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Factors Limiting the Fortymile Caribou Herd

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RESEARCH PROGRESS REPORT

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SUMMARY

This is an abbreviated progress report, because the final report for this 5-year project is due in Juneau 1 December 1997. It is premature to report on current status of the herd without counting caribou (*Rangifer tarandus granti*) in photographs taken during a photocensus on 26 June 1997. Also, we are waiting for weather data before writing the final report.

For 3 consecutive years we have made major progress in defining factors limiting the Fortymile Herd. Deployment of radiocollars on newborn and older caribou and regular monitoring allowed investigations of caribou productivity and causes and rate of mortality. These data allowed us to complete annual models illustrating how predation versus other demographic factors affected herd size from mid May 1994 through early May 1997.

The following points have not changed since the last progress report and will assist with continuing efforts to evaluate the new management objectives written by the Fortymile Team:

1 Herd numbers remained relatively stable during 1990-1995 (about 22,000 to 23,000 caribou) compared with annual growth rates of 7% to 10% in the 1980s. During 1996 the herd increased about 4%, in part, because of reduced wolf (*Canis lupus*) predation. This reduced wolf predation probably resulted from a combination of factors including elevated wolf harvest rates on the wintering grounds and more favorable weather. With less snow, wolves are less successful at killing caribou and caribou are in better condition. A slight increase in the herd is predicted for the 1997 photocensus but photos will not be developed until July.

2 Wolves and grizzly bears (*Ursus arctos*) continue to be the major factors limiting herd growth, despite over a decade of the most liberal regulations in the state for private harvesting of wolves and grizzly bears.

3 Reducing harvest of caribou to minimal levels is insufficient to achieve time-specific objectives for elevated caribou numbers. For example, humans harvested ≤ 1.5% (bulls-only) of the midsummer population in 1995 and 1996, which had negligible effects on the herd's population dynamics. Also, bull caribou are plentiful in the Fortymile Herd. Bull:cow ratios in the Fortymile Herd (42-49 bulls:100 cows during 1992-1995) are not reduced by harvest compared with ratios from the only Interior Alaska herd with no harvest in recent decades (39-44 bulls:100 cows in the Denali Herd, 1992-1994). Bull:cow ratios remain high (43 bulls:100 cows in Oct 1995) because harvests have intentionally been held low since 1973 to encourage herd growth. Further reduction of harvest rates will not result in significant herd growth.

4 Adverse weather presumably contributed to increased predation rates during 1990-1995, compared with the 1980s, and probably contributed to reduced natality in 1993.

5 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 most significant factor now limiting Fortymile Herd growth is predation on calves. Natural adult mortality and harvest are at minimal levels, and natality rates increased to average reported levels (82% to 85%) in 1994, 1995, and 1997 and an unusually high level (97%) in 1996. We studied Fortymile calf mortality from May 1994 through June 1997 by deploying radiocollars on newborns. These studies allow evaluation of the annual variability in the causes and extent of calf mortality.

Key words: Alaska, caribou, condition, Fortymile Caribou Herd, management objectives, mortality, nutritional status, 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) estimate of 568,000 caribou during a 20-day herd migration across the Steese Highway in 1920, compared to an aerial photocensus of 23,458 caribou in June 1996.

Caribou herds typically restrict range use as herd size declines. For example, the Fortymile Herd has not migrated across the Steese Highway for several decades 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; Boertje and Gardner 1996:Fig 1). Today, caribou are absent from much of the herd's historical range.

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 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 would probably 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 would die 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 1970s, especially during natural declines of caribou to low levels. Since 1984 radiocollaring of Fortymile caribou provided the ability to efficiently estimate herd size, recruitment, mortality, causes of mortality, and relative nutritional status (Valkenburg and Davis 1989, Valkenburg et al. 1994). 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 because of wolves switching to caribou as primary prey and because declines in wolf numbers lag behind declines in caribou (predator lag). 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. 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).

Ungulate-predator relationships were studied in a portion of the Fortymile Herd's range during the mid-1970s and 1980s (Davis et al. 1978; Boertje et al. 1987, 1988; Valkenburg and Davis 1989; Gasaway et al. 1992). These studies summarized historical and recent predator-prey relationships and documented that predation was the major factor limiting recovery of caribou and moose populations in the area.

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).

To definitively test the 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, only 15% to 31% of the original precontrol wolf numbers remained by late winter during the 4 to 6 winters of effective control efforts. These are the only well-documented studies where large reductions of wolves were maintained for more than 2 winters and wolves were subsequently allowed to recover.

MANAGEMENT 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 population objectives would be attained naturally. Instead, herd numbers were nearly stable between 1990 and 1995.

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. Substantial reductions in the human harvest of caribou were begun in 1973 to allow for herd growth. Since 1973 human harvest of caribou has been an insignificant factor affecting herd growth compared to predation by wolves and bears (Valkenburg et al. 1994, Boertje and Gardner 1996:Appendix B and C).

During autumn 1994 the Fortymile Planning Team was formed (Boertje and Gardner 1996:Appendix A:70) to write a new Fortymile Caribou Herd Management Plan (Boertje and Gardner 1996:Appendix A:57-78). The primary goal of this plan is to restore the Fortymile Herd to its former range, which entails initiating management actions to increase herd size. In

response, we drafted a new 5-year research plan (1997-2002, Boertje and Gardner 1996:Appendix A:28-56), which presents, in detail, management actions proposed by the Fortymile Team. Results of the current research project will provide baseline pretreatment data, which will allow us to evaluate the effectiveness of actions used to elevate herd numbers.

Objectives of the new plan include increasing herd 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 up to 15 packs, translocation of the remaining wolves in these 15 packs, diversionary feeding of wolves at dens, reduced caribou harvest quotas, encouraging trappers to shift trapping to this area, 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 between years.

GOAL

Our goal is 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. We will use historical and current data to help predict herd responses to management actions.

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.

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

PROCEDURES

Estimating Herd Numbers and Growth Rate From Censuses

Photos taken during a photocensus on 26 June 1997 have not been received during this reporting period. These data will be reported on in the final report due in Juneau 1 December 1997.

We estimated minimum numbers of Fortymile caribou in June or early July 1990, 1992, 1994, 1995, and 1996 using a radiosearch, total search, or aerial photo technique (Valkenburg et al. 1985), as in previous estimates of herd size during the 1970s and 1980s (Valkenburg and Davis 1989). To date, we used photocensus data to calculate growth rates of the herd. We also used data on herd composition, natality, and mortality to estimate population trends because photocensuses have, on occasion, substantially underestimated caribou numbers in the Delta Herd (Boertje et al. 1996).

Estimating Trend From Data on Herd Composition, Natality, and Mortality

We combined data on herd composition, natality, and mortality to model the herd's trend independent of photocensus data. To estimate herd composition, we classified caribou from a helicopter during late September or early October 1991-1996 using the distribution of radiocollared caribou to randomly select caribou for counting. Classifications were corrected for the random distribution of radiocollars when necessary. Cows, calves, and small, medium, and large bulls were counted.

We estimated natality rates of the herd by documenting the presence or absence of a calf, hard antlers, and/or a distended udder among radiocollared female caribou $\geq$ 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 in 1994-1997.

We estimated age-specific mortality rates from October 1992 to October 1996 by radiolocating all collared caribou 1 or 2 times monthly. In addition, in 1992 and 1993 we flew daily from mid May through early June. During 1994 through 1997 we flew daily from mid May through late May, 10-13 times in June, and weekly from 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 x 100, where A = the number of caribou dying during the 12-month period, and B = the total number of animals collared at the beginning of the 12-month period.

We radiocollared (ATS, Isanti, Minn and Telonics, Mesa, Ariz) 41 caribou from 27 September to 22 October 1991, 3 on 7 March 1992, 14 from 28 September to 30 September 1992, 14 on

4 October 1993, 14 on 1 October 1994, 15 on 29 September 1995, and 28 from 28 September to 1 October 1996. We also assisted the Bureau of Land Management collar 17 caribou from 3 April to 29 April 1992. Caribou were darted from a Robinson R-22 helicopter using 2 cc Cap-Chur® darts with 1.9 cm barbed needles. During 1991, darts contained 1.5 mg (0.5 cc) carfentanil citrate (Wildnil®, Wildlife Pharmaceuticals, Fort Collins, Colo), 65 g (0.65 cc) xylazine hydrochloride (Anased®, Lloyd Laboratories, Shenandoah, Ia) and 0.85 cc of propylene glycol. During autumns 1992 through 1996, we darted calves using 1 cc darts containing 1 mg (0.33 cc) carfentanil citrate and 67 mg (0.67 cc) xylazine hydrochloride. Most calves were heavily sedated by this dose. For recovery of calves, we administered 100 mg (2 cc) naltrexone hydrochloride (Trexonil®, Wildlife Pharmaceuticals) and 10 mg (2 cc) yohimbine hydrochloride (Antagonil®, Wildlife Pharmaceuticals) intramuscularly. We darted adults in 1996 using 2 cc darts containing 3 mg (1 cc) carfentanil citrate and 100 mg (1 cc) xylazine hydrochloride. For recovery of adults, we administered 300 mg (6 cc) naltrexone hydrochloride (Trexonil®, Wildlife Pharmaceuticals) and 30 mg (6 cc) yohimbine hydrochloride (Antagonil®, Wildlife Pharmaceuticals) intramuscularly. We radiocollared 50 newborn calves in May 1994, 52 in 1995, 60 in 1996, and 55 in 1997 using techniques described by Adams et al. (1995*b*), except that we used a 2-person, Robinson R-22 helicopter.

Evaluating Causes of Natural Mortality

To evaluate causes of death among caribou during their first 4 months of life, we used criteria and techniques described by Adams et al. (1995*b*). To assess cause of death for caribou older than 4 months, we examined death sites within a few days to a few weeks of each mortality using a helicopter, Bellanca Scout, or Supercub for access. Blood (noncoagulated) on collars or on remnants of hide served as evidence of a violent death. In these cases scats, tracks, other signs, and season of kill (bears hibernating in winter) served to identify the predator involved. A collar soaked in blood indicated lynx 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. During general season hunts before 1993, harvest was reported by mandatory mail-in report cards, but many hunters failed to report their harvest. Reported harvest was multiplied by a correction factor of 1.59. This correction factor was derived from road surveys and surveys of transporter services during 1973. To avoid biased reporting, hunters were not told the purpose of the road surveys. The surveys and subsequent mail-in harvest reports were treated as a mark-recapture sample to estimate total harvest. All harvest since 1993 and most harvest during 1990-1992 was conducted under permit hunts. We considered reported harvest from permit hunts to be accurate because about 97% of permittees reported.

Estimating Wolf Harvest

We estimated wolf harvest rates within annual ranges of the Fortymile Caribou Herd for the years 1992-1993 through 1995-1996. Annual ranges of the herd were delineated based on telemetry flights beginning 1 October. Wolf densities were then extrapolated to this area based

on annual estimates of wolf densities from radiocollared wolf packs and wolf surveys in most of the area. 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.

Evaluating Herd Condition and Nutritional Status

Five indices were used to evaluate relative condition and nutritional status of the herd: 1) live weights of autumn and newborn calves, 2) percent mortality of calves of radiocollared cows during the first 2 days of life (i.e., perinatal mortality), 3) percent natality of radiocollared cows, 4) age of first reproduction, and 5) median calving date. We weighed 14 or 15 female calves in late September or early October 1991 through 1996. Methods for determining birthweights of calves followed Adams et al. (1995*b*); for example, 0.6 kg was subtracted for each day of age > 1; 21% of the calves were > 1 day old.

High calf mortality (e.g., 20% to 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, Adams et al. 1995*a*). To detect calf mortality during the first 2 days of life, we observed a radiocollared sample of adult cows on consecutive days during calving seasons 1992 through 1997. 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 death among several of these calves to test the hypothesis that early mortality was attributable to malnutrition.

Daily radiolocations during the 1992 through 1997 calving seasons occurred as follows. In 1992 we radiolocated 30 adult females on 14 May and from 19 May through 3 June. In 1993 we radiolocated 48 adult females on 13 May, 16-28 May, and 3 June. In 1994 we radiolocated 45 adult females from 14 May through 31 May. In 1995 we radiolocated 41 adult females from 11 May through 30 May. In 1996 we radiolocated 39 adult females from 12 May through 30 May. In 1997 we radiolocated 46 adult females from 12 May through 27 May. The median calving date was the date by which 50% of the adult radiocollared females had given birth. Delayed calving is thought to indicate malnutrition (Espmark 1980, Reimers et al. 1983, Skogland 1985).

Identifying Adverse Weather

Nutritional indices will be compared with weather indices to determine what weather indices, if any, can be linked to poor caribou nutrition. For example, are hot, dry summers or deep snows, or both, correlated with herd condition or nutritional status? Is performance of the herd strongly linked to malnutrition during adverse weather? Can recruitment vary independently of nutrition because of overwhelming effects of predation? We plan to use Alaska weather data from Eagle, when available, to describe summer temperature and precipitation. We will attempt to analyze snow data from 6 weather stations surrounding the Fortymile range. Snow data will be corrected for elevation and distribution using universal block kriging (Cressie 1991:179).

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

We collected 13 fecal samples from the Fortymile Herd winter range during March and early April 1992 and 1993. 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. We collected an additional 17 samples during winters 1993-1994 through 1996-1997; data are forthcoming.

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% (Valkenburg et al. 1994). Based on estimates of calf recruitment in early October and estimates of adult mortality from radiocollared cows, the herd probably peaked in 1989 with about 23,000 caribou; herd numbers probably declined slightly through June 1992 and were stabilizing from June 1992 through June 1995. Photocensuses corroborate the stable trend during 1990-1995, with approximately 22,000 to 23,000 caribou in the herd.

Most recently we counted 23,458 caribou on 21 June 1996, which indicates an increasing trend (Boertje and Gardner 1996:Table 1). An increase was also predicted using 1995-1997 natality, composition, and mortality data (Boertje and Gardner 1996:Appendix C, this report).

Timing, Rates, and Causes of Age-Specific Natural Mortality

During the combined calving seasons of 1994-1997, we observed newborn calves during 11-28 May. By the end of June each year except 1997, 40% to 50% of the calves were dead. Another 20% died before reaching the age of 1 year (Boertje and Gardner 1996:Figs 2 and 3). This pattern of births and deaths is similar to that found in other Interior Alaskan caribou studies (Adams et al. 1995*b*; Valkenburg, unpubl data). In 1997 only about 20% of the calves were dead by 30 June.

We summarize data here on causes and rates of calf mortality (1994, 1995, and 1996 cohorts) to characterize these parameters prior to management actions planned for the 1997-2001 cohorts (Boertje and Gardner 1996:Appendix A). For the 1994 calf cohort, the annual mortality rate totaled 71% ($n = 55$) and wolves and grizzly bears, together, killed 24 (71%) of the 34 calves that died from known causes (Boertje and Gardner 1996:Fig 4). We attributed 13 (38%) of these 34 deaths to wolves, 11 (32%) to grizzly bears, 3 (9%) to eagles, 3 (9%) to accidents (broken legs), 1 (3%) to a black bear, 1 (3%) to a wolverine, 1 (3%) to abandonment, and 1 to

suffocation at birth. Two summer mortalities caused by either wolves or grizzly bears were divided between the 2 predators.

For the 1995 cohort, the annual mortality rate totaled 59% (n = 54) and wolves and grizzly bears killed 21 (70%) of the 30 calves that died from known causes (Boertje and Gardner 1996:Fig 5). We attributed 13 (43%) of these 30 deaths to wolves, 8 (27%) to grizzly bears, 4 (13%) to black bears, 3 (10%) to eagles, 1 (3%) to a wolverine, and 1 (3%) to an accident.

For the 1996 cohort, the annual mortality rate totaled 62% (n = 60) and wolves and grizzly bears killed 29 (78%) of the 37 calves that died from known causes. We attributed 18 (49%) of these 37 deaths to wolves, 11 (30%) to grizzly bears, 5 (14%) to eagles, 1 (3%) to a wolverine, and 2 (5%) to natural, nonpredation causes.

Wolf predation has consistently been the major cause of death among caribou older than 4 months. Of the 62 caribou older than 4 months for which cause of death was determined (Oct 1991-30 Jun 1997), wolves killed 54 (87%), lynx killed 2 (3%), grizzly bears killed 2 (3%), a wolverine killed 1 (2%), and 3 (5%) died from nonpredation deaths. Most (84%) of these deaths occurred during the 7 months (Oct through Apr) when snow was on the ground.

POPULATION MODELING

We completed 3 annual models using data on natality, mortality, herd size, and composition to illustrate the relative importance of predation versus other demographic factors affecting the Fortymile Caribou Herd. From 11 May 1994 through 10 May 1995, we estimated herd trend was stable because annual deaths almost equaled births. Annual deaths totaled 8200 of which wolves accounted for 48%, grizzly bears 24%, other predators 10%, nonpredation 13%, and hunters 4% (Boertje and Gardner 1996:Fig 6). Wolves killed an estimated 14% of the 1994 postcalving population in 1 year (2240 calves and 1680 adults and yearlings). In contrast, grizzly bears killed 7% of the postcalving population in 1 year (1900 calves and 100 adults and yearlings), other predators killed 3%, hunters killed 1%, and nonpredation took 4%.

The primary differences in the 1995-1996 model were that wolves killed several hundred fewer adult caribou and nonpredation deaths among calves declined, so herd size increased (Boertje and Gardner 1996:Fig 7). An increase in herd size was also documented using an independent photocensus in June 1996. From 11 May 1995 through 10 May 1996, we estimated annual deaths totaled 6500 of which wolves accounted for 50%, grizzly bears 22%, other predators 20%, nonpredation 4%, and hunters 3%. Wolves killed an estimated 11% of the 1995 postcalving population in 1 year (2170 calves and 1050 adults and yearlings). In contrast, grizzly bears killed 5% of the postcalving population in 1 year (1330 calves and 60 adults and yearlings), other predators killed 5%, hunters killed 1%, and nonpredation took 1%.

During 1996-1997 a herd growth of 800 is predicted by the model. Mortality rates of adults and calves increased slightly over the previous 2 years, but about 1800 more calves were produced. From 11 May 1996 through 10 May 1997, we estimated annual deaths totaled 9400 of which wolves accounted for 59%, grizzly bears 23%, other predators 11%, nonpredation 6%, and hunters 2%. Wolves killed an estimated 18% of the 1996 postcalving population in 1 year (3220

calves and 2280 adults and yearlings). In contrast, grizzly bears killed 7% of the postcalving population in 1 year (1970 calves and 180 adults and yearlings), other predators killed 3%, hunters killed 0.05%, and nonpredation took 2%.

CARIBOU HARVEST

Reducing harvest of caribou to minimal levels is insufficient to achieve time-specific objectives for elevated caribou numbers because other mortality factors more strongly affect herd dynamics (Boertje and Gardner 1996:Appendix B and C). For example, humans annually harvested ≤ 1% (bulls only) of the postcalving population during 1994-1996, while wolves killed 11% to 18% (Boertje and Gardner 1996:Figs 6 and 7). Estimated total annual harvest averaged 2.8% of the midsummer herd size during the 6 years before 1990. At this time, harvest was intentionally reduced because natural mortality increased and recruitment declined (Boertje and Gardner 1996:Table 1). Since 1990 harvest has averaged about 1% of the midsummer herd size. Virtually all legal harvest has consisted of bull caribou, and 93% of estimated legal and illegal harvest since 1984 consisted of bulls.

Restricted harvests of bulls do not necessarily provide for herd growth because each bull can impregnate many cows. In reindeer (*Rangifer tarandus tarandus*) herds 4 to 6 bulls per 100 cows is considered sufficient for breeding (Sjenneberg and Slagsvold 1968). Bull caribou are plentiful in the Fortymile Caribou Herd. Bull:cow ratios in the Fortymile Herd (42-49 bulls:100 cows, 1992-1995) are not reduced by harvest compared with ratios from the only Interior Alaska herd with no harvest in recent decades (39-44 bulls:100 cows in the Denali Herd, 1992-1994). Bull:cow ratios remain high (43 bulls:100 cows in Oct 1995) because harvests have intentionally been held low since 1973 to encourage herd growth. Further reducing harvest rates of bulls will not result in significant herd growth.

WOLF HARVEST

The Fortymile Caribou Calf Protection Program, a group of private citizens, paid $400 per wolf from a large area including most of the Fortymile Herd's range beginning in winter 1995-1996. 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.

To evaluate the effect of the Caribou Calf Protection Program on the herd's wolf population, we compiled estimates of the wolf harvest rates from within the herd's annual range for 3 years prior to the program and during the first year of the program. Preliminary data indicate wolf harvest rates were approximately 20% to 30% during the 3 winters prior to the program and approximately 60% during the first year of the program. Data for the second year of the program and implications of these data are forthcoming in the final report.

HERD NUTRITIONAL STATUS AND ADVERSE WEATHER

We found no convincing support for using perinatal mortality rates to evaluate nutritional status (Boertje and Gardner 1996:8-9). Of the remaining potential indices of herd condition and nutritional status, natality rate and age of first reproduction were most negatively affected by the

adverse weather of 1992. 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. Many adult cows apparently did not gain sufficient fat to breed in 1992. The natality rate in 1993 was low in the Fortymile Herd (68%) and the Delta Herd (30%; Valkenburg 1994). Natality rates for caribou are commonly ≥ 82% (Boertje and Gardner 1996: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.

October calf weights were not significantly lower in 1992 (Boertje and Gardner 1996:Table 2). Median calving date was not late in 1993 (22 May, $n = 25$) compared with 1992 (23 May, $n = 25$). However, calving in both years was late relative to calving after the mild winter of 1993-1994 (18 May, $n = 31$).

Recommendations for acquiring meaningful indices to Fortymile Herd nutritional status are forthcoming in the final report. Data from natality rates probably provide indices to the previous summer/autumn condition, whereas birthweights and calving dates probably provide indices to winter and spring conditions. Data on natality rates indicate caribou nutritional status was poor in autumn 1992, excellent in autumn 1995, and average in autumn 1991, 1993, 1994, and 1996.

Birthweights are available from only 4 years (1994-1997). During 1994 male calves weighed 7.60 kg ($n = 22$, $s_{\bar{x}} = 0.185$) and females weighed 7.47 kg ($n = 22$, $s_{\bar{x}} = 0.257$). During 1995 males weighed 8.45 kg ($n = 24$, $s_{\bar{x}} = 0.136$) and females weighed 7.68 kg ($n = 25$, $s_{\bar{x}} = 0.161$). During 1996 males weighed 8.47 kg ($n = 26$, $s_{\bar{x}} = 0.228$) and females weighed 8.05 kg ($n = 32$, $s_{\bar{x}} = 0.160$). During 1997 males weighed 8.43 kg ($n = 24$, $s_{\bar{x}} = 0.213$) and females weighed 7.88 kg ($n = 32$, $s_{\bar{x}} = 0.179$). Median calving dates were: 23 May in 1992 ($n = 25$), 22 May in 1993 ($n = 24$), 18 May in 1994 ($n = 32$), 20 May in 1995 ($n = 28$), 18 May in 1996 ($n = 37$), and 18 May ($n = 39$) in 1997.

From 1952 to 1990 proportions of calves in September or October were positively correlated with July rainfall and negatively correlated with an index to snow depth (Valkenburg et al. 1994). The snow index was correlated with July temperature and negatively correlated with July rainfall, indicating high snowfall winters were usually followed by relatively warm and dry conditions in July and poor calf survival. We have not yet analyzed weather data from the 1990s.

We hope to further explore whether annual fluctuations in caribou numbers can be explained, in part, by extremes in weather patterns and resulting nutritional status. Because we saw no strong decline in caribou numbers during 1992 when nutritional status was poor, we conclude that periodic poor nutritional status has not been as strong a factor affecting caribou numbers in the Fortymile Herd as in the Delta and Denali herds.

Range Condition

Range condition seemed excellent during winters 1991-1992 and 1992-1993, as evidenced by high proportions (x = 72% to 81%) of lichen fragments in caribou fecal samples (Boertje and Gardner 1996:Table 3). Samples were collected from different wintering areas each year

(Boertje and Gardner 1996:Fig 8). Samples collected during winters 1993-1996 are undergoing analysis. 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 winter forage. Fecal samples from overgrazed winter ranges contained higher proportions of mosses and evergreen shrubs and reduced proportions of lichens compared to values observed in this study.

OTHER ACTIVITIES

Preliminary data were presented at an interagency and international meeting focusing on Fortymile Herd management in Tok on 9 February 1994. This meeting stimulated the creation of the Fortymile Planning Team responsible for writing the new Fortymile Herd Management Plan (Appendix A:57-78). Several presentations of research data were made to the Fortymile Team and the Board of Game during the planning process. Research data were also incorporated into 5 editions of *The Comeback Trail* and various management reports published by ADF&G. *The Comeback Trail* is a newsletter informing the public and agencies of Fortymile Herd planning, management, and research.

CONCLUSIONS

For those considering future management direction of the Fortymile Herd, several points are significant:

1 Herd numbers remained relatively stable during 1990-1995, compared with annual growth rates of 7% to 10% in the 1980s. The herd probably increased slightly during 1996 and 1997, and we predict an increase in 1998 because of reduced mortality of calves born in 1997.

2 Wolves and grizzly bears continue to be the major factors limiting Fortymile Herd growth, despite over a decade of the most liberal regulations in the state for public harvesting of wolves and grizzly bears.

3 Harvest of Fortymile caribou has been intentionally restricted to allow for growth of the herd, but minimizing harvest is insufficient to achieve time-specific objectives for elevated caribou numbers. For example, harvest was only about 150 bull caribou during the 1996-1997 hunting season (< 1% of the postcalving population), and bull caribou are plentiful in the herd compared to unhunted herds.

4 Adverse weather contributed to reduced natality and, presumably, increased predation rates in some recent years, compared with the 1980s.

5 Winter range can support elevated caribou numbers both in regard to lichen availability on currently used winter range and availability of vast expanses of former winter range.

Assuring achievement of time-specific objectives for increased caribou numbers will depend on actions that measurably reduce predation. 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 and Ward 1995, Boertje et al. 1996).

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