Status of the Chisana Caribou Herd 2002

June 2002

Richard Farnell and Craig L. Gardner

Status of the Chisana Caribou Herd
2002
Yukon Fish and Wildlife Branch
TR-03-01

Acknowledgements
We thank the White River and Kluane First Nations and the Yukon Fish and Wildlife Management Board for supporting this study.
A. Baer, C. Domes, D. Drummond, K. Egli, M. Kienzler, G. Kuzyk, L. Laberge, L. LaRocque, R. Leef, M. Oakley, K. Zittlau, assisted with field studies.
Pilots C. Drinnan, D. Drinnan, D. Washington, P. Zaczkowski, flew safely often in difficult conditions.
An earlier draft was improved by suggestions from J. Carey and M. Oakley.

Yukon
Environment

Status of the Chisana Caribou Herd
2002

Richard Farnell
Yukon Fish and Wildlife Branch

Craig L. Gardner
Alaska Department of Fish and Game

Director, Yukon Fish and Wildlife Branch

Chief, Wildlife Management Section

Table of Contents

List of Figures

List of Tables

List of Appendices

Introduction

The Chisana Caribou Herd (CCH) is a small, rapidly declining caribou herd that ranges across the Yukon–Alaska border. The herd inhabits east-central Alaska and southwest Yukon (Fig. 1). The governments of Yukon and Alaska have agreed that it is essential to develop a recovery plan for this herd. This report summarizes the information that biologists and co-management boards need to develop a management strategy to protect and conserve the CCH.

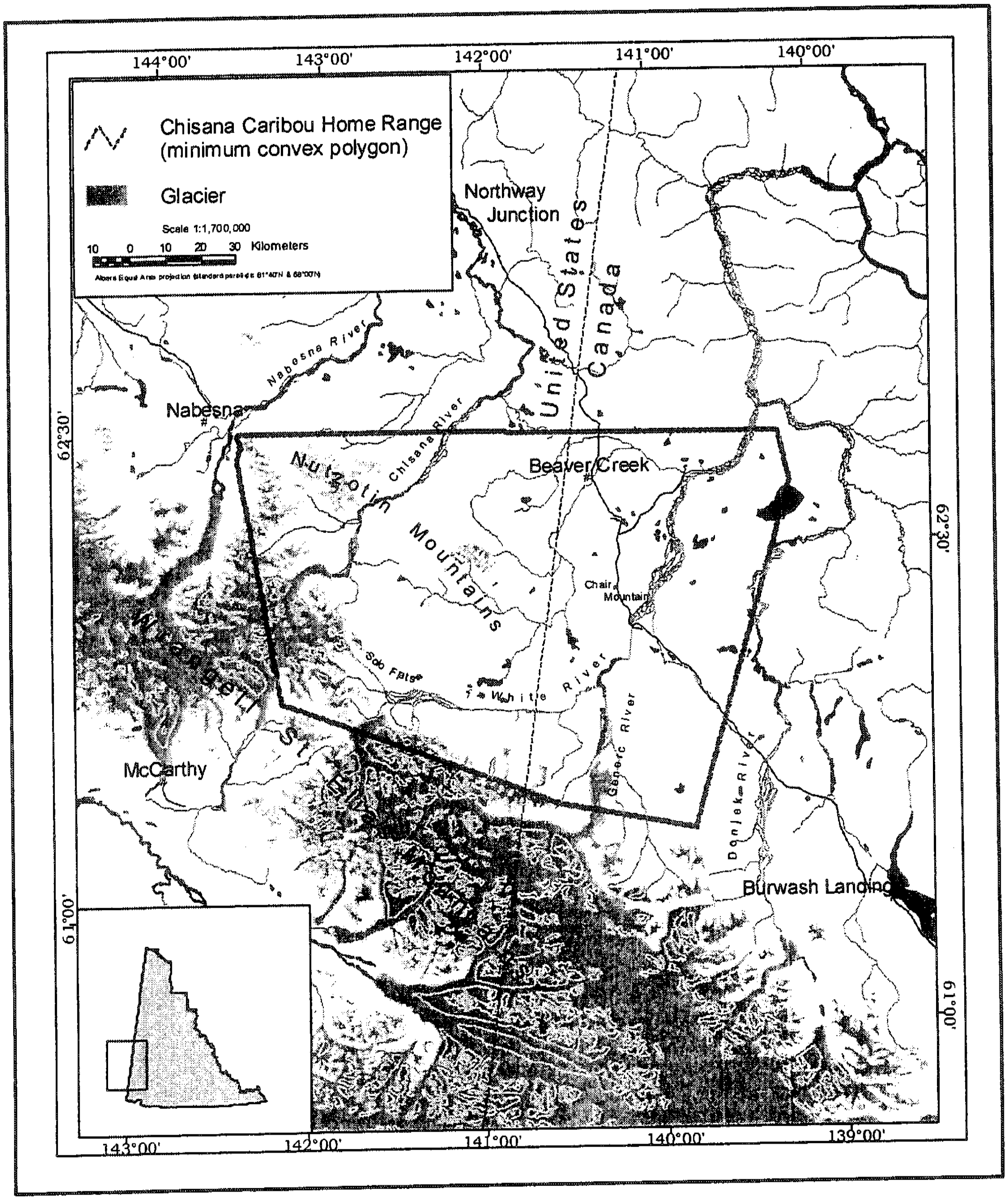

Figure 1. Location of the Chisana Caribou Herd in Yukon and Alaska

Who is involved

Many government agencies and First Nation governments play a role in planning for the recovery of the CCH.

In Alaska they include:

- the Alaska Department of Fish and Game (ADF&G);
- the National Park Services (NPS);
- the Tetlin National Wildlife Refuge; and
- the Northway Tribal Village Council.

In the Yukon they include:

- the Yukon Department of the Environment (YDE);
- the White River First Nation (WRFN);
- the Kluane First Nation (KFN); and
- the Yukon Fish and Wildlife Management Board.

The Klutlan Plateau region of Kluane Wildlife Sanctuary (from the Alaska border to the Donjek River) is a significant portion the herd's winter range and is presently under negotiation as a special management area within the WRFN and KFN land claims agreements.

Where the information comes from

Biologists from Yukon and Alaska have been studying the CCH since 1989. They have gathered information about the CCH's size, reproduction, physical condition, herd management, herd range and climate and terrain in the range area.

Interested parties have held 2 workshops to discuss CCH management. Fifteen biologists from Yukon and Alaska attended the first, a research and management planning workshop on July 14, 1999 in Tok, Alaska. Then, on June 11 and 12, 2001, the White River First Nation hosted a local knowledge workshop in Beaver Creek, Yukon. Present at the workshop were representatives of the YDE, ADF&G, the Tetlin National Wildlife Refuge, and the Northway (Alaska) Tribal Village Council. A number of cross-border fish and wildlife management concerns were discussed and in particular, the population status of the CCH. Community members and elders from Beaver Creek and Northway shared their knowledge of the herd's movements, habitat use and population fluctuations. Most information was taken in map form and discussion notes. In general the scientific knowledge of the CCH was found to conform to local knowledge about the herd and accepted as a good information base with which to proceed.

This report reviews cooperative monitoring work on the herd from 1987 to 2002 and summarizes background information about the herd, caribou and wolf population studies, caribou radio collar relocation data, caribou physical condition studies, genetics information, caribou range and climatic conditions, an assessment of limiting factors, First Nation traditional knowledge, and management options. It presents information on herd movements, wolf predation and provides an update on the recovery planning process.

Workshop participants:

- reviewed the technical information about the herd;
- discussed factors which might limit the population;
- determined whether these factors are reversible;
- examined the likelihood of extinction;
- identified which parameters should be monitored; and
- reviewed possible management options.

This report brings together the results of those workshops and more recent technical information.

Herd background information

Human use of the herd:

Few people in Alaska or Yukon depend on Chisana caribou as their primary source of food. Most harvesting has been by 4 Alaskan and 1 Yukon big game outfitter. Harvest size has ranged from 13 to 65 male caribou in Alaska and 6 to 15 male caribou in Yukon.

Because of the herd's decline, all licensed hunting of Chisana caribou has been prohibited in both jurisdictions since 1994. In 2002, the herd was designated a *species at risk* in Yukon under Specially Protected Wildlife regulation of the *Yukon Wildlife Act*. All forms of harvest from the herd are now legally prohibited.

Herd identity:

The CCH inhabits east-central Alaska, U.S.A. and southwest Yukon, Canada (Fig. 1). The herd summers almost entirely in Wrangell–St. Elias National Park and Preserve in Alaska and winters in Yukon within Kluane Wildlife Sanctuary and Alaska within the Preserve. During the winters of 1989 to 1995 the herd was known to periodically intermingle with about 50–100% of the larger Nelchina herd (40,000–45,000 animals; Hughes 1995).

The classification of the CCH is presently uncertain. In Canada the CCH falls under the classification of woodland caribou (*Rangifer tarandus caribou*). Across the international boundary they are lumped with all other Alaskan herds and classified as barren-ground caribou (*R. t. granti*) (Banfield 1961). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designates them, along with all other woodland caribou of Yukon and northwestern British Columbia, as Northern Mountain ecotype based on ecological behavior (Thomas and Gray 2002).

Molecular DNA analyses have prompted some re-thinking of their classification (Zittlau et al. 2000). There is now increasing recognition that there are at least 2, not 1, subspecies in Alaska (Valkenburg 2001). Information on the genetic status of the CCH using microsatellite DNA analysis indicates that CCH are a genetically distinct population exhibiting different msDNA far distant from that of adjacent caribou herds in Yukon and Alaska (this report). We recognize, however, that some overlap of range with the Nelchina herd in the winter before 1995 could have resulted in a small degree of emigration or immigration.

The Chisana Caribou Herd is a genetically distinct population

The CCH appears to be a biologically distinct population from other herds. The herd acts and looks like Yukon woodland caribou. They conform to typical patterns of distribution of woodland caribou, being highly dispersed at calving (Fig. 1) (Farnell et al. 1996), rather than aggregated on traditional calving grounds (a characteristic of barren-ground caribou; Skoog 1968). Furthermore, their body size characteristics are similar to that of woodland caribou and are much larger in stature than most barren-ground caribou (Kuzyk et al. 1999).

Herd range:

The range of the herd is within the St. Elias ecoregion (Ecological Stratification Working Group 1995). This area is characterized by rugged and glaciated mountains with many peaks rising to 2,500 m. The herd's range is drained by the Donjek, Generc, White, Chisana, and Nabesna rivers. Treeline generally occurs at 1,050–1,200 m. White spruce (*Picea glauca*) dominates well-drained soils, while stunted black spruce (*Picea mariana*) is common on poorly drained sites. Paper birch (*Betula papyrifera*), aspen (*Populus tremuloides*), and balsam poplar (*P. balsamifera*) are found in warmer lowland areas. Lodgepole pine (*Pinus contorta*) does not occur. Willow (*Salix* spp.) dwarf birch (*Betula* spp.) soapberry (*Shepherdia canadensis*), and ericaceous shrubs dominate understory, riparian, and subalpine regions. Sedge–tussock fields are common in poorly drained sites and gentle slopes. Steeper slopes give way to alpine forbs, ericaceous shrubs, grasses, and lichens.

The CCH is an important component of the area's ecosystem. Together with moose, sheep, and smaller prey they help support a diverse mix of predators and scavengers including wolves, brown bears, black bears, golden eagles, foxes, coyotes, and wolverines. All are important to the functioning of a natural ecosystem that includes humans.

Predators:

Major predators of the CCH include wolf (*Canis lupus;* 5.6/1000 km^2 (this report)) and brown bears (*Ursus arctos;* 16–18/1000 km^2 (C. Gardner, unpublished data)). Lynx (*Lynx canadensis*) and coyote (*Canis latrans*) are temporarily abundant coincident with snowshoe hare population trends. Both lynx and coyote were abundant during 1990–1992 and 1998–2000 but crashed (O'Donoghue et al. 1997) following the snowshoe hare (*Lepus americanus*) decline (Boutin et al. 1995). Wolverines (*Gulo gulo*) were present at unknown densities. Golden eagles (*Aquila chrysaetos*) are known to nest in the study area (Windsor 1979). Moose (*Alces alces*) and sheep (*Ovis dalli*) are alternate prey species to caribou in the CCH range.

Other ungulates:

Moose density was estimated at 230/1000 km^2 in 1998 (C. Gardner, unpublished data) and sheep density was 1.05/km^2 of habitable sheep range (Sumanik 1987).

Area climate:

The CCH range is within the St. Elias Mountains rainshadow and is classified as a dry, cold, continental climate, receiving an average of 32 cm of annual precipitation. Annual snowfall averages approximately 115 cm in Burwash Landing and 132 cm at Beaver Creek. Mean annual temperature is -4.4°C at Burwash Landing and -6.6°C at Beaver Creek.

Caribou population studies

ADF&G, YDE, and NPS began a cooperative study of the CCH in 1987. Initially, we fitted only adult female caribou with conventional radio collars. We used telemetry to monitor the herd's seasonal movements and facilitate annual composition counts, population estimates, and estimates of birth rates and adult mortality. Since 1987 both adult female and calf caribou have been radio-collared to maintain a sample of 10–25 animals.

Seasonal movements:

We found that the CCH ranges within a 13,200-km^2 area (minimum convex polygon) on the north side of the ice-capped St. Elias Range (Fig. 2). The geography of this area tends to funnel caribou movements in a northwest-southeast alignment. In May, the herd is dispersed in the Alaska uplands portion of their range for calving. During the post-calving period (June–July), they aggregate into larger groups, mostly in the Solo Flats area and Flat Creek drainage of

Alaska. From calving to the rut, about 80–90% of collared caribou were found in Alaska. Caribou are usually found near summering–wintering areas during the fall breeding season. During winter much of the CCH tends to move into lowland spruce forest in the Yukon portion of their range; about 70% of collared caribou were found there each winter.

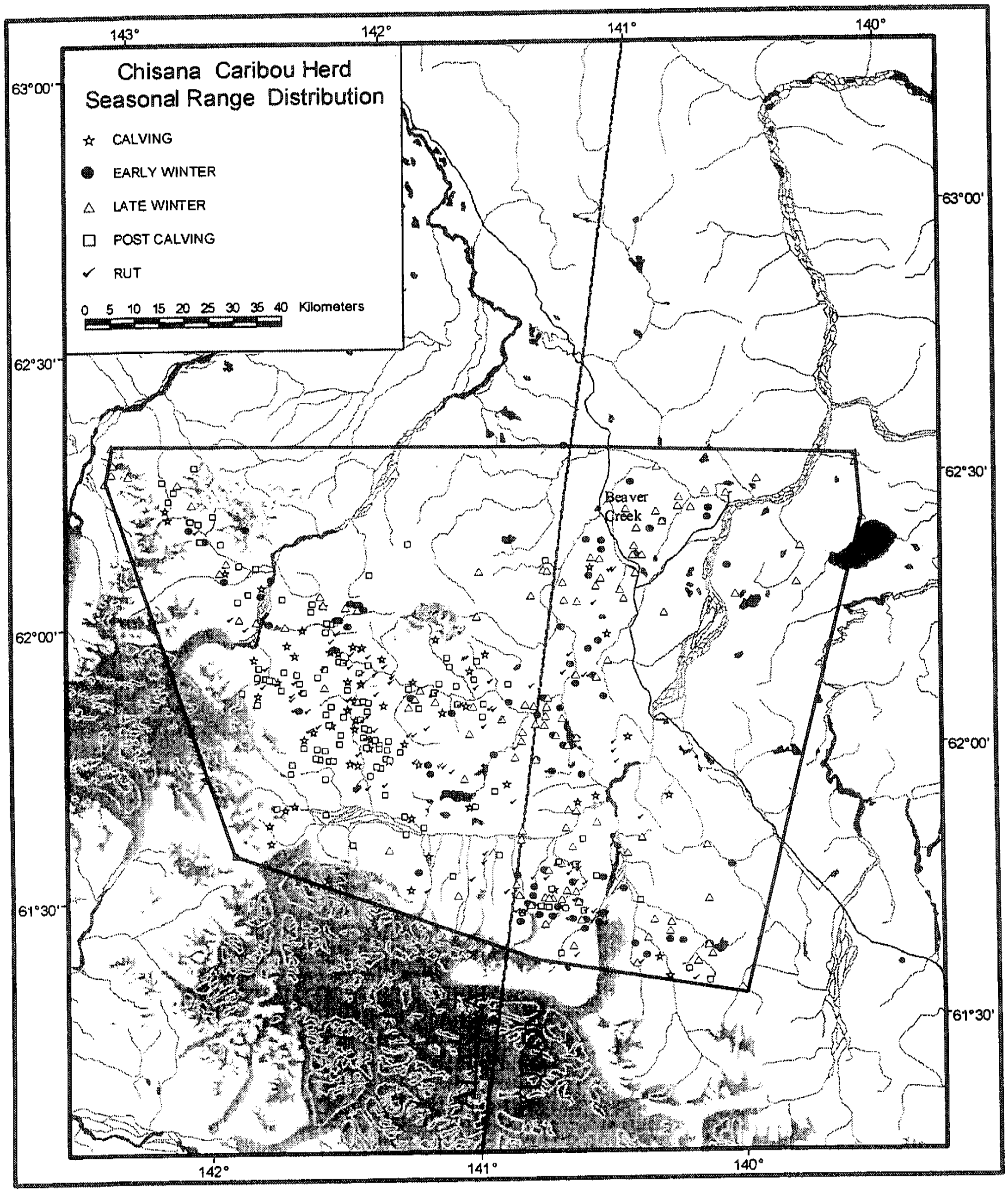

Figure 2. Chisana herd radio relocations 1987 - 2002.

An oral history of the arrival of the Nelchina herd

An oral history account (D. Eikland) of particular interest pertains to the unusual arrival of the Nelchina herd into the Beaver Creek area in recent years. Traditional knowledge points out that this is not the first time this large caribou herd has wintered in the area, as they were also common for a few years in the early 1960s. These range expansions seem to be related to periods when the herd is at high population levels and in need of new lichen pastures. It is likely a long-term recurring event spanning many decades and falls outside the scope of scientific studies that have accumulated knowledge only within the last couple decades.

A number of CCH winter locations, well north of their traditional winter range, are unusual and coincide with winters when the much larger Nelchina herd was present (1989–1995). Both herds likely intermingled at least in 1994 when 4 of 16 caribou radio collared caribou were later found on the Nelchina herd calving grounds and thereafter remained on Nelchina herd range. We suspect that these were Nelchina herd individuals that were inadvertently captured and not individuals emigrating from the CCH. This incident was an exception, as regular telemetry flights on both herd ranges did not document any case of exchange between these caribou populations. Periodic range overlap between migratory and sedentary caribou has been documented elsewhere as have anomalous movements likely caused by social facilitation (group pressure) (Farnell and Russell 1984, Davis et al.1986, Schaefer et al. 1999, D. Cooley, YDE, Dawson City, unpublished data, R. Boertje and C. Gardner unpublished data).

Composition counts and population estimates:

We did population composition surveys each year during late September or early October 1987–2001. Timing of these surveys coincides with the rut when the herd is aggregated and we can obtain a minimum herd count. We also counted the herd during June 1989–1995 and 1997 when the herd forms post-calving aggregations. If the herd was not aggregated sufficiently to obtain an accurate count in summer or fall, we estimated the herd size using a computer model (P. Valkenburg and D. Reed, ADF&G, Fairbanks, unpublished data). We estimated the annual rate of population change using the methods of Hatter and Bergerud (1991). Each October 1987–2001 we observed an estimated 35–100% of the caribou to determine calf recruitment (calves per 100 cows) and adult sex ratio (bulls per 100 cows).

In 1989 the CCH numbered about 1800 animals but then began an abrupt, unbroken population decline. By 2001 the herd numbered an estimated 360 animals (Fig. 3). The annual rate of decline was 11% from 1989 to 1992 but in 1992–1993 it experienced a drastic decline of –31.5%. Thereafter the herd had a fairly continuous annual rate of decline of 10.4%.

Estimates of calf recruitment:

The calf recruitment rate dropped from 28 calves/100 cows in 1987 and 39/100 in 1988 to 8/100 in 1989 and thereafter remained at less than 14/100 – averaging 6/100 over the same period as the decline (Fig. 3). The most pronounced year of poor calf survival was 1992 when only 1 calf was observed among the 1142 caribou tallied that fall. Extremely poor calf survival was the primary cause for the 80% loss in numbers over a 12-year period.

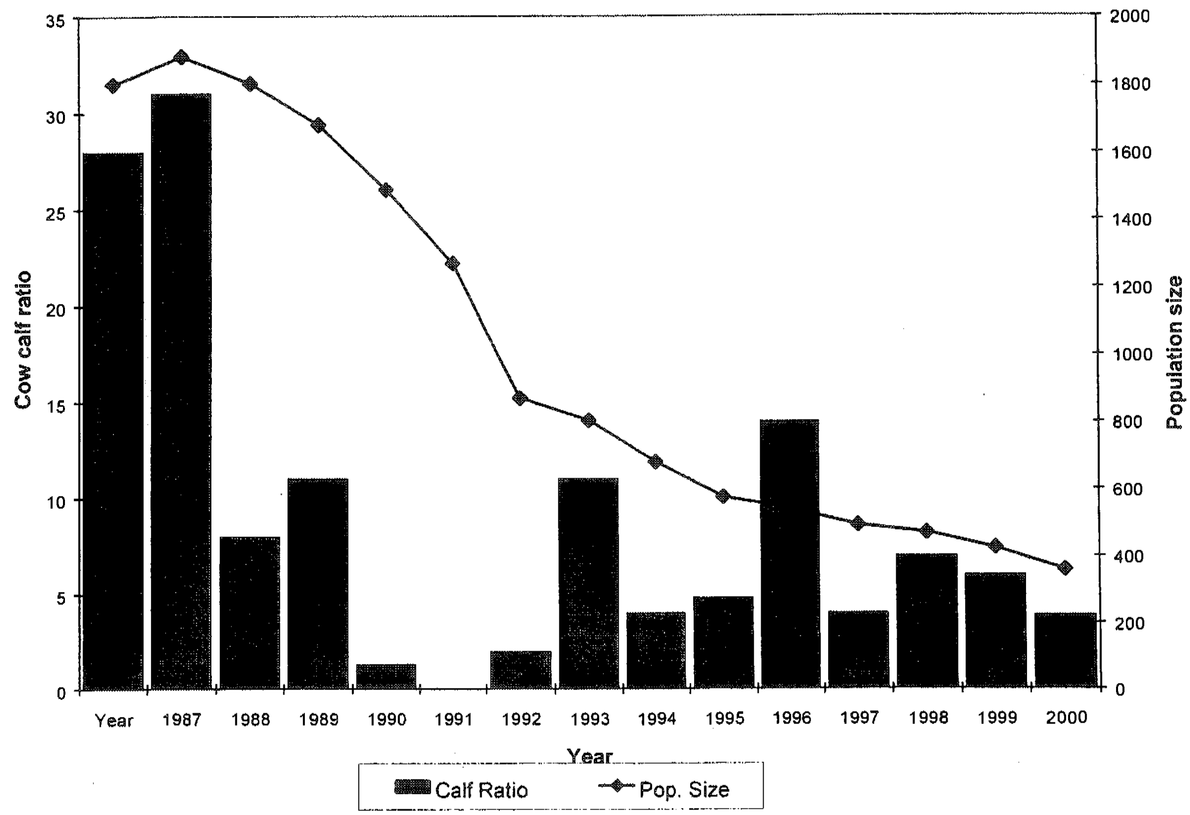

Figure 3. Population characteristics of the Chisana caribou herd.

Estimates of adult sex ratio:

As the herd declined from lack of replacement from calves so did the sex ratio. The sex ratio averaged 36.4 bulls /100 cows from 1987 to 1992 and thereafter averaged 21.2/100. In 1999 the sex ratio declined to 17.2/100 cows, the lowest sex ratio ever recorded in Yukon (R. Farnell, unpublished data). A very low sex ratio raises the concern that pregnancy rates may decline or calf survival may be compromised because there are too few bulls resulting in more breeding during second estrous.

Estimates of adult cow mortality:

We recorded 865 contacts with radio collared caribou and used the Kaplan-Meier survival estimator (Pollock et al. 1989) to calculate annual survival rates. We did not attempt to determine the causes of death for radio-collared caribou. Prior to the declining trend in 1989 adult survival averaged 83% (range 73–91%) (Fig. 4). During the declining phase survival was variable and decreased somewhat to an average of 79% (range 65–94%). The lowest years of adult survival were 1990 (65%), followed by 1992 and 2001 (67%).

A decreasing survival trend from 1998 to 2001 is apparent and of particular interest because it follows 9–12 years of extremely poor calf survival and population decline. The average age of adult females in the CCH is rapidly approaching the ecological longevity record of caribou (17 years) (Miller 1982) as a result of poor recruitment. We suspect that the low survival rate (67%) in 2001 is the beginning of a rapid die-off of old age females as their age-related vulnerability to predation increases.

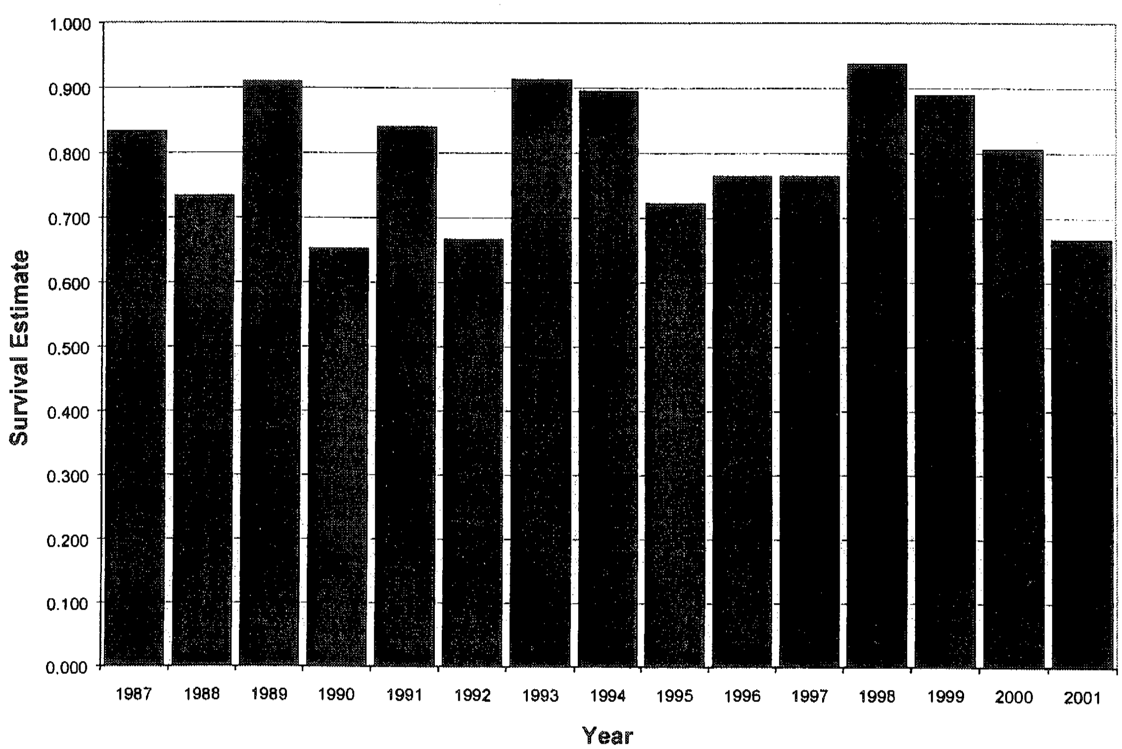

Figure 4. Adult cow survival estimates for the Chisana caribou herd 1987-2001

Population projection modeling:

We used a simple arithmetic model (P. Valkenburg and D. Reed, unpublished data) with the demographic information we collected to run population projections on the CCH. In this way we can predict possible outcomes and assess the relative importance of changes in harvest, adult survival and recruitment in producing the overall response in population trend. We first assumed the observed trend will continue with an annual adult survival rate of 70% for cows and 60% for bulls with no harvest by humans.

We predicted that if calf recruitment continues to average 6/100 the CCH would be headed for near extirpation by 2010 when only 16 cows, 1 calf and 2 bulls remain. With this scenario the herd functionally extirpates in 2016 when there are only 3 cows and no bulls remaining. The model also predicts that it will take an annual adult survival rate of 85% for cows and 80% for bulls with a 27/100 calf-cow ratio for the herd to stabilize. This calf and adult survival pattern is consistent with other observations of stability conditions for Yukon's Wolf Lake (Hayes et al. in press.) and Finlayson (R. Farnell, unpublished data) caribou herds and seems a reasonable scenario.

Wolf predation:

Predation by wolves is a primary force limiting caribou in Alaska (Gasaway et al. 1983, 1992; Ballard et al. 1987; Boertje et al. 1996) and Yukon (Gauthier and Theberge 1985, Farnell and McDonald 1988, Hayes et al. in press.). We looked for changes in wolf density relative to the CCH decline. Wolf numbers are not limited by trapping or hunting in the CCH range and their density should correlate with prey density or biomass (Keith 1983, Fuller 1989, Gasaway et al. 1992).

We estimated wolf numbers in February 2001 over a 19,000-km^2 area encompassing the entire range of the CCH (Fig. 5) using aerial snow-tracking methods (Stephenson 1978). Experienced observers using 2 fixed-wing aircraft searched the complete area. Wolf trails in the snow were followed until the wolves were seen or an estimate of the number of tracks was possible. We compared our results with previous wolf surveys in the Yukon side of the CCH range in 1986 (9,800 km^2) (Sumanik 1987) and in 1989 (12,820 km^2) (A. Baer, Yukon Environment unpublished data), the first winter the Nelchina herd arrived in the area. Wolf density in the CCH range has not changed since the late 1980s, indicating a lack of wolf numerical response to decreasing caribou. In 2001 we estimated the wolf population in the survey area was 106 wolves, or a density of 5.6 wolves/1000 km^2. There were an estimated 20 packs with a mean pack size of 4.8 wolves and an overall pack density of 1.1 packs/1000 km^2. In 1986 the wolf density for much of this area was 6.7 wolves/1000 km^2 and mean pack size was 4 wolves. In 1989 wolf density was 5.6 wolves/1000 km^2, mean

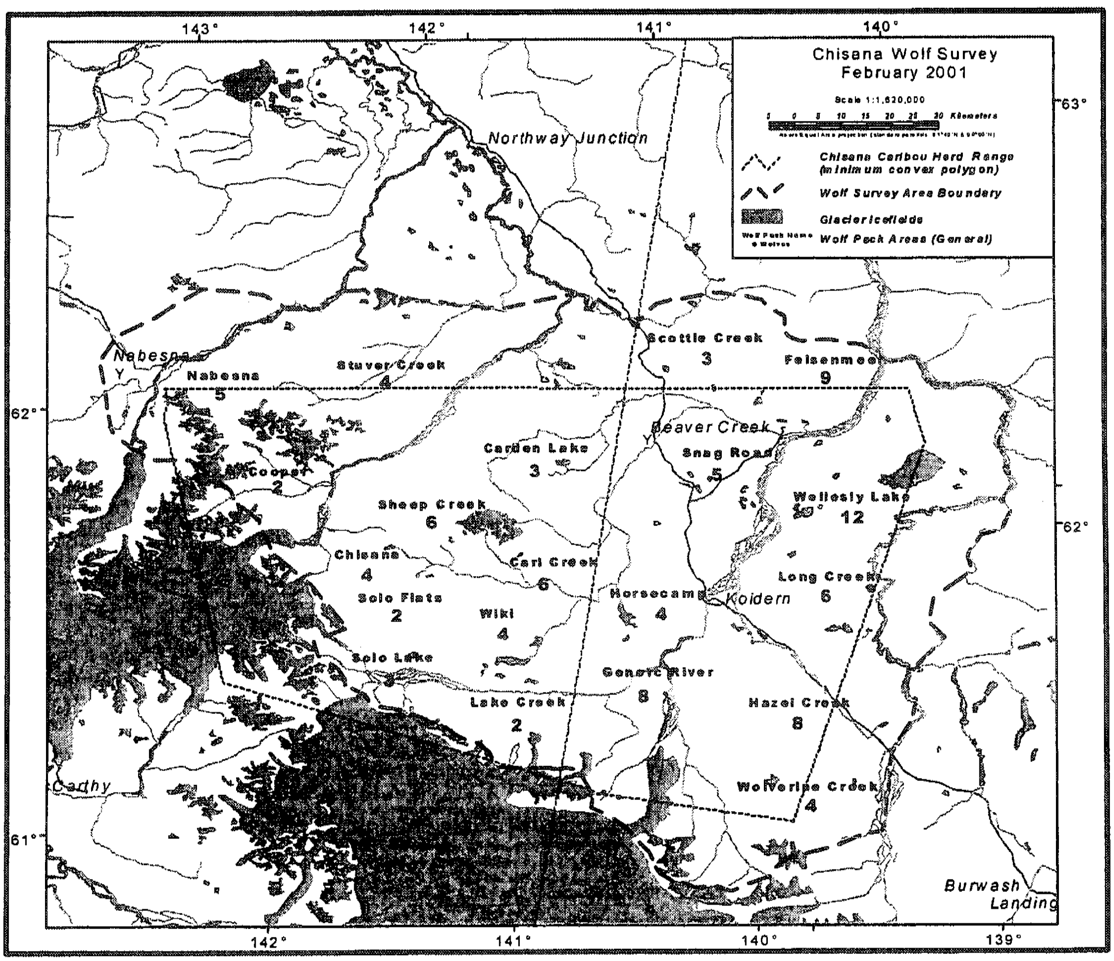

Figure 5. Wolf population survey results.

pack size was 5.0, and pack density was 1.01 packs/1000 km^2.

The wolf densities are well below the average density reported for Alaska and Yukon study sites (9 wolves/1,000 km^2; Gasaway et al. 1992) and rank fifth lowest among 18 wolf densities estimated for central and southern Yukon since 1983 (A. Baer, Yukon Environment, unpublished data). Low wolf density in the CCH range is a reflection of the low prey biomass. Wolf numbers did not decline even though the herd declined by about 80% during 1989–2001 indicating use of moose and Dall sheep as alternate prey. Moose exist at low density and Dall sheep are relatively abundant but Sumanik's (1987) prey selection studies found that Dall sheep were least preferred when caribou and moose were available. The presence of alternate prey has meant that caribou as prey are not as critical to wolf demography as wolf predation is to caribou demography.

Caribou physical condition studies

The effects of food limitation on the population dynamics of the CCH offer an explanation to these striking population trends. To study the relationship between nutrition, body condition, and reproductive success we needed to determine adult body condition, pregnancy rate, parturition, neonatal calf mortality, calf weight, disease and parasite prevalence, and age structure. We randomly captured and radio-collared 118 adult female and 21 calf caribou from 1987 to 2002. In 1994–95, 2000, 2002 additional adult female caribou were captured and ear tagged to increase sample sizes for these examinations. Multiple comparison with adjacent herds was made where data was available.

Adult body condition:

Winter body condition scores (BCS) were assessed from external body mass measurements of captured animals (Gerhart et al. 1996). BCS is reported on a scale of 1 to 15 and provides a subjective measure of body fatness that is a reliable means of identifying extremes in nutritional status. BCS is an important parameter to monitor because it is significantly related to pregnancy and provide a subjective measure of body fatness. This in turn can affect fetal growth rates and birth weights as a consequence of food limitation on winter range (Skogland 1984).

We compared BCS for the CCH between years 1994–95, 2000, 2002 and between the CCH and adjacent Aishihik herd in 1994–95, 2002 and the Kluane herd in 2000 and found no extremes in body condition (range 7.0–9.25) among these comparisons (Table 1). These BCS fall within the mid to upper range of multiple comparison scores previously reported for Yukon woodland caribou (6.2–8.3) (Kuzyk et al. 1999) and do not suggest that CCH physical condition was unfavorable for the years they were examined. Other researchers have shown however that all of interior Alaska caribou herds were impacted by adverse weather conditions in the early 1990s and this affected caribou nutritional status (Valkenburg et al. 1996). We therefore cannot rule out that poor physical condition may have played a role in the herd's initial decline. Regardless, it appears that physical condition was not a major factor during the herd's continued decline.

Table 1. Average body condition scores for the Chisana, Aishihik, and Kluane caribou herds.

Herd	Year	Sample Size	Body Condition Score ± SD
Chisana	1994-95	44	7.00 ± 1.42
	2000	28	8.29 ± 1.28
	2002	23	8.73 ± 0.60
Aishihik	1994-95	19	6.95 ± 1.90
	2002	11	9.25 ± 1.27
Kluane	2000	12	8.36 ± 1.21

Pregnancy rates based on progesterone concentrations:

Pregnancy can be determined by progesterone concentration in the blood (Wood et al. 1986, Russell et al. 1998). Pregnancy detection based on serum progesterone can be accurately diagnosed in caribou as early as 23 days after conception (Russell et al. 1998).

Captures took place in February and March, 4 to 5 months after conception (based on a peak rut date of 5–6 October). Blood samples were extracted, centrifuged and frozen until assayed. Progesterone analysis was carried out at the Central Laboratory for Veterinarians in Langley, British Columbia. Progesterone values of 6 nmol/L are indicative of luteal activity and were considered pregnant, those with values of 3 to 5 nmol/L are equivocal, and values less than 3 nmol/L are not pregnant (Russell et al. 1998). Pregnancy rates lower than the mean pregnancy rates (82%) reported for North American caribou herds by Bergerud (1980) would suggest that food limitation during summer was acting on caribou nutritional and body condition status to reduce their reproductive success. We compared progesterone pregnancy rates between the CCH and adjacent Aishihik and Kluane herds to see if there were regional effects influencing pregnancy rates.

Concentrations of progesterone for non-pregnant females ranged from 0.3 to 1.2 nmol/L and for pregnant females 3.0 to 40.0 nmol/L. A single equivocal result was found in the CCH in 2000; therefore, pregnancy rate is averaged (Table 2). Based on progesterone concentration pregnancy rates were low for the CCH in 1993 and 1994 – and possibly in 1992 when 1 calf was observed among 1,142 caribou in October. Rates were high in the Aishihik and Kluane herds in 1993 and 1994 but this does not rule out a regional trend, because all interior Alaska herds experienced poor pregnancy in 1993 (R. Boertje and C. Gardner, unpublished data). Pregnancy rates tended to be high thereafter and this was consistent with the adjacent herds. High pregnancy rates in the CCH for 2000 and 2002 suggest that despite the low sex ratio in those years large proportions of the cow caribou were impregnated. We acknowledge that the effect of small sample sizes in some years might overstate the effect of a single determination. However when coupled with data on pregnancy and parturition rates from May udder counts (next section) provide better estimates of CCH reproduction

Pregnancy, parturition rate and neonatal mortality based on surveys:

We estimated annual pregnancy rates of cows in the CCH in late May 1994–2000 by determining the presence or absence of a calf, antler retention, or distended udder (Whitten 1995). Parturition rate was considered to be the number of calves (estimated by calf: cow ratio) on 31 May. Neonatal survival was measured by the number of calves surviving until mid- to late

Table 2. Pregnancy rates in the Chisana, Aishihik, and Kluane herds 1993–2002 based on progesterone concentration.

Herd	1993	1994	1995	2000	2002
Chisana	25% (n=4)	74% (n=31)	100% (n=19)	90% (n=25)	96% (n=24)
Aishihik	93% (n=14)	88% (n=8)	100% (n=11)		90% (n=10)
Kluane	100% (n=7)	100% (n=5)		92% (n=12)	

June. We were particularly interested in determining the peak-of-calving date from these surveys because we wanted to know if many of the cows had been bred in their second estrus as a result of a highly skewed sex ratio. This would lead to their calves being born late and having a higher predisposition to mortality (Adams et al. 1995).

The low parturition rate in 1993 (Table 3) was expected. Only 1 of 4 caribou tested in March was pregnant (Table 2) and only 8 of 16 were determined pregnant in May using survey techniques. In 1997 the estimated minimum CCH pregnancy rate was 82% based on progesterone. There was no neonatal survival survey that year but parturition was 64:100 and declined to 14:100 by 1 October. CCH pregnancy rate was not estimated in 1998, but late May parturition was 14:100. We do not know if the low number of calves was due to a reduced pregnancy rate or to high early calf mortality in that year. In 2000 the May 31 parturition was 29:100 but declined to 6:100 by 1 October.

Pregnancy and parturition rates have been inconsistent since 1993. Pregnancy rates were not related to the number of calves born in May. Also, the number of calves on 31 May had little effect on the number that were alive by 21 June (Table 3).

There was little change between the number of calves alive on 21 June compared to 1 October. Fall composition data demonstrate that pregnancy rate and parturition rate had no influence on fall calf: cow ratios. This indicates that June neonatal calf mortality is the factor that most influences recruitment. Based on percent cows in the herd and on annual CCH pregnancy rates, we estimated 300–550 calves were born annually between 1994 and 2000. By 1 October, 83–95% of the calves died each year. Most calf mortality occurred between the end of May and late June. Predation was the primary cause of death, based on timing of the mortality and on results from caribou calf mortality studies for adjacent herds (Adams et al. 1995, Boertje and Gardner 2000).

The peak of calving dates for the herd indicates that high neonatal mortality is not from delayed parturition. The peak of calving for the CCH was 20–25 May, the same as other Yukon woodland caribou herds (R. Farnell, unpublished data).

Table 3. Pregnancy (%), parturition, neonatal and fall calf survival (calves/100 cows) based on survey data 1993–2000.

Year	May Pregnancy Rate (%)	May Parturition Rate (calves/100 cows	June Neonatal Survival (calves/100 cows	October (calves/100 cows
1993		38	19	2
1994	86	73	11	11
1995	>93	52	7	4
1996	>93	38	7	5
1997	82	64		14
1998		14		4
1999	92	25	9	7
2000	92	29		6

Table 4. CCH calf weights 1998–2000.

Year	Number of calves observed	Number of female calves observed	Number caught	$\bar{x}$ weight (kg)
1998	7	4	3	66.7
1999	18	10	8	63.5
2000	20	14	8	62.2

Fall calf body weights:

Summer nutrition can account for variation in autumn weights of Alaskan caribou calves independent of climate and nutrition (Valkenburg et al. 2000). We captured and weighed 19 CCH 5-month-old calves during fall composition count surveys from 1998 to 2000 (Table 4). There was only a small (7%) variation in calf weights between 1998 and 2000. The average calf weight for the CCH was 64.1 kg – the highest recorded for Alaskan caribou with varying nutritional status (Valkenburg et al. 2000, C. Gardner, unpublished data). These data indicate that what calves do survive the neonatal period have favorable physical condition and are likely very healthy animals.

Disease prevalence and parasites:

The CCH was included in a serologic survey of Yukon and Alaska caribou herds (Farnell et al. 1999, Zarnke 2000). These data provide an opportunity to evaluate the significance of disease as a potential mortality factor. Disease prevalence can reflect deficiencies in nutrient intake because of a poor quality diet (Woolf 1980). A poorly nourished animal is usually less resistant to infectious diseases, which can lead to direct mortality or in some cases reduced reproductive success (Dieterich 1981). Brucellosis in particular is commonly found in caribou and is of prime concern. Its major impact on caribou herds is reduced reproductive success because of abortion and sterility, and to a lesser extent, lameness that may make caribou more susceptible to predation (Dieterich 1981).

Sera were sent to the Serum Evaluation and Repository – Alaska (SERA) operated by the Alaska Department of Fish and Game, Fairbanks. Tests were carried out for the presence of antibody exposure for 8 disease agents known to infect caribou (Dieterich 1981, Farnell et al. 1999, Zarnke 1992; Appendix 1).

Evidence for Leptospirosis was found in 1987; the disease appears to be sporadic, as it did not persist as a pattern with further testing of 58 caribou from 1990 to 2000. A single positive test for IBR in 2000 indicates that it is in low prevalence in the CCH. The absence of serologic evidence for Brucellosis and the remaining bovine respiratory group of viruses in the CCH stand as a favorable statement of health in relation to these diseases. This is consistent with the serologic findings from other woodland caribou herds in Yukon (Farnell et al. 1999) and caribou herds south of the Brooks Mountain Range in Alaska (Zarnke 1992) where few cases of exposure have been found. Consequently there appears to be no relevance of these diseases in relation to observed population trends in the CCH.

Frozen fecal samples (N=20) were collected from CCH Range in March 2000 and 2001. These were submitted frozen to the Department of Veterinary Microbiology, Western College of Veterinary Medicine, Saskatoon, Saskatchewan. The parasite examination procedures used were a modified Wisconsin technique to isolate gastrointestinal nematodes, cestodes, and coccidia; the beaker Baermann technique to isolate protostrongylid larvae; a fluke flotation (Fluke Finder) to isolate fluke eggs; and a fluorescent antibody test to detect *Cryptosporidium* spp. and *Giarrdia* spp. Parasites were identified to the family or genus; specific identifications were not possible.

There was a low prevalence and intensity of gastrointestinal parasites: *Nematodirus* spp. (3/20, 0.8 eggs per gram of feces (epg)), *Trichuris* spp. (1/20, 1.2 epg), other Trichostrongyles (1/20, 0.4 epg), *Moniezia* (3/20, 20.7 epg) and *Eimeria* spp. (2/20, 15.4 oocysts per gram). All these genera have been reported in caribou previously. Dorsal-spined protostrongylid larvae were recovered from 60% of the samples but the intensity was low (4.3 larvae per gram). No samples were positive for *Cryptosporidium* spp. or *Giarrdia* spp.

Overall there was a low diversity, prevalence, and intensity of parasites. While this suggests that parasites are not a significant limiting factor in the CCH, winter samples were collected when parasite levels are low. Future fecal collections from the CCH should concentrate on mid- to late summer when there may be higher egg counts and more definitive evaluation of parasite intensity.

Age structure:

The trend in age estimates by incisor tooth wear implies a change over time for old-aged animals in the CCH (Fig. 6). In 1994–95 the CCH was composed of 51% old caribou and only 3.9% young animals. The age structure was even more skewed for old caribou in 2000 (71.4%). The old age distortion in the CCH age structure is the result of chronic poor calf recruitment associated with the 80% decline in numbers since 1989. The age structure of most stable woodland caribou herds in Yukon is predominantly middle-aged animals (50%, SD=16.37) (R. Farnell, unpublished data).

Because we are looking at ratios, a higher proportion of young animals does not mean that there are actually more young animals in the population. The change in ratio is likely because many of the old animals have died. If poor recruitment continues and most female cohorts reach the end of their life span, the herd will be extremely vulnerable to extirpation. Continued monitoring of the radio-collared female caribou will provide important information for management decisions.

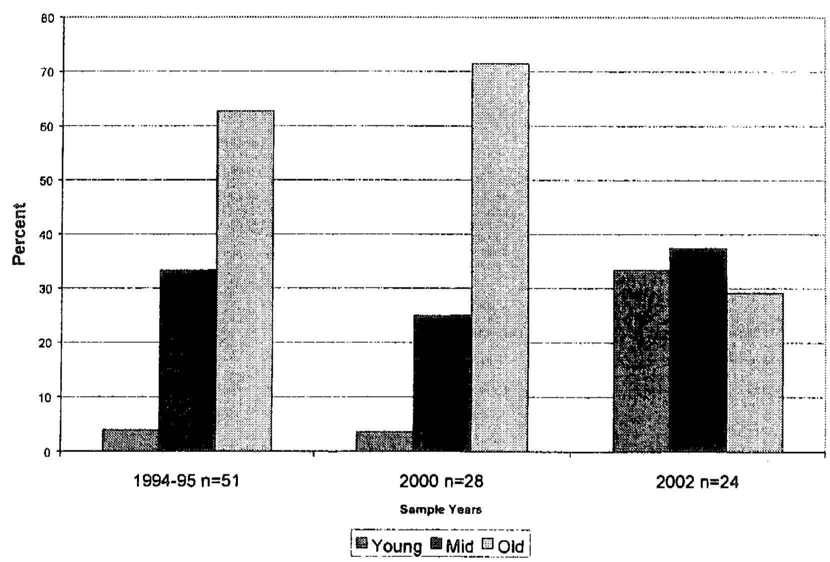

Figure 6. Chisana herd age structure subjectively estimated from tooth wear of captured animals.

Genetics

The detrimental effect of potential inbreeding (lower reproduction and survival because of lowered genetic variation) from the highly skewed sex ratio in the CCH is a concern. We captured 12 calves in 2000 to compare their genetic diversity to adults in 1994–95 and 2000. Whole blood samples (approximately 10ml) were collected from CCH caribou and submitted to the Department of Biological Sciences, University of Alberta, Edmonton for DNA fingerprinting using microsatellite analysis (Zittlau et al. 2000). Genetic distance test (Zittlau et al. 2000) between the CCH, Kluane, Aishihik, and Nelchina herds was calculated to determine the distinctiveness of the CCH (i.e. whether they are genetically related or not).

The genetic distance between the 4 herds was large (range = 0.217 to 0.459) despite their close geographic proximity to one another or occasional overlapping distribution (Table 5). The degree of genetic variation in CCH adults was 81.6% in 1994–95 and 82.2% in 2000. Genetic variation for calves in 2000 was 80.1%, indicating that genetic diversity in the population was not lost over this 5-year period. For the present, a high degree of genetic variation appears to persist in the CCH despite large-scale population decline and a highly skewed sex ratio. Continued monitoring of CCH genetic variability will be necessary for risk assessment and population viability analysis. The distinctive genetic structure of the CCH makes it a unique caribou population and an essential component to the biological diversity of the area's ecosystem.

Caribou range and climatic conditions

Winter range – food quality:

Poor winter nutrition could decrease the birth mass of calves and delay parturition to less advantageous dates (Skogland 1983, Couturier et al. 1990, Cameron et al. 1993). If the mean birth date is delayed then calf development will be retarded, reducing their chances of survival (Espmark 1980, Adams et al. 1995).

We randomly collected 20 groups of 20 fecal pellets from the range of the CCH in March 1994, 1995, 2000, and 2001. We then randomly selected 1 pellet from each group for fecal analysis (Sparks and Malechek 1968; Wildlife Habitat and Nutrition Laboratory, Washington State University). We compared the relative composition of important food including mosses, fruiticose and foliose lichens, horsetails, graminoids, deciduous shrubs, evergreen shrubs, and forbs.

The diet composition of CCH was consistently very high in moss and low in lichen (Table 6). In contrast the winter diets of 13 Yukon woodland caribou herds sampled (n=95 samples) between 1981 and 2001 were predominantly lichen (74.94% SE=1.73, range=59.67–86.34) and moss (3.57% SE=0.59, range=1.33–8.09) made up only a minor component of these diets (Appendix 2).

Table 5. Genetic distances between the Chisana and adjacent caribou herds – indicates how distinctly related populations are to each other.

	Aishihik	Chisana	Kluane	Nelchina
Aishihik	0.00			
Chisana	0.35	0.00		
Kluane	0.46	0.22	0.00	
Nelchina	0.43	0.29	0.42	0.00

Table 6. Percent composition of the winter diet of the Chisana herd estimated from fecal composition analysis.

Plant Group	1994	1995	2000	2001	Mean (SD)
Moss	29.78	17.59	55.10	51.00	51.00 (38.87)
Lichen	47.46	51.46	27.90	31.90	31.90 (39.68)
Horsetails	1.62	2.79	0.00	7.70	7.70 (3.03)
Graminoids	2.63	3.63	2.80	3.40	3.40 (3.11)
Deciduous Shrubs	0.00	2.70	0.00	0.00	0.68 (1.35)
Evergreen Shrubs	17.85	5.38	11.30	6.00	10.13 (5.79)
Forbs	0.33	17.84	1.552.90	0.00	5.27 (8.48)
Other	0.33	0.00	0.00	0.00	0.08 (0.17)

The high proportion of mosses raises questions about the adequacy of winter forage quality and winter range condition for the CCH because mosses have extremely low nutritional value and digestibility. Lichens are a highly digestible source of energy for caribou in winter (Russell and Martell 1984).

In addition to low pregnancy rates in 1993 and 1994 the poor winter diet of Chisana caribou may have played a role in this herd's observed population trend by predisposing newborn calves to higher rates of mortality.

Winter range – snow conditions:

The CCH range is mountainous with low treeline; arid and windy conditions persist, and minimal snow limitation conditions are encountered by caribou. Snow depths of 80–90 cm are thought to impede caribou mobility and foraging (Russell and Martell 1984). Mech et al. (1998) observed increased wolf predation on caribou when snow was deep. Valkenburg et al. (1996) examined snow depth as a contributing factor to adult mortality and summer calf survival near the range of the CCH (snow data from Northway). They found that in the period of the initial decline (1989–1994), only the winter of 1989–90 was marginally severe and snow depth barely exceeded 70 cm. However snow conditions immediately within the range of the CCH at the Chair Mountain, Yukon site (Environment Canada, Whitehorse) (Fig. 1) were consistently below depths limiting caribou and averaged 49 cm.

Summer range – climate variation:

Summer weather may have major influences on nutrition, body condition, and reproduction in caribou, but many questions remain about the mechanisms involved (Russell et al. 1993, Valkenburg et al. 1996). Lenart (2002) found that summers were significantly warmer during the initial years of the decline (1989–1995). The warmer drier summers may have adversely affected the CCH by increasing insect harassment and decreasing nitrogen content in caribou forage.

The low pregnancy rate in 1993 (Table 2) and perhaps 1992 was due to adverse weather. The early arrival of winter (11 September) in 1992 following a very late spring green-up produced the least number of snow-free days on record (<34days) affecting plant growth (Boertje et al. 1996). The early deep fall snowfall caused unusual movements outside of the normal range and possibly, onto sub optimal winter range. Other interior Alaska caribou herds also did aberrant movements and wintered in different areas that winter (Valkenburg et al. 1996). This may have affected CCH reproduction in 2 ways by first predisposing 1992 calves to higher rates of mortality in that year and second by reducing female nutrition and body condition hence calf viability in the subsequent year. This is also the highest year of population decline (31%) documented for the herd.

Factors that influenced the decline of the CCH

With the foregoing information base we are able to draw important conclusions respecting the causes and implications of Chisana herd population decline.

Firstly, the density of the CCH prior to its decline (136 caribou/1000 km^2) was within the low end of ranges reported for naturally-regulated (without wolf control) herds in Alaska (100–500 caribou/ 1000 km^2) (Bergerud 1980, Gasaway et al. 1992, Valkenburg et al. 1996) and within the normal ranges of densities for Yukon woodland caribou (30–183 caribou/1000 km^2) (R. Farnell, unpublished data). In 2001 the CCH density (28 caribou/1000 km^2) became the lowest recorded in Yukon. Because the density of the CCH has been low relative to other herds we do not believe that range carrying capacity has been exceeded and is responsible for the herd's decline. Density-dependent limitation as a factor in the CCH decline therefore seems unlikely.

Secondly, the initial decline of the CCH was most likely influenced by a combination of factors such as weather, forage quality, and predation. By 1995 pregnancy rates increased to >82%, yet recruitment remained low. Valkenburg et al. (1996) showed that declines of Interior Alaska caribou herds, including the CCH, in the early 1990s was widespread and nearly simultaneous because there was a nutritional link among these populations resulting from extensive adverse weather. It is possible that predation by wolves, grizzly bears, and coyotes exasperated the decline of the CCH. Boertje et al. (1996) suggested that direct and indirect effects of adverse weather increased vulnerability to predation and influenced population size in Interior Alaska caribou herds during the 1990s. We did not determine causes of neonatal mortality for the CCH. However, in the adjacent Denali and Mentasta herds of interior Alaska and the nearby Aishihik herd, wolf and bear predation were the major causes of calf mortality (Adams et al. 1995, Hayes et al. in press).

Thirdly, decrease in CCH recruitment coincided with the onset of severe summer weather, however this was insufficient to cause a continued decline. High pregnancy and parturition rates as well as optimal body condition scores, low disease prevalence, and high fall calf weights are evidence of favorable summer and fall range conditions for the CCH since the mid-1990s. They also indicate that cows are not suffering large over-winter weight loss by expending too much energy cratering for forage on a low-energy diet from lichen-poor range.

Fourthly, our data indicate that parturition is May 25-27 and that fall calf weights are the heaviest among Alaskan herds. If calving dates were delayed or protected and if there was evidence for lowered calf birth mass then we would have concluded that nutritional stress of mothers had ultimately predisposed their calves to high mortality. However, we believe that predation is preventing adequate recruitment into the CCH. Wolves are not numerically responding to reduced herd size and adult caribou survival rates are decreasing drastically, as old age animals become more vulnerable to predation.

Lastly, modeling CCH demography shows that if these patterns of survival continue the herd will extirpate or nearly extirpate in the not too distant future. At this time even the viability of the CCH as a population is in question.

Management implications and constraints

Concern regarding the declining trend in the herd was strongly voiced by both aboriginal groups (White River First Nation and the Northway Tribal Village Council), and a number of steps were identified to work with government to pursue increased protection for the herd. It was uniformly held that intensive management actions should begin immediately and not when the herd has reached some threshold level and may be too late to recover. Involvement of these communities, along with the neighboring Kluane First Nation in the Yukon, will be key for support of local implementation of a recovery plan.

Managers have limited ability to control caribou numbers (Valkenburg 2001). Realistic management proposals to recover the CCH have to distinguish between factors limiting the population that are manageable and those that are unmanageable. Proposed measures must also be socially acceptable and have the support of the major stakeholders and agencies with interest in the herd. Because most of the herd's range is within protected areas, management proposals will have to conform to the legal mandates of these areas.

Physical condition and adverse weather were major causes in the herd's initial decline (Valkenburg et al. 1996, Lenart 2002, this paper). These unmanageable factors predisposed caribou to high predation rates and lowered their productivity. However since the mid-1990s the herd has continued to decline even though the physical condition indices no longer indicate a predisposition of caribou to high predation rates. Decline is accelerating as predation gains an increasing effect on a diminishing population.

CCH has a strong fidelity to its range based on radio-telemetry study and genetic differentiation from other herds. Re-colonization by dispersal from adjacent populations seems unlikely in the short-term. The unique genetic make-up of the CCH makes it important to ensure that their genetic code is not lost. Genetics work on CCH shows that woodland caribou (*R. t. caribou*) are not totally endemic in Canada and extend into Alaska.

Literature cited

ADAMS, L.G., F. J. SINGER, AND B. W. DALE. 1995. Caribou calf mortality in Denali National Park. Journal of Wildlife Management 59:584–594.

BALLARD, W. B., J. S. WHITMAN, AND C. L.GARDNER. 1987. Ecology of an exploited wolf population in south-central Alaska. Wildlife Monographs 98.

BANFIELD, A. W. F. 1961. A revision of the reindeer caribou, genus *Rangifer*. National Museum of Canada Bulletin 177, Biology Series 66. Ottawa, Ontario, Canada.

BERGERUD, A.T. 1980. A review of population dynamics of caribou and wild reindeer in North America. Pages 556–581 *in* E. Reimers, E. Gaare, and S. Skjenneberg, editors. Proceedings of the Second International Reindeer/Caribou Symposium, Røros, Norway. Direktoratet for vilt og ferskvannsfisk, Trondheim, Norway.

BOERTJE, R., AND C. L. GARDNER. 2000. The Fortymile caribou herd: novel proposed management and relevant biology, 1992–1997. Rangifer Special Issue No. 12: 17–37.

_____, P. VALKENBURG, AND M. E. MCNAY. 1996. Increases in moose, caribou, and wolves following wolf control in Alaska. Journal of Wildlife Management 60:474–489.

BOUTIN, S., C. J. KREBS, R. BOONSTRA, M. R. T. DALE, S. J. HANNON, K. MARTIN, A. R. E. SINCLAIR, J. N. M. SMITH, R. TURKINGTON, M. BLOWER, A. BYRON, F. I. DOYLE, C. DOYLE, D. HIK, L. HOFER, A HUBBS, T. KARELS, D. L. MURRAY, V. NAMS, M. O'DONOGHUE, C. ROHNER, AND S. SCHWEIGER. 1995. Population changes of the vertebrate community during a snowshoe hare cycle in Canada's boreal forest. Oikos 74:69–80.

CAMERON, R.D, W.T. SMITH, S.G. FANCY, K.L GERHART, AND R.G. WHITE. 1993. Calving success of female caribou in relation to body weight. Canadian Journal of Zoology 71:480–486.

COUTURIER, S., J. BUNNELLE, D. VANDAL, AND G. ST-MARTIN. 1990. Changes in the population dynamics of the George River caribou herd, 1976–87. Arctic 43:9–20.

DAVIS, J. L., P. VALKENBURG, R. D. BOERTJE. 1986. Emprical and theoritical considerations toward a model for caribou socioecology. Rangifer, Special Issue No. 1:103–109.

DIETERICH, R.A. 1981. Alaskan wildlife diseases. University of Alaska, Fairbanks, Alaska, USA.

ECOLOGICAL STRATIFICATION WORKING GROUP. 1995. A National Ecological Framework for Canada. Agriculture and Agri-Food Canada, Research Branch, Centre for Land and Biological Resources Research and Environment Canada, Ottawa, Ontario, Canada.

ESPMARK, Y. 1980. Effects of maternal pre-partum under-nutrition on early mother-calf relationships. Pages 485–496 *in* E. Reimers, E. Gaare, and S. Skjenneberg, editors. Proceedings of the Second International Reindeer/Caribou Symposium, Røros, Norway. Direktoratet for vilt og ferskvannsfisk, Trondheim, Norway.

FARNELL, R. AND D. RUSSELL. 1984. Wernecke mountain caribou studies 1980 to 1982. Final Report. Yukon Fish and Wildlife Branch Report TR-84-1, Whitehorse, Yukon, Canada.

_____, AND J. MCDONALD. 1988. The influence of wolf predation on caribou mortality in Yukon's Finlayson caribou herd. Proceedings of the North American Caribou Workshop 3:52–70.

_____, N. BARICHELLO, K. EGLI, AND G. KUZYK. 1996. Population ecology of two woodland caribou herds in southern Yukon. Rangifer Special Issue No. 9:63–72.

_____, R. L. ZARNKE, AND G.W. KUZYK. 1999. Serologic survey of Yukon caribou 1988–1997: A look at disease prevalence. Yukon Fish and Wildlife Branch Report TR-99-01, Whitehorse, Yukon, Canada.

FULLER, T. K. 1989. Population dynamics of wolves in north-central Minnesota. Wildlife Monographs 105.

GASAWAY, W. C., R. O. STEPHENSON, J. L. DAVIS, AND O. E. BURRIS. 1983. Inter-relationshps of wolves, prey and man in Interior Alaska. Wildlife Monographs 84.

_____, R. D. BOERTJE, D. V. GRANGAARD, D. G. KELLYHOUSE, R. O. STEPHENSON, AND D. G. LARSEN. 1992. The role of predation in limiting moose at low densities in Alaska and Yukon and implications for conservation. Wildlife Monographs 120.

GAUTHIER, D. A., AND J. B. THEBERGE. 1985. Wolf predation in the Burwash caribou herd, southwest Yukon. Rangifer Special Issue 1:137–144.

GERHART, K.L., R. G. WHITE, CAMERON, R.D., AND RUSSELL, D.E. 1996. Estimating fat content of caribou from body condition scores. Journal of Wildlife Management 60(4):713–718.

HATTER, I. W. AND W. A. BERGERUD. 1991. Moose recruitment, adult mortality and rate of change. Alces 27:65–73.

HAYES, R. D., R. FARNELL, R. M. P. WARD, J. CAREY, M. DEHN, AND G. W. KUZYK. In press. Response of ungulates to experimental reduction of wolves in Yukon. Wildlife Monographs.

HUGHES, J. 1995. Southcentral Alaska caribou management – Nelchina herd. Pages 8–10 *in* Annual performance report of survey – inventory activities, 1 July 1994 – 30 June 1995. Juneau, Alaska, USA.

KEITH, L. B. 1983. Population dynamics of wolves. Pages 66–77 *in* L. N. Carbyn, editor. Wolves in Canada and Alaska. Candian Wildlife Service report Series 45, Ottawa, Ontario, Canada.

KUZYK, W.G., M. M. DEHN, AND R. FARNELL. 1999. Body size comparisons of alpine and forest wintering woodland caribou in Yukon. Canadian Journal of Zoology 77:1017–1024.

LENART, E. A. 2002. Climate change and caribou: effects of summer weather on forage. Canadian Journal of Zoology 80:664–678.

MECH, L.D., L. G. ADAMS, T. J. MEIER, J. W. BURCH, AND B. W. DALE. 1998. The wolves of Denali. University of Minnesota Press, Minneapolis, Minnesota, USA.

MILLER, F. L. 1982. Caribou (*Rangifer tarandus*). Pages 932–959 *in* J. Chapman and G. A. Feldhamer, editors. Wild mammals of North America: biology, management, and economics. John Hopkins University Press, Baltimore, Maryland, USA.

O'DONOGHUE, M., S. BOUTIN, C. J. KREBS, AND E. J. HOFER. 1997. Numerical responses of coyotes and lynx to the snowshoe hare cycle. Oikos 80:150–162.

POLLOCK, K., SCOTT, R.W., BUNCK, C.M., AND CURTIS, P.D. 1989. Survival analysis in telemtry studies: The staggered entry design. Journal of Wildlife Management 53:7–15.

RUSSELL, D.E., AND A. M. MARTELL. 1984. Winter range ecology of caribou (*Rangifer tarandus*).: Pages 117–144 *in* R. Olson et al, editors. Northern ecology and resource management. University of Alberta Press, Edmonton, Alberta, Canada.

_____, A. M. MARTELL, AND W. A. C. NIXON. 1993. Range ecology of the Porcupine caribou herd in Canada. Rangifer Special Issue No. 8.

_____, K. L. GERHART, R. G. WHITE, AND D. VAN DE WETERING. 1998. Detection of early pregnancy in caribou: Evidence for embryonic mortality. Journal of Wildlife Management 62:1066–1075.

SCHAEFER, J. A., A. M. VEITCH, F. H. HARRINGTON, K. W. BROWN, J. B. THEBERGE, AND S. N. LUTTICH. 1999. Demography of decline of the Red Wine Mountains herd. Journal of Wildlife Management 62:580–587.

SPARKS, D. R. AND J. C. MALECHEK. 1968. Estimating percent dry weight in diets using a microscope technique. Journal of Range Management 21:264–265.

SKOGLAND, T. 1983. The effects of density dependant resource limitation on size of wild reindeer. Oecologia 60:156–168.

_____. 1984. The effects of food and maternal conditions on fetal growth and size in wild reindeer. Rangifer 4(2):39–46.

SKOOG, R. O. 1968. Ecology of the caribou in Alaska. Dissertation, University of California, Berkeley, California, USA.

STEPHENSON, R. O. 1978. Characteristics of exploited wolf populations. Alaska Department of Fish and Game Federal Aid in Restoration. Final Report, Projects W-17-3 through W-17-8. Fairbanks, Alaska, USA.

SUMANIK, R. S. 1987. Wolf ecology in the Kluane region, Yukon Territory. Thesis, Michigan Technological University, Houghton, Michigan, USA.

THOMAS, D. C. AND D. R. GRAY. 2002. Updated COSEWIC status report on "forest dwelling" woodland caribou – caribou des bois – *Rangifer tarandus caribou.* Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Ottawa, Ontario, Canada.

VALKENBURG, P. 2001. Stumbling towards enlightenment: understanding caribou dynamics. Alces Vol. 37: 457–474.

_____, J. L. DAVIS, J. M. VER HOEF, R. D. BOERTJE, M. E. MCNAY, R. M. EAGAN, D. J. REED, C. L. GARDNER, AND R. W. TOBEY. 1996. Population decline in the Delta caribou herd with reference to other Alaskan herds. Rangifer Special Issue No. 9:53–62.

_____, T. H. SPRAKER, M. T. HINKES, L. H. VAN DAELE, R. W. TOBEY, AND R. A. SELLERS. 2000. Increases in body weight and nutritional status of transplanted Alaskan caribou. Rangifer Special Issue No. 12:133–138.

WHITTEN, K. R. 1995. Antler loss and udder distention in relation to parturition in caribou. Journal of Wildlife Management 59: 273–277.

WINDSOR, J. 1979. Birds of prey in the southern Yukon in relation to the Alaska highway and proposed gas pipeline. Yukon Fish and Wildlife Branch Report TR-79-5, Whitehorse, Yukon, Canada.

WOOD, A. K., R. E. SHORT, A. DARLING, G. L. DUGEK, R. G. SASSER, AND S. A. RUGER. 1986. Serum assays for detecting pregnancy in mule and white-tailed deer. Journal of Wildlife Management 50:684–687.

WOOLFE, A. 1980. Pathology and necropsy techniques. *In:* Big game of North America, ecology and management. Stackpole Books, Harrisburg, Pennsylvania, USA.

ZARNKE, R. L. 1992. Alaska wildlife serologic survey 1975–1992. Alaska Dept. of Fish and Game, Juneau, Alaska, USA.

_____. 2000. Serologic survey of Alaska wildlife for microbial pathogens. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Final Report. Grants W-27-3 and W-27-4, Study 18.71. Juneau, Alaska, USA.

ZITTLAU, K., J. COFFIN, R. FARNELL, G. KUZYK, AND C. STROBECK, 2000. Genetic relationships in 3 Yukon woodland caribou herds determined by DNA typing. Rangifer Special Issue 12:59–62.

Appendix 1. Chisana herd serum antibody exposure to disease agents known to affect caribou.

Year	1987	1990	1991	1993	1994	1995	1997	2000	Total
Brucella spp.	0/16	0/8	0/11		0/29	0/21	0/4	0/31	0/120
Infectious Bovine Rhinotracheitis (IBR)	0/16	0/11	0/11	0/4	0/30	0/21	0/4	**1/31**	1/128
Bovine Viral Diarrhea (BVD)	0/16	0/12	0/11	0/4	0/28	0/21	0/4	0/31	0/127
Parainfluenza 3 (PI3)	0/16	0/12	0/11	0/4	0/29	0/21	0/4	0/31	0/128
Respiratory Syncytial Virus (RSV)	0/16	0/12	0/11	0/4	0/25	0/21	0/4	0/31	0/124
Bluetongue	0/15	0/8	0/11	0/4	0/25	0/21	0/4	0/31	0/119
Epizootic Hemorrhagic Disease	0/15	0/12	0/11	0/4	0/29	0/21	0/4	0/22	0/127
Leptospirosis interrogans	**3/14**	0/12	0/11				0/4	0/31	3/72
Total Number Tested	16	12	11	4	30	21	4	31	129

Appendix 2. Average percent moss and lichen in the diets of 13 Yukon woodland caribou herds sampled between 1981 and 2001.

Herd	Moss	Lichen
Aishihik (n=11)	4.77 (2.57)	79.49 (9.90)
Atlin (n=1)	8.09	59.67
Bonnet Plume (n=5)	7.18 (6.33)	79.13 (6.63)
Carcross (n=6)	1.51 (1.91)	77.15 (7.49)
Ethel Lk. (n=3)	2.81 (1.71)	72.51 (11.71)
Finlayson (n=30)	2.07 (1.74)	73.94 (9.24)
Ibex (n=7)	2.41 (2.71)	86.34 (6.99)
Klaza (n=6)	3.22 (0.92)	78.35 (8.12)
Little Rancheria (n=11)	1.33 (1.48)	72.98 (11.08)
Moose Lk. (n=1)	2.23	69.04
Tay R. (n=5)	4.37 (2.27)	75.21 (10.43)
Tatchun (n=1)	4.47	74.68
Wolf Lake (n=8)	1.98 (1.95)	75.79 (9.72)