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The Fortymile caribou herd: novel proposed management and relevant biology, 1992–1997

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Abstract: A diverse, international Fortymile Planning Team wrote a novel Fortymile caribou herd (*Rangifer tarandus granti*) Management Plan in 1995 (Boertje & Gardner, 1996: 56–77). The primary goal of this plan is to begin restoring the Fortymile herd to its former range; >70% of the herd's former range was abandoned as herd size declined. Specific objectives call for increasing the Fortymile herd by at least 5–10% annually from 1998–2002. We describe demographics of the herd, factors limiting the herd, and condition of the herd and range during 1992–1997. These data were useful in proposing management actions for the herd and should be instrumental in future evaluations of the plan's actions.

The following points summarize herd biology relevant to management proposed by the Fortymile Planning Team:

1. Herd numbers remained relatively stable during 1990–1995 (about 22 000–23 000 caribou). 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 implementing management actions during a period of natural growth would be opportune.
2. Wolf (*Canis lupus*) and grizzly bear (*Ursus arctos*) predation were the most important sources of mortality, despite over a decade of the most liberal regulations in the state for harvesting of wolves and grizzly bears. Wolves were 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. Reducing wolf predation was judged by the Team to be the most manageable way to help hasten or stimulate significant herd growth. To reduce wolf predation, the Team envisioned state-sponsored wolf translocations and fertility control in 15 key wolf packs during November 1997–May 2001. Also, wolf trappers were encouraged to shift their efforts to specific areas.
3. To increase social acceptance of the management plan, the Fortymile Team proposed reducing the annual caribou harvest to 150 bulls for 5 years beginning in 1996. Reducing annual harvests from 200–500 bulls (≤2% of the herd, 1990–1995) to 150 bulls (<1% of the herd, 1996–2000) will not result in the desired 5–10% annual rates of herd increase.
4. We found consistent evidence for moderate to high nutritional status in the Fortymile herd when indices were compared with other Alaskan herds (Whitten *et al.*, 1992; Valkenburg, 1997). The single evidence for malnutrition during 1992–1997 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). No significant diseases were found among Fortymile caribou.
5. Winter range can support elevated caribou numbers both in regards to lichen availability on currently used winter range and the availability of vast expanses of winter range formerly used by the herd.

Key words: Alaska, condition, fertility control, mortality, nutrition, predation, pregnancy rate, translocation, sterilization.

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Introduction

We describe the Fortymile Herd Management Plan (Boertje & Gardner, 1996) as a "novel" plan because of its unique holistic approach to wildlife management, its nonlethal proposals for reducing wolf predation, and the diversity of interests

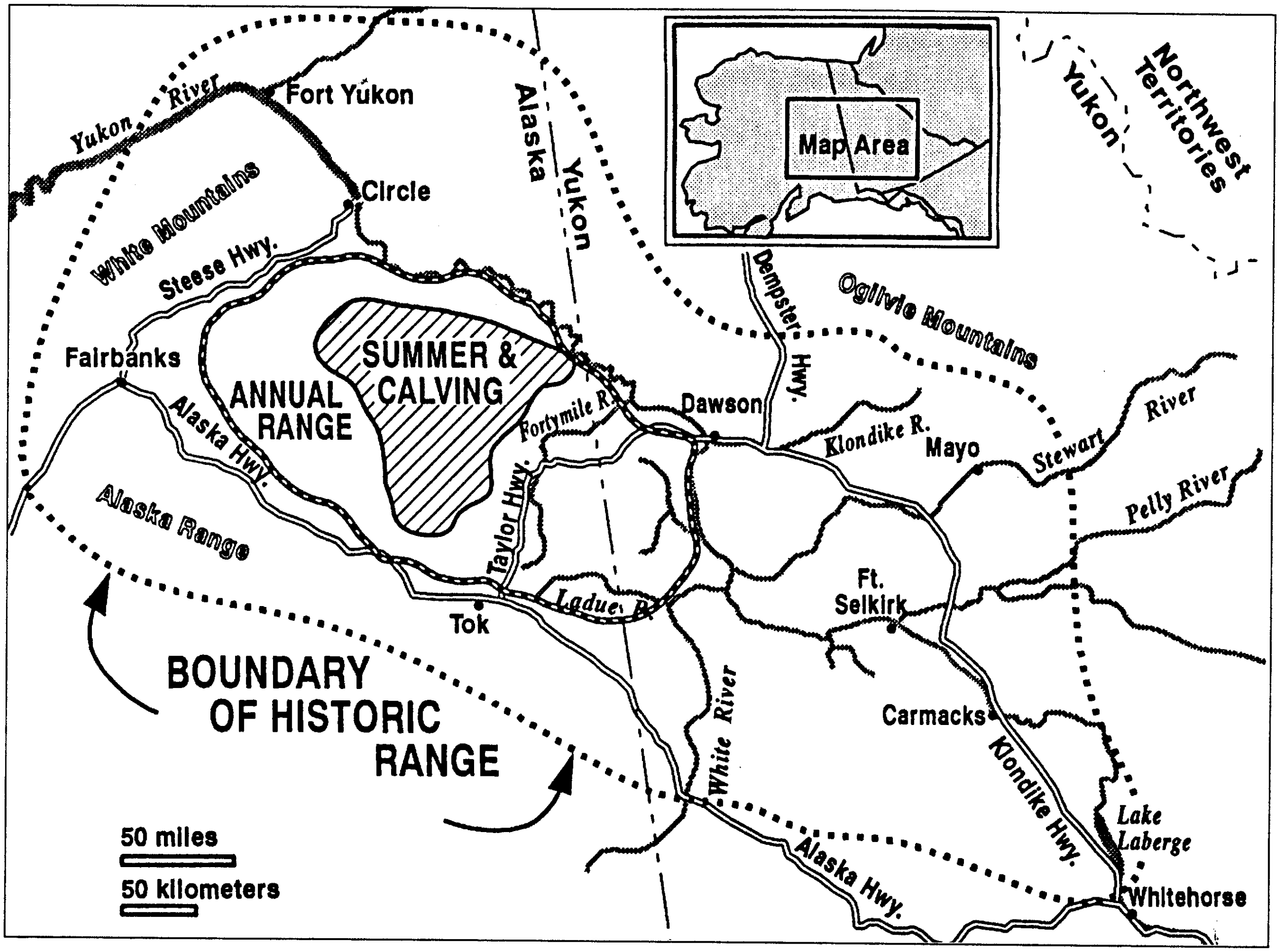

Fig. 1. Range of the Fortymile caribou herd, 1984–1997, and historic range during the 1920s.

involved, representing Alaska and Yukon villages, environmentalists, hunters, and several governmental agencies. No similar plan exists to our knowledge. Although the management plan emphasizes habitat protection objectives, these details are beyond the scope of this paper. This paper provides the 5-year baseline pretreatment data for the study area and presents herd responses following recent management actions, i.e., increased wolf harvest and decreased caribou harvest. We summarize demographics of the herd, factors limiting the herd, and condition of the herd and range during 1992–1997. These data were useful in proposing management actions for the herd and should be instrumental in evaluating the effectiveness of proposed management actions.

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 herd's 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. Public support has flourished 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 & 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, managers 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 & 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, & 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 & 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.*, 1995a; Boertje *et al.*, 1996). Adverse weather in Interior Alaska in the early 1990s and the simultaneous decline of several Interior Alaskan 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 and wolf numbers can increase (Mech *et al.*, 1995; Boertje *et al.*, 1996). Predation can accelerate declines because of increased vulnerability of prey and underutilization of carcasses (Peterson & Page, 1983). After weather improves, the increased wolf numbers may prolong declines in caribou herds until wolf numbers also decline. Examples exist where 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.*, 1995a; 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 & Davis, 1989; Adams *et al.*, 1995b; 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 & 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 & 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 7–10% 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 predators were not sufficiently reduced and adverse weather occurred.

To definitively test the effectiveness of predator control, large reductions in predator abundance are necessary for several years (Crete & Jolicoeur, 1987; Larsen & Ward, 1995; Boertje *et al.,* 1996; Farnell & Hayes, unpubl.). 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 & MacDonald, 1988; Larsen & Ward, 1995; Farnell & Hayes, unpubl.). In both studies, late winter wolf numbers were 69–85% lower than precontrol autumn wolf numbers during the 4–6 winters of effective control efforts. These are the only well-documented studies where large reductions of wolves were maintained for more than two 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 7–10% 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.

By 1994, conflicting interagency management objectives and stagnant low caribou numbers stimulated an interagency and international meeting focusing on Fortymile herd management in Tok, Alaska on 9 February 1994. Following this meeting, a diverse Fortymile Planning Team was created to write a new Fortymile Herd Management Plan. The Team completed the management plan and the Board of Game endorsed the plan 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 input on 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 & Gardner, 1996), 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 3 300 interested parties for their input. 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 herd numbers by at least 5–10% per year through the year 2002. Management actions are to include fertility control in dominant wolf pairs in up to 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.

Materials and methods

Caribou capture

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

To immobilize adult caribou, we currently 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 current 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.* (1995b), 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. Most calves selected for collaring had a collared dam, and we distributed the 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 a radio-search, total search, aerial photo technique (Valkenburg *et al.*, 1985), as in previous estimates of herd size during the 1970s and 1980s (Valkenburg & 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 9 x 9 format camera. This camera was used to photograph all groups numbering over about 100 caribou; usually 20–30 groups were photographed during a census. Smaller groups totaling about 500 caribou were visually counted. Photographed caribou were counted using 10X magnification. Counts probably include a high proportion of the total calves, but we are certain some calves are missed because of their small size and because of 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, & 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 (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 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 that 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 to 13 times in June, and weekly during July through September. Radiocollars contained a mortality

Table 1. Estimated numbers, harvest, natural mortality, pregnancy rates, and composition in the Fortymile herd, 1984–199

Year	Estimate of herd size		Estimated harvest[a] M	Estimated harvest[a] F	% Mortality of collared caribou 4–16 mo old for year ending 1 Oct (n)		% Mortality of collared females 17–28 mo old for year ending 1 Oct (n)	
1984	13 402	(19)[c]	430	20				
1985	–	–	421	20				
1986	15 307	(19)	360	20				
1987	–	–	229	20				
1988	19 975	(39)	645	150				
1989	–	–	401	100				
1990	22 766	(16)	321	22				
1991	–	–	495	10	21	(14)		
1992	21 884	(64)	432	35	57	(14)	8	(12)
1993	–	–	335	11	8	(12)	10	(10)
1994	22 104	(91)	313	15	17	(12)	10	(10)
1995	22 558	(85)	203	22	20	(30)	10	(10)
1996	23 458	(97)	145	5	18	(39)	14	(7)
1997	25 910	(113)	143	8	18	(44)	9	(11)

[a] Some harvest occurred during Jan, Feb, or Mar of the subsequent year, but was included in the autumn tally of the previou
[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. Pregna square test of proportions, 2 x 2 tables, $P \leq 0.12$).
[e] Pregnancy rate in 1996 was significantly greater than other rates during 1994–1997 (chi-square test of proportions, 2 x 2 t

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 x 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).

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 (non-coagulated) 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 checkstations and by including

% Mortality of collared females ≥28 mo old for year ending 1 Oct	(*n*)	Pregnancy rate of collared females ≥36 mo old	(*n*)	Bulls or Calves:100 females Sep to Oct: Bulls	Calves	(*n*)[b]
10	(21)	87	(23)	–	–	–
9	(22)	100	(19)	50	36	(574)
17	(24)	95	(21)	36	28	(842)
5	(19)	95	(19)	40	37	(1274)
9	(33)	95	(20)	38	30	(770)
19	(27)	–	–	27	24	(1182)
40	(20)	88	(16)	44	29	(1002)
17	(12)	91	(11)	39	16	(931)
17	(35)	87	(39)	48	30	(1416)
10	(51)	68[d]	(47)	46	29	(2095)
11	(37)	82	(45)	44	27	(1710)
8	(40)	85	(41)	43	32	(1879)
5	(42)	97[e]	(39)	41	36	(2601)
8	(61)	85	(46)	46	41	(3313)

ear.

rate in 1993 was significantly lower than rates for each of the other years on this table (chi-

es, $P \leq 0.02$).

caribou shot but not retrieved along roads and trails. 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. The surveys and subsequent mail-in harvest reports were treated as a mark-recapture sample to estimate total harvest. Harvest reported 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 estimated wolf numbers in the respective annual caribou ranges. We estimated wolf numbers using radio-collars, standard track counts, and information from local trappers and pilots (Boertje *et al.*, 1996). 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 44–60 newborn calves using a calibrated spring or electronic scale. Third, we estimated the median

Table 2. Timing of mortality of radiocollared calves in the Fortymile caribou herd, 1994–1997.

Year	May	Jun	Jul	Aug	Sep	Oct	Nov–May	Total
	Radiocollared calves dying by period/Calves radiocollared in May (proportion dying, %)							
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)	6/55 (11)	20/55 (36)

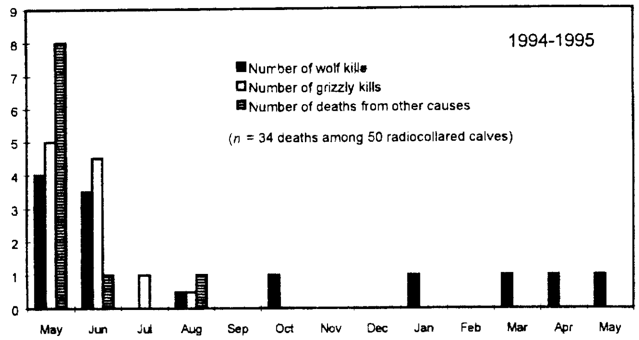

Fig. 2. Frequency distribution of causes of death among 34 radiocollared caribou calves that died from May 1994 through early May 1995, Fortymile caribou herd, Eastcentral Alaska.

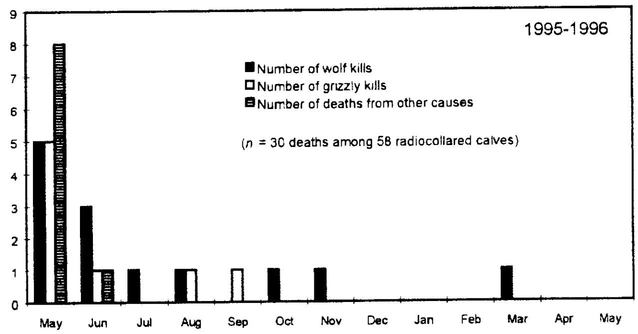

Fig. 3. Frequency distribution of causes of death among 30 radiocollared caribou calves that died from May 1995 through early May 1996, Fortymile caribou herd, Eastcentral Alaska.

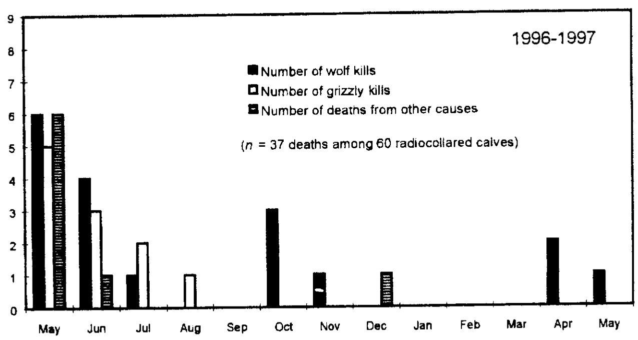

Fig. 4. Frequency distribution of causes of death among 37 radiocollared caribou calves that died from May 1996 through early May 1997, Fortymile caribou herd, Eastcentral Alaska.

calving date during 1992–1997, which is the date by which 50% of the pregnant radiocollared cows had given birth.

Lastly, we estimated the percent mortality of calves during their first 2 days of life. High calf mortality (e.g., 15–25%) 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.

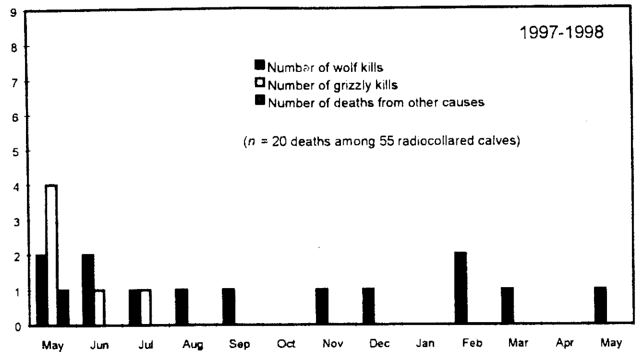

Fig. 5. Frequency distribution of causes of death among 20 radiocollared caribou calves that died from May 1997 through early May 1998, Fortymile caribou herd, Eastcentral Alaska.

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, USA.

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) 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 5740–8610 caribou remained (Valkenburg *et al.,* 1994). Herd numbers increased during the late 1970s and 1980s at annual rates of 7–10% 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 22 000–23 000 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, & C). The Team deemed that initiating and continuing management actions to improve caribou survival during a period of natural growth would be opportune.

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, 40–50% 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, 2 x 3 table, $P=0.56$). This pattern of births and deaths is similar to that found in other Interior Alaskan caribou studies (Adams *et al.*, 1995b; Valkenburg, 1997).

A major change occurred in the 1997 cohort when calf mortality rates declined 38–47% compared with the previous 3 years; this decline was statistically significant (Table 2, chi-square test of proportions, 2 x 2 table, $P=0.0008$). By the end of June 1997 only 18% of the calves were dead and the total annual mortality rate was only 36% (Fig. 5; Table 2). Decreased mortality in the 1997 cohort through September 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 & 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 fresh snow cover, which allowed caribou cows to more easily hide their newborns and increased the search effort required for predators to find calves (Bergerud & Page, 1987). Calving did not appear more concentrated or dispersed in 1997 compared to 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. 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 natural causes other than predation (nonpredation). Of the 30 caribou >12 months old for which cause of death was determined (1 Oct 1991–30 Sep 1997), wolves killed 26 (87%), grizzly bears killed 2 (7%), and 2 (7%) died from nonpredation. Most (84%) of these 62 deaths occurred during the 7 months (Oct–Apr) when snow was on the ground.

Annual wolf predation rates (24–32%) on radiocollared calves ($n=50–60$) varied little among the 1994–1997 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

Table 3. Causes of mortality among radiocollared calves in the Fortymile caribou herd from birth to 30 September 1994–1997.

	1994	1995	1996	1997
Calves collared	50	52	60	55
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, 8 during winter 1996–1997, and 6 during winter 1997–1998.

[b] During 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). During 1995, 1 died from a broken leg when trapped in a natural rock pit. During 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).

could partially affect survival of the 1998 cohort. Full treatment of 15 key wolf packs is expected from May 1999 through May 2001, which will provide 2 years during which to test whether wolf predation on calves is significantly reduced (1-tailed test) compared to the 4 pretreatment years (May 1994–May 1998). We will also test for decreasing trends in summer wolf caused mortality. Interpretations of data will depend in part on how caribou are distributed in relation to the treatment area among the various years.

Fairly stable mortality rates among caribou older than 4 months during 1993–1997 indicates 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, 2 x 2 table, P=0.90).

We found significantly higher mortality among caribou 4–16 months old compared with older caribou for the years 1993–1997 (Table 1, chi-square test of proportions, 2 x 2 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 three 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 (Table 4). With certain qualifications, the models can help explain why the photocensus results remained stable or changed among years. For example, if the herd increased, was it because of decreased mortality or increased productivity? These models are sensitive to small, statistically insignificant changes in mortality rates, e.g., 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.

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 (Table 4). This stable trend was consistent with independent late June photocensuses from 1990–1995 (Table 1).

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 the photocensus increase probably resulted from the approximately 2000 additional calves born during late May 1996 compared to 1994 and 1995 (Tables 1 & 4). The model indicated about 1000 more adult caribou survived wolf predation compared to the

Table 4. Population modeling outputs for the Fortymile caribou herd, 1994–1995 through 1996–1997. Values are from Appendices A, B, and C.

	Approximate number of adults and yearlings			
Year	Beginning of the year	End of the year	Population trend	Calves born
11 May 1994–10 May 1995	20 000[a]	17 370 + 2360[b] = 19 730	Approximately stable	8 090
11 May 1995–10 May 1996	20 000[a]	18 550 + 3420[b] = 21 970	Increasing slightly	8 390
11 May 1996–10 May 1997	21 000[a]	18 230 + 3840[b] = 22 070	Increasing slightly	10 150

[a] Estimated from results of June photocensus each year (Table 1). Significant numbers of calves (2500–4000) were subtracted fr

[b] Yearlings recruited into population at 12 months of age calculated as number of calves born minus number of calves dying.

1994–1995 model and about 1000 more calves survived because of slightly reduced nonpredation and grizzly bear predation (Appendices A & B). 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 & B); these differences are not significant (chi-square test of proportions, 2 x 2 table, P=0.34).

The 1996–1997 photocensus and modeling data also indicated the herd was increasing. We counted about 2 500 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 (Table 4) 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). Calf survival was significantly higher during May and June 1997 compared to the previous three springs (Table 2; chi-square test of proportions, 2 x 2 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, 2 x 2 table, P=0.89); neither did survival rates of caribou older than calves differ significantly (Appendices A, B, & C; chi-square test of proportions, 2 x 2 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 Table 4. 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 two 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 (*Ovis dalli*) 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 5). We analyzed wolf harvest rates over the herd's 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

Total initial calves and older caribou killed by: (%)					
Wolves	Grizzly bears	Other predators	Hunters	Nonpredation	All factors
4190 (15)	2010 (7)	840 (3)	330 (1)	990 (4)	8360 (30)
3210 (11)	1410 (5)	1330 (5)	225 (1)	240 (1)	6415 (23)
5340 (17)	2055 (7)	1020 (3)	150 (<1)	515 (2)	9080 (29)

om the photocensus to derive a prior May precalving population estimate.

Table 5. Estimated autumn wolf numbers and harvest in the respective annual ranges of the Fortymile caribou herd, 1992–1996.

	Column				
	A	B	C	D	E
Winter	Area of annual caribou range (1000 km²)	Number of wolf packs preying on the herd (number of border packs)[a]	Estimated autumn wolf numbers in annual caribou range[b]	Wolf harvest in and adjacent to respective range	Estimated percent wolf harvest (Columns D/C x 100)
1992–1993	29.1	32 (7)	187	54	29
1993–1994	23.1	26 (6)	156	49	31
1994–1995	30.4	35 (7)	186	40	22
1995–1996	27.7	33 (7)	220[b]	126[c]	57[c]
1996–1997	35.0	37 (5)	239	68[c]	28[c]

[a] Border packs were packs that ranged only about 50% in the annual caribou range.

[b] Autumn wolf numbers are from the respective annual ranges of the Fortymile herd for the years beginning 1 Oct. We included only 50% of the wolves in the border packs, except in 1995–1996 when large numbers of wolves were harvested along the border. Wolves in 1995–1996 ranged in about 31 000 km². To account for single wolves, we added 10% to the number of wolves estimated to be in the annual range.

[c] Caribou Calf Protection Program provided a private incentive to increase harvest.

winter 1995–1996 when 57% of the wolves were harvested (Table 5). 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 69–85% below initial autumn wolf numbers for several years (Larsen & Ward, 1995; Boertje *et al.,* 1996). In contrast, wolf densities in the respective annual ranges of the Fortymile herd were reduced only 19–28% by harvest during winters 1992–1993 through 1996–1997, except during winter 1995–1996 (Table 5).

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 & Ward, 1995; Boertje *et al.,* 1996). Recent autumn densities of 7–8 wolves/1000 km² in this study were similar to estimates prior to the private incentive program, when trapping pressure was less intense (Table 5). 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 km² during 1986–1992. Average autumn densities of 8 wolves/1000 km² 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).

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 allowed us to evaluate the relative nutritional status of the Fortymile herd. Second, nutritional data lent insights into what weather factors could be 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 twelve 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 6; 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.,* 1995b). Fortymile birthweights during this study were relatively high and stable compared with nutritionally stressed herds (Table 7; Valkenburg, 1997). Birthweights indicated spring nutritional status improved significantly during 1995–1997 compared to 1994 (Table 7). Unlike data from the Denali herd, an increase in birthweights was not observed when calf mortality declined in 1997 (Tables 2 & 7; Adams *et al.,* 1995b). Median calving dates indicate spring nutritional status may have improved beginning in 1994, e.g., median calving dates were 23 May in 1992 (n=25) and 22 May in 1993 (n=24) compared with 18 May in 1994 (n=32), 1996 (n=37), and 1997 (n=39) and 20 May (n=28) in 1995.

Lastly, 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 largely 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 appear to be correlated with nutritional status.

In contrast, we will continue to collect data on pregnancy rates, weights of calves, and calving dates to evaluate the varying role of nutrition during the period of reducing predation. The effects of nutrition and predation on a herd's performance are clearly intertwined (Boertje *et al.,* 1996).

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

Table 6. Ranked mean weights (kg) with standard error of the mean of autumn calf caribou in 11 Alaskan herds of various size and density.

Herd	Year	$\bar{x}$ weight (kg)	$s_{\bar{x}}$	n	Herd size in 1993[a]	Herd multiyear density per km[2a]
Western Arctic	1994	32.4	1.3	15	450 000	1.5
	1995	36.8	1.2	9		
	1992	40.4	1.8	13		
Northern Alaska Peninsula	1995	44.7	1.6	10	18 000	0.5
	1996	46.0	2.4	10		
	1997	48.3	2.1	10		
Nelchina	1996	48.3	2.1	10	40 361	0.5
	1995	53.5	1.5	15		
	1997	55.5	1.8	10		
Chisana	1990	51.7	1.8	13	850	<0.1
Fortymile	1990	52.8	1.1	14	22 000	0.4
	1991	53.9	1.4	14		
	1994	54.5	1.2	14		
	1996	54.7	1.4	14		
	1992	55.1	1.7	14		
	1993	56.1	0.9	15		
	1995	56.7	1.1	15		
	1997	59.3	1.3	15		
Delta	1992	54.6	1.4	14	3 661	0.5
	1993	55.6	1.4	11		
	1996	55.7	1.4	14		
	1991	57.9	1.2	14		
	1997	58.2	1.0	20		
	1995	59.5	1.3	13		
	1994	59.6	1.3	15		
Macomb	1996	58.4	2.6	8	500	0.1
Wolf Mtn	1995	59.6	2.1	8	650	<0.1
White Mtns	1991	58.5	2.1	9	1 000	0.1
	1995	60.6	2.1	6		
	1997	61.6	1.1	6		
Ray Mtn	1994	60.9	1.3	20	700	<0.1
Galena Mtn	1994	65.6	1.3	9	275	<0.1
	1993	66.5	3.2	4		

[a] Herd sizes and multiyear densities from Valkenburg *et al.* (1996) for 1993.

numbers in the Fortymile herd as in the Delta and Denali herds (Boertje *et al.*, 1996). A contributing factor may be that weather patterns are more continental in the Fortymile herd's range.

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 where infectious diseases have had a detectable effect on caribou herds in Alaska. Brucellosis in arctic caribou herds is a notable exception (Valkenburg *et al.*, 1996b; 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 appeared excellent during winters 1991–1992 through 1995–1996, as evidenced by high proportions ($\bar{x}$=80%) of lichen fragments in

Table 7. Average newborn caribou weights from 6 Alaskan herds.

Herd and year	Males			Females		
	Weight (kg)	$s_{\bar{x}}$ [a]	n	Weight (kgs)	$s_{\bar{x}}$ [a]	n
Porcupine 1984	7.30	0.22	33	6.70	0.18	23
Porcupine 1983	7.40	0.19	24	6.60	0.16	28
Porcupine 1985	7.70	0.23	27	7.30	0.20	26
Nelchina 1996	8.26	0.24	23	7.19	0.19	17
Nelchina 1997	8.43	0.18	30	7.89	0.23	30
Fortymile 1994[b]	7.71	0.20	22	7.55	0.27	22
Fortymile 1997	8.52	0.25	24	7.97	0.21	32
Fortymile 1996	8.54	0.24	26	8.09	0.17	32
Fortymile 1995	8.65	0.16	24	7.94	0.19	25
Delta 1997	8.35	0.18	40	7.98	0.21	35
Delta 1996	8.39	0.23	22	7.40	0.19	28
Delta 1995	8.72	0.29	26	8.31	0.24	19
Mentasta 1994[c]	8.83	0.21	18	8.09	0.19	23
Mentasta 1993[c]	8.90	0.23	15	7.91	0.20	23
Denali 1984–1987[d]	9.00	0.11	67	7.80	0.11	60

a With standard errors of about 0.2 kg, a difference in means of 0.6 kgs would be significant at the P=0.05 level (Student's 2-tailed t-test).

b Fortymile birthweights of males (P=0.001, t=3.36) and females (P=0.075, t=1.80) increased significantly during 1995–1997 compared with 1994.

c Data from Jenkins (1996).

d Denali data is corrected for calf age; uncorrected weights would be 0.3–0.5 kg higher (Adams *et al.*, 1995a).

caribou fecal samples (Table 8). Samples were collected from several different wintering areas (Fig. 6). 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 elsewhere in Alaska contained reduced proportions of lichens (30–40%) and higher proportions of mosses (30–60%) or evergreen shrubs (30%) compared to values observed in the Fortymile herd's range (Table 8; 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 km², 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 Alaskan caribou herds have commonly remained at multiyear densities of ≤500 caribou/1000 km² during the last 2 decades largely because of predation (Bergerud, 1980; Valkenburg *et al.*, 1996a). Exceptions were found where strong predator control and favorable weather occurred and where predation is lessened by a natural lack of alternative prey for wolves (particularly on seasonal calving areas).

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.

Table 8. Proportions of discerned plant fragments (mean % ± standard error of the mean) in 24 fecal samples collected from Fortymile caribou during January–April 1992 through 1996. Collection sites are depicted in Fig. 6.

Plant genus or group	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

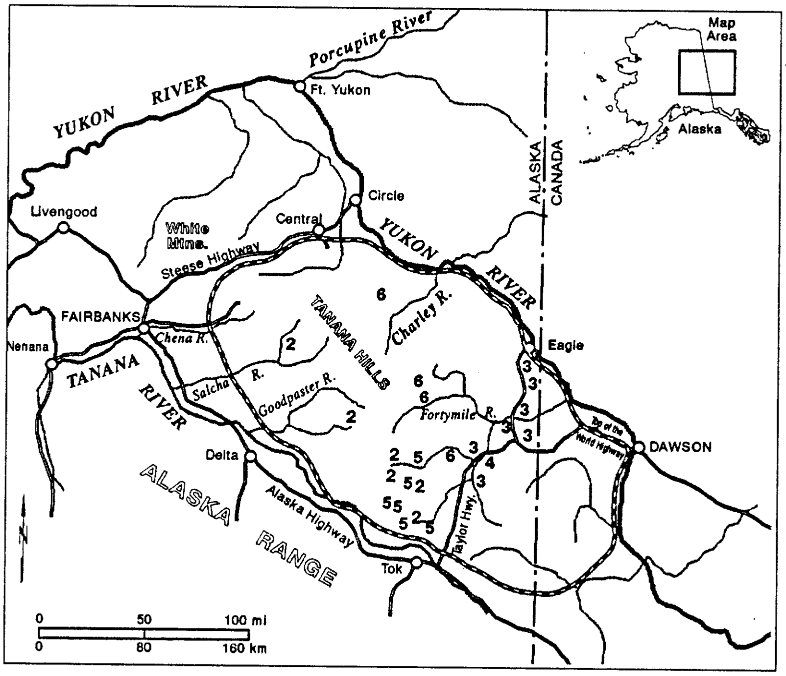

Fig. 6. Locations where caribou fecal samples were collected during Jan.–Apr. 1992 (2), 1993 (3), 1994 (4), 1995 (5), and 1996 (6).

Reducing predation is a value-based socioeconomic and political decision beyond the scope of this report. 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 & Ward, 1995; Boertje *et al.*, 1996).

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Appendices

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
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 (20000)	11400
Cows 24 months old in May 1994 = percent calves in herd in October 1992 (0.17) x estimated herd size in early May 1993 (20000) x survival rate from 12 to 24 months old (0.90) x proportion of females (0.5)	1530
Cows ≥36 months old in May 1994 = (11400–1530)	9870
Calves produced in May 1994 = (9870 x 0.82)	8090
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
Nonhunting deaths among caribou ≥12 months old from 15 May 1994–14 May 1995 = (20000) (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 22104 on 1 July 1994 with some calves included in photos)	20000
Estimated herd size 14 May 1995 = (20000 + 8090 - 5740 - 2310 - 330) rounded to nearest 100	19700
Conclusion: Herd trend approximately stable, consistent with photocensus results	