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Factors Limiting the Fortymile Caribou Herd

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SUMMARY

Major progress was made during 1994-1997 in developing and implementing objectives for managing the Fortymile Caribou (*Rangifer tarandus granti*) Herd. A novel management plan was written in 1995 by a diverse, international Fortymile Planning Team (Boertje and Gardner 1996:Appendix A) and was endorsed by the Board of Game in October 1995. The primary goal of the Teamš plan is to begin restoring the Fortymile Herd to its former range, much of which was abandoned as herd size declined. Specific objectives call for increasing the herd at least 5% to 10% annually during 1998-2002. In spring of 1997 the Board of Game approved an implementation plan; a second 5-year research plan was approved by 10 independent international scientists for 1997-2002.

Since 1994, intensive monitoring of radiocollars on newborn and older caribou allowed investigations of caribou productivity and mortality rates and causes. These data enabled us to complete 3 annual models illustrating how predation and other demographic factors affected herd size from mid May 1994 through May 1997.

We identified wolf (*Canis lupus*) predation as a major limiting factor in all 3 annual models. Reducing wolf predation was deemed by the Team to be the most manageable way to help hasten or stimulate herd growth. The Team envisioned 2 strategies for reducing wolf predation: first, state-sponsored wolf translocations and fertility control in 15 key packs which began November 1997 and, second, shifting private wolf trappers to specific areas. This document reports pretreatment data and describes the effects of increased private wolf trapping on Fortymile wolves and caribou. The second 5-year research project was initiated to monitor the effects of wolf trapping, fertility control, and translocations on caribou and wolf populations through 2002 (Boertje and Gardner 1996:Appendix A).

The following points will assist with continuing efforts to evaluate management objectives proposed by the Fortymile Planning Team:

1 Herd numbers remained relatively stable during 1990-1995 (about 22,000 to 23,000 caribou) compared to annual growth rates of 7% to 10% in the 1980s. On 21 June 1996 we counted about 900 additional caribou in the herd, probably a result of increased pregnancy rates in 1996. On 26 June 1997 we counted about 2500 additional caribou in the herd, probably a result of recruitment of the abundant 1996 calves and excellent early survival of the 1997 calves. The Team deemed that initiating management actions during a period of natural increase would be opportune.

2 Wolf and grizzly bear predation continue to be the most important sources of mortality, despite over a decade of the most liberal regulations in the state for harvesting wolves and grizzly bears. Wolves continue to be the most important predator. Wolves killed between 2000 and 3000 caribou calves annually during this study and between 1000 and 2300 older caribou; 1200-1900 calves were killed from May through September. No significant differences in annual wolf predation rates on calves or adults were observed between 1994 and early winter 1997.

3 To increase social acceptance of the management plan, the Fortymile Team chose to reduce the annual caribou harvest to 150 bulls for 5 years beginning in 1996. We illustrated the minor role that harvest has played in herd dynamics in recent years. Harvests have been intentionally held low since 1973 to encourage herd growth (Valkenburg et al. 1994). Reducing harvests from 200-500 bulls (≤2% of the herd, 1990-1995) to 150 bulls (<1% bulls, 1996-2000) will not result in the 5% to 10% annual rates of herd increase desired by the Fortymile Team. Bull:cow ratios in the Fortymile Herd ($\bar{x}$ = 43 bulls:100 cows, range = 36-50, 1985-1997) are not reduced by harvest compared to ratios from the only Interior Alaska herd with no harvest in recent decades ($\bar{x}$ = 43 bulls:100 cows, range = 29-56 in the Denali Herd, 1985-1997).

4 Despite private efforts that increased wolf harvest during this study, autumn wolf densities on the respective annual ranges of the Fortymile Herd remained at densities (7-8 wolves/1000 km^2) often observed in Alaska-Yukon study areas with similar low prey densities and low wolf harvest rates. Without strong reductions in autumn wolf densities, wolf predation on caribou is not expected to decline significantly.

5 We found consistent evidence for moderate to high nutritional status in the Fortymile Herd during this study when indices were compared with other Alaskan herds (Whitten et al. 1992; Valkenburg 1997). The single evidence for malnutrition during this study was the low pregnancy rate during 1993 following the abnormally short growing season of 1992. However, this low pregnancy rate resulted in no strong decline in Fortymile Herd numbers, as occurred in the Delta and Denali herds (Boertje et al. 1996).

6 Winter range can support elevated caribou numbers both in regard to lichen availability on currently used winter range and the availability of vast expanses of winter range formerly used by the herd. The herd currently uses <30% of its historic range.

Predicting trends in caribou numbers is problematic. We know that a variety of factors can cause a surge or drop in numbers, that stability is seldom long term, and that rapid declines can occur from the synergistic effects of adverse weather and increased predation (Boertje et al. 1996). Also, we know that continental caribou herds have commonly remained at multiyear densities of ≤500 caribou/1000 km^2 during the last 2 decades (Bergerud 1980; Valkenburg et al. 1996*a*). Exceptions occur when strong predator control is accompanied by favorable weather or, in some coastal areas, when wolf density is naturally lessened by a lack of alternative prey for wolves (particularly on calving areas). The Fortymile Herd multiyear density is about 500 caribou/1000 km^2. The only proven method we know to promote continued growth is to substantially reduce predation during a period of favorable weather.

We will continue studies of Fortymile calf mortality during 1998-2002 by deploying radiocollars on newborns. These studies will allow evaluation of whether reduced wolf numbers in the treatment area result in significantly reduced wolf predation on calves. Treatment of 15 key wolf packs is planned from May 1999 through May 2001. During this 2-year period, we will test whether wolf predation on calves is significantly reduced compared to the 3 pretreatment years (May 1994-May 1997) when wolves killed 13-19 (25%-32%) of 50-60 radiocollared calves.

Key words: Alaska, caribou, condition, Fortymile Caribou Herd, management objectives, mortality, nutrition, predation, pregnancy rate.

CONTENTS

BACKGROUND

The Fortymile Caribou (*Rangifer tarandus granti*) Herd has the potential to be the most economically important wildlife population in Interior Alaska and the southern Yukon, both for consumptive and nonconsumptive uses. Potential for growth is indicated by Murie's (1935) extrapolated estimate of 568,000 caribou during a 20-day herd migration across the Steese Highway in 1920, compared to an aerial photocensus of 25,912 caribou on 26 June 1997. The herds̓ low point was in 1973 with about 6500 caribou.

Caribou herds typically restrict range use as herd size declines. For example, the Fortymile Herd has not migrated across the Steese Highway since 1963 and rarely enters the Yukon because of its reduced size. The herd's historical range encompassed 220,000 km^2 (Murie 1935) compared with about 50,000 km^2 total for all years since 1968 (Valkenburg et al. 1994; Fig 1) and about 30,000 km^2 annually in recent years. Today, the historical range of the herd is largely devoid of caribou.

Population objectives for increasing the Fortymile Caribou Herd have wide public support in Alaska and the Yukon for consumptive and nonconsumptive reasons. This public support has developed because most of the herd's former range was abandoned as herd size declined and because current low numbers are, in part, a result of past management decisions.

We have learned much from past management of the Fortymile Herd. Valkenburg et al. (1994) detailed a case history of the herd from 1920 to 1990. The decline in the herd from about 50,000 in 1960 to only 6500 in 1973 was partly a result of errors in the prevailing management beliefs. Overharvest was allowed in the early 1970s, and, simultaneously, high numbers of wolves (*Canis lupus*) and unfavorable weather contributed to the herd's decline to critically low levels (Davis et al. 1978; Valkenburg and Davis 1989; Valkenburg et al. 1994). Had this overharvest been prevented, the herd probably would have declined to only 10,000-20,000 caribou during the early 1970s and may have increased to 30,000-50,000 during favorable conditions in the 1980s.

Overharvest was allowed in the early 1970s in part because of the belief that poor range condition was the major factor causing low yearling recruitment. Thus, biologists allowed high harvests and largely ignored wolf predation while awaiting a compensatory rebound in yearling recruitment from improved range. However, it was a futile vigil; calf caribou became increasingly scarce through 1973. It was mistakenly believed hunters and predators usually killed animals that were about to die anyway (before successfully reproducing) and wolf and grizzly bear (*Ursus arctos*) predation were minor influences on the herd. Also, the size of the Fortymile Herd was grossly overestimated and the trend in herd size inadequately monitored (Davis et al. 1978; Valkenburg and Davis 1989).

Today harvest programs for caribou are managed much more conservatively than in the early 1970s. During natural declines of caribou to low levels, harvests are eliminated or restricted to small percentages of bulls or are carefully monitored using permit systems. Since 1973, substantial reductions in the human harvest of Fortymile caribou have made harvest an insignificant factor affecting herd growth compared to predation by wolves and bears (Valkenburg et al. 1994; Appendices A, B, and C). Since 1984 radiocollaring of Fortymile caribou has given biologists the ability to efficiently estimate herd distribution to predict hunter success, particularly along roads. Other benefits from radiocollaring include efficient estimates of herd size, recruitment, mortality, causes of mortality, and relative nutritional status (Valkenburg and Davis 1989; Valkenburg et al. 1994; Valkenburg 1997).

Today managers know adverse weather can initiate declines in caribou herds (Valkenburg et al. 1994; Adams et al. 1995*a*; Boertje et al. 1996). Adverse weather in Interior Alaska in the early 1990s and the simultaneous decline of several Interior caribou herds were, in part, the stimuli for this renewed study of the Fortymile Herd. During periods of adverse weather, herd condition can decline and predation can increase (Mech et al. 1995; Boertje et al. 1996). After weather improves, prolonged declines in caribou herds can occur from continued high wolf predation probably because of wolves' switching to caribou as primary prey and because declines in wolf numbers are not tied strictly to caribou numbers and can lag behind declines in total caribou numbers (predator lag). We know of examples in which the proportion of a herd killed by wolves increased during adverse weather because caribou were more vulnerable and because wolf numbers increased as caribou declined (Adams et al. 1995*a*; Mech et al. 1995; Boertje et al. 1996).

Today it is a well-accepted belief that wolf and bear predation are often the major factors limiting caribou and moose (*Alces alces*) at low densities (Davis et al. 1978, 1983; Gasaway et al. 1983, 1992; Boertje et al. 1987, 1988; Larsen et al. 1989; Valkenburg and Davis 1989; Adams et al. 1995*b*; Boertje et al. 1996). Several studies summarized historical and recent predator-prey relationships in the Fortymile area and documented that predation was a major factor limiting recovery of caribou and moose populations (Davis et al. 1978; Boertje et al. 1987, 1988; Valkenburg and Davis 1989; Gasaway et al. 1992).

From 1981 through 1987, management actions were implemented to reduce grizzly bear and wolf predation in a portion of the Fortymile Herd's range (Valkenburg and Davis 1989; Gasaway et al. 1992). Control of wolf numbers by department personnel was terminated before desired reductions were achieved, and grizzly bear numbers were only moderately reduced in a small portion of the range. Subsequent 7% to 10% annual increases in caribou numbers could not be definitively linked to predator control because pretreatment studies were lacking and only small reductions in predator abundance occurred in the annual range of the Fortymile Herd (Valkenburg et al. 1994). Increased harvests of wolves and grizzly bears in the 1980s were insufficient to allow for herd growth during 1990-1995, presumably because of adverse weather and predators not being sufficiently reduced.

To definitively test effectiveness of predator control, large reductions in predator abundance are necessary for several years (Crete and Jolicoeur 1987; Larsen and Ward 1995; Boertje et al. 1996; Farnell and Hayes, unpubl data). Large reductions in wolf numbers for several years resulted in dramatic increases in caribou numbers in central Alaska (16% per year; Gasaway et al. 1983; Boertje et al. 1996) and Eastcentral Yukon (18% per year; Farnell and MacDonald 1988; Larsen and Ward 1995; Farnell and Hayes, unpubl data). In both studies, late winter wolf numbers were 69% to 85% lower than precontrol autumn wolf numbers during the 4 to 6 winters of effective control efforts. These are the only well-documented studies in which large reductions of wolves were maintained for more than 2 winters and wolves were subsequently allowed to recover.

MANAGEMENT PLANNING, PRESENTATIONS, AND OBJECTIVES

International draft management objectives from the mid-1980s through 1995 called for increasing the herd to 50,000 adults or 60,000 caribou by the year 2000. These management objectives were written when the herd was growing at 7% to 10% per year and when population objectives were expected to be reached without further management actions. Instead, herd numbers were nearly stable between 1990 and 1995 at about 22,500 caribou.

Conflicting interagency management objectives by 1994 stimulated an interagency and international meeting focusing on Fortymile Herd management in Tok on 9 February 1994. Following this meeting, a diverse Fortymile Planning Team was created to write a new Fortymile Herd Management Plan (Boertje and Gardner 1996:56-77). This novel plan was completed and endorsed by the Board of Game in October 1995. The Team met 8 times between autumn 1994 and autumn 1995 to develop the plan and continues to meet to address issues of importance. Ten public meetings were held in various places to gather public opinion of the plan. The Board of Game approved a detailed implementation plan for the Fortymile Management Plan in spring 1997, and we began implementation (wolf fertility control and translocations) in November 1997. We also drafted a new 5-year research plan (1997-2002, Boertje and Gardner 1996:Appendix A:28-56), which was edited by 10 independent, international scientists familiar with wolf biology and/or predator-prey relationships.

We presented our findings in 5 editions of *The Comeback Trail*; a newsletter written to inform the public and agencies of Fortymile Herd planning, management, and research. This newsletter is published by the Alaska Department of Fish and Game and mailed to 3300 interested parties to solicit their opinions. We also assisted Northern Native Broadcasting of Whitehorse in the production of a 52-minute documentary video on Fortymile Herd history, planning, and biology. This video was released in January 1998.

The primary goal of the new Fortymile Management Plan is to restore the Fortymile Herd to its former range, which entails initiating management actions to increase herd size. Specific objectives include increasing caribou numbers by at least 5% to 10% per year through the year 2002. Management actions are to include fertility control in dominant wolf pairs in no more than 15 key packs, translocation of the remaining wolves in these 15 packs, reduced caribou harvest quotas, encouraging trappers to shift trapping to specific areas, and possibly translocation of grizzly bears from calving areas during the final spring. Herd response to these management actions will depend largely on changes in wolf and bear predation, weather, and caribou distribution and productivity. Thus, response to the proposed management actions could vary considerably among years.

This report provides the 5-year baseline pretreatment data for the study area and describes herd responses following recent management actions, i.e., increased wolf harvest and decreased caribou harvest. We describe recent demographics of the herd, factors limiting the herd, and condition of the herd and range. These data were useful in proposing management actions for the herd and should be instrumental in evaluating the effectiveness of proposed management actions.

GOAL

Our goal was to determine demographics of the Fortymile Caribou Herd, herd condition (nutritional status), and factors limiting the herd for the purpose of 1) predicting how herd growth rate may respond to various potential predator management and harvest management programs and 2) evaluating responses to potential programs implemented by the ongoing planning process.

JOB OBJECTIVES

1 Literature review.

2 Assess extent and cause of death among collared caribou ≥4 months old.

3 Estimate herd condition.

4 Estimate age-specific mortality rates by collaring 4-month-old calves.

5 Determine total numbers and population trend.

6 Estimate recruitment and mortality rates during the first 4 months of life by annually classifying caribou about 1 October 1993-1997.

7 Evaluate winter range condition with respect to relative lichen versus moss abundance in caribou feces.

8 Determine extent and cause of death among calves during the first year of life.

9 Determine what weather factors are related to poor herd condition.

10 Analyze data and draft figures for written and oral presentations of data.

11 Write progress reports and either publish a final report or recommend continuation of this study for 5 additional years. This final report will be published as part of the Eighth North American Caribou Workshop in Whitehorse. An additional 5-year study has been approved.

12 Incorporate results into appropriate Alaska wildlife management plans and survey-inventory activities.

PROCEDURES

CARIBOU CAPTURE

Since September 1990, we have radiocollared 49 adults and 129 autumn calves. Each autumn we collared 14 or 15 calves. Adults were collared during 1991, 1992, and 1996 to provide a sample of productive, older caribou. We routinely took blood samples and body measurements. Radiocollars transmitted for 6 or 7 years (Telonics, Mesa, Arizona, USA and Advanced Telemetry Systems, Isanti, Minnesota, USA).

To immobilize adult caribou, we use 3 mg carfentanil citrate (3 mg/ml, Wildnil,® Wildlife Pharmaceuticals, Fort Collins, Colorado, USA) and 100 mg xylazine hydrochloride (100 mg/ml, Anased,® Lloyd Laboratories, Shenandoah, Iowa, USA) administered in a 2-cc dart with a 1.9-cm barbed needle using a short-range Cap-Chur pistol fired from a Robinson R-22 helicopter. To reverse the immobilization, we inject 275 mg naltrexone hydrochloride (50 mg/ml, Trexonil,® Wildlife Pharmaceuticals) and 27.5 mg yohimbine hydrochloride (5 mg/ml, Antagonil,® Wildlife Pharmaceuticals) intramuscularly. Our dose for immobilizing autumn calves includes 1 mg carfentanil citrate and 67 mg xylazine hydrochloride reversed with 125 mg naltrexone hydrochloride and 12.5 mg yohimbine hydrochloride intramuscularly.

We radiocollared 50 newborn calves in May 1994, 52 in May 1995, 60 in May 1996, and 55 in May 1997, using techniques and collars described by Adams et al. (1995*b*) except that we used a 2-person, Robinson R-22 helicopter. Usually a person was dropped off to capture the calf by hand, but occasionally the helicopter was used to slowly herd the cow and calf toward the hidden person. For collaring, usually we selected calves that accompanied a collared dam, and we distributed remaining collars both geographically and temporally to mimic the calving of collared dams. Handling took <1.5 minutes/calf. Radiocollars transmitted for about 17 months.

ESTIMATING HERD NUMBERS AND GROWTH RATE FROM PHOTOCENSUSES

We estimated minimum numbers of Fortymile caribou between 14 June and 1 July 1990, 1992, and 1994 through 1997 using radio-search, total search, and aerial photo techniques (Valkenburg et al. 1985), as in previous estimates of herd size during the 1970s and 1980s (Valkenburg and Davis 1989). The entire summer range was divided among observers in 4 or 5 light aircraft during a 1-day census. These aircraft and a separate radiotracking plane communicated locations of caribou groups to the pilot of a DeHavilland Beaver aircraft equipped with a 9x9 format camera. This camera was used to photograph all groups numbering over 100 caribou; usually 20 to 30 groups were photographed during a census. Smaller groups totaling 500 caribou were visually counted. Photographed caribou were counted using 10X magnification. Counts probably include a high proportion of calves, but we are certain some calves are missed because of their small size and varying photo quality. We suspect that a fairly consistent proportion of the calves are counted among years, but counters cannot consistently separate calves from adults in the photos, so we have no way of testing this hypothesis.

To date we have used photocensus data to calculate growth rates of the herd (Boertje et al. 1996). We also used data on herd composition, pregnancy, and mortality to model population trends because photocensuses have, on occasion, substantially underestimated caribou numbers in the Delta Herd (Boertje et al. 1996).

Explaining Causes for Herd Fluctuations and Estimating Trend From Data on Herd Composition, Pregnancy, and Mortality

We developed simple conceptual models to assess how productivity and various mortality factors affected herd size among years. Data on herd composition and total numbers allowed us to calculate the number of potentially productive cows in the herd, i.e., cows ≥36 months old (Appendices A, B, and C). We then calculated the number of calves born (pregnancy rate x number of cows ≥36 months old). Finally, we calculated the number of calves and adults dying from various causes using proportions of mortalities among collared samples. This allowed us to calculate net recruitment (number of calves surviving 12 months minus the number of adults dying during those 12 months).

To estimate herd composition, we classified caribou from a helicopter during late September or early October 1991-1997 using the distribution of radiocollared caribou to randomly select caribou for counting. Cows, calves, and small, medium, and large bulls were counted during the 1-day survey each year. Caribou bulls and cows are more randomly mixed during this period than during the remainder of the year. The helicopter crew relied on a Bellanca Scout pilot to relay locations of radiocollared caribou. After each count, we verified the proportion of caribou counted in an area closely matched the proportion of radiocollars in that area, and we corrected biases in the counts using ratios when necessary.

We estimated pregnancy rates of the herd during mid to late May by documenting the presence or absence of a calf, hard antlers, and/or a distended udder among radiocollared female caribou ≥24 months old (Whitten 1995). Pregnancy was easy to confirm using these techniques. To confirm nonpregnancy, we repeated observations at least twice during 11-31 May 1984-1997.

We estimated mortality rates among different age classes from October 1992 to October 1997 by radiolocating all collared caribou 1 or 2 times monthly. In addition, during 1994 through 1997, we flew daily between 11 May and 31 May, 10-13 times in June, and weekly during July through September. Radiocollars contained a mortality sensor that doubled the pulse rate if the collar remained motionless for 1 hour (newborn calf collars) or 6 hours (other collars). Annual mortality rate (M) was calculated as $M = A/B \times 100$, where A = the number of caribou dying during the 12-month period and B = the total number of collared caribou at the beginning of the 12-month period. We used the chi-square test of proportions to test for statistical differences among proportions (Conover 1980:144-151).

Evaluating Causes of Natural Caribou Mortality

When a mortality was detected during daily May flights, we investigated the site via helicopter, usually within 4 hours of detection. After May, we investigated mortality sites as soon as possible, usually within 1 day of detection. We necropsied carcass remains either on site or in the laboratory and noted wounding patterns. Hemorrhaging associated with puncture wounds, blood (noncoagulated) on collars, or blood on remnants of hide served as evidence of a violent death. In these cases scats, tracks, wounding patterns, other signs, and season of kill (bears hibernating in winter) served to identify the predator involved (Ballard et al. 1979; Adams et al. 1989). Bears often scraped up portions of the tundra mat and buried portions of the carcass or left crushed, cleaned bones in a small area with the collar. Wolves often left the carcass intact, cached whole or half carcasses in snow or muskeg without obvious digging, or carried the bloody collar some distance from the kill site. A collar soaked in blood indicated lynx (*Lynx canadensis*) predation, based on evidence of lynx predation in the snow at several sites.

ESTIMATING CARIBOU HARVEST

Procedures for estimating total and female caribou harvest varied, depending on the type of harvest reporting system. We considered harvest reports collected from permit hunts accurate estimates of total harvest because about 97% of permittees responded. In addition, we added estimates of illegal harvest from road and trail surveys each year. All harvest since 1993 and most harvest during 1990-1992 was conducted under permit hunts. During general season hunts, harvest was reported by mandatory mail-in report cards without the benefit of reminder letters. Correction factors for general season hunts were derived from road surveys and surveys of transporter services during 1973. To avoid biased reporting, hunters were not told the purpose of these surveys. The surveys and subsequent mail-in harvest reports were treated as a mark-recapture sample to estimate total harvest. Harvest from general season hunts was multiplied by 1.59.

ESTIMATING WOLF HARVEST RATES IN THE HERD'S ANNUAL RANGES

To estimate wolf harvest rates within the respective annual ranges of the Fortymile Caribou Herd for the years 1992-1993 through 1996-1997, we delineated annual ranges of the herd based on monthly telemetry flights beginning 1 October. We then digitized the size of the annual ranges used by the herd and extrapolated wolf densities to these areas based on respective annual estimates of wolf densities from radiocollared wolf packs and wolf surveys in most of the annual caribou ranges. Mandatory reporting forms provided information on wolf harvest locations. Regulations allowed wolf hunting during 10 August-30 April and wolf trapping during 15 October-30 April on most of the herd's annual ranges.

EVALUATING HERD NUTRITIONAL STATUS

We used 4 indices to evaluate relative condition/nutritional status of the herd. First, we estimated pregnancy rates and age of first reproduction during the 1992 through 1997 calving seasons, using a radiocollared sample of cows as described above. Sample sizes varied annually from 39-47 cows ≥36 months old and 5-6 cows 24 months old. Second, we annually weighed 14 or 15 female autumn calves and 50 to 60 newborn calves using a calibrated spring or electronic scale. Third, we estimated the median calving date during 1992-1997, which is the date by which 50% of the pregnant radiocollared cows had given birth.

Last, we estimated the percent mortality of calves during their first 2 days of life. High calf mortality (e.g., 20-30%) during the first 2 days of life has been linked to malnutrition, and we evaluated this factor as an index to herd nutritional status (Whitten et al. 1992). To detect calf mortality during the first 2 days of life, we observed a sample of 32 to 39 radiocollared, pregnant cows on consecutive days during calving seasons 1992 through 1997. These cows were observed each day until they gave birth and on the first 2 consecutive days after birth. During 1994-1997, we determined the cause of mortality among calves to test the hypothesis that early mortality was attributable to malnutrition.

Evaluating the Lichen Component of the Herd's Winter Diet to Assess Range Condition

We collected 24 fecal samples from the Fortymile Herd winter ranges during January through April 1992-1996. Each sample contained 25 pellets; 1 pellet was collected from each of 25 different piles found afield (Boertje et al. 1985). Samples were analyzed at the Composition Analysis Laboratory in Fort Collins, Colorado.

RESULTS AND DISCUSSION

Herd Numbers and Trend

The first systematic estimate of herd numbers occurred in 1920 when several observers counted portions of the Fortymile Caribou Herd crossing the Steese Highway on a 20-day autumn migration that was 60 miles wide. Murie's (1935:6) extrapolated estimate in 1920 was a "conservative" 568,000.

The low point for the herd came during 1973-1975 when the first photocensuses were conducted and only 5740 to 8610 caribou remained (Valkenburg et al. 1994). Herd numbers increased during the late 1970s and 1980s at annual rates of 7% to 10% reaching about 23,000 caribou by 1989 (Valkenburg et al. 1994).

During this study, photocensuses indicated a fairly stable trend during 1990-1995, with approximately 22,000 to 23,000 caribou in the herd, followed by an increase to almost 26,000 by 26 June 1997 (Table 1). The increase rate was 4% between 14 June 1995 and 21 June 1996 and 10% between 21 June 1996 and 26 June 1997. Increases were also predicted by models using 1995-1997 composition, pregnancy, and mortality data (Table 1; Appendices A, B, and C).

Timing, Rates, and Causes of Natural Mortality

During the combined calving seasons of 1994-1997, we observed newborn calves during 11-28 May. By the end of June 1994-1996, 40% to 50% of the calves were dead. Another 20% died before reaching the age of 1 year (Figs 2-4; Table 2). No significant differences occurred during these 3 years (chi-square test of proportions, 2x3 table, $P = 0.56$). This pattern of births and deaths is similar to that found in other Interior Alaskan caribou studies (Adams et al. 1995*b*; Valkenburg 1997).

A major change occurred in 1997 when calf mortality rates declined >50% compared with the previous 3 years; this decline was statistically significant (Table 2, chi-square test of proportions, 2x2 table, $P = 0.004$). By the end of June 1997 only 18% of the calves were dead and the total mortality rate by 31 October was 25% (Fig 5; Table 2). Decreased mortality in the 1997 cohort was caused by small declines in all causes of mortality (Table 3). A factor contributing to decreased wolf predation probably included successfully spacing calves between wolf territories in the upper elevations of the Seventymile River (Bergerud and Page 1987). The herd had not previously concentrated its calving in the upper Seventymile, and we know of no wolf packs that regularly used this area in recent years. Also, frequent snowstorms and cool weather during the 1997 calving season provided mottled snow cover, which allowed caribou cows to more easily hide their newborns and increased the search effort required for predators to find calves (Bergerud and Page 1987). Calving did not seem more concentrated in 1997 compared with previous years.

Causes of death among calves <4 months old were similar among years (Table 3). Wolves and grizzly bears were consistently the major predators. Golden eagles (*Aquila chrysaetos*), black bears (*Ursus americanus*), and wolverines (*Gulo gulo*) were common minor predators. Relatively few calves died from causes other than predation (Table 3).

Since 1991, wolf predation was the major cause of death among caribou calves 4-12 months old and caribou >12 months old. Of the 32 calves 4-12 months old for which cause of death was determined (Oct 1991-30 Sep 1997), wolves killed 28 (88%), lynx killed 2 (6%), a wolverine killed 1 (3%), and 1 (3%) died from nonpredation. Of the 30 caribou >12 months old for which cause of death was determined (Oct 1991-30 Sep 1997), wolves killed 26 (87%), grizzly bears killed 2 (7%), and 2 (7%) died from nonpredation deaths. Most (84%) of these 62 deaths occurred during the 7 months (Oct-Apr) when snow was on the ground.

Annual wolf predation rates (25%-32%) on radiocollared calves (n = 50-60) varied little among the 1994-1996 cohorts and will provide the pretreatment data needed to see if reducing wolf numbers in the treatment area can significantly reduce wolf predation. Wolf sterilizations and translocations began during November 1997 and may slightly influence winter survival of the 1997 cohort. Full treatment of 15 key wolf packs is expected from May 1999 through May 2001, which will provide 2 years to test whether wolf predation on calves is significantly reduced (1-tailed test) compared to the 3 pretreatment years (May 1994-May 1997). We will also test for decreasing trends in summer wolf-caused mortality. Interpretations of data will depend in part on the distribution of caribou in relation to the treatment area among the various years.

Fairly stable mortality rates among caribou older than 4 months during 1993-1997 indicate other factors must be responsible for the herd's increase in 1996 and 1997 (Table 1). No significant declines in these mortality rates were observed during 1996-1997 when the herd was increasing, compared with data from 1993-1995 when the herd was stable (chi-square test of proportions, 2x2 table, $P = 0.90$).

We found significantly higher mortality among caribou 4 to 16 months old compared with older caribou for the years 1993-1997 (Table 1, chi-square test of proportions, 2x2 table, $P = 0.007$). These data conflict with those of Davis et al. (1988) who reported similar mortality rates among >5-month-old calves, yearlings, and adults in the Delta Herd.

Elevated mortality from age 4 to 16 months in the 1991 cohort (57%, n = 14, Table 1) may have been associated with inadvertent separation of calves from their dams at collaring (27 Sep-22 Oct). We darted calves and their dams simultaneously in 1991 and only 2 of 14 cow-calf pairs reunited after recovery from drugging. In 1990 and 1992 through 1997, we radiocollared calves, but not their dams, and cow-calf pairs consistently reunited. Implications of these data are that human hunting of cows with calves during autumn or early winter may reduce the survival of orphaned calves where wolves are major predators. Seven (88%) of the 8 dead calves were killed by wolves.

POPULATION MODELING

We completed 3 annual models using data on herd size, herd composition, pregnancy, and mortality to illustrate the relative importance of factors affecting the size of the Fortymile Caribou Herd (Figs 6-8; Appendices A, B, and C). With certain qualifications, the models can help us understand why photocensus results changed or remained stable among years. For example, if the herd increased, was this increase caused by decreased mortality or increased productivity. These models are sensitive to small, statistically insignificant changes in mortality rates, i.e., when an additional 3 among 50 caribou die and adult mortality rates change from 6% to 12%. Therefore caution should be used when interpreting model output, as described below.

The first year's model (11 May 1994-10 May 1995) indicated a fairly stable trend, i.e., the number of births almost equaled the number of deaths (Fig 6; Appendix A). This stable trend was consistent with independent late June photocensuses from 1990-1995 (Table 1). To summarize, of the 20,000 adults and yearlings and 8090 newborn calves present in May 1994, we estimate wolves killed 4190 (15%) caribou within 12 months. In contrast, grizzly bears killed 2010 (7%), other predators killed 840 (3%), hunters killed 330 (1%), and nonpredation accounted for 990 deaths (4%).

The primary difference in the 1995-1996 photocensus and modeling data was that the herd increased. We counted 900 additional caribou on 21 June 1996 (23,458 caribou) compared to 14 June 1995 (22,558). Much of this increase probably resulted from the approximately 2000 additional calves born during late May 1996 (see Herd Nutritional Indices, Weather, and Related Herd Performance for increased birth rates) compared to 1994 and 1995 (Figs 6-8; Table 1). These calves are not included in the 11 May 1995-10 May 1996 modeling data. The model indicated about 1000 more adult caribou survived wolf predation compared to the 1994-1995 model and about 1000 more calves survived because of slightly reduced nonpredation and grizzly bear predation (Figs 6-7). However, the model inputs which resulted in increased survival were not statistically significant. For example, adult mortality decreased from 12% (6/52) during May 1994-May 1995 to 6% (3/49) during May 1995-May 1996 (Appendices A and B); these differences are not significant (chi-square test of proportions, 2x2 table, $P = 0.34$).

The 1996-1997 photocensus and modeling data also indicated the herd was increasing. We counted about 2500 additional caribou on 27 June 1997 (25,912) compared to 21 June 1996 (23,458). The most likely causes of this increase were the recruitment of additional calves born during May 1996 (Figs 6-8) and improved calf survival in May and June 1997 (see Timing, Rates, and Causes of Natural Mortality; Table 2), not changes in annual survival rates in the 1996-1997 model (Tables 1-2; Fig 8). Calf survival was significantly higher during May and June 1997 compared to the previous 3 springs (Table 2; chi-square test of proportions, 2x2 test, $P = 0.0003$). Calf survival rates in the 1996-1997 model were not significantly different from rates in the previous models (Table 2; chi-square test of proportions, 2x2 table, $P =$

0.89); neither did survival rates of caribou older than calves differ significantly (Appendices A, B, and C; chi-square test of proportions, 2x2 table, $P = 0.46$).

CARIBOU HARVEST

To increase social acceptance of the management plan, the Fortymile Team chose to reduce the annual harvest to 150 bulls for 5 years beginning in 1996. We illustrated the relatively minor role that harvest has recently had on herd dynamics in Figures 6-8. Harvests have been intentionally held low since 1973 to encourage herd growth (Valkenburg et al. 1994). Reducing harvests from 200-500 bulls (≤2% of the herd, 1990-1995) to 150 bulls (<1% bulls, 1996-2000) will not result in the 5% to 10% annual rates of herd increase desired by the Fortymile Team. Estimated total annual harvest averaged 2.8% of the midsummer herd size during the 6 years before 1990. In 1990, harvest was intentionally reduced because natural mortality increased and calf:cow ratios declined (Table 1).

Following 2 hunting seasons with a quota of 150 bulls, we have observed no increase in the bull:cow ratio (Table 1). No significant increases in bull:cow ratios are expected during the next 3 years. For example, bull:cow ratios in the Fortymile Herd ($\bar{x}$ = 43 bulls:100 cows, range = 36-50, 1985-1997, Table 1) are not reduced by harvest compared with ratios from the only Interior Alaska herd with no harvest in recent decades ($\bar{x}$ = 43 bulls:100 cows, range = 29-56 in the Denali Herd, 1985-1997).

WOLF HARVEST

The Fortymile Caribou Calf Protection Program, a group of private citizens, paid $400 per wolf from a large area (33,200 km^2) including most of the Fortymile Herd's range beginning winter 1995-1996 and continuing through winter 1996-1997. This $400 approximately doubled the market value of pelts and was provided to stimulate increased wolf harvest with the goal of increasing the Fortymile Herd and associated moose and sheep populations.

To evaluate the effect of the Caribou Calf Protection Program on wolves and caribou, we compiled estimates of wolf densities and harvest rates from within the herd's respective annual ranges for 3 years prior to the program and during the 2 years of the program (Table 4). We analyzed wolf harvest rates over the herd's entire respective annual ranges because caribou used different areas each year, especially during winters. Most of the wolf harvest occurred on caribou wintering areas. We detected no substantial reductions in the autumn wolf densities during this program, although a slight decline was detected following winter 1995-1996 when 57% of the wolves were harvested (Table 4). Without substantial reductions in autumn wolf densities, annual wolf predation on caribou is not expected to decline significantly.

Sustained wolf harvest rates exceeding about 28% of the autumn wolf population are expected to result in wolf population declines (Fuller 1989; Gasaway et al. 1992). However, significant increases in moose and caribou numbers have been reported only after maintaining spring wolf densities 69% to 85% below initial autumn wolf numbers for several years (Larsen and Ward 1995; Boertje et al. 1996). In contrast, wolf densities in the respective annual ranges of the Fortymile Herd were reduced only 19% to 28% by harvest during winters 1992-1993 through 1996-1997, except during winter 1995-1996 (Table 4).

Sustained high harvest rates are required to keep wolf populations below levels found in systems with little or no harvest because wolves have high reproductive and immigration rates (Larsen and Ward 1995; Boertje et al. 1996). Recent autumn densities of 7-8 wolves/1000 km^2 in this study were similar to estimates prior to the private incentive program, when trapping pressure was less intense (Table 4). In Denali National Park and Preserve, where little wolf harvest occurred and prey densities were similar to those in the Fortymile Herd's range, Meier et al. (1995) reported autumn densities of 5-10 wolves/1000 km^2 during 1986-1992. Average autumn densities of 8 wolves/1000 km^2 were reported in 13 Alaska and Yukon study areas where wolves were lightly harvested and prey densities were similar to those in the Fortymile Herd's range (Gasaway et al. 1992:36-38).

HERD NUTRITIONAL INDICES, WEATHER, AND RELATED HERD PERFORMANCE

We studied indices to nutritional status, weather data, and herd productivity and survival for several reasons. First, comparisons with similar data from other herds enabled us to evaluate the relative nutritional status of the Fortymile Herd. Second, nutritional data provided us insights about weather factors important to herd performance. Third, we wanted to identify which nutritional indices may be useful in predicting herd performance.

We found consistent evidence for moderate to high nutritional status in the Fortymile Herd during this study when indices were compared with other Alaskan herds (Whitten et al. 1992; Valkenburg 1997). However, more data are needed during a natural decline and increase in the Fortymile Herd to describe the potential lower and upper level of nutritional indices in the Fortymile ecosystem. For example, we found no evidence of pregnancy in 32 radiocollared 2-year-olds during this study. Pregnant 2-year-old caribou are rarely found in Alaska and their calves rarely survive, but pregnancy in 2-year-olds signifies extremely good nutritional status (Davis et al. 1991; Valkenburg 1997).

The single evidence for malnutrition during this study was the low pregnancy rate during 1993 following the abnormally short growing season of 1992. However, this single evidence for malnutrition resulted in no strong decline in herd numbers, as occurred in the Delta and Denali herds (Table 1; Boertje et al. 1996). Many adult cows (≥3 years old) apparently did not gain sufficient fat to breed in autumn 1992. The pregnancy rate in 1993 was low in the Fortymile Herd (68%; Table 1), the Delta Herd (30%), the Nelchina Herd (66%), and the Chisana Herd (50%, Valkenburg 1993). Pregnancy rates for caribou are commonly ≥82% (Table 1; Bergerud 1980). Only 5 (42%) of 12 3-year-olds produced calves in the Fortymile Herd in 1993, compared with 5 (83%) of 6 in 1994, 5 (71%) of 7 in 1995, 9 (100%) of 9 in 1996, and 6 (100%) of 6 in 1997. Only 126 snow-free days occurred in Fairbanks in 1992 compared with 160 to 199 days during the previous 19 years (Boertje et al. 1996). Snowmelt was several weeks late during spring 1992, and snowfall was several weeks early in autumn 1992.

Data from pregnancy rates probably provide indices to the previous spring/summer/autumn condition, similar to data on autumn calf weights. Data on pregnancy rates indicate caribou nutritional status was poor in autumn 1992, excellent in autumn 1995, and average in autumns 1991, 1993, 1994, and 1996 (Table 1). Autumn calf weights have been relatively high and stable compared with nutritionally stressed herds (Table 5; Valkenburg 1997). Autumn calves reached relatively high weights in 1992 despite the short growing season. Only during 1997 were weights significantly higher than all other years ($P = 0.02$ in comparing cumulative years, ANOVA, and $P = 0.001$-0.056 when comparing individual years, Student's *t*-test).

Birthweights and calving dates probably provide indices to winter and spring conditions. Low birthweights and delayed calving are thought to indicate malnutrition (Espmark 1980; Reimers et al. 1983; Skogland 1985; Adams et al. 1995*b*). Fortymile birthweights during this study were relatively high and stable compared to nutritionally stressed herds (Table 6; Valkenburg 1997). Birthweights indicated spring nutritional status improved during 1995-1997 compared to 1994 (Table 6). Unlike data from the Denali Herd, an increase in birthweights did not occur when calf mortality declined in 1997 (Tables 2 and 6; Adams et al. 1995*b*). Median calving dates indicate spring nutritional status may have improved beginning 1994 (Table 6).

We examined the rates (1992-1997) and causes (1994-1997) of mortality among calves during their first 2 days of life to test whether perinatal mortality in the Fortymile Herd is caused primarily by nutrition-related factors, as concluded by studies of the Porcupine Herd (Whitten et al. 1992). We found no convincing support for this hypothesis in the Fortymile Herd. Instead, predation was the major cause of death among calves ≤2 days old, e.g., in 17 (74%) of 23 cases of observing radiocollared cows or calves. Also, rates of perinatal mortality were highly variable among years and not highest in 1993 when nutritional status was low. Perinatal mortality rates observed among offspring of collared cows were 3% ($n = 30$) in 1992, 14% ($n = 28$) in 1993, 22% ($n = 32$) in 1994, 7% ($n = 28$) in 1995, 21% ($n = 38$) in 1996, and 3% ($n = 35$) in 1997. In conclusion, we do not recommend mortality rates among young Fortymile calves be used as an index to herd nutritional status. The data is difficult and expensive to collect and does not seem to be correlated with nutritional status.

Because we saw no strong decline in the Fortymile Herd during 1992 when nutritional status was poor, we conclude that poor nutritional status was not as strong a factor affecting caribou numbers in the Fortymile Herd as in the Delta and Denali herds (Boertje et al. 1996). Contributing factors may be that weather patterns are more continental in the Fortymile Herd's range, and the Fortymile Herd consumes more lichens than the Delta Herd (Table 7; Valkenburg 1994).

HERD DISEASES

Potential exposure of the Fortymile Herd to 10 ungulate diseases has been monitored since 1980 using blood sera collected from immobilized caribou ≥4 months old. Similar data have been collected from other herds in Alaska and the Yukon (Zarnke 1996). Few documented cases exist in which infectious diseases have had a detectable effect on caribou herds in Alaska. Brucellosis in arctic caribou herds is a notable exception (Valkenburg et al. 1996*b*, Zarnke 1996). From 1980-1995, 159 sera samples have been collected from Fortymile Herd caribou. There was no evidence of exposure to *Brucella suis IV* in any of these samples.

RANGE CONDITION

Range condition was excellent during winters 1991-1992 through 1995-1996, as evidenced by high proportions (x = 80%) of lichen fragments in caribou fecal samples (Table 7). Samples were collected from several different wintering areas (Fig 9). Boertje (1981) and Boertje et al. (1985) provided data showing the usefulness of fecal samples in evaluating use of lichens on winter ranges. Lichens are slower growing than vascular plants and are a highly preferred and highly digestible winter forage, in contrast to mosses and evergreen shrubs (Boertje 1990). Fecal samples from overgrazed winter ranges contained reduced proportions of lichens (30%-40%) and higher proportions of mosses (30%-60%) or evergreen shrubs (30%) compared to values observed in this study (Table 7; Boertje et al. 1985; Valkenburg 1994).

CONCLUSIONS

The Fortymile Herd clearly has the potential to grow. The herd currently uses <30% of its historic range, its multiyear density is about 500 caribou/1000 km^2, and nutrition is not a strong limiting factor. Predicting trends in caribou numbers is problematic. We know that a variety of factors can cause a surge or drop in numbers, that stability is seldom long term, and that rapid declines can occur from the synergistic effects of adverse weather and increased predation (Boertje et al. 1996). Also, we know that continental caribou herds have commonly remained at multiyear densities of ≤500 caribou/1000 km^2 during the last 2 decades mainly because of predation (Bergerud 1980; Valkenburg et al. 1996*a*). We found exceptions where strong predator control occurred during favorable weather and where predators were scarce on caribou calving grounds.

Assuring achievement of time-specific objectives for increased Fortymile caribou numbers will depend on actions that substantially reduce predation, presumably combined with favorable weather. Novel, experimental approaches to reducing predation have been proposed, and we are well prepared to test the effectiveness of these approaches.

Reducing predation is a value-based socioeconomic and political decision beyond the scope of this paper. Ecological and biological issues are more easily addressed. For example, sustainable harvest of a caribou herd is ecologically sound compared to dependency on alternative livestock and agricultural industries. Past studies have shown wolf reductions can be biologically effective and sound, i.e., 1) caribou herds can grow rapidly following large reductions in wolf numbers and 2) wolf numbers can recover within a few years (Larsen and Ward 1995; Boertje et al. 1996).

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LITERATURE CITED

ADAMS LG, BW DALE, AND B SHULTS. 1989. Population status and calf mortality of the Denali Caribou Herd, Denali National Park and Preserve, Alaska, 1984-1988. US National Park Service. Alaska Regional Natural Resources. Progress Report AR-89/13, Anchorage. 131pp.

——, ——, AND LD MECH. 1995*a*. Wolf predation on caribou calves in Denali National Park, Alaska. Pages 245-260 *in* LN Carbyn, SH Fritts, and DR Seip, eds. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute, Occasional Publication 35. University of Alberta, Edmonton, Canada. 620pp.

——, FJ SINGER, AND BW DALE. 1995*b*. Caribou calf mortality in Denali National Park, Alaska. *Journal of Wildlife Management* 59:584-594.

BALLARD WB, AW FRANZMANN, KP TAYLOR, T SPRAKER, AND RO PETERSON. 1979. Comparisons of techniques utilized to determine moose calf mortality in Alaska. *Alces* 15:363-387.

BERGERUD AT. 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, eds. Proceedings of second international reindeer/caribou symposium, Roros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim, Norway.

—— AND RE PAGE. 1987. Displacement and dispersion of parturient caribou at calving as antipredator tactics. *Canadian Journal of Zoology* 65:1597-1606.

BOERTJE RD. 1981. Seasonal diets of the Denali Caribou Herd, Alaska. *Arctic* 37:161-165.

——. 1990. Diet quality and intake requirements of adult female caribou of the Denali Herd, Alaska. *Journal of Applied Ecology* 27:420-434.

——, JL DAVIS, AND P VALKENBURG. 1985. Uses and limitations of fecal analyses in *Rangifer* studies. Pages 307-316 *in* TC Meredith and AM Martell, eds. Proceedings second North American caribou workshop. Val Morin, Canada. McGill Subarctic Research Station. Paper No. 40.

—— AND CL GARDNER. 1996. Factors limiting the Fortymile Caribou Herd. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Progress Report. Study 3.38. Grant W-24-4. Juneau. 79pp.

——, WC GASAWAY, DV GRANGAARD, AND DG KELLEYHOUSE. 1988. Predation on moose and caribou by radio-collared grizzly bears in eastcentral Alaska. *Canadian Journal of Zoology* 66:2492-2499.

——, ——, ——, ——, AND RO STEPHENSON. 1987. Factors limiting moose population growth in Subunit 20E. Alaska Department Fish and Game. Federal Aid in Wildlife Restoration. Progress Report. Grant W-22-5. Juneau. 86pp.

——, P VALKENBURG, AND ME MCNAY. 1996. Increases in moose, caribou, and wolves following wolf control in Alaska. *Journal of Wildlife Management* 474-489.

CONOVER WJ. 1980. Practical Nonparametric Statistics, Second Edition. John Wiley and Sons, New York, New York. 493 pp.

CRETE M AND H JOLICOEUR. 1987. Impact of wolf and black bear removal on cow:calf ratio and moose density in southwestern Quebec. *Alces* 23:61-87.

DAVIS JL, LG ADAMS, P VALKENBURG, DJ REED. 1991. Relationships between body weight, early puberty, and reproductive histories in Central Alaskan caribou. Pages 115-142 *in* CE Butler and SP Mahoney, eds. Proceedings of the fourth North American caribou workshop. St John's, Newfoundland.

——, RE LeResche, and RT Shideler. 1978. Size, composition, and productivity of the Fortymile Caribou Herd. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Final Report. Grants W-17-6 and W-17-7. Juneau. 69pp.

——, P Valkenburg, and RD Boertje. 1983. Demography and limiting factors of Alaska's Delta Caribou Herd, 1954-1981. *Acta Zoologica Fennica* 175:135-137.

——, ——, and DJ Reed. 1988. Mortality of Delta Herd caribou to 24 months of age. Proceedings of third North American caribou workshop. Alaska Department of Fish and Game. Juneau. Wildlife Technical Bulletin 8:35-37.

Espmark Y. 1980. Effects of maternal prepartum undernutrition on early mother-calf relationships in reindeer. Pages 485-496 *in* E Reimers, E Gaare, and S Skjenneberg, eds. Proceedings of the second international reindeer/caribou symposium, Roros, Norway, 1979. Direktoratet for vilt og ferskvannsfisk, Trondheim.

Farnell R and J MacDonald. 1988. The influence of wolf predation on caribou mortality in Yukon's Finlayson Caribou Herd. Proceedings of the third North American caribou workshop. Alaska Department of Fish and Game. Juneau. Wildlife Technical Bulletin 8:52-70.

Fuller TK. 1989. Population dynamics of wolves in north-central Minnesota. *Wildlife Monograph* 105. 41pp.

Gardner CL. 1997. Unit 20E wolf management report, 1993-1996. Management report of survey-inventory activities. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. In press. Juneau. 14pp.

Gasaway WC, RD Boertje, DV Grangaard, DG Kelleyhouse, RO Stephenson, and DG Larsen. 1992. The role of predation in limiting moose at low densities in Alaska and Yukon and implications for conservation. *Wildlife Monograph* 120. 59pp.

——, RO Stephenson, JL Davis, PEK Shepherd, and OE Burris. 1983. Interrelationships of wolves, prey, and man in interior Alaska. *Wildlife Monograph* 84. 50pp.

Larsen, DG, DA Gauthier, RL Markel, and RD Hayes. 1989. Limiting factors on moose population growth in the southwest Yukon. Yukon Department of Renewable Resources. Final Report. Whitehorse. 105pp.

—— and RMP Ward. 1995. Moose population characteristics in the Frances Lake and North Canol areas, 1991. Department of Renewable Resources, Project PR-95-1. Whitehorse, Yukon. 43pp.

Mech LD, TJ Meier, JW Burch, and LG Adams. 1995. Patterns of prey selection by wolves in Denali National Park, Alaska. Pages 231-244 *in* LN Carbyn, SH Fritts, and DR Seip, eds. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute, Occasional Publication 35. University of Alberta, Edmonton, Canada. 620pp.

Meier, TJ, JW Burch, LD Mech, and LG Adams. 1995. Pack structure and genetic relatedness among wolf packs in a naturally-regulated population. Pages 293-302 *in* LN Carbyn, SH Fritts, and DR Seip, eds. Ecology and conservation of wolves in a changing world. Canadian Circumpolar Institute, Occasional Publication 35. University of Alberta, Edmonton. Canada. 620pp.

Murie OJ. 1935. Alaska-Yukon caribou. North American Fauna No. 54. US Department of Agriculture, Washington, DC. 93pp.

Reimers E, DR Klein, and R Sorumgard. 1983. Calving time, growth rate, and body size of Norwegian reindeer on different ranges. Arctic and Alpine Research 15:107-118.

SKOGLAND T. 1985. Life history characteristics of wild reindeer (*Rangifer tarandus tarandus* L.) in relation to their food resources; ecological effects and behavioral adaptations. Papers of the Norwegian State Game Research Institute Series 3, Number 14. Direktoratet for Wildlife and Freshwater Fish, Trondheim. 34pp.

VALKENBURG P. 1993. Investigation of regulating and limiting factors in the Delta Caribou Herd. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Progress Report. Grant W-24-1. Juneau. 19pp.

——. 1994. Investigation of regulating and limiting factors in the Delta Caribou Herd. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Progress Report. Grant W-24-2. Juneau. 18pp.

——. 1997. Investigation of regulating and limiting factors in the Delta Caribou Herd. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Final Report. Grants W-23-5, W-24-1, W-24-2, W-24-3, W-24-4. Juneau. 45pp.

——, DA ANDERSON, JL DAVIS, AND DJ REED. 1985. Evaluation of an aerial photocensus technique for caribou based on radio-telemetry. Pages 287-299 *in* TC Meredith and AM Martell, eds. Proceedings second North American caribou workshop. Val Morin, Canada. McGill Subarctic Research Station, Schefferville, Quebec.

—— AND JL DAVIS. 1989. Population status of the Fortymile Caribou Herd and identification of limiting factors. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Final Report. Grant W-23-1. Juneau. 33pp.

——, ——, JM VER HOEF, RD BOERTJE, ME MCNAY, RM EAGAN, DJ REED, CL GARDNER, AND RW TOBEY. 1996*a*. Population decline in the Delta Caribou Herd with reference to other Alaskan herds. *Rangifer* Special Issue 9:53-62.

——, DG KELLEYHOUSE, JL DAVIS, AND JM VER HOEF. 1994. Case history of the Fortymile Caribou Herd, 1920-90. *Rangifer* 14:11-22.

——, JM VER HOEF, AND RL ZARNKE. 1996*b*. Investigation and improvement of techniques for monitoring recruitment, population trend, and nutritional status in the Western Arctic Caribou Herd. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Final Report. Grants W-24-1, W-24-2, W-24-3, W-24-4. Juneau. 53pp.

WHITTEN KR. 1995. Antler loss and udder distention in relation to parturition in caribou. *Journal of Wildlife Management* 59:273-277.

——, GN GARNER, FJ MAUER, AND RB HARRIS. 1992. Productivity and early survival in the Porcupine Caribou Herd. *Journal of Wildlife Management* 56:201-212.

ZARNKE RL. 1996. Serologic survey of Alaskan wildlife for microbial pathogens. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration. Final Report. Grants W-23-5, W-24-1, W-24-2, W-24-3, W-24-4. Juneau. 64pp.

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FIGURE 1 UNAVAILABLE IN THIS FORMAT

Figure 1 Range of the Fortymile Caribou Herd, 1984-1997

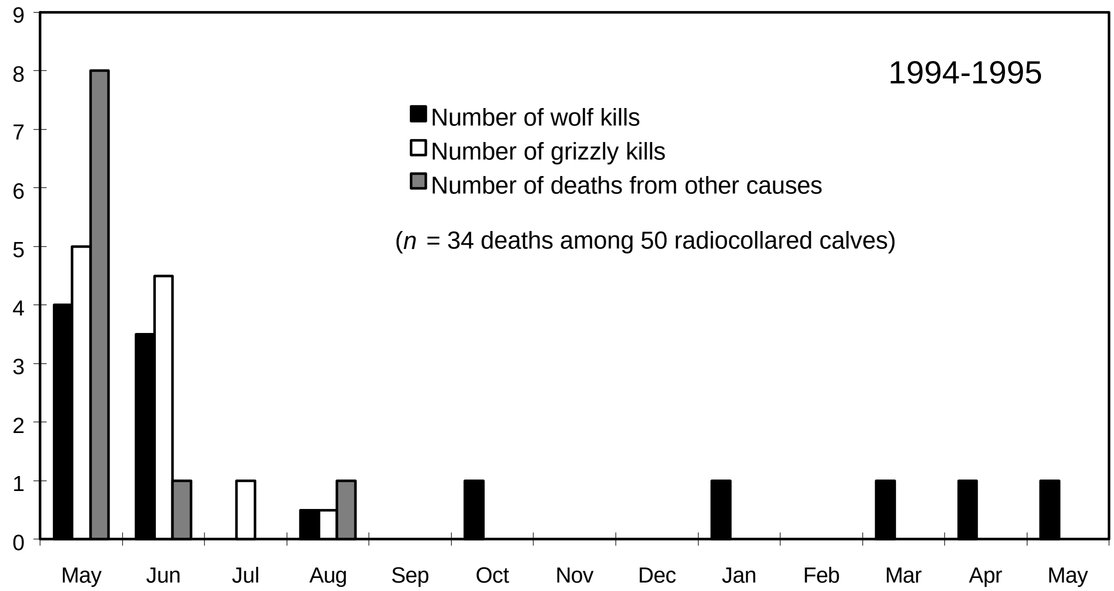

Figure 2 Frequency distribution of causes of death among 34 radiocollared caribou calves that died from May 1994 through early May 1995, Fortymile Caribou Herd, Eastcentral Alaska

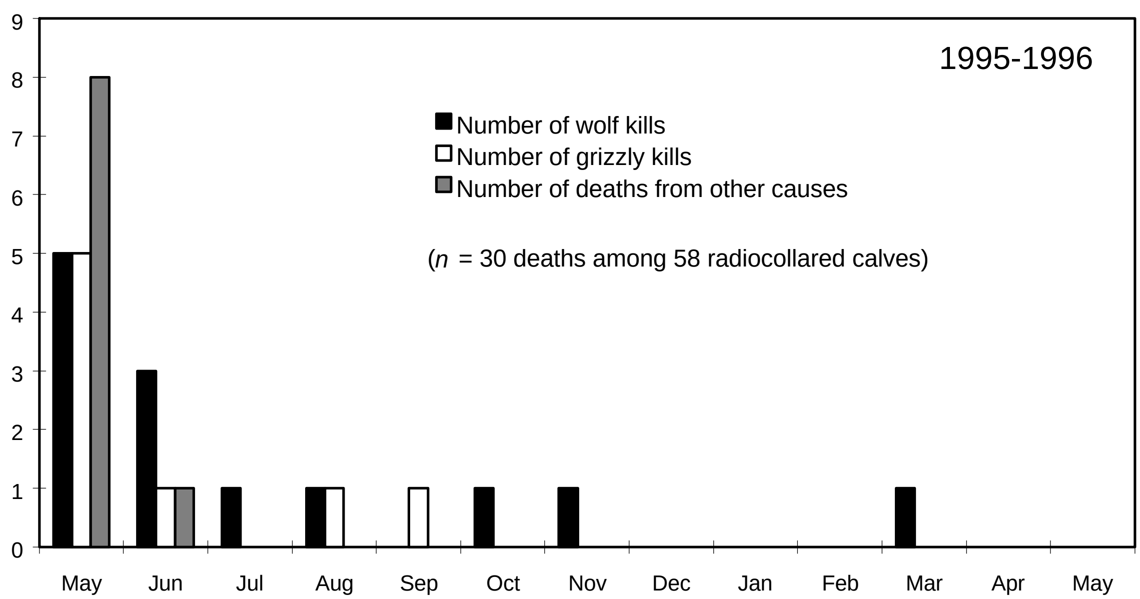

Figure 3 Frequency distribution of causes of death among 30 radiocollared caribou calves that died from May 1995 through early May 1996, Fortymile Caribou Herd, Eastcentral Alaska

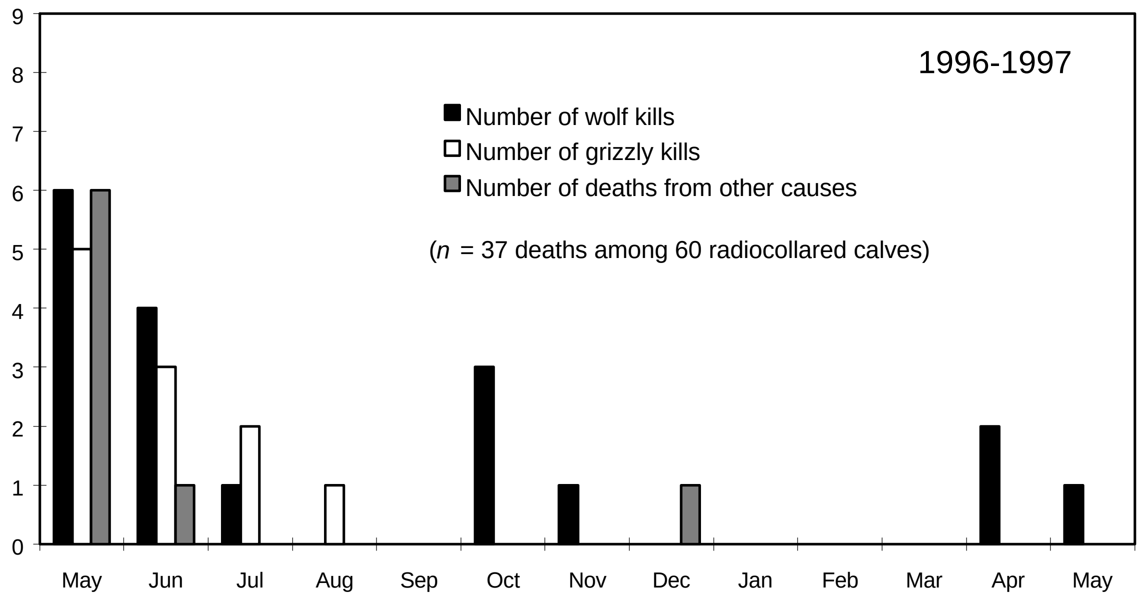

Figure 4 Frequency distribution of causes of death among 37 radiocollared caribou calves that died from May 1996 through early May 1997, Fortymile Caribou Herd, Eastcentral Alaska

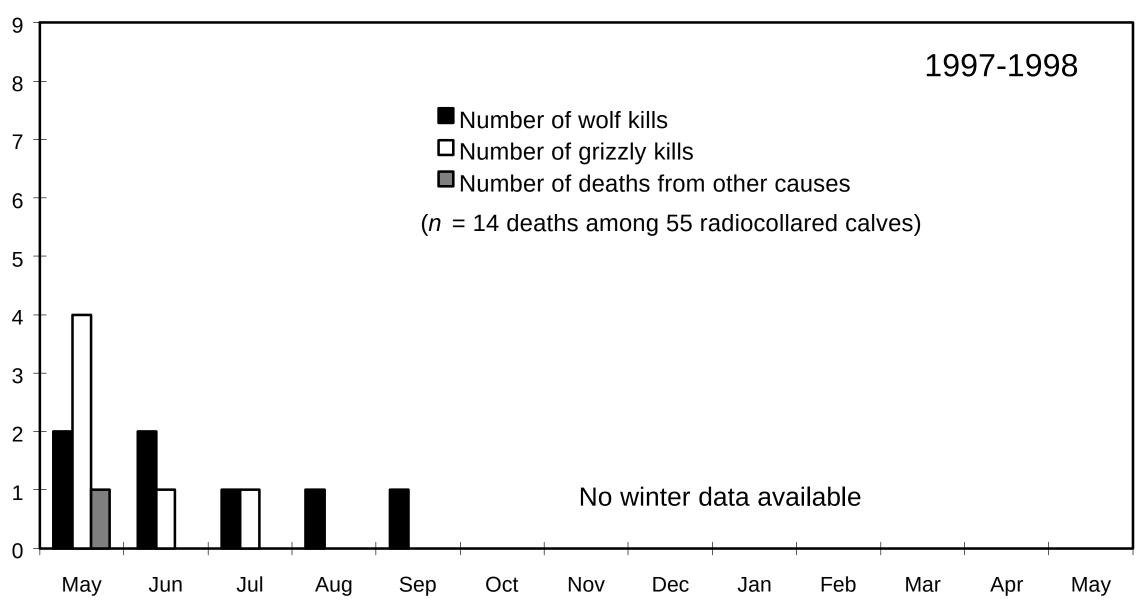

Figure 5 Frequency distribution of causes of death among 14 radiocollared caribou calves that died from May 1996 through late October 1997, Fortymile Caribou Herd, Eastcentral Alaska. No winter data were available when this report was written.

FIGURE 6 UNAVAILABLE IN THIS FORMAT

Figure 6 A conceptual model of births and deaths in the Fortymile Herd from 11 May 1994 to 10 May 1995. Black arrows point to numbers of caribou dying from specific causes during the 12-month period, as estimated from telemetry flights and follow-up investigations of causes of death. This model independently arrived at the same conclusion as recent censuses, i.e., that herd size is nearly stable (2360 calves were recruited at the end of 12 months and 2630 adults and yearlings died during the same 12 months). Of the 8360 caribou that died during the 12-month period, wolves killed 50%, grizzly bears killed 24%, other predators killed 10%, nonpredation factors killed 12%, and hunters killed 4%. This model is derived from data in Appendix A.

FIGURE 7 UNAVAILABLE IN THIS FORMAT

Figure 7 A conceptual model of births and deaths in the Fortymile Herd from 11 May 1995 to 10 May 1996. Black arrows point to numbers of caribou dying from specific causes during the 12-month period, as estimated from telemetry flights and follow-up investigations of causes of death. About 8390 calves were produced during this period and 6415 caribou died, indicating the herd increased. Of the 6415 caribou that died in the 12-month period, wolves killed 50%, grizzly bears killed 22%, other predators killed 21%, nonpredation factors killed 4%, and hunters killed 4%. This model is derived from data in Appendix B.

FIGURE 8 UNAVAILABLE IN THIS FORMAT

Figure 8 A conceptual model of births and deaths in the Fortymile Herd from 11 May 1996 to 10 May 1997. Black arrows point to numbers of caribou dying from specific causes during the 12-month period, as estimated from telemetry flights and follow-up investigations of causes of death. About 10,150 calves were produced during this period and 9080 caribou died, indicating the herd increased. Of the 9080 caribou that died in the 12-month period, wolves killed 59%, grizzly bears killed 23%, other predators killed 11%, nonpredation factors killed 6%, and hunters killed 2%. This model is derived from data in Appendix C.

FIGURE 9 UNAVAILABLE IN THIS FORMAT

Figure 9 Locations where caribou fecal samples were collected during January-April 1992 (2), 1993 (3), 1994 (4), 1995 (5), and 1996 (6)

Table 1 Estimated numbers, harvest, natural mortality, pregnancy rates, and composition in the Fortymile Herd, 1984-1997

Year	Estimate of herd size		Estimated harvest[a] M	F	% Mortality of collared caribou 4-16 months old for year ending 1 Oct (*n*)		% Mortality of collared females 17-28 months old for year ending 1 Oct (*n*)		% Mortality of collared females ≥28 months old for year ending 1 Oct (*n*)		Pregnancy rate of collared females ≥36 months old (*n*)		Bulls or Calves:100 females Sep to Oct: Bulls	Calves	(*n*)[b]
1984	13,402	(19)[c]	430	20					10	(21)	87	(23)	--	--	--
1985	--	--	421	20					9	(22)	100	(19)	50	36	(574)
1986	15,307	(19)	360	20					17	(24)	95	(21)	36	28	(842)
1987	--	--	229	20					5	(19)	95	(19)	40	37	(1274)
1988	19,975	(39)	645	150					9	(33)	95	(20)	38	30	(770)
1989	--	--	401	100					19	(27)	--	--	27	24	(1182)
1990	22,766	(16)	321	22					40	(20)	88	(16)	44	29	(1002)
1991	--	--	495	10	21	(14)			17	(12)	91	(11)	39	16	(931)
1992	21,884	(64)	432	35	57	(14)	8	(12)	17	(35)	87	(39)	48	30	(1416)
1993	--	--	335	11	8	(12)	10	(10)	10	(51)	68[d]	(47)	46	29	(2095)
1994	22,104	(91)	313	15	17	(12)	10	(10)	11	(37)	82	(45)	44	27	(1710)
1995	22,558	(85)	203	22	20	(30)	10	(10)	8	(40)	85	(41)	43	32	(1879)
1996	23,458	(97)	145	5	18	(39)	14	(7)	5	(42)	97[e]	(39)	41	36	(2601)
1997	25,910	(113)	--	--	18	(44)	9	(11)	8	(61)	85	(46)	46	41	(3313)

[a] Some harvest occurred during Jan, Feb, or Mar of the subsequent year, but was included in the autumn tally of the previous year.

[b] *n* = number of females ≥1 year old classified.

[c] Number of caribou with radiocollars during census.

[d] In 1993, 5 of 12 (42%) females 3 years old were pregnant, and 27 of 36 (75%) females ≥4 years old were pregnant. Pregnancy rate in 1993 was significantly lower than rates for each of the other years on this table (chi-square test of proportions, 2x2 tables, $P \leq 0.12$).

[e] Pregnancy rate in 1996 was significantly greater than other rates during 1994-1997 (chi-square test of proportions, 2x2 tables, $P \leq 0.02$).

Table 2 Timing of mortality of radiocollared calves in the Fortymile Caribou Herd, 1994-1997

	Number of radiocollared calves dying by period/Number of calves radiocollared in May (proportion dying, %)							
Year	May	Jun	Jul	Aug	Sep	Oct	Nov-May	Total
1994	17/50 (34)	9/50 (18)	1/50 (2)	2/50 (4)	0/50 (0)	1/50 (2)	4/50 (8)	34/50 (68)
1995	18/52 (35)	5/52 (10)	1/52 (2)	2/52 (4)	1/52 (2)	1/52 (0)	2/52 (6)	30/52 (58)
1996	17/60 (28)	8/60 (13)	3/60 (5)	1/60 (2)	0/60 (0)	3/60 (5)	5/60 (8)	37/60 (62)
1997	7/55 (13)	3/55 (5)	2/55 (4)	1/55 (2)	1/55 (2)	0/55 (0)	-[a]	-[a]

[a] No winter 1997-1998 data were available when this report was written.

Table 3 Causes of mortality among radiocollared calves in the Fortymile Caribou Herd from birth to 30 September 1994-1997

	Year			
	1994	1995	1996	1997
Number of calves collared	50	52	60	55
Number of deaths[a]	29	27	29	14
Cause of death:				
Wolf[a]	8	10	11	7
Grizzly bear	11	8	11	6
Eagle	3	3	5	0
Black bear	1	4	0	0
Wolverine	1	1	0	1
Nonpredation[b]	5	1	2	0

[a] In addition, wolves killed 5 calves during winter 1994-1995, 3 during winter 1995-1996 and 8 during 1996-1997.

[b] In 1994, 3 calves broke their legs, 1 died from abandonment when its dam had no distended udder and 1 was suffocated at birth due to its large size (10.5 kg). In 1995, 1 died from a broken leg when trapped in a natural rock pit. In 1996, 1 died from abandonment when its dam had no distended udder, and 1 probably died from an unknown birth defect 48 hours after birth (no milk in stomach but dam present with distended udder).

Table 4 Estimated autumn wolf densities, numbers and harvest in the respective annual ranges of the Fortymile Caribou Herd, 1992-1996

	Column				
	A	B	C	D	E
Winter	Estimated autumn wolf density[a] (Numbers/1000 km^2)	Area of annual caribou range 1 Oct-30 Sep (1000 km^2)	Total wolves in caribou range (Column A x B)	Wolf harvest in respective range	Percent wolf harvest (Columns D/C x 100)
1992-1993	7.3[a]	29.0	212	54	25
1993-1994	7.6[a]	23.0	175	49	28
1994-1995	7.0[a]	30.4	213	40	19
1995-1996[b]	8.0[a]	27.7	223	126	57
1996-1997[b]	7.5[c]	35.0	262	68	26

[a] Wolf densities from Gardner (1997) in 28,000 km^2 (Unit 20E) encompassing most of the caribou's respective annual range.
[b] Caribou Calf Protection Program provided a private incentive to increase harvest.
[c] Wolf densities from surveys in the herd's respective annual range.

Table 5 Autumn (late Sep-late Oct) weights (kg) of female calves radiocollared in the Fortymile Caribou Herd, 1990-1997

	Year							
	1990	1991	1992	1993	1994	1995	1996	1997
	59.4	61.3	67.2	61.3	60.9	66.7	67.1	48.5
	56.7	59.0	65.3	60.3	60.7	61.3	61.2	53.3
	56.3	57.6	60.3	58.1	59.1	60.3	60.0	54.8
	55.8	57.2	60.3	58.1	58.9	60.2	58.9	54.9
	55.8	56.3	58.5	57.6	56.2	59.9	54.7	56.4
	55.4	55.4	54.4	57.6	55.9	59.0	54.6	57.9
	53.5	55.4	54.0	57.2	54.9	57.6	53.0	59.6
	52.6	54.4	52.2	57.2	54.2	57.2	52.8	60.2
	51.7	54.4	51.3	56.7	53.8	54.4	52.7	61.7
	51.7	54.4	51.3	55.8	52.8	54.0	52.6	62.0
	49.9	51.7	50.8	55.4	51.3	53.6	50.4	62.0
	49.0	48.5	50.8	54.0	49.2	52.5	50.0	63.2
	47.6	48.1	49.9	52.6	48.4	51.7	49.2	63.6
	43.1	41.3	45.4	51.7	46.0	51.0	49.1	63.8
				48.5		50.9		67.7
$\bar{x}$	52.8	53.9	55.1	56.1	54.5	56.7	54.7	59.3
s	4.32	5.13	6.28	3.32	4.61	4.58	5.25	4.99
$s_{\bar{x}}$	1.15	1.37	1.68	0.86	1.23	1.18	1.40	1.29

Table 6 Birthweights of newborn calves and median calving dates in the Fortymile Caribou Herd, 1992-1997

Year	Birthweights (kg) $\pm s_{\bar{x}}$		Median
	Females (*n*)	Males (*n*)	calving date[a] (*n*)
1992	--	--	23 May (25)
1993	--	--	22 May (24)
1994	7.47 ±0.257 (22)	7.60 ±0.185 (22)	18 May (32)
1995	7.68 ±0.161 (25)[b]	8.45 ±0.136 (24)[b]	20 May (28)
1996	8.05 ±0.160 (32)	8.47 ±0.228 (26)	18 May (37)
1997	7.88 ±0.179 (32)	8.43 ±0.213 (24)	18 May (39)

[a] Median calving date is the date by which 50% of the radiocollared cows had given birth.

[b] Birthweights of females (P = 0.075, t = 1.80) and males (P = 0.001, t = 3.36) increased significantly during 1995-1997 compared to 1994.

Table 7 Proportions of discerned plant fragments in 24 fecal samples collected from Fortymile caribou during January-April 1992 through 1996. Collection sites are depicted in Figure 9.

Plant genus or group	Mean % (± $s_{\bar{x}}$) of discerned plant fragments					
	1992 *n* = 6	1993 *n* = 7	1994 *n* = 1	1995 *n* = 6	1996 *n* = 4	All years *n* = 24
Lichens	72 ± 9	81 ± 4	80	84 ± 3	86 ± 4	80 ± 3
Equisetum	7 ± 6	3 ± 1	6	8 ± 3	6 ± 2	6 ± 2
Mosses	9 ± 3	7 ± 2	4	1 ± <1	1 ± 1	5 ± 1
Ledum	7 ± 2	5 ± 1	5	3 ± 1	4 ± 1	5 ± 1
Graminoids	1 ± <1	1 ± <1	4	2 ± 1	2 ± 1	2 ± 1
Forbs	3 ± 2					1 ± 1
Picea	2 ± <1	2 ± <1	<1	1 ± <1	1 ± <1	1 ± <1
Dryas	1 ± 1					<1
Salix		1 ± <1		<1	<1	<1

APPENDIX A Values and calculations used to model caribou population dynamics, Fortymile Caribou Herd, 15 May 1994-14 May 1995

Estimated parameters and calculations	Observed or calculated values
Number of cows ≥24 months old in May 1994 = percent cows in herd in October 1993 when randomly mixed (0.57) x estimated herd size in early May 1994 (20,000)	11,400
Number of 24-month-old cows in May 1994 = percent calves in herd in October 1992 (0.17) x estimated herd size in early May 1993 (20,000) x survival rate from 12 to 24 months old (0.90) x proportion of females (0.5)	1530
Number of cows ≥36 months old in May 1994 = (11,400-1530)	9870
Number of calves produced in May 1994 = (9870 x 0.82)	8090
Number of calves dying by 14 May 1995 = (8090 x 39/55)	5740
Number and cause of calf deaths, 15 May 1994-14 May 1995 (*n* = 34 deaths from known causes)	
Wolf (0.382 x 5740)	2190
Grizzly bears (0.324 x 5740)	1860
Other predators (0.147 x 5740)	840
Nonpredation (0.147 x 5740)	840
Number of nonhunting deaths among caribou ≥12 months old from 15 May 1994-14 May 1995 = (20,000) (6 ÷ 52)	2310
Number and cause of nonhunting deaths among these 2310 caribou (30 adult and yearling death sites were examined from 1 Oct 1991-1 Oct 1997)	
Wolf (0.867 x 2310)	2000
Nonpredation (0.067 x 2310)	150
Grizzly bear (0.067 x 2310)	150
Annual harvest of adults and yearlings May 1994-May 1995	330
Estimated herd size 15 May 1994 (counted 22,104 on 1 July 1994 with some calves included in photos)	20,000
Estimated herd size 14 May 1995 = (20,000 + 8090 - 5740 - 2310 - 330) rounded to nearest 100	19,700
Conclusion: Herd trend approximately stable, consistent with photocensus results	

APPENDIX B Values and calculations used to model caribou population dynamics, Fortymile Caribou Herd, 15 May 1995-14 May 1996

Estimated parameters and calculations	Observed or calculated values
Number of cows ≥24 months old in May 1995 = percent cows in herd in October 1994 when randomly mixed (0.57) x estimated herd size in early May 1995 (20,000)	11,400
Number of 24-month-old cows in May 1995 = percent calves in herd in October 1993 (0.17) x estimated herd size in early May 1994 (20,000) x survival rate from 12 to 24 months old (0.90) x proportion of females (0.5)	1530
Number of cows ≥36 months old in May 1995 = (11,400-1530)	9870
Number of calves produced in May 1995 = (9870 x 0.85)	8390
Number of calves dying by 14 May 1996 = (8390 x 32/54)	4970
Number and cause of calf deaths, 15 May 1995-14 May 1996 (*n* = 30 deaths from known causes)	
Wolf (0.433 x 4970)	2150
Grizzly bears (0.267 x 4970)	1330
Other predators (0.267 x 4970)	1330
Nonpredation (0.033 x 4970)	160
Number of nonhunting deaths among caribou ≥12 months old from 15 May 1995-14 May 1996 = (20,000) (3 ÷ 49)	1220
Number and cause of nonhunting deaths among these 1220 caribou (30 adult and yearling death sites were examined from 1 Oct 1991-1 Oct 1997)	
Wolf (0.87 x 1220)	1060
Nonpredation (0.07 x 1220)	80
Grizzly bear (0.07 x 1220)	80
Annual harvest of adults and yearlings May 1995-May 1996	225
Estimated herd size 15 May 1995 (counted 22,558 on 14 June 1995 with some calves included in photos)	20,000
Estimated herd size 14 May 1996 (20,000 + 8390 - 4970 - 1220 - 225) rounded to nearest 100	22,000
Conclusion: Herd trend increasing, consistent with photocensus results	

APPENDIX C Values and calculations used to model caribou population dynamics, Fortymile Caribou Herd, 15 May 1996-14 May 1997

Estimated parameters and calculations	Observed or calculated values
Number of cows ≥24 months old in May 1996 = percent cows in herd in October 1995 when randomly mixed (0.57) x estimated herd size in early May 1996 (21,000)	11,970
Number of 24-month-old cows in May 1996 = percent calves in herd in October 1994 (0.16) x estimated herd size in early May 1995 (21,000) x survival rate from 12 to 24 months old (0.90) x proportion of females (0.5)	1510
Number of cows ≥36 months old in May 1996 = (11,970-1510)	10,460
Number of calves produced in May 1996 = (10,460 x 0.97)	10,150
Number of calves dying by 14 May 1996 = (10,150 x 38/61)	6320
Number and cause of calf deaths, 15 May 1996-14 May 1997 (*n* = 37 deaths from known causes)	
Wolf (0.486 x 6320)	3070
Grizzly bears (0.297 x 6320)	1880
Other predators (0.162 x 6320)	1020
Nonpredation (0.054 x 6320)	340
Number of nonhunting deaths among caribou ≥12 months old from 15 May 1996-14 May 1997 = (21,000) (8 ÷ 64)	2620
Number and cause of nonhunting deaths among these 2620 caribou (30 adult and yearling death sites were examined from 1 Oct 1991-1 Oct 1997)	
Wolf (0.867 x 2620)	2270
Nonpredation (0.067 x 2620)	175
Grizzly bear (0.067 x 2620)	175
Annual harvest of adults and yearlings May 1996-May 1997	150
Estimated herd size 15 May 1996 (counted 23,458 on 21 June 1996 with some calves included in photos)	21,000
Herd size 14 May 1996 (21,000 + 10,150 - 6320 - 2620 - 150) rounded to nearest 100	22,000
Conclusion: Herd trend increasing, consistent with photocensus results	