and are less likely to be used by caribou.

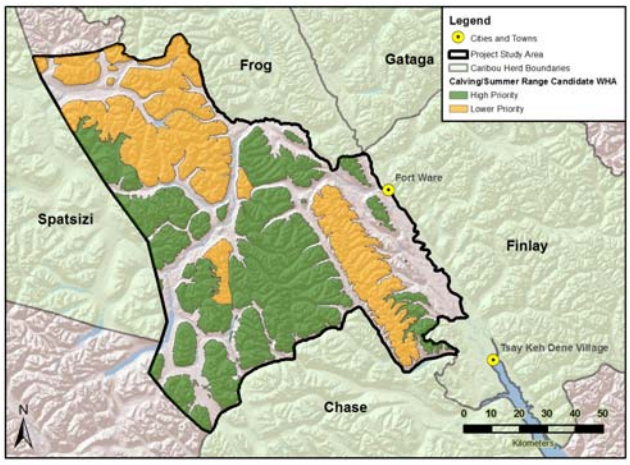

Figure 13. Candidate polygons for calving summer caribou habitat areas based on habitat modeling in the zone of trace occurrence (ZTO) in the Thutade-Upper Finlay study area of north-central British Columbia. Low priority areas (yellow) where identified as areas of high ruggedness and are less likely to be used by caribou.

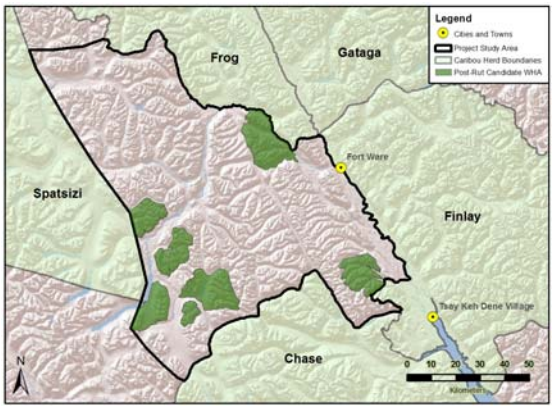

Figure 14. Candidate post rut caribou habitat areas based on GPS locations of collared female caribou between 2012-2015 in the zone of trace occurrence (ZTO) in the Thutade-Upper Finlay study area of north-central British Columbia.

DISCUSSION

Based on previous exploratory and reconnaissance-level surveys (McNay 2011)[7], and the data presented in this report we now know there is a significant number of caribou in the southern ZTO. For example, in 2010, a total of 216 caribou were observed in the ZTO; 27 of the 52 herds in BC (52%) have fewer caribou (McNay and Hamilton 2010) yet caribou in the zone of trace occurrence have no formal delineation and hence no formal conservation measures. In addition, the average density (#/1000km^2) of caribou observed within the zone was 42 in 2010; 28 of BC's 52 herds have the same or lower

[7] McNay, R.S. 2011. Fall Population Survey of Woodland Caribou in the Thutade – Upper Finlay River Area of North-central British Columbia. Wildlife Infometrics Inc. Report No. 383. Wildlife Infometrics Inc., Mackenzie, British Columbia, Canada.

density (McNay and Hamilton 2010). The data and information gained in our surveys indicate the significance of caribou in the area to the provincial population of caribou and hence a clear need to delineate herd areas within which these caribou and their habitat can be properly managed.

There are two main strategies employed when developing and or refining herd boundaries adjacent to existing herd boundaries: 1) lumping, or 2) splitting. Lumping involves expanding current herd boundaries to incorporate the caribou in the surrounding area. The disadvantage of this method is that smaller pockets of spatially separated caribou are aggregated within the larger herd boundary and the management needs of these caribou are diluted into the needs of the larger herd. Consequently, if a small group is on the brink of extirpation, it will likely not have an effect on the larger herd. The second strategy, splitting, is to delineate new smaller herds. The advantage here is that the management protection allotted to these areas will be better able to address the needs of the smaller groups. The final refinement used a combination of these approaches and at this point in time, with the data we have collected, we feel that it best portrays the behavior and biology of the caribou that reside in the ZTO. We do, however, acknowledge that there is likely some overlap between the Thutade and the Spatsizi as well as the Thutade and the Chase herds. In the Yukon, the caribou herd boundaries overlap each other[8], but for mapping purposes in BC, Government Biologists have decided to use discrete boundaries and recognize that caribou will overlap to some extent (Dale Seip, personal communication, 16 April, 2015).

The majority of the animals we observed during the survey that were associated with the Spatsizi herd were very close in proximity to the herd boundary and we expect would have been counted in the last survey for the Spatsizi. Therefore the expansion of the Spatsizi herd boundary by 26.5% will not likely influence the population demographics, it simply better reflects the distribution of the caribou that live in the southern portion of the of the herd based on the information from the GPS-collared individuals. It is unclear if the expansion of the Frog herd by 48% will affect the population demographics of the herd. In both years of the survey we counted over 80 caribou with several groups occurring south of the old Frog herd boundary. The small changes to the Finlay and Chase herd (decrease of 1.6 and 5.8% respectively) will not likely have an impact on their population demographics. There was evidence that there is some overlap with the caribou from the Chase herd and the Thutade herd in the area north of the Ingenika and west of Pelly Creek.

Animal movements are an important metric for consideration for defining herd boundaries, but administrative and management needs of the caribou also need to be considered. For example, the caribou in the “Thutade” herd in the future could face a high amount of landscape change due industrial development and the issues associated with these changes will likely be different than those of the Spatsizi herd or Chase herd.

Recommendations and Priority for Future Monitoring:

We recognize and appreciate the difficulty in doing field work in remote regions of northern BC but we have identified a few research gaps have provided a few recommendations below:

[8] www.environmentyukon.ca/maps/view/zoom/1/8/68

Resurvey the Herds

There is an imminent need to resurvey all of the northern caribou herds. As some of the caribou herds in the south are dwindling, it is even more important to monitor the herds in the north. The Spatisizi herd is recorded to be the largest herd in BC with an estimated 3,000 caribou (McNay and Hamilton 2010) but the last survey conducted in the area was almost 20 years ago[9]. It has been 14 years since the Frog herd has been surveyed and estimated to be at a population of 250 animals[10]. The Finlay herd was at sensitive level (>30 animals) in 2002 when they were last surveyed over 13 years ago[11]. The Chase herd was last surveyed in 2009 and appeared to have a stable population at 475 caribou, but this herd will be facing unprecedented levels of pine salvage harvesting in the next two- five years and it is imperative that managers resurvey the herd to monitor the impact this may have on the population.

We were unable, due to weather, time and money, to survey the northern portion of the study area between the Spatsizi and the Frog herds nor the eastern extent of the Thutade herd in the Finlay Russel Range. Past surveys in the 80's and 90's in the area were focused primarily on Stone's sheep and mountain goat with incidental sightings of caribou (Watts and Childs 1986, Corbould 2001). We did have one caribou collared in the area and she remained on the eastern slope for two years. Information on the numbers and demographics of the caribou that live here is lacking and we recommend it be resurveyed.

Habitat Modeling

All northern caribou herds were Blue-listed by the BC Conservation Data Center which means the herds are considered of "special concern" and in need of special management to ensure their survival. Under the BC Conservation Framework[12] northern caribou are considered priority 2 as a species that contributes to Goal 2 "to prevent species and ecosystems from becoming at risk".

Defining herd boundaries around the caribou in the ZTO will afford a basis for protection (i.e., a defined management unit) but does not automatically mean the animals are protected from risk posed by industrial development or other land uses. We have provided candidate polygons for Wildlife Habitat Areas for three seasons for the entire ZTO. Wildlife Habitat Areas are spatially defined areas that are designated to fulfill the critical habitat needs of specific wildlife species. Within a WHA, industrial and recreational activities are subject to guidelines designed to limit their impact on habitat quality for the species[13]. Brumovsky and McNay (2015) recently developed the Wildlife Areas designations for the Chase, Finlay and Wolverine herds and we recommend that this should be done and implemented for all the herds in the north including the Spatsizi Frog, and Gataga.

[9] www.env.gov.bc.ca/wld/speciesconservation/ecotype_distribution/nc_spatzizi.html
[10] www.env.gov.bc.ca/wld/speciesconservation/ecotype_distribution/nc_frog.html
[11] www.env.gov.bc.ca/wld/speciesconservation/ecotype_distribution/nc_finlay.html
[12] http://www.env.gov.bc.ca/conservationframework
[13] http://www.env.gov.bc.ca/wld/frpa/iwms/wha.html

Northern Zone of Trace Occurrence

This project has been successful in identifying and delineating herd boundaries around caribou in the southern ZTO. But there is still a large area within the distribution of caribou in BC where caribou are of an unknown status or "trace occurrence". The next most significant are of trace occurrence occurs directly north of our study area in north-central BC. There are four previously delineated herds sharing common boundaries with this area Spatsizi, Horseranch, Rabbit, and Frog (Figure 15). The area is also a shared boundary between the Peace and Skeena regions of the province. We recommend a survey of the area be conducted to obtain a population estimate as well as placing GPS collars on caribou to better understand the behavior, movement patterns and adult survival of the caribou that reside here.

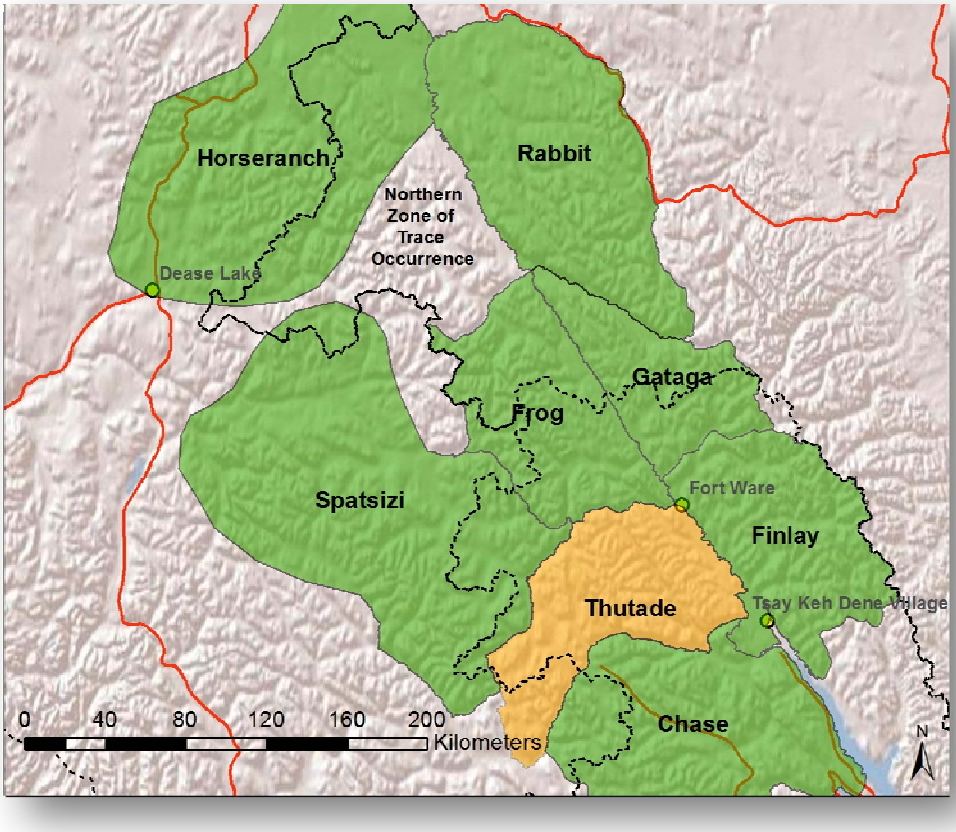

Figure 15. Location of northern zone of trace occurrence between the Horseranch, Rabbit, Spatsizi and Frog herds in north-central British Columbia (BC). BC Government regional boundaries are shown by with the black hashed line: Peace in the northeast, Omineca in the southeast and Skeena in the west.

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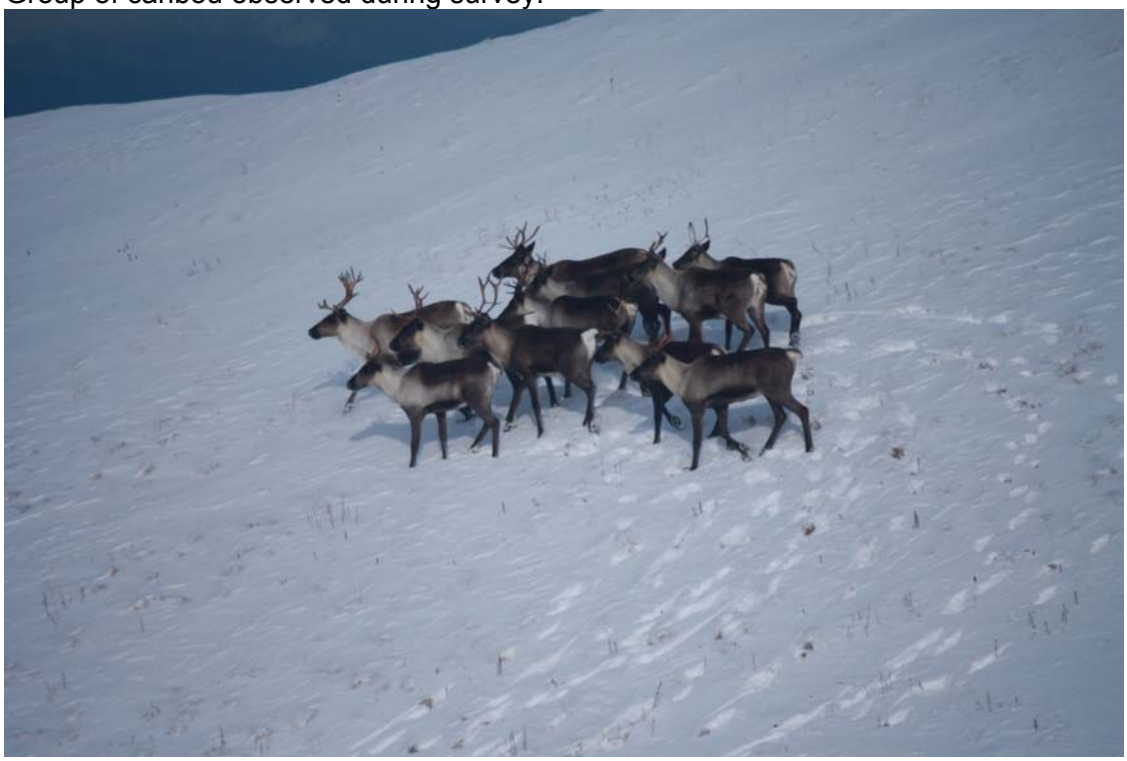
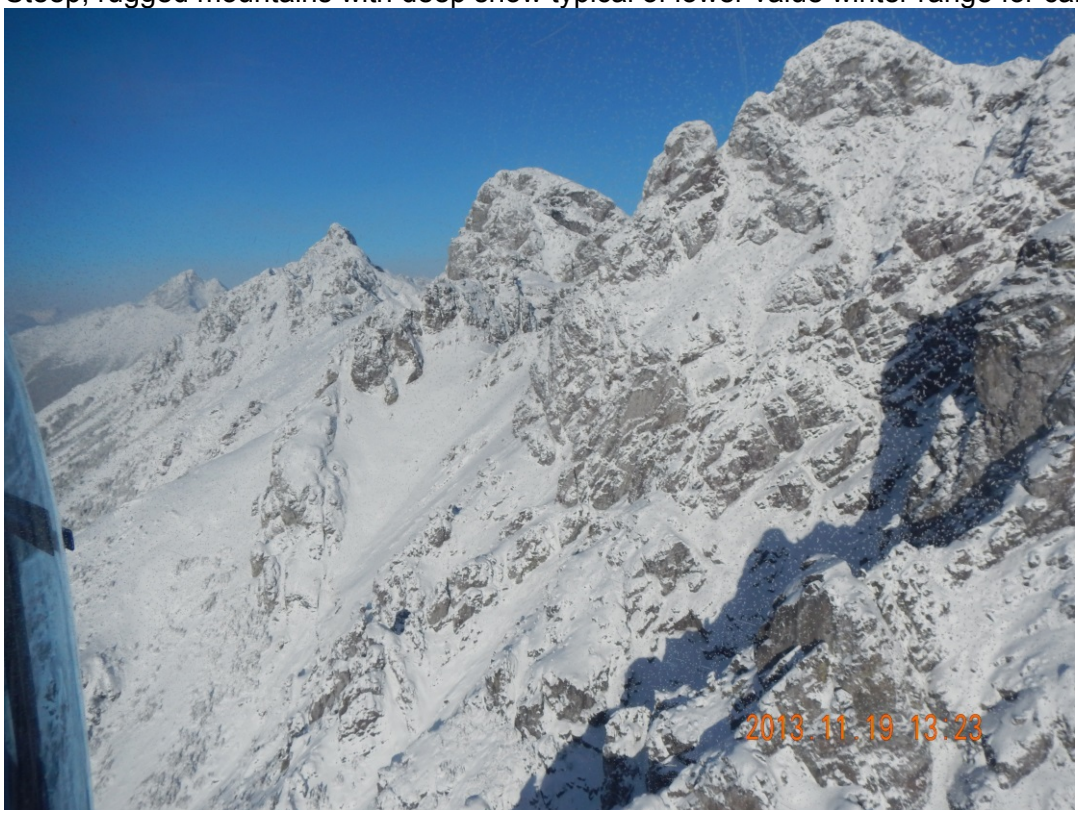
APPENDIX A. Selected photographs from field work

Caribou in open alpine habitat

Group of caribou observed during survey.



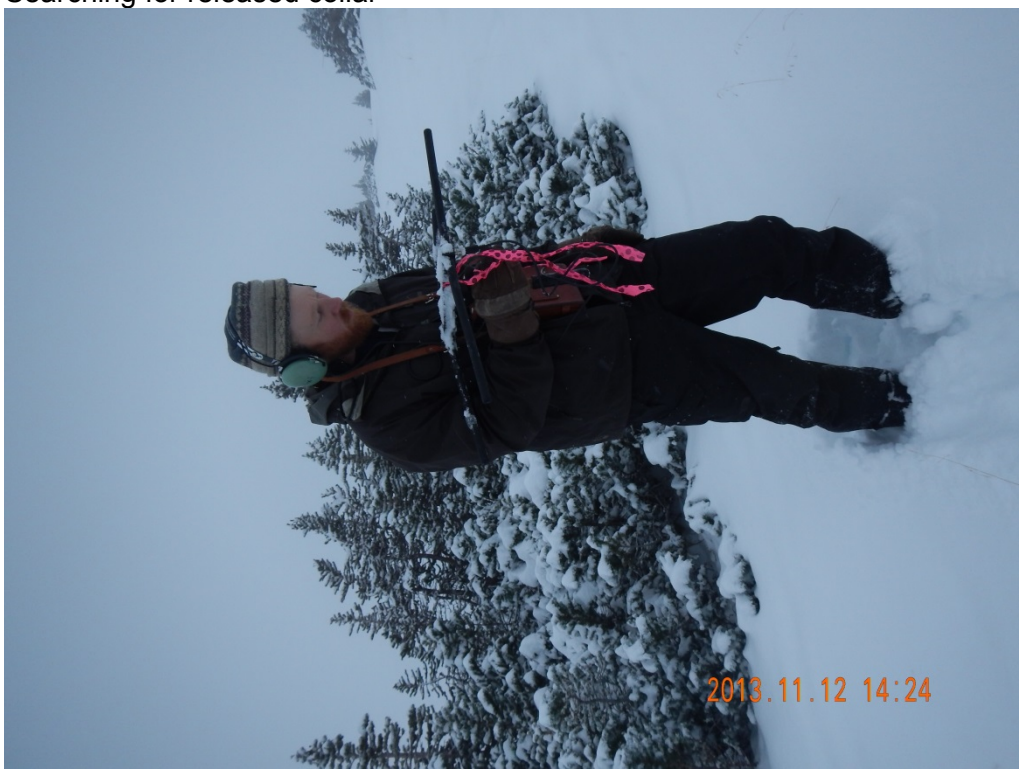
Steep, rugged mountains with deep snow typical of lower value winter range for caribou



Tracks of caribou on wind swept mountain typical of high value winter range for caribou

Caribou at alpine mining exploration site

Searching for released collar



Caribou mortality

Wolves observed in deep snow up in alpine, these wolves were observed feeding on three dead caribou.

Other encountered species - moose observed foraging in alpine

Other encountered species - mountain goats in the rocks

APPENDIX B. POTENTIAL HERD BOUNDARIES FOR DISCUSSION WITH STAKEHOLDERS

We developed 5 different potential scenarios for redefining herd boundaries and/or defining new herd boundaries for the caribou within the "southern zone of trace occurrence".

Potential Scenario 1 - Expansion of current ranges

This approach incorporated the caribou within the southern ZTO into existing herds by expanding the current herd boundaries (Figure 16). Depending on the legislative restraints of developing 'new caribou herds', expansion of current herd boundaries might be a simpler more efficient approach.

Several caribou that were collared in the central part of the southern ZTO and they traveled long distances (up to 143 kms away) northwest into the Spatsizi herd, for this reason the Spatsizi herd boundary was expanded to the south east. Similar to the Spatizi herd, several collared female caribou south of the Frog herd moved north into the Frog herd at certain times of the year leading to the southern expansion of the Frog herd. The Chase boundary was expanded to the north to incorporate the caribou residing in this area as a few of the collared individuals moved south into the Chase herd several times a year. Only one caribou was collared just west of the Finlay herd. This caribou remained west of the Finlay River in the Finlay-Russel Mountains. In scenario 1, the herd boundary was expanded west across the Finlay River to incorporate the caribou in this area. This refinement was turned down because it did not reflect what the behaviour of GPS-collared caribou. The caribou north of the Chase do not exhibit the same behaviours as the Chase animals.

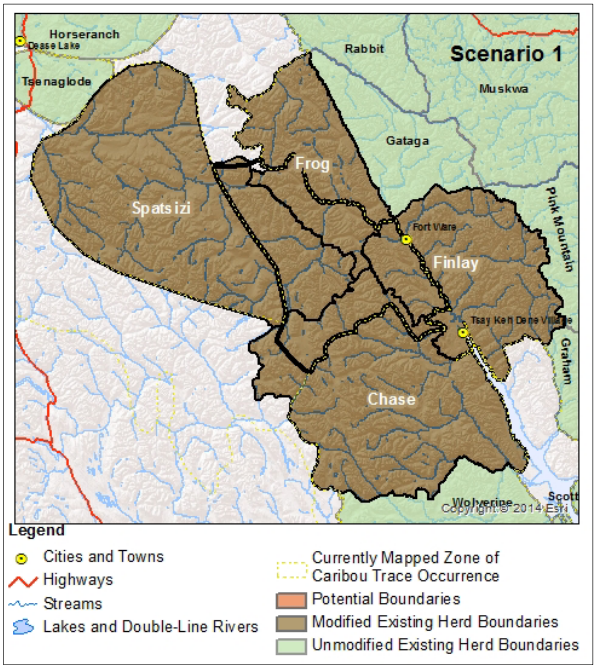


Figure 16. Potential herd boundary refinement to incorporate caribou within the southern zone of trace occurrence into a herd. This scenario resulted from expanding current herd boundaries.

Potential Scenario 2 – All Thutade

In this scenario, the entire southern ZTO would become the new Thutuade herd. The herds adjacent to the southern ZTO were delineated for a reason. The caribou that reside within the southern ZTO will likely face different management issues than the herds directly adjacent to them. There are currently 3 proposed mines and one inactive mine in some of the core area for caribou. Again this was rejected because it does not reflect the behavior and biology of the caribou that reside in the ZTO.

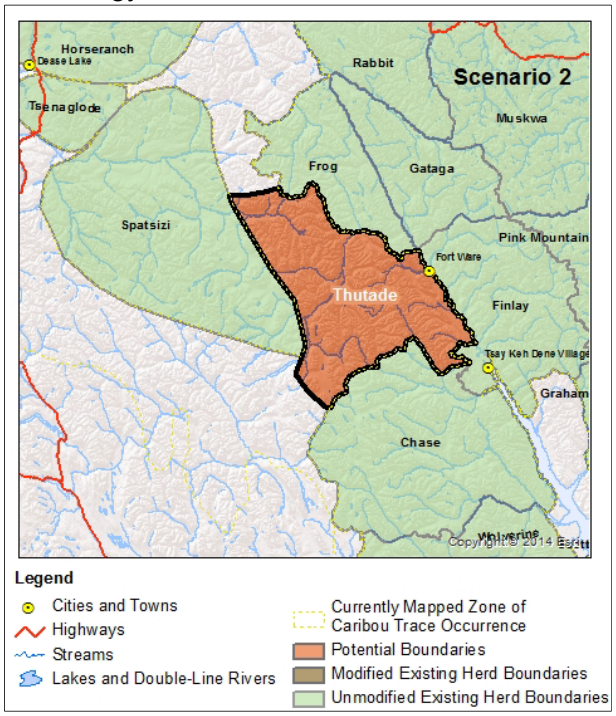


Figure 17. Potential herd boundary refinement to incorporate caribou within the southern zone of trace occurrence into a herd. This scenario resulted from creating a new herd "Thutade" encompassing the entire zone of trace occurrence.

Potential Scenarios 3, 4 & 5 New Herds-Thutade and Finlay-Russel

In these scenarios smaller new herds would be developed to incorporate caribou that may exhibit different behaviors (i.e., Finlay-Russel) or require different management measures (i.e., Thutade).

In these scenarios, we expanded the Spatsizi herd boundary west to incorporate the caribou that move east-west through the large plateaus, but we did not extend the border to the south. Instead to the south we proposed a new herd be established called the Thutade herd. The Frog was expanded again, as it was very obvious that the caribou that reside to the south of the boundary move north into the Frog herd. During our 2010 and 2012 surveys, block T12 (south of the Frog herd) had some of the highest counts and largest groups of caribou. Additionally, there were no changes to the Chase or the Finlay caribou herds boundary.

In scenario 3, a new herd was proposed to be delineated for the caribou that reside on the west side of the Finlay, "Finlay-Russell" herd. This would happen if for example, the caribou on the west side of the Finlay do not cross over to the east side (or vice versa)

and/or they exhibit different behaviors (migratory vs resident). Two new herds have been proposed for this scenario. The first is the Thutade, which encompasses the caribou that reside to the north of the Chase caribou and southeast of the Spatsizi caribou. Some of the caribou in this area make relatively small movements annually not moving out of the areas, while others make larger movements. The second herd is the Finlay-Russell, and it encompasses the caribou on the west side of the Finlay River in the Russel range. It is difficult to know with our current data if these animals move across the Finlay to the east. In scenario 4, we combined the two proposed herds from scenario 3 and created just one herd "Thutade". And in scenario 5, the Finlay herd was expanded west across the Finlay River to incorporate the caribou that reside in the Finlay Russel Range.

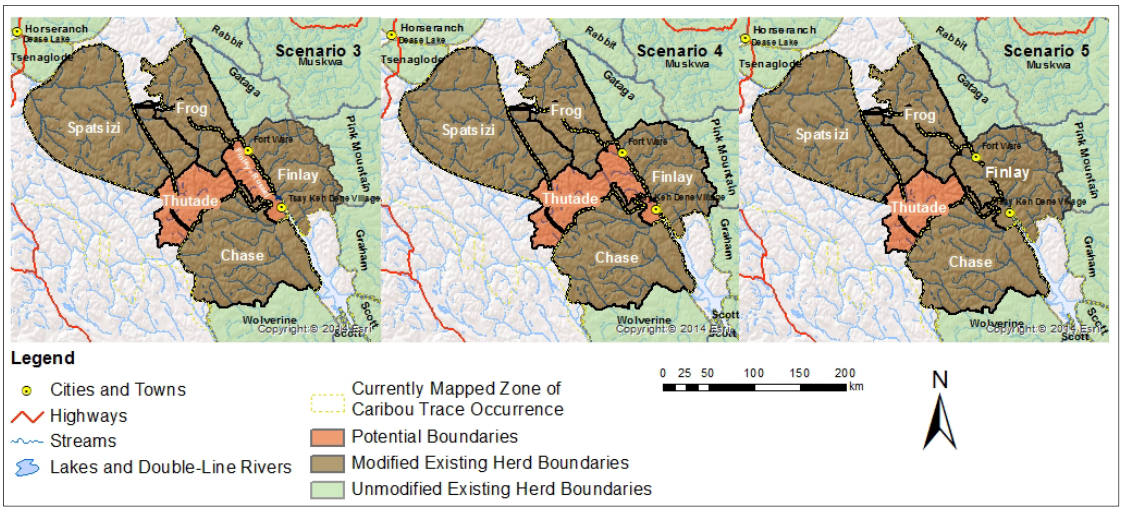
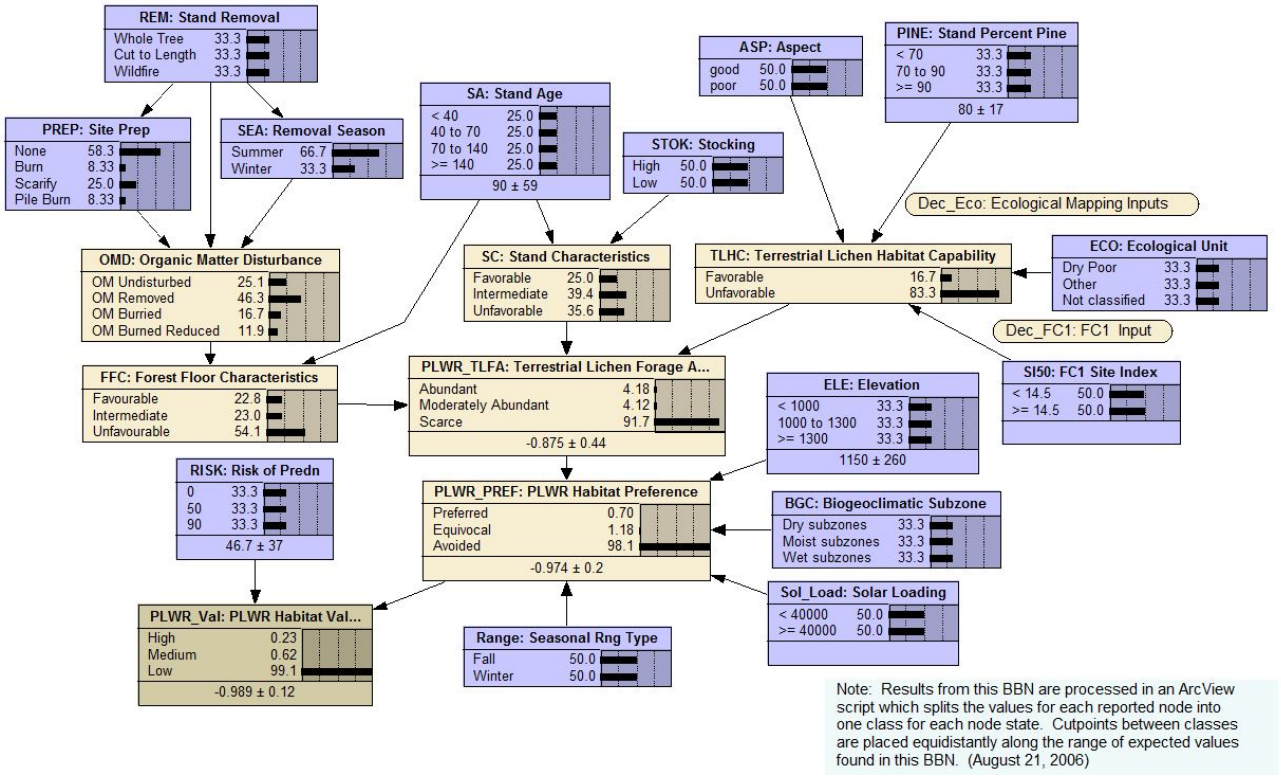


Figure 18. Three potential herd boundary refinement to incorporate caribou within the southern zone of trace occurrence into a herd. This scenario resulted from expanding current herd boundaries.

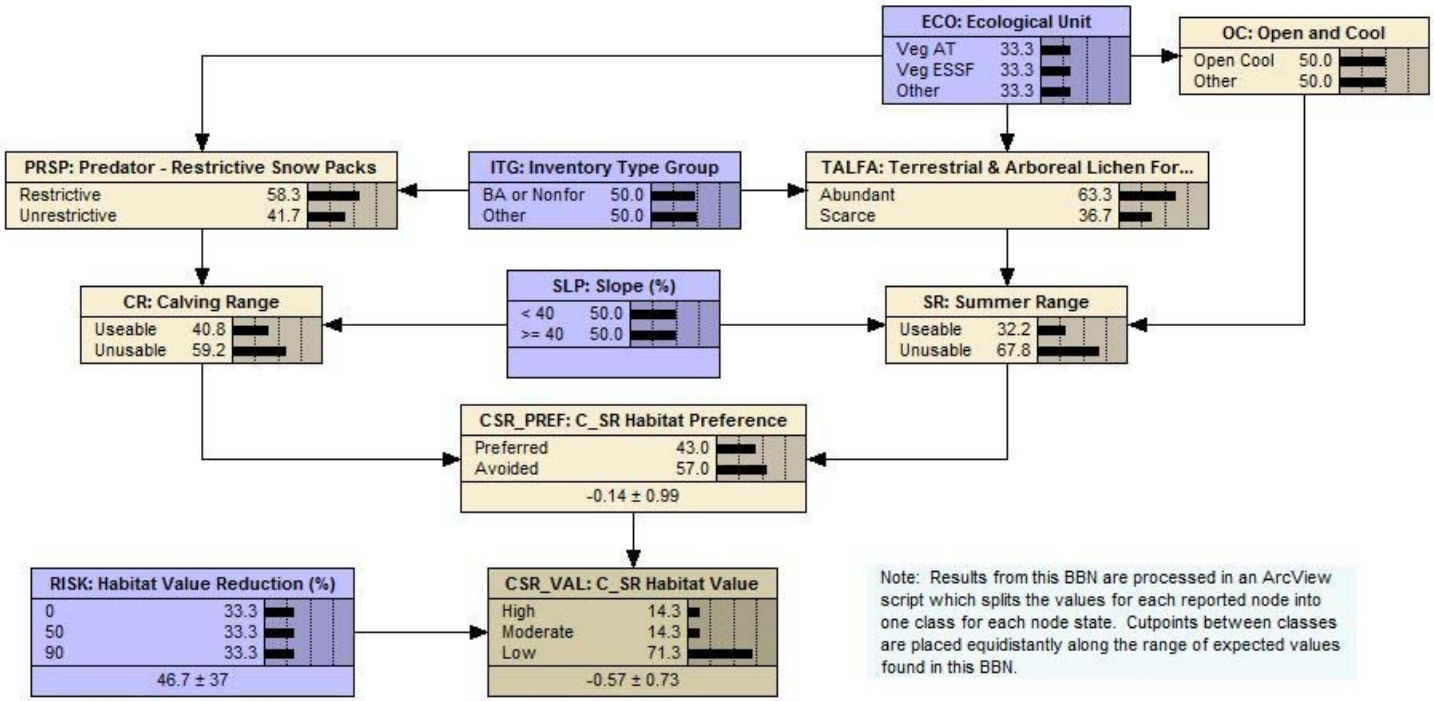
After discussion with stakeholders a final boundary was decided on which closely resembles Scenario 4 with a few changes small changes to the Chase and Finlay herd (see Figure 11).

APPENDIX C. NETICA MODELS FOR BAYSIEN BELIEF NETWORK.

Pine Lichen Winter Range Model



Calving Summer Range Model



Black Spruce Swamp Complex Model