ANNUAL REPORT

Aerial Surveys of the Wolverine and Chase Woodland Caribou Herds in North-central British Columbia

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ABSTRACT

Our goal was continued implementation of an adaptive management project which is focused on mitigating risk of predation for woodland caribou (*Rangifer tarandus caribou*). Completed surveys from annual work contribute to the required baseline information for the project where our specific emphasis was on surveying caribou population status incorporating assessments of recruitment and mortality, as well as completing an assessment wolf movements based on downloaded GPS collar information. We updated population summaries for caribou in the Wolverine and Chase recovery plan areas by conducting aerial surveys to estimate post-neonatal calf survival (July), post-summer calf survival (November), potential late winter juvenile recruitment (March), and a total count of animals (March). We authoritatively sampled seasonal ranges based on outputs of the Caribou Habitat Assessment and Supply Estimator (CHASE) surveying areas that we knew had a high likelihood of being occupied by caribou relative to the seasonal timing of the sampling period. We supplemented the evaluations of the range types by surveying as much open alpine habitat as our budget would allow. During the post neonatal survey we accounted for 64 of 67 collared caribou and 12 of 15 collared wolves (*Canis lupus*). All collared caribou were accounted for during the post summer survey (65/65) but only 10 of 15 collared wolves were accounted for. During the late winter survey we accounted for 61 of 64 collared caribou and 10 of 13 collared wolves. During the late winter survey we observed 36 groups of caribou in the Wolverine herd area and 37 groups in the Chase herd area. The total number of caribou counted in the Wolverine was 230 corresponding to a population estimated of 341 animals. The total count for the Chase herd was 292 animals corresponding with a population estimate of 347. For the Wolverine and Chase areas, calf recruitment was estimated in late winter to be 13 and 14%, respectively. Estimates of calf recruitment from the June and November calf recruitment surveys indicated that most mortality of calves occurred during the summer months for both herd areas. Calves appeared to remain relatively free of mortality during winter months. Through the year (i.e. for all survey sessions) 23 mortality investigations were completed which were located by: 1) analyzing wolf collar data, and 2) visual observations of sites found during census or telemetry surveys. Five of these mortalities were moose (*Alces alces*), 11 were caribou, three were wolves, two could not be classified, and two were locations identified using GPS collar data but no mortality was found. All survey data: telemetry, census, collar relocations, and mortality site investigations were entered into the Wildlife Information Management System, a data based specifically designed for this purpose to ensure the long-term accessibility of the data as a baseline dataset for the adaptive management project.

ACKNOWLEDGEMENTS

The survey was funded by the BC Forest Investment Account Land Base Inventory Program and completed under contract to the Canadian Forest Products Ltd. Mackenzie Operations. We'd specifically like to thank Dan Szekely for the management and administration of the project funding. Greg Altoft and Ryan Madley did a great job of flying us to caribou and putting us in a position to complete our work. Viktor Brumovsky assembled spatial mapping products for the field team. Assistance in the field was provided by Fraser MacDonald, Kayla McNay, and Don Doyle. We would like to thank Ruth and Ron Repko for their wonderful hospitality and great help dealing with the usual fieldwork logistics.

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INTRODUCTION

Background

Woodland caribou (*Rangifer tarandus caribou*) in the Southern Mountain National Ecological Area were designated "threatened" by COSEWIC in 2002, were added to the Species at Risk Act Schedule 1, and are a species at risk under the Forest and Range Practices Act in BC. Caribou are also commonly considered to be a leading indicator of biodiversity and ecosystem health in the boreal and sub-boreal forests (e.g., see ENGO programs such as Caribou Nation[1], Grey Ghosts[2], and Staring at Extinction[3]). In the late 1970s, the BC government sensed potential mismanagement of caribou with an apparent decline in populations while annual harvests were exceeding 1,500 animals (MacGregor 1985). After curtailing hunting, caribou populations continued to decline and, despite the current legal status, the rate of decline indicated extirpation for many herds in a matter of decades (Wittmer 2004). The common denominator in this decline was considered by Messier et al. (2004) to be increased ungulate (other than caribou) populations. Other ungulates are primary prey for many predators of caribou and their increased numbers have been associated with increased predation on caribou (Wittmer et al. 2005). Under conditions of high ungulate density, caribou apparently suffer more incidental predation from wolves (*Canis lupus*) than would occur otherwise (Bergerud 1983, Seip 1992, Racey et al. 1999). The increased mortality is exacerbated because caribou are possibly more susceptible to wolf predation than other ungulates (Seip 1991, Seip 1992, Thomas 1995). Increases in non-caribou ungulate populations (e.g., moose, deer, and elk) have been related to the abundance of young seral forests resulting from logging (Hatter 1950, Wallmo 1969, Spalding 1990, Rempel et al. 1997, Rettie and Messier 1998). Roads and other linear corridors may also benefit predator search rates and allow predator's access to caribou in places that would otherwise be less accessible (Jalkotzy et al. 1997; Bradshaw et al. 1997, James and Stuart-Smith 2000, Dyer et al. 2001). The most proximal cause of declining caribou populations is assumed to be predation-related effects that reduce adult caribou survival and juvenile recruitment. Corrective measures to reverse the decline of caribou in the short-term therefore must involve predation mitigation either by managing early seral forest conditions, roads and linear corridors, non-caribou ungulates, predators, or a combination of these. Presumably, such measures would be part of a comprehensive conservation strategy which included longer-term measures to manage habitat to reduce the likelihood of overlap between caribou and predators hence minimizing the need for continuous management of predators.

Other than the experimental reduction of wolf populations (Elliot 1985, Janz 1989, Seip 1992, Boertje et al. 1996, Youds and Roorda 2001, Hayes et al. 2003), other mitigation techniques have held relatively little attention. Also, there are few published accounts expounding on the relative management efficacy of mitigation techniques other than that of Boertjie et al. (1996) and Hayes et al. (2003). Both accounts demonstrated reduced predation rates and more abundant ungulate populations following experimental reduction of wolves. Both accounts also indicate however, that the result is only feasible with considerable long-term effort, the effects of which may ultimately be short-lived. Even so, where recovery of caribou is considered feasible through habitat management,

[1] http://www.caribounation.org
[2] http://23120.vws.magma.ca/work/caribou/index.php
[3] http://www.forestethics.org/article.php?id=1122

short-term mitigation of predation is still likely to occur while habitat is being restored (MCTAC 2003, Seip 2005, McNay et al. 2008). The effects of predator reduction treatments within the Chase herd area were evaluated in part by McNay et al. (2009) in an ongoing project which relies on monitoring population status of both the Wolverine and Chase caribou herds. McNay and Giguere (2008) also summarized disjointed studies of the Chase and Wolverine herds (Heard and Vagt 1998) that provided an initial dataset to update annual findings. Prior to 2008 several studies had been undertaken since the early 1990's (Terry and Wood 1999, Wood and Terry 1999) but few results were published. Since 1999 surveys have been conducted at more regular intervals and at consistent times in the year. Post neonatal mortality surveys were conducted in June/July, post summer mortality surveys were conducted in early November and late winter surveys were conducted in February and March (McNay and Giguere 2008, McNay et al. 2009). From June 2009 to March 2010 we conducted the three seasonal surveys to evaluate: caribou population status, calf recruitment, wolf movements, and complete mortalities investigations. This report contains a summary of the data that was collected during the three surveys.

General Objectives and Expected Outcomes

Our objectives were to:

- determine the location and status (dead or alive) of radio-collared caribou (n=73) and wolves (n=18);
- summarize the location, timing and cause of death of any animals found dead;
- provide an estimate of radio-collared caribou mortality rates during what has been found to be the peak mortality period of march through late June;
- provide an estimate of the percent calves in the population (i.e., calf recruitment surveys), post summer and late winter; and,
- to conduct an evaluation of the daily movements of radio-collared wolves (data collected during the period of March through June) in order to determine the location of potential kill sites.

Outcomes of this research are expected to affect decisions regarding the efficacy of mitigating caribou mortality throughout BC; especially as applied within the range of the mountain caribou ecotype. We also expect to increase the number of caribou within the Chase herd and to enhance knowledge about interactions among wolves, their primary prey, and caribou.

STUDY AREA

The study areas extended from the town of Mackenzie (N55º 18' 16'', W123º 07' 56'') in north-central BC west of Williston Reservoir in the Omineca Mountains ecoregion and north to the Ingenika River extending into the southern portion of the Northern Mountains and Plateau ecoregion. Study areas were essentially two of the four Recovery Planning Areas (RPAs) for herds of woodland caribou in north-central BC (Figure 1): the Chase and Wolverine herds (Heard and Vagt 1998). The Williston Reservoir, with its major drainages, is one of the dominant physiographic features in the area and formed the eastern boundary of the study. Valley bottoms and mid-slopes of the two herd areas were described by Meidinger and Pojar (1991) as being dominated by relatively cool

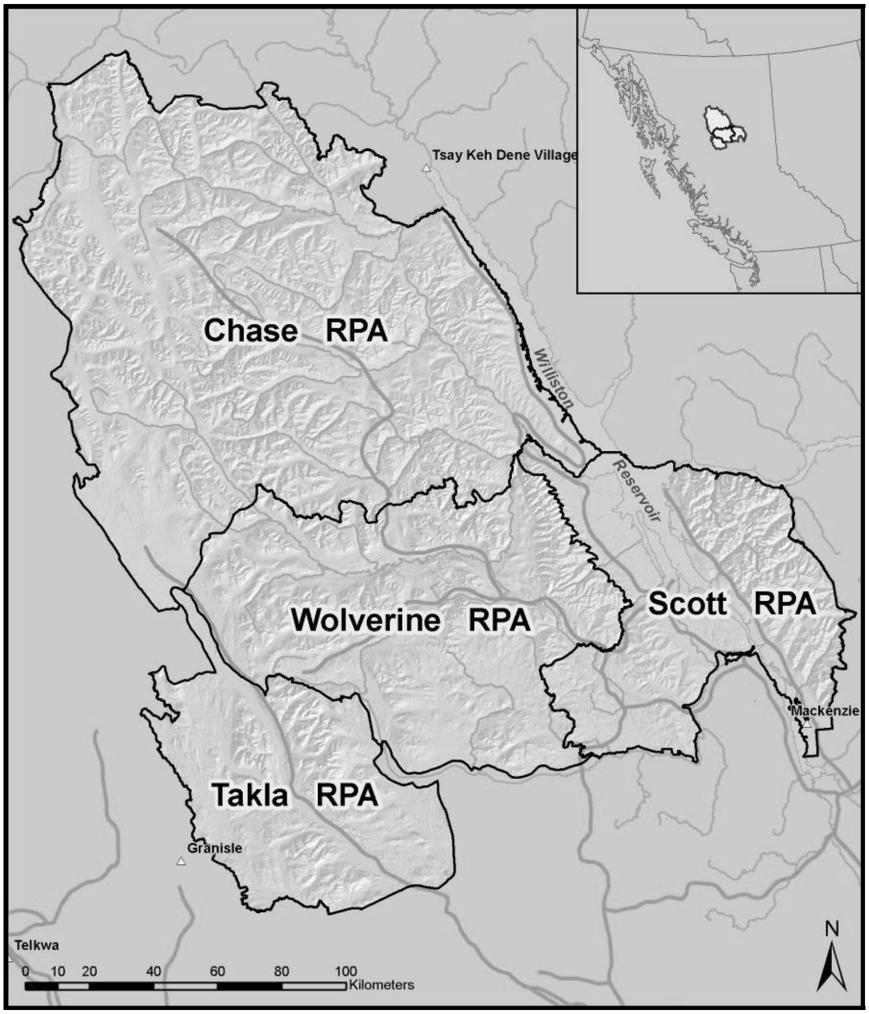

Figure 1. Location of recovery plan areas (RPA) for herds (Wolverine, Chase, Takla, and Scott) of threatened woodland caribou in north-central British Columbia.

and dry, or cool and moist macroclimates of short growing seasons leading to boreal ecosystems of white and black spruce (*Picea glauca* and *P. mariana*). Cold temperatures dominate the climate with average daily temperatures below freezing for half the year and three-quarters of the annual precipitation falling as snow. Large-scale and frequent wildfires were characteristic prior to fire control policy (Delong 2002).

Common in these ecosystems are large, relatively flat areas of well-drained fluvial deposits, which in combination with frequent and large fires gave rise to large areas of even-aged lodgepole pine (*Pinus contorta*) dominated forest stands. Generally, a cold moist macroclimate with long, cold winters characterize upper slopes where Engelmann spruce (*P. engelmannii*) dominates. First Nations reported historic seasonal use of the area by wolves and described an increase in the abundance of wolves and their more persistent presence following the first appearances of moose in the early 1920’s (McKay 1997). Predators of caribou, other than wolves, included grizzly bear (Ursus arctos (Linnaeus 1758)), black bear (Ursus americanus (Pallas 1780)), lynx (Lynx Canadensis) and wolverine (Gulo gulo (Linnaeus 1758)). Occasional, infrequent reports of cougar (Puma concolor (Linnaeus 1771)) have been made apparently consistent with periodic increases in deer (Odocoileus spp. (Rafinesque, 1832)) and elk (Cervus elaphus (Linnaeus, 1758)). Other abundant ungulates in the area include stone sheep (Ovis dalli stonei (Nelson, 1884)) and mountain goats (Oreamnos americanus (de Blainville, 1816)). Regulated hunting of mature male caribou occurred in the Chase area and the northern half of the Wolverine area for 12 weeks beginning every August 15th. Regulated hunting was discontinued in the southern portion of the Wolverine area prior to 1981. Hunting by aboriginal people is permitted in all areas and regulated, licensed trapping of wolves has been a focal activity in the Chase herd area since 2003.

The Wolverine RPA is 844,313 ha, ranging in elevation from 676 to 2134 m in rolling high-elevation foothills, and includes four major watersheds of the Omineca, Manson, Klawli, and Germansen Rivers. It is roughly bounded in the north by the headwaters of Goat, Nina, and Big Creeks, in the west by Takla, Tsayta, and Indata lakes, in the south by Tchentlo and Chuchi lakes, and in the east by Sylvester and Gaffney creeks, and the eastern slopes of the Wolverine Mountain Range. Habitat suitability mapping derived using CHASE (McNay et al. 2006) indicated 10,981 ha of pine-lichen winter range, 478,449 ha calving and summer range, 18,762 ha post rut range and 24,918 ha high elevation winter range for the Wolverine herd area (McNay et al. 2008). The Chase RPA is 1,733,039 ha situated in steep mountainous terrain ranging in elevation from 671 to 2466 m, and has three major watersheds including the Ingenika, Osilinka, and Mesilinka Rivers. 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. Habitat suitability mapping of the Chase herd area indicated 12,407 ha of pine-lichen winter range, 1,069,999 ha calving and summer range, 16,679 ha post rut range and 59,462 ha high elevation winter range (McNay et al. 2008).

METHODS

Population Surveys

Herd, sample unit, and winter range designations

Sample design and priority for sampling were based on survey units adopted from previous surveys (Giguere and McNay 2007) (Figure 2). Delineation of high elevation range within sample units was based on BEC coverage and included all alpine and parkland zones. The units were an arbitrary accumulation of high elevation ranges bounded by one or several drainages, which made logical breaks between units. The arbitrary choice for these unit boundaries was based on general knowledge of animal ranges, which we acquired over several years of data collection. The rationale for the sample units was based in part on minimizing the possibility of animal movement between units and in part on establishing a reasonably constant effort of approximately 2-3 hours per unit. Selection of sample units was conducted in a manner that would allow for progressive surveys over successive years to cover the entire portion of the

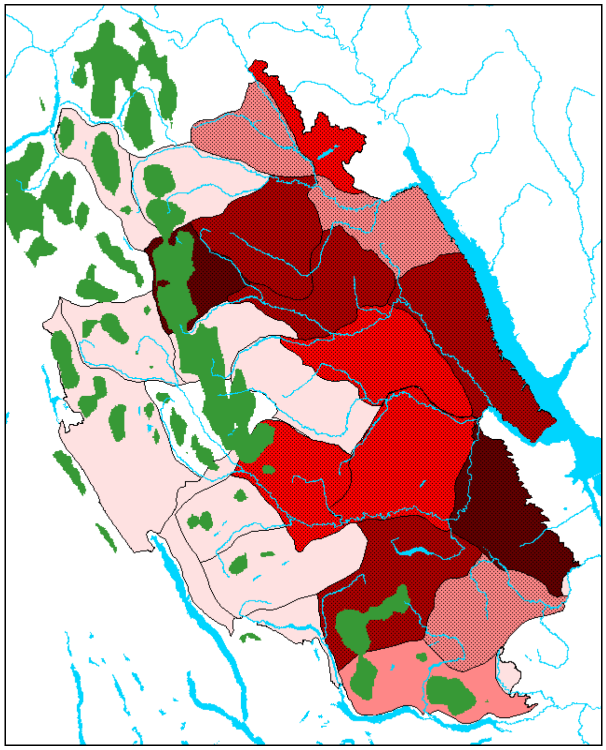

Figure 2. Distribution of area predicted to have deep annual snowfall (green; Wang et al. 2006) in relation to population survey units of varying likelihood of observing woodland caribou in north-central British Columbia (1996-2008). Darker shading indicates higher likelihood of observing caribou.

Mackenzie TSA south of Tsay Keh and north of Mackenzie. Winter range within sample units was stratified into alpine, subalpine, and low-elevation using ArcMap® (Environmental Systems Research Institute, Redlands, California) and confirmed by cross referencing the resultant with observations of elevation, habitat type, and % open area collected during the surveys. Alpine was area >1600 m elevation or parkland area <1600 m elevation with <40 % canopy closure. Low-elevation area was area < 1200 m elevation, and subalpine was defined as the remaining area.

Calf recruitment surveys

We relied on relocations of radio-collared, female caribou to find aggregations of post-calving maternal groups during late spring/early summer and fall. Survey techniques and data collection protocols adhered to the BC RISC guidelines for Aerial-based Inventory Methods for Selected Ungulates (BC MSRM 2002) and for Wildlife Radio-telemetry (BC MELP 1998). The survey was conducted using a Bell 206 helicopter with an experienced pilot. The crew members accompanying the pilots consisted of one navigator and two observers (in the back). Animals were classified according to the level two classifications standards (BC MSRM 2002). For each observation the following was recorded: project name, study area, crew name, survey and census type, date, general location, general weather conditions, animal identification if marked, species, observation time, group number, group size, gender (if possible), age class, if calf observed belong to a marked animal (if calf present), 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 telemetry data form was used for calf recruitment surveys since it was based on re-locating all radio-collared female caribou. Any caribou observed between re-locations of radio-collared females were also recorded as part of the survey.

Late-winter survey

We conducted the late-winter survey of caribou populations in early March in an attempt to coincide the surveys with periods when caribou have the greatest likelihood of being in the alpine. Survey techniques and data collection protocols adhered to the BC RISC guidelines for Aerial-based Inventory Methods for Selected Ungulates (BC MSRM 2002). The modified total count survey was conducted using two Bell 206 helicopters with experienced pilots in rugged mountainous terrain during winter. The crew members accompanying the pilots consisted of one navigator and two observers (in the back) for each helicopter. Inexperienced crew members were well-trained prior the survey and at were always grouped with experience crew members. The navigators used lap top computers with ArcView® (Environmental Systems Research Institute, Redlands, California) and DNR Garmin ArcView extensions[4] to navigate during the survey and record flight lines. This allowed us to ascertain our exact position inside each sample unit, to insure full coverage of the unit, and to provide a means for estimating sampling effort.

Aerial radio-telemetry, for marked animals in the survey areas, was conducted from a fixed-wing aircraft prior to the survey, confirming locations for the marked animals. The information provided guidance to the navigator improving the efficiency of the rotary wing aerial survey. During the survey, only the navigator was aware of the location of radio-collared caribou. Identification of radio-collared caribou by the observers could then be used as an estimate of the ability to detect caribou within varying topographic and vegetation conditions.

The high-elevation portions, alpine and parkland range, of each sample unit were surveyed following contour-based flight lines working upwards in elevation from tree-line unless unfavorable winds were encountered (Figure 3). In relatively gentle terrain with very good visibility, we increased the distance between flight lines (500-800 m) otherwise, in conditions of steeper slopes or lower visibility; flight lines were between 100 and 400 m. Aircraft speed varied from 40-100 mph depending on relative visibility and terrain of each flight line. Height-above-ground ranged from 50-200 m and depended on openness, tree density, and safety of the crew. Subalpine areas were not surveyed even though we knew animals occupied that habitat. The relatively closed-canopy nature of subalpine areas rendered the likelihood of detecting caribou insufficient to conduct a useful or statistically robust survey. Rather, when we observed use of that habitat through telemetry of radio-collared caribou, we sought out their locations, and recorded observations of accompanying animals as best we could. The low elevation portions of each sample unit was surveyed for the most part by following lakes, pine lichen winter ranges[5], black spruce wetlands[7]/meadows, and rivers normally occupied by caribou to verify their absence based on lack of tracks or foraging sign. Data collection

[4] http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html
[5] These range types were delineated using the Caribou Habitat Assessment and Supply Estimator (CHASE) model (McNay et al. 2006).

involved flying systematic transects, spaced 250 - 350 m apart, over the survey polygon (Figure 3). If caribou tracks or foraging were observed, then more effort was spend to try to find animals.

Snow measurements were recorded from seven stations representative of conditions at low-, mid-, and high-elevations in both the Wolverine and Chase herd areas. The high-elevation stations established in the alpine provided data on areas typically used by caribou and were not intended to represent average alpine conditions. At each station, nine points spaced approximately two metres apart along a single line transect were sampled. At each point, measurements of the snow depth and the occurrence/depth of crusts were recorded.

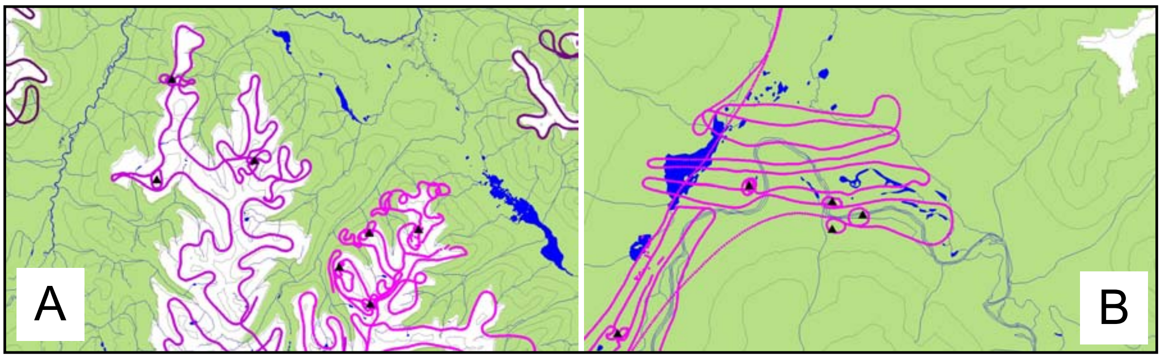

Figure 3. An example of a flight path taken during a survey at high- and low-elevation (A and B, respectively) of selected woodland caribou herds during winter survey in north-central British Columbia. Elevation contours (grey) are 200 m intervals and ▲ represent caribou observations.

Data collection

During surveys, if animal tracks were observed before the animal, effort was spent following them until the animal(s) was sighted. In most of cases, once animals were sighted, the pilot attempted to hover in close proximity but only long enough so animals could be counted and classified with minimal harassment. Animals were classified according to the level two classifications standards (BC MSRM 2002). We did not use level three classifications because most mature bulls had lost their antlers by the time of the survey. Groups were considered to be separate if they were at least 150 m apart, occurred in different habitats, or displayed different group characteristics or behaviors. Marked animals (i.e., ear-tags or collars) were noted and identified. After completing the sample unit, radio telemetry was used to determine if any radio-collared caribou within the survey unit were missed by the observers.

For each observation the navigator recorded, study area surveyed, crew names, aircraft type and speed, survey and census type, date, start and end time for each flight line, UTM coordinate at start and end for each flight line, general location and description of the sample unit, general weather conditions, observation time, UTM co-ordinates, animal identification if marked, marking descriptions (e.g., radio-collar color, ear tag number and color), approximate sinking depth in the snow, and status of detection (whether marked animals were observed or missed during the survey). One of the observers recorded the detailed count and classification for each group of animals observed, including species, group size, gender (if possible), and age class. The second observer recorded habitat features, including slope, aspect, elevation, and habitat type.

Investigating mortalities

Site investigations were conducted as soon as possible after first discovering mortality signals or of observing mortality locations during survey flights. Site investigations included determination of the time of death as well as cause of death. Time of death was 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, or grizzly bear), or (4) unknown. Regarding mortalities classed as predation, assessments of the predator were undertaken where kills made by wolverine were generally recognized by substantial head and/or neck injury and by feeding signs consisting of burrowing into the carcass. Kills made by wolves were generally scattered in a wide area around the site while remains of caribou killed by bears were often buried. 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. Malnutrition was identified by examination of the bone marrow; red, gelatinous bone marrow indicating malnutrition (Cheatum 1949).

Investigating mortalities based on wolf relocations

Site investigations were done at locations identified using data downloaded from GPS collars that were on wolves in the study area. GPS collar information (point locations) was viewed in ArcView and subjectively evaluated for aggregation of points indicating extended use of a site by a collard wolf. The evaluation was based on the spread of the points and movement patterns to adjacent points within an aggregation, and on the caribou/moose range type that the aggregate was located in. In moose range (e.g. wetlands and riparian areas) a grouping of 4 or more points in a 5 to 10 m radius circle indicated a site for investigation. In caribou range groupings of 3 points were used to delineate investigation sites. A sample of sites were visited to verify if a kill had been made or not and to determine species and age class of prey (if available and if sufficient remains were found). If prey remains (e.g., bones, hair, etc.) were found, samples were collected for analysis. A mortality investigation form was completed for all sites visited regardless of findings.

Analytical Methods

All results were summarized in tabular format. Logistic regression was used to estimate annual mortality and to investigate environmental conditions that helped distinguish the binomial condition of a radio-collared animals' fate (i.e., alive or dead).

Data summaries providing basic statistics for population parameters were prepared using SAS (SAS Institute Inc., Cary, North Carolina). An alpha (α) of 0.05 was used for all analysis. Calf recruitment was calculated as a ratio of calves to the total number of animals observed. Estimates of total population followed procedures applied by McNay and Giguere (2008) where a correction factor for the population estimate was based on the proportion of the area done (*pad*) in each habitat strata *j* within each herd area *i* was therefore:

$$pad_i = ai_i * \left(1 + \left(wr_j / su_j\right)\right)$$; where

ai_i was the area habitat index for herd area *i* (either .25 or .35), wr_j was the amount of habitat *j* in the wintering area and su_j was the amount of habitat in the survey unit. Although we created population survey units and habitat strata these were used as domains for summarizing statistics only since none of the surveys had been designed as a stratified random sample.

A detection correction factor (*dcf*) was used to normalize observations based on differing detection rates among habitat strata. The strata-specific *dcf* was calculated as the sum of all radio-collared caribou observed in the strata (without the use of telemetry) divided by the sum of all radio-collared caribou that were monitored within the strata (both with and without the use of telemetry). Due to generally low sample sizes, we pooled all *dcf* estimates across years to calculate a weighted average *dcf*. Within years, we also calculated a population correction factor (*pcf*) to normalize survey observations within a strata based on the proportional use of the strata by radio-collared caribou. Survey observations occurring in the j^{th} habitat strata were then weighted by the combination of these factors as follows:

$$Wt_j = pad_j * \left(1 + \left(1 - \left(dcf_j * pcf_j\right)\right)\right)$$

We obtained weighted estimates of the total population and associated variance using the survey means procedure of SAS. Group size was calculated as a weighted average using the method of Jarman (1982) which we referred to as typical group size. Recruitment of calves into the subsequent age class was assumed to be represented by the sum of percent of calves observed (calves / total number of caribou) in each group (Bergerud 1983). Variance of recruitment was calculated from the binomial distribution using the survey means procedure of SAS.

Standards

A number of standards for the proposed sampling were applied as follows:

- Species Inventory Fundamentals Standards for Components of British Columbia's Biodiversity No.1;
- Aerial-Based Inventory Methods for Selected Ungulates Standards for Components of British Columbia's Biodiversity No. 32;
- Inventory Methods for Wolf and Cougar Standards for Components of British Columbia's Biodiversity No. 34;
- Wildlife Radio-telemetry Standards for Components of British Columbia's Biodiversity No. 5;
- Live Animal Capture and Handling Guidelines for Wild Mammals, Birds, Amphibians & Reptiles Standards for Components of British Columbia's Biodiversity No.3; and

- Voucher Specimen Collection, Preparation, Identification and Storage Protocol: Animals Standards for Components of British Columbia's Biodiversity No. 4a.

RESULTS

Caribou Population Surveys

Calf Recruitment Surveys

Total number of animals observed in the survey during spring post neonatal survey was lower by comparison to both the post summer and late winter surveys, totaling only 105 and 141 animals in the Wolverine and Chase areas respectively. Potential recruitment of calves following the neonatal mortality period was good in both herd areas; it was 30% in the Wolverine and 21% in the Chase area (Table 2). Recruitment, based on calf survival, in both areas dropped through the summer months to 16% in the Wolverine and 14% in the Chase area.

Late-winter Survey

The survey, conducted over a total area of 9,216 km^2, occurred in the Wolverine herd area March 1-3 using 20.2 hours of helicopter support and in the Chase herd area March 3-6 using 30.0 hours; a further 26.4 hours were used for positioning to the survey units. Mean survey effort for alpine, subalpine, and low-elevation ranges in each sample unit of the Wolverine area was 0.88 min/km^2 (se = 0.21, n = 5), 0.52 min/km^2 (se = 0.12, n = 4) and 0.48 min/km^2 (se = 0.37, n = 5), respectively (Table 1). Mean survey effort for alpine, subalpine and low-elevation ranges in each sample unit of the Chase area was 1.03 min/km^2 (se = 0.27, n = 12), 0.76 min/km^2 (se = 0.71, n = 5) and 1.68 min/km^2 (se = 1.46, n = 6), respectively (Table 1).

Our sample area for the Wolverine and Chase herds covered approximately 31% and 41%, of the total herd areas, respectively. We were able to account for 61 of 64 radio-collared caribou known to be in the survey area. In the Wolverine herd areas, more effort was spent surveying high- (At, SAt) rather than low-elevation range (Table 1). In the Chase herd area, roughly equal effort was spent searching high- and low-elevation ranges. During the late winter survey we located 73 groups of caribou totaling 522 individuals (Table 2) distributed throughout the wintering areas. The ratio of caribou bulls to cows for the Wolverine was 47:100 and 42:100 for the Chase (Table 2). The ratio of caribou calves to cows, and calf recruitment, was 22:100 and 13% in the Wolverine area and 21:100 and 14% in the Chase area, respectively (Table 2). In the Wolverine herd area group sizes varied from two caribou to a group of 33 caribou. The typical group size in the Wolverine area was 13 (se = 3.6, n = 5) caribou. In the Chase area, the groups sizes ranged from one caribou to 31 caribou and the typical group size was 13 (se = 3.3, n = 11) caribou. In both herd areas the largest groups were observed in the alpine.

Table 1. Sampling effort used to estimate populations for selected woodland caribou herds during a survey conducted March 2009 in north-central British Columbia.

Herd	Range[3]	[1]RPA Area (km^2)	[1]Herd Area (km^2)	[1]Winter Range (km^2)	Area Surveyed (km^2)	Number of Sample Units	Total Survey Time (min)	Average Effort min/km^2 (se, n)
	At			790	713	4	123	0.88 (0.21, 5)
	SAt			2,977	1,363	2	350	0.52 (0.12, 4)
Wolverine	Low			2,937	1,814	3	739	0.48 (0.37, 5)
	Total	9,590	12,566	6,704	3,890	9	1,212	0.67 (0.15, 14)
	At[2]			2,305	1,903	8	113	1.03 (0.27, 12)
	SAt			2,957	1,147	3	166	0.76 (0.71, 5)
Chase	Low			2,807	2,276	5	739	1.68 (1.46, 6)
	Total	16,346	12,995	8,070	5,326	16	1,258	1.18 (0.46, 23)
Total			**25,561**		**9,216**	**25**	**2,470**	

1 Values were taken from McNay and Giguere (2008).

2 The totals for Chase - At include one observation on 289 ha considered to be outside the winter range area as defined by McNay and Giguere (2008).

3 At = Alpine, Low = Low-elevation, and SAt = area between Alpine and Low-elevation.

The population estimate for the Wolverine herd derived from the late winter survey data was 341 (se = 9.2, n = 36) caribou and the estimate for the Chase herd was 347 (se = 8.3, n = 37) caribou.

Snow depths measured at the snow stations in the Wolverine herd ranged from 50-100 cm (0=74 cm, se=3.5 cm) at valley bottom, to 69-78 cm (0=74 cm, se=1.1 cm) at mid-slope positions, and 7-77 cm (0=33 cm, se=4.2 cm) in alpine. In the Chase herd, the snow depths ranged from 30-108 cm (0=68 cm, se=8.2 cm) at valley bottom, to 75-97 cm (0=91.9 cm, se=2.3 cm) at mid-slope positions, and 2-157 cm (0=62 cm, se=8.3 cm) in alpine. Snow conditions/characteristics were similar in both herd areas and neither had significant new accumulations within the two week period just prior to census activities. The structure of the snow pack at low- and mid-elevation was generally soft loose snow consisting of a mix of powder and wet loose spring snow without significant layers or hard crusts. A weak crust was observed at approximately 18 cm depth at Wolverine stations and approximately 25 cm depth at Chase stations, which did not bear the weight of the surveyors and was easily penetrated with the measuring rod/probe. Sinking depth at the mid- and low-elevations ranged between 24-90 cm for the Wolverine stations and 10-98 cm for the Chase stations. At high-elevation in both herd areas, many slopes were windblown with large areas of bare ground being exposed. Where snow existed, it was hard and compacted from the strong winds and wind crusts were evident at 10-15 cm from the surface.

Table 2. Composition of woodland caribou groups observed during population surveys (PN – post neonatal mortality, PS – post summer mortality, and LW – late winter) and stratified by range type (At = alpine, SAt = area between alpine and low-elevation, and Low = low-elevation) conducted within the Wolverine and Chase caribou herd areas in north-central British Columbia. Table values represent the number of caribou followed by the standard error in parentheses.

Herd	Survey	Strata	Groups (n)	Adult Males	Adult Females	Adult Unknown	Juvenile	Calf	Unknown	Total	Bulls/100 Cows	Calves/100 Cows	% Calves
Wolverine	PN	At	18	4(0.4)	38(1.7)	0(0)	1(0.2)	18(1.2)	0(0)	61(2.5)	11(5.9)	47(8.8)	30(4.3)
		SAt	16	0(0)	19(0.4)	0(0)	0(0)	7(0.5)	0(0)	26(0.7)	0(0)	37(10.5)	27(5.6)
		Low	3	1(0.6)	11(4.6)	0(0)	0(0)	6(3.5)	0(0)	18(8.6)	9(2.5)	55(14.9)	33(5.6)
		Total	37	5(0.3)	68(1.8)	0(0)	1(0.2)	31(1.3)	0(0)	105(3)	7(3.2)	46(6.4)	30(3.1)
	PS	At	2	1(0.7)	5(0.7)	3(0.7)	0(0)	3(0.7)	0(0)	12(2.8)	20(16)	60(8)	25(0)
		SAt	8	7(1)	14(0.7)	23(1.4)	0(0)	10(1)	0(0)	54(2.6)	50(22.9)	71(12.9)	19(4)
		Low	18	28(1.5)	28(1.3)	51(5.1)	0(0)	18(1.8)	0(0)	125(7)	100(36.7)	64(21.2)	14(3.5)
		Total	28	36(1.3)	47(1.1)	77(4.2)	0(0)	31(1.6)	0(0)	191(5.9)	77(21.6)	66(13)	16(2.4)
	LW	At	17	35(2.3)	86(7.5)	0(0)	0(0)	20(1.5)	0(0)	141(10.3)	41(11.6)	23(4.8)	14(2.4)
		SAt	7	9(2.3)	17(2.5)	0(0)	0(0)	3(0.8)	0(0)	29(5.0)	53(24.3)	18(11.6)	10(6.4)
		Low	12	17(2.2)	26(2.9)	10(1.5)	0(0)	6(0.8)	1(0.3)	60(5.3)	65(33.9)	23(8.7)	10(3.3)
		Total	**36**	**61(1.8)**	**129(4.9)**	**10(0.9)**	**0(0)**	**29(1.0)**	**1(0.2)**	**230(6.5)**	**47(11.1)**	**22(3.8)**	**13(1.8)**
Chase	PN	At	32	12(1)	85(2.1)	3(0.4)	6(0.4)	27(0.9)	0(0)	133(3)	14(7.2)	32(5.4)	20(2.8)
		SAt	4	0(0)	4(0)	0(0)	0(0)	2(0.6)	0(0)	6(0.6)	0(0)	50(28.9)	33(12.8)
		Low	1	0(0)	1(0)	0(0)	0(0)	1(0)	0(0)	2(0)	0(0)	100(0)	50(0)
		Total	37	12(0.9)	90(2)	3(0.4)	6(0.4)	30(0.8)	0(0)	141(2.8)	13(6.8)	33(5.3)	21(2.7)
	PS	At	8	21(3.7)	25(2.6)	12(2.2)	2(0.7)	9(1.1)	0(0)	69(7.1)	84(39.5)	36(15.8)	13(6.2)
		SAt	21	21(0.9)	61(1.3)	20(1.4)	1(0.2)	17(0.9)	0(0)	120(3)	34(7.5)	28(6.6)	14(2.7)
		Low	3	5(1.2)	7(2.1)	1(0.6)	0(0)	3(1)	0(0)	16(3.8)	71(39.8)	43(7.1)	19(4.7)
		Total	32	47(2)	93(1.8)	33(1.6)	3(0.4)	29(0.9)	0(0)	205(4.4)	51(12.2)	31(5.9)	14(2.6)
	LW	At	15	29(2.6)	98(8.4)	0(0)	0(0)	24(2.2)	0(0)	151(11.4)	30(11.1)	24(4.8)	16(2.8)
		SAt	7	4(0.7)	32(4.9)	7(1.7)	0(0)	5(1.0)	0(0)	48(7.0)	13(5.7)	16(6.9)	10(3.8)
		Low	15	17(1.7)	63(4.5)	2(0.5)	0(0)	11(1.0)	0(0)	93(6.5)	27(9.1)	17(3.5)	12(2.4)
		Total	**37**	**50(1.8)**	**193(4.9)**	**9(0.8)**	**0(0)**	**40(1.4)**	**0(0)**	**292(6.4)**	**42(9.4)**	**21(2.9)**	**14(1.8)**

[a] % Calves does not include "Unknown" animals.

Wolf Movements Surveys

Relocations from four GPS collars were downloaded over the course of the three survey field sessions providing 5504 relocation points. Two collars (W052W and W057W) were from animals in the Wolverine herd area providing 1288 relocations stored in the collars from March through June 2009. The relocations from these two collars corresponded well with the boundaries delineated as common wolf use areas by McNay et al. (2009a). W052W was found to use mostly the MAN_R common wolf use area and W057W used the common wolf use area identified as both OMI_M and OMI_B (McNay et al. 2009a). The two animals with collars that were located in the Chase herd area (W060S and W061C) both ranged across multiple common wolf use areas. A total of 4216 relocations were collected which represented wolf positions for the entire year (March 2009 to March 2010). These two collared animals heavily used SWA_H and SWA_R common wolf use areas. A few additional points were also located in common wolf use areas ING_I, MES_F and to the west near Sustut Lake in an area not zoned by McNay et al. (2009a). The collared wolves in the Chase area appear to utilize the alpine to a greater extent than the Wolverine animals, but one of the Wolverine wolves appears to make use of low elevation caribou winter range (Table 3). The use of the range type represented by the relocations corresponds well with relative presence of each habitat type in each of the common wolf use areas.

Table 3. Wolf GPS collar relocations summarized by caribou range types.

Collar ID	High Elev Alpine Relocations	High Elev Alpine (%)	Low Elev Winter Range Relocations	Low Elev Winter Range (%)	Non Winter Range[1] Relocations	Non Winter Range[1] (%)	Total Relocations
W052W	0	0	6	0.8	785	99.2	791
W057W	32	6.4	202	40.6	263	52.9	497
W060C	917	34.4	90	3.4	1659	62.2	2666
W061C	557	35.9	37	2.4	956	61.7	1550

[1] Included forests in the sub-alpine, and low elevation non winter range areas.

Mortality investigations

Nine collared caribou and three collared wolves were killed between March and November of 2009. In addition to these 12 mortalities, site investigations were conducted at 11 other sites for a total of 23 mortality site investigations. The locations of the additional 11 sites were derived using wolf GPS collar data. Of the 11 sites not associated with caribou or wolf collars, two were caribou mortalities, five were moose mortalities, two were large mammal mortalities that could not be identified to the species level (generally due to access restrictions), and two sites were visited based on aggregations of wolf GPS collar data, but signs of a mortality were not found (Table 4). Relative to all mortalities investigated, caribou mortalities were most frequent in March and April (7 of 11), and wolf mortalities generally occurred in the last half of April and the first half of May (3 of 3). Predation was found to be the primary cause of mortality for collared caribou (six by wolves, one by grizzly bear, and two unknown predators). One caribou collar was located in the middle of an alpine lake and could not be thoroughly investigated, thus the cause of mortality was classed as unknown (Table 4). The rate of mortality for collared caribou during the peak mortality period (March through June) was 11% in each of the herd areas.

Table 4. Summary of the species found during mortality investigation by herd area and the number of locations associated with collared animals, where the value in parentheses is a subset of the total for each classification.

		Number of Sites Investigated				
Herd Area		Caribou	Moose	Wolf	Unknown	No Mortality
Wolverine	Total	5	4	3	1	
	(collars)	*(4)*		*(3)*		
Chase	Total	6	1		1	2
	(collars)	*(5)*				
Total	Total	11	5	3	2	2
	(collars)	*(9)*		*(3)*		

DISCUSSION

Fixed wing telemetry flights, conducted just prior to the late winter census (February/March) indicated relatively large proportions of radio collared caribou were at lower elevations using forests in the subalpine and low elevation ranges. This information was used to guide the late winter census approach where full surveys of low elevation ranges were implemented. Compounding the difficulties associated with undertaking a survey in forested conditions, was a lack of fresh snow for a period of more than two weeks prior to the census. Our typical survey approach involves conducting aerial survey transects over low elevation range areas with the highest likelihood of having caribou present. When tracks are observed, the survey search pattern is modified to determine if animals can be found. In a year like this one, the lack of fresh snow made tracking very difficult as there were too many old tracks to allow for differentiation between the multiple sets, thus, several animals in both herd areas had to be located by radio telemetry. These animals were recorded on separate data sheets from the survey areas so they would not be considered for updated calculations of the *dcf* used to calculate population estimates (McNay and Giguere 2008).

The population estimates from this year are in line with findings from previous surveys though variation between the years is evident (Table 5). Variation results from several factors related to the seasonal movements of the caribou and the timing of the surveys. During the late winter survey this year we noticed that both the alpine and low-elevation winter range areas were heavily tracked by caribou; however, the animals had moved on. Had the survey timing been adjusted a week or more earlier, the count could likely have been much different. Unfortunately there is no cost effective method to predict precise movements of caribou on a monthly basis, thus, all that can be done is to select the optimum period for surveys based on the most regular patterns observed by caribou. The conditions of the snow pack and general weather conditions impact caribou range selection (Johnson 2000, Cichowski 1993, Adamscewski 1988). This year average

Table 5. Selected population parameters from previous surveys of caribou in the Wolverine and Chase herds of north-central British Columbia.

Recovery Planning Area	Year	Total Counted	Calves/100 Cows	Calves/% of Pop.	Bulls/100 Cows	Reference
Wolverine	1989	214 [b]	26	16	34	Hatler 1989
	1996	204[b]	19	10	68[c]	Wood 1996
	1999	91	31	14	74[c]	Hengeveld and Wood 2000
	2000	115[a]	14-15	07	42	Zimmerman et al. 2000
	2001	134 [a]	26-30	12	62[c]	Zimmerman et al. 2001
	2002	152 [a]	44-58	24	44	Zimmerman et al. 2002
	2004	205 [a]	31-44	19	46	Wilson et al. 2004
	2007	356 [a]	34	15	66	Giguere and McNay 2007
	2008	340 [a]	26	14	50	Giguere and McNay 2008
	2009	378[a]	50	11	50	McNay et al. 2009b
	2010	341[a]	22	13	47	
Chase	1993	397 [b]	34	17	51	Corbould 1993
	2000	127 [a]	19	12	32	Zimmerman et al. 2000
	2001	174 [a]	34-37	16	76[c]	Zimmerman et al. 2001
	2002	225 [a]	38	12	68[c]	Zimmerman et al. 2002
	2007	431 [a]	31	14	72	Giguere and McNay 2007
	2008	335 [a]	36	18	49	Giguere and McNay 2008
	2009	475[a]	29	15	42	McNay et al. 2009b
	2010	347[a]	21	14	42	

a – attempted full counts (assuming current recovery planning areas)
b – relatively severe winter weather compared to average
c – suspect ratio of males to females which could alter the calf/100 cow estimate

snow depths at low-elevations appeared lower than previous years, in addition indications were that the mean winter temperature was warmer. Many rivers in the study area had patches that were ice free, and even the ice thickness on the Omineca River at Germansen Landing, which is typically 60 cm thick around the beginning of March was only 40 cm thick this year (Scott Muller pers. com., March 7, 2010). Warmer weather and less restrictive snow conditions this year likely resulted in more suitable range throughout the herd area such that animals were not forced to high elevation winter ranges during the census survey.

The four wolf collars that provided GPS relocations helped confirmation of the common wolf use areas depicted by McNay et al. (2009a). The movements observed by the wolves in the Wolverine herd area coincide well with boundaries for two individual common wolf use area. The two collared animals in the Chase herd area, however, which were assumed to be from the same pack showed heavy use of two adjacent common wolf use areas. It is very possible that these two areas, SWA_H and SWA_R represent a single common wolf use area and redefinition of the boundaries should be considered. This annual summary though did not incorporate previous years data, which would be required for redefinition of any areas.

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