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Population growth, movements, and status of the Nushagak Peninsula Caribou Herd following reintroduction, 1988 - 2000

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Abstract: Barren ground caribou (Rangifer tarandus) were reintroduced to the Nushagak Peninsula, Alaska in February of 1988 after an absence of more than 100 years. Since reintroduction, herd growth and population dynamics have been monitored closely. At this time, there has been no significant dispersal from the herds' core range. The Nushagak Peninsula Caribou Herd (NPCH) grew rapidly from 146 reintroduced individuals to over 1000 in 13 years. Dramatic mean annual growth during the first 6 years (1988-1994) of 38% ($r = 0.32$) can be attributed to the high percentage of females in the initial reintroduction, high calf production and survival, exceptional range conditions, few predators, and no hunting. However, the populations' exceptional growth (peak counts of 1400) slowed and stabilized between 1996-1998 and then decreased between 1998 and 2000. Size, body condition and weights of calves captured in 2000 were significantly lower than those captured in 1995 and 1997. Although calf production also decreased from close to 100% (1990-1995) to about 91% (1996-2000), overall calf survival continued to be high. Legal harvest began in 1995, and harvest reports have accounted for approximately 3% of population mortality annually. Although brown bears (Ursus arctos) and wolves (Canis lupus) are present, the extent of predation is unknown. Mean home range of the NPCH was 674 km^2 and group sizes were greatest during post-calving aggregation in July ($\bar{x} = 127$). Caribou population density on the Nushagak Peninsula reached approximately 1.2 caribou/km^2 in 1997 before declining to about 1.0 caribou/km^2. A range survey in 1994 noted only trace utilization of lichens on the Nushagak Peninsula by caribou. A subsequent survey in 1999 found moderate to severe utilization in 46% of plots, suggesting the reintroduced herd was beginning to alter range condition. Between 1997 and 2000, both calf production and condition of 10-month-old calves declined. Calving has also been delayed in recent years. However, we suspect the reduced herd growth can be attributed to increasing hunting pressure and some dispersal of caribou from the Peninsula, not reduced range condition.

Key words: aerial radio telemetry, barren ground caribou, calf production, condition, distribution, home range, mortality, range condition, Rangifer tarandus, subsistence.

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Introduction

Historically, a large caribou population occupied the coast of the Bering Sea from Bristol Bay to Norton Sound and archaeological investigations suggest that caribou were important to the native population (Kotwa, 1963). While still numerous in the upper Kuskokwim drainage, caribou were noted as absent from the Togiak and Goodnews drainages as early as 1900 coinciding with a period of human population growth and intense commercial trade (Capps, 1929). Reindeer were introduced into Bristol Bay in the early 1900s to provide the native communities with an economic base, however, the industry failed by the 1940s (Alaska Planning Group, 1974).

Togiak National Wildlife Refuge (Togiak Refuge) in southwest Alaska, established in 1980, was directed to reestablish wildlife populations to historic levels (U.S. Fish and Wildlife Service, 1986). As a result, barren ground caribou were reintroduced to the Nushagak Peninsula in February 1988 (Fig. 1). The reintroduction was intended to reestablish caribou in an area where local residents had been depen-

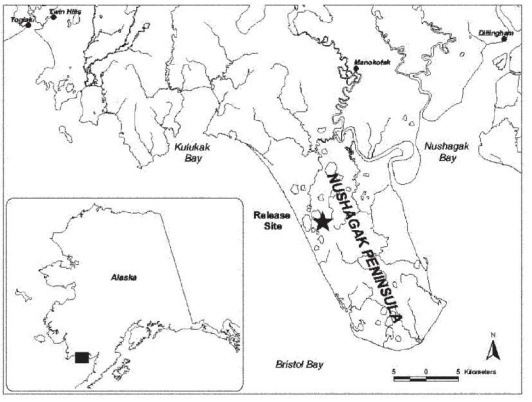

Fig. 1. Release site of the reintroduced NPCH, southwest Alaska.

dant on them for thousands of years. The principle goal was to maintain an expanding population with sustainable subsistence harvest. The nearest caribou herds to the Togiak Refuge were the Mulchatna Caribou Herd (MCH), the Kilbuck Caribou Herd (KCH) and the Northern Alaska Peninsula Caribou Herd (NAPCH). However, it should be noted that in 1994, the KCH was assimilated by the larger MCH (Patten, 1996) and the two herds remain indistinguishable. Previously, hunting pressure, natural barriers, and human settlements appeared sufficient to prevent these herds from expanding onto Togiak Refuge; recently the MCH has begun expanding onto Togiak Refuge in large numbers.

Study area

The Nushagak Peninsula is located in the southeast corner of the Togiak National Wildlife Refuge in southwest Alaska and encompasses approximately 1050 km^2. It is almost entirely lowland tundra with increasing elevation toward the northern portion. The climate is arctic maritime with temperatures ranging from an average minimum of –16 °C to an average maximum of 15 °C. The frost free period averages 120 days. Normal annual precipitation is 63.5 cm, including 186.7 cm of snow annually. Autumn is generally the wettest season of the year, while spring is generally the driest (U.S. Fish and Wildlife Service, 1986).

Methods

Radio-collaring

Details of the reintroduction of the NPCH are discussed in Hinkes & Van Daele (1996). Additional radio-collars were added in 1992, 1995, 1997, and 2000. Data collected during capture operations included weight, neck girth, total length, heart girth, metatarsus, hindfoot and mandible length. Body condition scores (condition index) were also taken. The condition index was determined by palpating the withers, ribs, and rump of captured animals and giving a subjective rating of 1 (emaciated) to 5 (obese) (Gerhart, 1995); an overall condition score was used in this analysis. We tested for differences in calf weights, heart girth, hindfoot length, metatarsus length, and mandible length over time using a one-way ANOVA. When differences existed, a Fisher's least significant difference test was used to identify which means differed significantly at the 95% confidence level. A Chi-square test was used to test for differences in condition index between years.

Monitoring

Monthly flights to monitor radio-marked caribou began in 1988. Weekly flights during the calving period were initiated in 1991. When possible, visual confirmation of association with a calf was made. However, to avoid disturbance, visual observations were not made during post-calving aggregations. Sex and age composition counts were conducted by helicopter in the fall of 1992, 1994, and 1997 - 1999. Population censuses were conducted in 1990 - 1993, 1996 - 1998, and 2000 using a total-count technique. Transects were flown at 1.0 - 1.5 km intervals depending on snow, light, and wind conditions. For 1994, 1995, and 1999 (years when a population census was not conducted), herd size was estimated using the formula: $N_{t+1} = (N_t - H)S + N_c \times R \times 0.90)$ where N_{t+1} is the estimate, N_t is the most recent population count or estimate; H is the reported harvest during the calendar year; S is the previous 5 year average survival rate for radiocollared caribou; N_c is the most recent estimate of the number of females ≥ 2-years-old; and R is the previous 5 year average fall calf recruitment rate for radiocollared females ≥ 2-years-old. We assumed that male survival equaled that of females or 0.90, whichever was less, and that calf survival from fall to the end of the year was 0.90 (Aderman & Woolington, 2001). Separate counts of caribou on and off the Nushagak Peninsula were conducted in 1996 through 1998 when substantial numbers of caribou were noted to the west (total population counts). However, a proportion of those individuals were suspected to be part of the dispersing MCH.

Home range, movements, and population growth

The Animal Movement Analysis extension (Hooge & Eichenlaub, 1997) for ArcView (ESRI, 2000) was used to determine MCP (minimum convex polygon) home range size and calving distribution

Table 1. Mean body measurements of captured NPCH 10-month-old female calves.

	1995			1997			2000		
	$\bar{x}$	n	(SD)	$\bar{x}$	n	(SD)	$\bar{x}$	n	(SD)
Weight (kg)	56.6	15	(5.0)	50.5	10	(6.1)	48.8	10	(2.1)
Condition Index	3	13	---	4	13	---	2	10	---
Heart Girth (cm)	98.1	13	(3.6)	96.5	13	(5.3)	95.0	10	(2.7)
Mandible (cm)	23.4	14	(0.9)	22.7	13	(1.1)	22.5	10	(0.8)
Hindfoot (cm)	51.1	13	(5.1)	53.3	13	(2.9)	51.4	10	(3.1)
Metatarsus (cm)	36.9	15	(1.2)	37.6	12	(1.8)	35.3	10	(0.7)

(Valkenburg et al., 1988), and distances moved between relocations. The MCP home range was grouped for all years due to small sample sizes. Distances moved between relocations were calculated as the distance moved between successive locations and were grouped for all individuals. Linear regression was used to identify relationships between home range size and distances between relocations, and the number of relocations. There was an indication of nonnormality in the data, therefore, a Kruskal-Wallis (KW) was used to test for differences between the medians for successive distances moved and group sizes. All statistical analyses were performed using STATGRAPHICS Plus (Manugistics, 1998).

The population was modeled in a Lotus 1-2-3 (Lotus, 1997) spreadsheet. Estimates of natality (% radio-collared cows observed with calves), survival (% radio-collar survival), and harvest rates were calculated each year from observed values. Projected population numbers were calculated by estimating the number of male and female calves (# females * % calves * 50% sex ratio) and adults (((# calves * % survival) + (# $adults_{t-1}$ * % survival)) – harvest))). The average radio-collar natality and survival rates were used for population projections and survival rates were assumed to be equal between the sexes.

Range condition

Severe overgrazing by caribou was well documented in western Alaska during the early 1900s (Palmer & Rouse, 1945). Because lichen communities are known to be sensitive to over-grazing and trampling (Klein, 1967), a range condition study was initiated in 1989 to assist in management (Johnson, 1994). Permanent transects and / or exclosures at 5 sites on the Nushagak Peninsula were established in 1993 and visited in 1994 and 1999 to monitor changes in vegetation production and cover over time. In addition, selected lichen – rich upland sites were surveyed in 1994 and 1999 and classified into eight utilization classes ranging from trace to extreme (Swanson & Barker, 1992).

Results

Radio-collaring

A total of 146 caribou were reintroduced to the Nushagak Peninsula in February 1988 (Hinkes & Van Daele, 1996). In 1988, 20 radio-collars were deployed and, since reintroduction, an additional 56 radio-collars have been added (16 in 1992; 10 in 1995; 20 in 1997; 10 in 2000).

Body Measurements

Adult caribou captured in 1992 (2-year-olds) were larger and appeared to be in better condition than 2-year-old caribou originally transplanted to the Peninsula in 1988 (Hinkes & Van Daele, 1996). In contrast, Nushagak Peninsula caribou calves (approximately 10-month-old) captured in 2000 were smaller and appeared in poorer condition than those captured in both 1995 and 1997 (Table 1). NPCH calves captured in 2000 had significantly smaller metatarsus lengths compared with both 1995 and 1997 captures ($F_{(2, 34)}=8.21$, $P=0.001$). Calf mandible lengths were also significantly larger in 1995 ($F_{(2, 34)}=3.40$, $P=0.045$) than during subsequent captures. The mean spring weights of calves captured in 1997 and 2000 were comparable ($\bar{x}=50.5$ kg, SD=5.0, n=10; $\bar{x}=48.8$, SD=6.1, n=10, respectively), but both were significantly ($F_{(2,32)}=9.49$, $P < 0.001$) lighter than calves captured in 1995 ($\bar{x}=56.6$ kg, SD=2.1, n=15). Further, the overall body condition index was significantly lower ($x^2_6=29.97$, $P < 0.001$) for NPCH calves caught in 2000 compared to those caught in both 1995 and 1997. Other body measurements (heart girth and hindfoot length) did not differ significantly between the years.

Calf production and survival

Peak calving for radio-marked NPCH caribou

Table 2. Average progression of calving for NPCH radio-collared cows, 1992-2000.

Calved By:	Average Percent
May 15th	7%
May 22nd	33%
May 27th	74%
May 30th	88%
June 10th	98%

occurred in late May which is consistent with other caribou herds at similar latitudes in Alaska (Skoog, 1968; Hemming, 1971). Peak calving is defined as the date by which 50% of calving has occurred. The mean calving date from 1992 to 2000 was 24 May (Table 2). From 1992-1995, mean calving occurred by 21 May. Between 1996 and 2000, the mean calving date was 26 May. Calving in 2000 was delayed with no radio-collared cows noted with calves by May 22nd and only 80% with calves by May 30th.

Calving grounds are perhaps the most predictably used portions of caribou annual ranges (Valkenburg et al., 1988), however, there is no apparent distinct calving area for the NPCH. The total calving distribution for the NPCH for all years combined was 760 km^2 (75% of the Peninsula). Annual calving areas were approximately 330 km^2 (SD=114 km^2, n=11) and appeared to be expanding north since 1993. Other than one individual, all radio-collared females calved on the Peninsula until 1994. Between 1994 and 1999, four radio-marked females have been observed calving off of the Peninsula, though not consistently.

Natality estimates derived from radio-collared females have been found to be similar to estimates of the herd at large (Davis et al., 1991). In 1990, 1992, 1993, and 1995 all radio-collared females in the NPCH produced calves (100%). The natality rate has since decreased (1996 - 2000), overall averaging 91% (Table 3). All five females estimated to be 2-years-old during the 1992 NPCH capture effort produced calves (Hinkes & Van Daele, 1996). Subsequently, 2-year-old radio-collared cows (captured as 10-month-old calves in 1995 and 1997) had lower incidences of calf production; none produced calves (0%) in 1996 and 3 out of 13 (23%) produced calves in 1998. The mean fall survival of calves associated with radio-collared cows from 1990 to 1999 averaged 62% (SD=9.8; n=9) (Table 3). Calf survival in 2000 dropped dramatically to 30%, though this may be due to a small sample of collared cows (n=10), bringing the overall mean fall survival to 60% (SD=13.7, n=10).

Mortality

Legal harvest of NPCH caribou began in January 1995 with 38 caribou reported killed. From 1995 to 2000, 3%-4% of the Peninsula population has been taken each year during the reported subsistence harvest. Mortality causes of radio-marked caribou from 1988 to 2000 were: 49% from unknown causes (n=25), 16% taken by hunters (n=8), and 6% by predation (n=3). Two other caribou were also documented as dead (4%), including one from birth related causes and another that locked antlers with another bull. An additional 25% were missing or had collars fail (n=11) or were capture related mortalities (n=2). The average age for caribou that died from unknown causes was 8.9 years (SD=4.4, n=25), from hunting was 5.4 years (SD=2.6, n=8), and from predation was 7.2 years (SD=3.3, n=3) suggesting no age specific mortality. Of note is one radio-collared female that lived approximately 15 years before dying of apparently natural causes.

Table 3. Production and survival of calves associated with NPCH radio-collared cows, February 1988 to October 2000.

Year	Production[a]	Calf Survival[b]
1988	---	---
1989	---	---
1990	100	62
1991	---	---
1992	100	64
1993	100	54
1994	96	75
1995	100	78
1996	86	67
1997	76	52
1998	80	54
1999	79	53
2000	91	30
Mean	91	60
SD	11	14
N	10	10

[a] Production = % of 3-years or older radio-collared cows observed with calves in the spring.

[b] Calf Survival = % of calves associated with radio-collared cows observed in October.

Home range, movements, and distribution

From March 1988 to March 2000, we obtained over 3000 relocations on 62 radio-collared caribou. The total number of relocations per radio-collared caribou averaged 59. Home range size was related to the

Table 4. Herd composition of the NPCH, 1988-2000.

Regulatory Year	Bulls:100 cows	Calves:100 cows	Calves (%)	Cows (%)	Bulls (%)
Feb 1988a	12	10	8	82	10
1992/1993	60	72	31	43	26
1993/1994	---	---	---	---	---
1994/1995	71	65	27	42	30
1995/1996	---	---	---	---	---
1996/1997	---	---	---	---	---
1997/1998	64	62	28	44	28
1998/1999	57	63	28	46	26
1999/2000	48	53	26	50	24
2000/2001	52	38	20	53	27

[a] Original reintroduction.

number of telemetry locations at n < 30 (r^2=0.55, P=0.009), therefore caribou with fewer than 30 locations were excluded from further analyses. Two radio-collared caribou with ranges to the village of Togiak (Fig. 1), beyond the Nushagak Peninsula (1551 km^2 and 1479 km^2), were also excluded. With those exclusions, the average home range of NPCH caribou between 1988 and 2000 was 674 km^2 (SD=173, n=48). The mean home range was similar to that previously reported for NPCH caribou with 64-74 locations ($\bar{x}$=606 km^2, SD=98, n=11) (Hinkes & Van Daele, 1996). The age of NPCH caribou was not significantly related to home range size (r^2=0.09, P=0.842).

Mean distances moved each year between successive relocations during 1988 - 1999 ranged from 9.2 km (1988) to 15.7 km (1998) ($\bar{x}$=12.4 km). There was a significant linear relationship between average overall distances moved and home range size for individuals (r^2=0.30, P<0.001). However, there was no relationship between the number of and distance between relocations (r^2=0.07, P=0.069) suggesting samples were representative of movements. Differences in movements between years were significant (KW=175.3, df=12, P<0.001) and generally increased through time as the herd expanded its range along the Peninsula. Mean distances moved each month were also significantly different (KW=292.8, df=11, P<0.001) and ranged from a low of 9.4 km during the calving period (May) to a high of 17.7 km in December ($\bar{x}$=12.5 km).

Seasonal variation of group sizes in the NPCH was significant (KW=531.9, df=11, P<0.001). Group size was greatest in July during post-calving aggregation ($\bar{x}$=127) and decreased through Sep ($\bar{x}$=15), remaining stable throughout the winter months (October – March) ($\bar{x}$=25). The lowest mean group size was observed in the spring (April – May) ($\bar{x}$=12) as pregnant females dispersed to calve. Group sizes for the NPCH were significantly different between years (KW=127.9, df=12, P<0.001) with the group size increasing on average from 1988 to 1999 (range 13 to 28 caribou, $\bar{x}$=21) as the population increased.

Caribou observations were plotted by month and season, with no significant pattern noted. The caribou did concentrate more in the center of the Peninsula during the calving and summer seasons and then expanded their range towards the coast during the winter months. No significant dispersal from the herds' "core range" on the Peninsula has occurred. Of over 3600 radiolocations during tracking flights and surveys, 92% were observed on the Nushagak Peninsula. This is compared to over 99% noted earlier (Hinkes & Van Daele, 1996).

Population growth and composition

The NPCH grew rapidly in the first 6 years following reintroduction (1988 to 1994) with a mean annual growth of 38% (SD=7.3, n=6) or an exponential rate of increase r=0.32 (Hinkes & Van Daele, 1996). After 1996, the NPCH's exceptional growth slowed; between 1996 and 1998, the NPCH only grew about 1% (Fig. 2). The herd's Nushagak Peninsula population level then dropped 19% between the 1998 and 2000 counts. The population density of the NPCH was estimated to be 1.0 caribou/km^2 in 1993. By 1997, the estimated density had reached 1.2/km^2 on the Peninsula but had dropped to 1.0 caribou/km^2 by 2000. Though no known dispersal has occurred, there have been as many as 100+ individuals reported near the village of Twin Hills that are suspected to be from the NPCH. Also beginning in 1996, caribou were noted off the Peninsula to the west in greater numbers, and although several collared NPCH caribou have been observed in this area, many of those individuals are suspected to be from the dispersing Mulchatna Caribou Herd. This is supported by confirmed locations of radio-collared Mulchatna (and Kilbuck) caribou near the village of Twin Hills.

Herd composition of the NPCH also changed dramatically in the first 5 years following reintroduc-

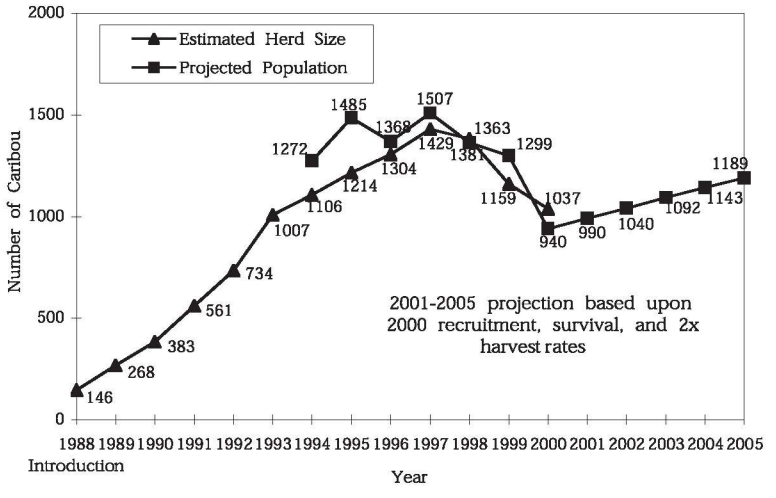

Fig. 2. Release site of the reintroduced NPCH, southwest Alaska.

tion (Hinkes & Van Daele, 1996). Initial herd composition was 82% cows, 10% bulls (12 bulls:100 cows), and 8% calves (10 calves:100 cows). Average herd composition from 1992 to 2000 (n=6) was 46% cows, 27% bulls (59 bulls:100 cows), and 27% calves (59 calves:100 cows) (Table 4). Although average bull:cow ratios in the NPCH continued to exceed that of most hunted Alaskan populations (45 bulls:100 cows) (Leib et al., 1991), bull:cow ratios in the NPCH have steadily decreased from a high in 1994/1995 (71 bulls:100 cows). By 2000, the ratio was 52 bulls:100 cows in the NPCH. Proportions of cows and calves remained constant between 1992 and 2000.

Range condition

A range condition inventory on the Nushagak Peninsula in 1994 noted only trace utilization of lichen tundra uplands by the reintroduced herd. In other areas, lichens appeared to be virtually ungrazed (Johnson, 1994). By 1999, however, obvious signs of grazing were prevalent and condition was beginning to be altered by the NPCH. Of 160 plots surveyed on the Peninsula in 1999, 54% were described as trace to slightly grazed, 44% were moderately to heavily grazed, and 2% were rated as severely grazed.

Discussion

Caribou do not generally come into estrus until 28 months of age (Skoog, 1968; Bergerud, 1971), although it has been noted that with good nutrition, caribou can conceive at 17 months (Bergerud, 1980). The initial observed increased production in young females (2-year-olds) in the NPCH has also been observed in several other transplanted herds in Alaska (Valkenburg et al., 2000). Despite a slight decline, the natality rates observed for the NPCH continue to be high; at least 91% compared to an average natality rate of 82% for other populations (Bergerud, 1980). The lighter calf weights in 1997 and 2000 of the NPCH are comparable to calves in the Northern Alaska Peninsula Caribou Herd ($\bar{x}$=50.9 kg, SD=3.0, n=19), the parent herd for the NPCH (Hinkes & Van Daele, 1995). The neighboring Mulchatna Caribou Herd also showed a marginally significant decrease in spring weights of 10-month-old calves (F (1,19)=3.14, P=0.09) between 1995 and 2000 ($\bar{x}$=49.8 kg, n=10; 46.6 kg, n=11, respectively) (P. Valkenburg, Alaska Department of Fish and Game, unpubl. data).

During 1988 – 2000, brown bears were common and wolves were rare on the Nushagak Peninsula; the effect of predation on NPCH herd dynamics is unknown. Incidental sightings of brown bears on the Peninsula have increased since 1997, especially of sows with cubs. Brown bears are known to be effective predators of ungulate calves (Adams et al., 1995; Valkenburg, 1997; Sellers et al., 2002) and sows with young have been shown to kill more caribou calves (< 2 weeks old) than other classes of bears (Young & McCabe, 1997).

The initial growth rate of the NPCH exceeded the maximum theoretical potential of $r \approx 0.30$ or about 35% as described by Bergerud (1980) and Bergerud et al. (1983). Bergerud (1980) also surmised that Alaska caribou herds without predators show rapid growth approaching r=0.30, while those with predators showed little or no growth. However, Davis et al. (1991) stated that only transplanted caribou herds approach this level and that growth over 20% is uncommon even under optimum conditions. The initial impressive growth of the NPCH can be attributed to the high percentage of females in the reintroduced herd, high calf production and survival, pristine range conditions, few predators, and little hunting (Hinkes & Van Daele, 1996). Growth rates of other reintroduced caribou herds in Alaska have been more variable (Valkenburg et al., 2000). Expansion of range, including calving areas, has been documented in many herds across Alaska and

Quebec (Mercer et al., 1986; Couturier et al., 1990; Tobey, 1999; Woolington, 1999). Haber & Walters (1980) suggested that competition for food at densities approaching 2.0 caribou/km^2 will cause such dispersal, although dispersal (i.e. movement of caribou from one calving range to another) has not been documented in caribou as a response to increasing densities (Valkenburg et al., 1996; Valkenburg, 1997).

While the population dynamics of the NPCH continue to be similar to other reintroduced herds with high quality forage and few predators (Hinkes & Van Daele, 1996), growth rate of the herd has slowed. Decreased calf condition and size, reduced calf production, and a decline in range condition all suggest that the population has reached a plateau. In addition, delayed calving may further be symptomatic of poor nutrition (Skogland, 1985; Boertje & Gardner, 1999). Although, it should be noted that the winter of 1999/2000 was one of exceptional snow accumulation and winter severity is an important factor affecting caribou survivorship and condition (Russell & Martell, 1984); it is possible the observed effects were a result of short term weather conditions. However, while there can be annual fluctuations in body condition, increasing herd size in the Delta Caribou Herd also coincided with reduced calf weights and condition which, subsequently, have not returned to the levels of the 1980s when herd size was low (Valkenburg et al., 1999). Valkenburg et al. (2000) also noted that similar declines in body weight and natality in other transplanted herds occurred after relatively short periods of grazing pressure as densities within herds increased.

Modeling the NPCH using current estimates for natality, survival and harvest (~ 3%) results in a population increase to over 2000 caribou by 2005. However, we suspect that unreported harvest may be as much as 2 to 3 times the reported rate for the reason that a minimum of 16% of all radiocollared caribou mortalities between 1988 and 2000 could be attributed to hunting. Models using twice the reported harvest rate closely resemble observed total population counts for 1996 (1368 vs. 1304), 1997 (1507 vs. 1429), and 1998 (1363 vs. 1381) (Fig. 2). Movements of caribou off the Nushagak Peninsula are becoming more common. In addition, an increased number of caribou are also being counted off the Peninsula; however, a portion of those individuals may be from the expanding MCH. The neighboring Mulchatna Caribou Herd increased by over 10% annually from 1992 to 1994 and it continued expanding onto new range (Van Daele, 1995). The NPCH may also continue to grow if it disperses off the Peninsula. Although continued growth of the NPCH will verify the success of the reintroduction, changing densities and movement patterns, and higher potential for overgrazing will present managers with increasingly difficult decisions.

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