

Calving distribution of the Teshekpuk caribou herd, 1994–2003

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Abstract: Parturient female caribou from the Teshekpuk caribou (*Rangifer tarandus granti*) herd (TCH) have been observed across the western North Slope, but most cows that were seen with calves during the calving period were in the area surrounding Teshekpuk Lake. During surveys conducted between 1994 and 2003, 155 (91%) of 171 collared cows seen with calves were within an area given protected status in the 1998 Bureau of Land Management Final Integrated Activity Plan/Environmental Impact Statement (IAP/EIS). The percentage of adult collared cows seen with a calf between 1994 and 2003 has ranged from 44% to 86%, with a mean of 66%. The years with the lowest percentage of collared cows seen with calves were 1997 (50%) and 2001 (44%). In 1997 most of the herd migrated much farther south than usual, and in 2001 unusually deep, persistent snow restricted spring migration, resulting in fewer cows returning to the traditional calving area during the calving period. When snowmelt dates were earlier, calving locations were farther north. Average standardized travel rates for parturient cows were significantly greater before they had calves (7.25 km/day) than after 3.89 (km/day). Geographically, protections granted by the 1998 BLM IAP/EIS appear to adequately cover the concentrated calving grounds, allowing for variance in the annual distribution of calving cows.

Key words: barren-ground caribou, caribou calving, coastal plain, petroleum development, *Rangifer tarandus*.

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Introduction

Justification for the protection of barren ground caribou (*Rangifer tarandus granti*) calving grounds is based on the premise that access to those habitats has direct population level fitness consequences. A multitude of techniques have been used to assess the importance of the calving grounds to the ecology of barren-ground caribou. While the fitness benefits gained through use of the calving grounds, or some definable region within the calving grounds, are only occasionally quantified (Griffith *et al.*, 2002), descriptions of how habitat varies between calving and peripheral areas are more common (e.g., Eastland *et al.*, 1989; Fancy & Whitten, 1991; Nelleman & Cameron, 1996; Young & McCabe, 1998; Wolfe, 2000; Kelleyhouse, 2001; Barten *et al.*, 2001). The latter studies relied on the assumption, central to habitat selection studies, that differences between

selected and avoided habitats represented variation in habitat quality, with subsequent fitness implications. Observations of fidelity to historical calving grounds are also highlighted when discussing the importance of calving grounds to annual cycles (e.g., Gunn & Miller, 1986; Fancy & Whitten, 1991; Schaefer *et al.*, 2000; Mahoney & Schaefer, 2002; Russell *et al.*, 2002; Ferguson & Elkje, 2004).

The primary mechanisms for increased calf survival on the calving grounds are thought to include reduced risk of predation and access to newly emergent, high quality forage with the relative magnitude and scale of importance of these factors in calving ground selection varying among herds (e.g., Kelsall, 1968; Klein, 1970; Bergerud & Page, 1987; Whitten & Cameron, 1980; Fancy & Whitten, 1991; Russell *et al.*, 1993; Barten *et al.*, 2001; Griffith *et al.*, 2002;

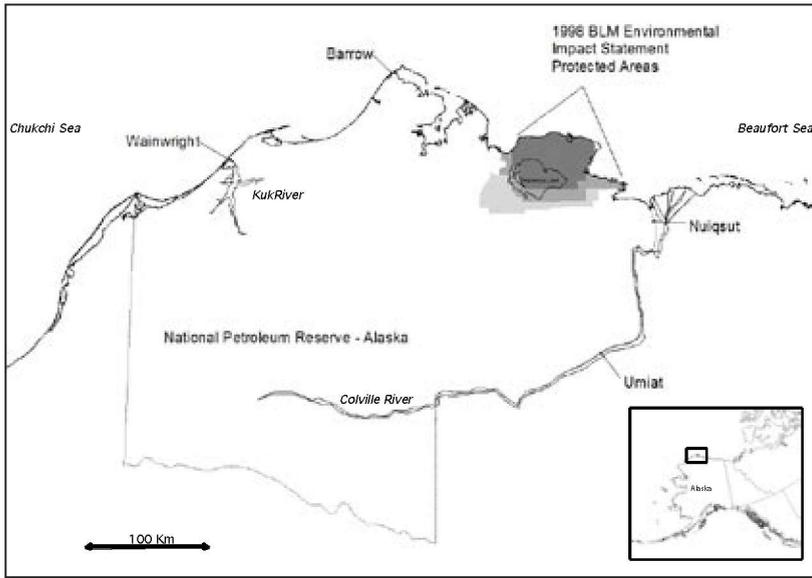


Fig. 1. The western portion of the North Slope Alaskan coastal plain, with National Petroleum Reserve – Alaska boundary in dashed line. Three stipulation areas from the 1998 Bureau of Land Management Final Integrated Activity Plan/ Environmental Impact Statement (EIS) are shaded. From north to south, they are termed “no leasing,” “no surface activity,” and “special caribou stipulations.” Collectively, we have termed this area the “protective boundary,” which was used for further analyses.

Russell *et al.*, 2002). Despite the variation in analytical tools used to assess the importance of the calving grounds to the productivity of caribou, the preponderance of information suggests that calving grounds are important.

The Teshekpuk caribou herd (TCH) is one of four large, barren-ground caribou herds that calve on the northern coastal plain of Alaska. First recognized as a distinct herd in the early 1970s (Silva *et al.*, 1985), the herd size has been estimated using photocensus techniques (Davis *et al.*, 1979) at 2–4 year intervals since 1984, with 45 166 counted in 2002 (Carroll, 2003). Studies using systematic-strip transects, satellite radio collars, and VHF radiotracking have all indicated fidelity to the calving area near Teshekpuk Lake, particularly to the area southeast, east, and northeast of the lake (Carroll, 1992; Philo *et al.*, 1993; Kelleyhouse, 2001; Prichard *et al.*, 2001; Carroll, 2003; Noel & George, 2003).

The annual range of the TCH contains the National Petroleum Reserve – Alaska (NPR-A), which is currently being leased for oil exploration and development. Planning for exploration and development included an extensive consultation process, resulting in the 1998 Northeast NPR-A Final Integrated Activity Plan/Environmental Impact Statement (IAP/EIS; BLM, 1998). As a result of this process, 3 protective areas were established in the area

surrounding Teshekpuk Lake due to their value to wildlife resources, including caribou and waterfowl. These areas were termed “No Leasing Area,” “No Surface Activity Area,” and “Special Caribou Stipulation Area,” and varied in their protective rigor (Fig. 1). The combined extent of these areas, termed the “protective boundaries” hereafter, were intended to protect large portions of the calving ground and insect relief areas (BLM, 1998). Revisions to the 1998 IAP/EIS are being considered, which might change the status of the protective boundaries (BLM, 2005).

In this paper, we evaluate the geographic adequacy of protective boundaries established in 1998 to

protect the calving grounds of the TCH. We also describe some of the factors that influence calving site selection on an annual basis, and suggest how those factors should be accounted for when establishing long-term protective measures.

Study area

The study area included the portion of the coastal plain between the Colville River and the Chukchi Sea (Fig. 1). This area, north of the Brooks Range in Alaska, encompassed the area utilized by most radio-collared cows of the TCH during the calving period, which we defined as the first 16 days of June. This area is also delimited by the calving grounds of the Western Arctic Herd (WAH) to the southwest (Kelleyhouse, 2001; Dau, 2003), and the Central Arctic Herd (CAH) to the east (Wolfe, 2000). Vegetation on the TCH calving grounds is primarily composed of wet (54%) and moist (24%) sedge communities (Kelleyhouse, 2001), which are dominated by *Carex aquatilis* and *Eriophorum* species other than *E. vaginatum* (Muller *et al.*, 1999). The area contains thousands of thaw lakes and the riparian habitats of several major rivers. June temperatures in Barrow, 140 km northwest of Teshekpuk Lake, averaged 0.91 ± 2.75 °C during 1990–2002 (National Weather Service).

The low density of predators is a significant feature

of the area. Bear density in low elevation (<800 m) areas of the western portion of the North Slope was estimated to be 0.5–2.0 bears per 1000 km², compared to 10–30 bears per 1000 km² in areas greater than 800 m in elevation (Reynolds, 1989). No wolves were seen during TCH calving surveys conducted during 1994–2003 (this study). Golden eagles (*Aquila chrysaetos*) have been seen occasionally during aerial surveys, but their numbers have not been quantified.

The TCH annual range overlaps with the annual ranges of the CAH (Wolfe, 2000) to the east and the WAH (Davis & Valkenburg, 1978; Kelleyhouse, 2001; Dau, 2003) to the southwest. During the snow-free period the TCH typically ranges across the Arctic Coastal Plain between the Colville River and the Chukchi Sea (Prichard *et al.*, 2001). The coastal plain is also used during the winter, although segments of the herd have occasionally made more dramatic movements, migrating to the foothills of the Brooks Range, the Seward Peninsula, and most recently, the mountains and coastal plain of the Arctic National Wildlife Refuge (ANWR) (Carroll, 1995, 1997, 2001, 2005).

Methods

In late June or early July 1990–2003 (except in 2002 when captures occurred in early Sep), caribou were captured within 50 km of Teshekpuk Lake and fitted with VHF radio collars or combined Platform Terminal Transmitter (PTT)/VHF collars (Telonics Inc., Mesa, Arizona, USA). A Hughes 500 helicopter, with a skid mounted net gun, or a Robinson-44 helicopter, with a hand-held net gun, were used during capture work. Once captured, we restrained caribou by placing a mask over their eyes and using hobbles and/or ropes to control their legs.

The number of active radio collars deployed in the herd gradually increased during the course of the study. We had 15–20 active radio collars on female caribou until 1995, 27–30 from 1996–1998, and 30–40 from 1999–2003. Satellite collars have been attached to 83 caribou since 1990, with a similar increasing trend in active collars per year. Summaries of movement patterns of satellite collared TCH caribou are summarized elsewhere (Philo *et al.*, 1993; Prichard *et al.*, 2001); here we report the results of VHF radiotracking surveys during the calving period.

VHF Radiotracking

VHF radiotracking surveys were based out of Umiat and Barrow, Alaska. The typical area surveyed each year was an area roughly bounded by the villages of Barrow, Wainwright, Umiat, and Nuiqsut (Fig. 1), although much of the flight time was concentrated

around the Teshekpuk Lake area due to the greater number of collars found in the area.

Surveys were conducted from Piper Super Cub (PA-18), Bellanca Scout, or Cessna-185 aircraft. An ATS R4000 telemetry receiver connected to directional antennae was used to radiotrack collared caribou. Prior to 1996, locations were taken from the aircraft Global Positioning System (GPS). Since 1996, locations and flight paths have been recorded with a Garmin 12 XL hand-held GPS.

Weather permitting, we initiated calving surveys between 2 and 5 June, but started 8 June in 1995, and flew as frequently thereafter as weather and logistics would allow, usually every 1, 2, or 3 days. Surveys were terminated between 12 and 18 June when it appeared that all or nearly all the parturient collared cows had calved. We flew directly over each collared caribou and noted the location, presence or absence of a calf, and antler condition. When surveys were flown with a Piper Super Cub or Bellanca Scout we also attempted to establish udder condition. We assumed that cows with new, velvet-covered antlers did not conceive during the previous fall or lost the calf during pregnancy (but see Gagnon & Barrette, 1992), so we recorded their location and listed them as nonparturient. We continued to observe cows with hard antlers or no antlers through the calving period to determine if, when, and where they had calves (Gagnon & Barrette, 1992; Whitten, 1995). The first location a female was seen with a calf at heel was recorded as the approximate calving site (Fancy & Whitten, 1991), based on the limited mobility of calves shortly following parturition (Fancy *et al.*, 1989; Kelleyhouse, 2001; Griffith *et al.*, 2002; Ferguson & Elkie, 2004). The location recorded nearest to the middle of the calving period (8 Jun) was used for cows that were not seen with a calf. The estimated calving sites and locations of cows that were not seen with a calf were plotted using a Geographic Information System (GIS) (ESRI ArcView 3.3, Redlands, California, USA) to determine the location with respect to the protective boundaries.

On several occasions cows had calves at heel the first time we observed them. If the calves appeared to be very young, we assumed that they had been born shortly before we observed them and that observation was used as their calving location. In 2002 calving began earlier than normal and many of the cows already had calves on 2 June.

Snowmelt

To estimate relative spring phenology in the region for a given year, the date of snowmelt was obtained from the National Oceanic and Atmospheric Administration Global Monitoring of Climate Change (NOAA GMCC) site near Barrow (Dutton & Endres,

Table 1. Numbers of collared female Teshekpuk Herd caribou seen with a calf or never seen with a calf during calving season, 1994–2003; numbers of calving locations located inside the BLM protective boundaries (see Fig. 2); and the estimated dates of snowmelt in Barrow, Alaska (see Fig. 3).

Year	Cows with calf	Cows without calf	Total	Percent of collared cows with calf	Number calves inside	Percent inside	Snowmelt date
1994	10	6	16	63%	9	90%	11 Jun
1995	11	4	15	73%	9	82%	10 Jun
1996	24	4	28	86%	24	100%	30 May
1997	8	8	16	50%	7	88%	9 Jun
1998	15	12	27	56%	15	100%	1 Jun
1999	24	12	36	67%	23	96%	13 Jun
2000	23	4	27	85%	19	83%	14 Jun
2001	15	19	34	44%	13	87%	11 Jun
2002	22	8	30	73%	19	86%	25 May
2003	19	12	31	61%	17	89%	3 Jun
Total	171	89	260	66%	155	91%	
\bar{x}	17	8.9	26	66%	15.5	90.0%	6 Jun
SE	1.9	1.5	2.4	4.4%	1.9	2.1%	2.1 days

1991; Stone *et al.*, 2002; Dan Endres, pers. comm.). NOAA uses a threshold of 30% albedo, the ratio of upward to downward short wave irradiance, as an indicator of snowmelt. The date recorded was the first day the daily average was below 30%. A change from >75% albedo to <30% typically occurred over the course of only 2–3 days, making it a reliable and repeatable index of spring phenology from year to year. This index was measured at a location about 160 km northwest of the TCH calving ground. The occurrence of snow melt on the calving ground was assumed to be temporally correlated with snow melt in Barrow, based on the large scale meteorological factors influencing snow melt on the north slope (Stone *et al.*, 2002).

Geographic centers of distribution in relation to snowmelt date

The geographic center of the calving distribution for each year was estimated with the Weighted Mean of Points Extension in ArcView 3.3 (Jenness Enterprises, Flagstaff, Arizona, USA), which determined the average latitude and longitude of points in a given sample. The relationships between the coordinates of the distribution centers and snowmelt date were evaluated using simple linear regression. In addition, 2 maps were produced, one showing calving locations during years of earlier than average snowmelt (average snowmelt date 30 May) and one of later snowmelt (average snowmelt date 12 Jun).

Percentage of cows seen with a calf

We report the percentage of monitored VHF-collared cows, ≥ 3 years old, that were seen with a calf during the calving season because parturition rates were not always possible to estimate. During some time periods, only Cessna 185 aircraft were available for surveys, which made it difficult to determine whether cows had distended udders. In addition, during some years TCH caribou were so scattered at the beginning of calving season it was impossible to find many of them to determine whether they had a calf and lost it or were nonparturient. The annual percentages of cows with calves were compared with Barrow snowmelt dates using simple linear regression.

Movement rates from VHF radiotracking information

In 2002, movements of collared cows were monitored more closely than other years to estimate movement rates and direction of travel. Mean angular direction of travel was calculated from the net movement of individual cows during the calving period. Rayleigh's test was used to estimate whether the mean direction of travel differed from random (Zar, 1999). Daily rate of travel between the location the cow was first found (2 or 5 Jun) and the location on 12 June was calculated for cows seen with a calf versus cows that were not seen with a calf. Additionally, the movement rates of parous cows before and after being observed with a calf were estimated. We compared movement rates of parous cows before and after parturition with

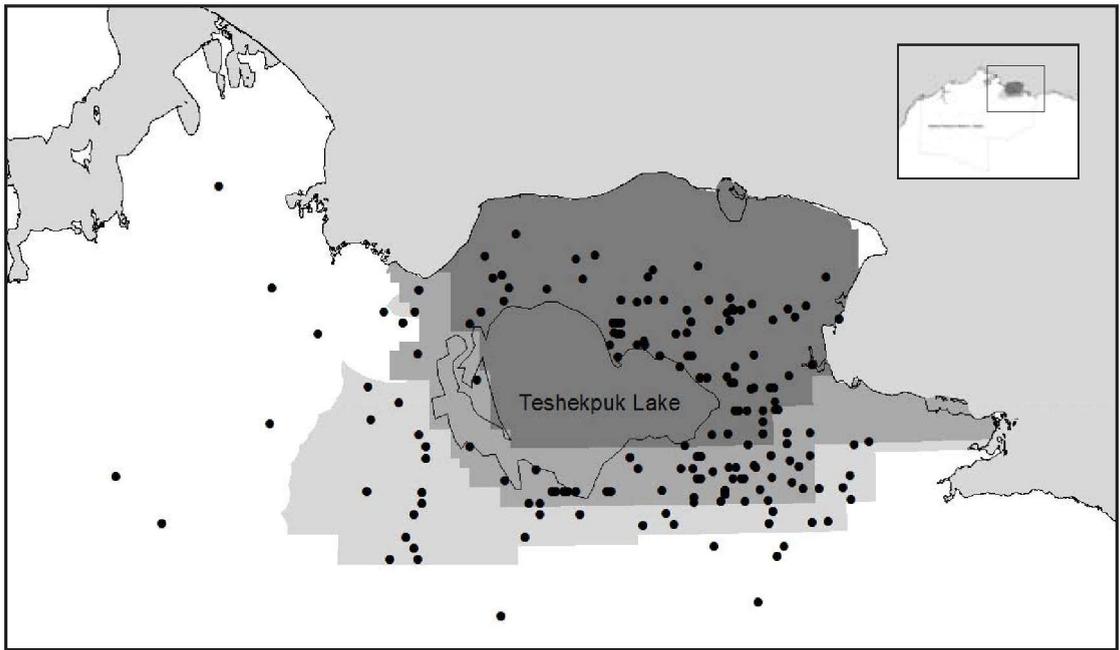


Fig. 2. Teshekpuk Lake area showing Teshekpuk caribou herd calving locations in relation to Bureau of Land Management Environmental Impact Statement protective boundaries from 1994 to 2003 (see Fig. 1). Note, there are 2 calving locations located farther west that are not shown on this close-up.

a paired *t*-test, and movement rates of cows that were seen with a calf versus cows that were not with an unpaired *t*-test (Zar, 1999).

Because re-location intervals differed slightly among individuals, average daily movement rates were calculated from the net distance moved and the number of days moved between relocations. Because the number of days between relocations was inversely related to the calculated rate of travel ($P = 0.03$) (suggesting that longer intervals between relocations were likely to underestimate the true daily rate of travel), rates were standardized, adding 497 meters per day between relocations to the estimated rate, based on the slope of the relocation interval and movement-rate regression.

Results

Calving distribution

BLM protective boundaries, as established in the 1998 EIS for the northeast section of the NPR-A, encompassed the area that received the highest use during the calving period (Fig. 2). Of 171 collared cows seen with a calf, 155 (91%) were located within the protective boundaries delineated in 1998. The mean annual percentage of collared cows with calves found within the protective boundaries was 90.0% (Table 1). In contrast, of the 89 cows that were not seen with a calf during the survey period, only 40

(44.9%) were within the protective boundaries at the middle of the calving period.

Yearly calving distributions in relation to snowmelt

Snowmelt date in Barrow ranged from 25 May to 14 June. Latitude of the center of the annual calving distribution was inversely related to the date of snowmelt ($P = 0.004$, $r^2 = 0.66$) (Fig. 3). When snowmelt dates were earlier, calving locations were farther north. The longitude of the distributional center of annual calving and snowmelt date were not correlated ($P = 0.62$). There was also no trend in calving site location over time ($P = 0.27$).

Percentage of cows seen with calves

The percentage of cows seen with calves during the calving period has ranged from 44% in 2001 to 86% in 1996 (Table 1). The 2 years that had the lowest percentage of observed calves were 2001 (44%) when late, deep snow conditions appeared to hinder the spring migration and 1997 (50%), when most of the herd migrated much farther south in winter than usual. There was no correlation however, between the percentage of cows seen with calves and snowmelt date in Barrow ($P = 0.59$).

Calving period movements

Of the 23 cows observed with calves in 2002, 7 were first observed before being seen with a calf, and 16

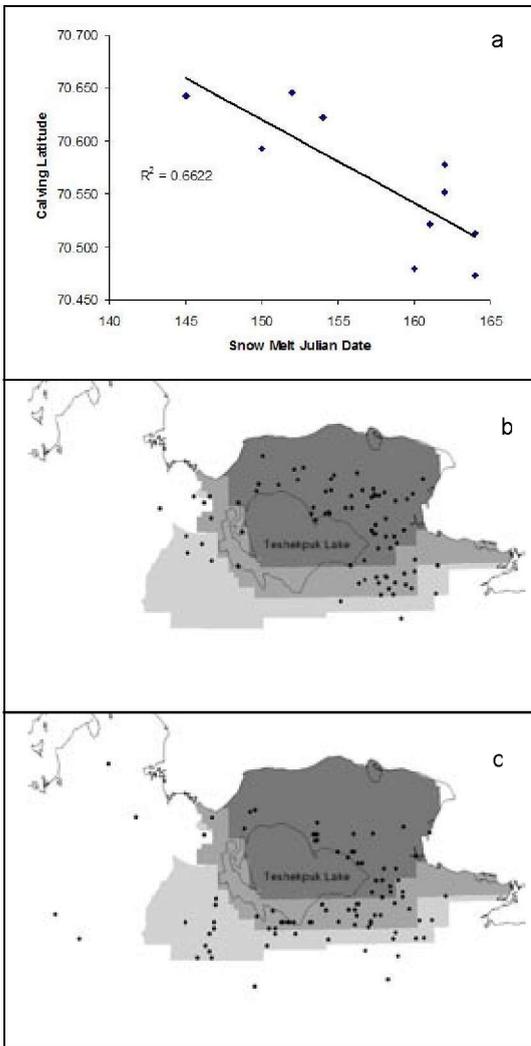


Fig. 3. Teshekpuk caribou herd calving distributions and snowmelt dates 1994 to 2003: (a) latitude of the center of annual calving distribution vs. Julian date of snowmelt, (b) calving distribution in years with earlier than average snowmelt, average date 30 May, (c) calving distribution in years with later than average snowmelt, average date 12 June.

were seen with a calf when first observed. For parturient cows, average standardized travel rate was significantly higher before being observed with a calf than after (7.25 vs. 3.89 km/d, $P = 0.02$, $n = 7$). The difference in net distance moved during the calving period for cows with calves versus cows without calves was marginally significant (1.09 vs. 3.97 km/d, $P = 0.058$, $n = 28$). Net movement direction of cows averaged 104 degrees, but was not significantly different from random (Rayleigh's $R = 4.57$, $n = 28$).

Discussion

Multiple previous studies have shown fidelity of the TCH to the calving area near Teshekpuk Lake (Carroll, 1992; Philo *et al.*, 1993; Kelleyhouse, 2001; Prichard *et al.*, 2001; Carroll, 2003; Noel & George, 2003). In order to protect this calving area and waterfowl habitat areas, BLM created protective boundaries in its 1998 IAP/EIS, which appear to adequately encompass annual variance in the preferred calving areas of the TCH. During our study, from 1994 through 2003, 171 collared cows were seen with a calf and 155 (91%) were located within the protective boundaries. Annually, the mean proportion of calving cows within the protected boundaries averaged $90 \pm 2\%$. If development occurs within these protective boundaries in the future, this baseline measure could be compared to future averages as an indicator of displacement, absent any simultaneously occurring environmental changes.

Similar to other studies of telemetered female caribou (Fancy *et al.*, 1989; Kelleyhouse, 2001; Griffith *et al.*, 2002; Ferguson & Elkie, 2004), TCH females in our study moved at relatively slow rates during the calving period, and slowed even more following parturition, giving us confidence that the location where a cow was first seen with a calf was reasonably close to the calving site. We also found that cows, parturient or otherwise, were not moving in a consistent direction during the calving period, similar to findings by Fancy & Whitten (1991). This implies that there is no systematic directional bias in calving site estimation. We assume that the results of movement analyses from 2002 are consistent in other years, although it should be mentioned that 2002 was a year with very early snowmelt. Years with deep or persistent snow may lead to different patterns in calving period movement.

Annual variation in the distribution of TCH calving sites during most years appeared to be related primarily to time of snowmelt. During years when the snowmelt was earlier, calving sites tended to be farther north. Unlike bull caribou, which appear to track the northward progression of green-up during the spring (Whitten & Cameron, 1980; G. Carroll, ADF&G, unpubl. data), parturient cows in the CAH and TCH often arrive on the calving grounds before green-up has occurred (Whitten & Cameron, 1980; Kelleyhouse, 2001). Newly emergent and rapidly growing vegetation is high in soluble carbohydrates, nitrogen and phosphorus, which rapidly decline as the summer progresses (White *et al.*, 1975; Whitten & Cameron, 1980; Jorgenson *et al.*, 2002). By calving in areas just beginning to initiate new growth, the relatively immobile cow-calf pairs are able to take advantage of this green-up without having to follow

this progression northwards, and this perhaps allows calves to initiate independent foraging with high quality, low bulk forage. This result supports the findings of Kelleyhouse (2001), who concluded that at the scale of the concentrated calving area versus the annual calving ground, the TCH consistently selected areas with high rates of biomass increase, as measured by the change in the Normalized Difference Vegetation Index (NDVI). The tendency for caribou to shift the distribution of the annual calving ground in response to the unique conditions encountered each year within the protective boundaries needs to be considered when establishing long-term protective measures. Specific areas within the protective boundaries may be more likely to be used in an average year than others, but the entire area is utilized, given enough variance in environmental conditions.

In addition to snowmelt date, distribution of female caribou during the calving periods, along with calf percentages, can be affected by factors such as where the caribou migrated the previous fall and unusual weather conditions. During winter 1996–1997 most of the herd migrated much farther south than usual, and in spring 2001 unusually deep, persistent snow throughout northern Alaska restricted spring migration (Lawhead & Prichard, 2002; Griffith *et al.*, 2002; Dau, 2003), resulting in fewer cows arriving at the traditional calving area during the calving period. The lowest percentages of collared cows with calves were recorded during spring 1997 (50%) and 2001 (44%), compared to a range of 56%–86% for other years. The low calf percentages during these 2 years may have been partially due to poor perinatal calf survival resulting from the unusually long migration in 1997; adverse snow conditions in 2001; and, possibly, because some parturient cows were hindered from getting to the preferred calving area. The condition of cows during the previous fall would have also had a substantial, but unknown, effect on the productivity of the herd (Cameron *et al.*, 1993, 1994).

While Teshekpuk caribou showed great fidelity to the calving area, it is unknown if development in the area would result in negative population size effects. In the neighboring CAH, concentrated calving in the western, developed portion, of the calving ground shifted to the south and southwest as infrastructure density increased, 1980–1995 (Wolfe, 2000; Cameron *et al.*, 2002). Although photocensus results from the Alaska Department of Fish and Game indicate that the herd has continued to grow through 2002 (Cameron *et al.*, 2002; Noel *et al.*, 2004), density of caribou in the developed area north of the “spine road” has decreased, particularly during calving, from 1978 to

2001 (Lawhead & Prichard, 2003; Noel *et al.*, 2004). Portions of the historical CAH calving grounds west of the Kuparuk River that have received the most use during the calving and postcalving periods in recent years (1993–2003) are south or southwest of the Kuparuk oilfield complex (Wolfe, 2000; Lawhead & Prichard, 2003). Although the CAH population size continued to increase (Cameron *et al.*, 2002) after the shift in concentrated calving away from the Kuparuk Development Area (Wolfe, 2000), lower parturition rates of cows calving in the more developed, western portion of the calving ground compared to those calving in the relatively undeveloped eastern portion of the calving ground were documented from 1988 through 1994 (Cameron *et al.*, 2002), and from 1998 through 2001 (E. Lenart, presented by the National Research Council [NRC], 2003). However, there were not similar differences in calf survival between the western and eastern portions of the calving ground (NRC, 2003).

Although we have shown that parturient TCH cows have demonstrated a historical fidelity to the calving area within the protected boundaries described in this paper, the potential for negative population size effects as a result of displacement due to forthcoming industrial development is a serious issue, and one that cannot be adequately addressed for the TCH at this time. Future research should be directed toward determining the fitness advantages derived from use of preferred, or concentrated calving areas versus peripheral areas, as well as determining baseline levels of calf survival and weight gain of cows and calves during the period that cow–calf pairs use the calving grounds.

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References

- Barten, N. L., Bowyer, R. T. & Jenkins, K. J. 2001. Habitat use by female caribou: tradeoffs associated with parturition. – *Journal of Wildlife Management* 65 (1): 77–92.
- Bergerud, A. T. & Page, R. E. 1987. Displacement

- and dispersion of parturient caribou at calving as anti-predator tactics. – *Canadian Journal of Zoology* 65: 1597–1606.
- Bureau of Land Management.** 1998. *Northeast National Petroleum Reserve-Alaska: final integrated activity plan/environmental impact statement*. Department of Interior, Bureau of Land Management. Anchorage, Alaska, USA.
- Bureau of Land Management.** 2005. Final Amended Northeast National Petroleum Reserve-Alaska: final integrated activity plan/environmental impact statement. Department of Interior, BLM, Anchorage, Alaska, USA.
- Cameron, R. D., Smith, W. T., Fancy, S. G., Gerhart, K. L. & White, R. G.** 1993. Calving success of female caribou in relation to body weight. – *Canadian Journal of Zoology* 71: 480–486.
- Cameron, R. D. & Ver Hoef, J. M.** 1994. Predicting parturition weight of caribou from autumn body mass. – *Journal of Wildlife Management* 58: 674–679.
- Cameron, R. D., Smith, W. T., White, R. G. & Griffith, B.** 2002. The Central Arctic caribou herd. – In: Douglas, D. C., Reynolds, P. E. & Rhode, E. B. (eds.). *Arctic Refuge coastal plain terrestrial wildlife research summaries*. U.S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR-2002-0001, pp. 38–45.
- Carroll, G. M.** 1992. Teshekpuk Lake caribou herd management report. – In: Abbott, S. M. (ed.). *Annual caribou report of survey and inventory activities 1 July 1989–30 June 1991*. Alaska Department of Fish and Game. Project 3.0. Juneau, Alaska, USA, pp. 177–186.
- Carroll, G. M.** 1995. Teshekpuk Lake caribou herd management report. – In: Hicks, M. V. (ed.). *Caribou management report of survey–inventory activities*. Alaska Department of Fish and Game. Project 3.0. Juneau, Alaska, USA, pp. 200–210.
- Carroll, G. M.** 1997. Teshekpuk Lake caribou herd management report. – In: Hicks, M. V. (ed.). *Caribou management report of survey–inventory activities*. Alaska Department of Fish and Game. Project 3.0. Juneau, Alaska, USA, pp. 208–218.
- Carroll, G. M.** 2001. Teshekpuk Lake caribou herd caribou management report. – In: Healy, C. (ed.). *Caribou management report of survey–inventory activities 1 July 1998–30 June 2000*. Alaska Department of Fish and Game. Project 3.0. Juneau, Alaska, USA, pp. 245–264.
- Carroll, G. M.** 2003. Teshekpuk Lake caribou herd caribou management report. – In: Healy, C. (ed.). *Caribou management report of survey–inventory activities 1 July 2000–30 June 2002*. Alaska Department of Fish and Game. Project 3.0. Juneau, Alaska, USA, pp. 280–303.
- Carroll, G. M.** 2005. Teshekpuk Lake caribou herd caribou management report. – In: Brown, C. (ed.). *Caribou management report of survey and inventory activities 1 July 2002–30 June 2004*. Alaska Department of Fish and Game. Project 3.0. Juneau, Alaska, USA. In press.
- Dau, J.** 2003. Western Arctic caribou herd caribou management report. – In: Healy, C. (ed.). *Caribou management report of survey–inventory activities 1 July 2000–30 June 2002*. Alaska Department of Fish and Game. Project 3.0. Juneau, Alaska, USA, pp. 204–251.
- Davis, J. L. & Valkenburg, P.** 1978. *Western Arctic caribou herd studies*. Alaska Department Fish and Game. Federal Aid in Wildlife Restoration. Research Final Report. Projects W–17–8 and W–17–9. Jobs 3.19R, 3.20R, and 3.21R. Juneau, Alaska, USA. 95pp.
- Davis, J. L., Valkenburg, P. & Harbo, Jr., S. J.** 1979. *Refinement of the aerial photo-direct count-extrapolation caribou census technique*. Alaska Department Fish and Game. Federal Aid in Wildlife Restoration. Research Final Report. Project W–17–11. Job 3.25R. Juneau, Alaska, USA. 23pp.
- Dutton, E. G. & Endres, D. J.** 1991. Date of snowmelt at Barrow, Alaska, USA. – *Arctic and Alpine Research* 23: 115–119.
- Eastland, W. G., Bowyer, R. T. & Fancy, S. G.** 1989. Effects of snow cover on selection of calving sites by caribou. – *Journal of Mammalogy* 70 (4): 824–828.
- Fancy, S. G. & Whitten, K. R.** 1991. Selection of calving sites by the Porcupine caribou herd. – *Canadian Journal of Zoology* 69: 122–128.
- Fancy, S. G., Pank, L. F., Whitten, K. R. & Regelin, W. L.** 1989. Seasonal movements of caribou in arctic Alaska as determined by satellite. – *Canadian Journal of Zoology*. 67: 644–650.
- Ferguson, S. H. & Elkie, P. C.** 2004. Seasonal movement patterns of woodland caribou (*Rangifer tarandus caribou*). – *Journal of Zoology* 262: 125–134.
- Gagnon, L. & Barrette, C.** 1992. Antler casting and parturition in wild female caribou. – *Journal of Mammalogy* 73 (2): 440–442.
- Griffith, B., Douglas, D. C., Walsh, N. E., Young, D. D., McCabe, T. R., Russell, D. E., White, R. G., Cameron, R. D. & Whitten, K. R.** 2002. The Porcupine caribou herd. – In: Douglas, D. C., Reynolds, P. E. & Rhode, E. B. (eds.). *Arctic Refuge coastal plain terrestrial wildlife research summaries*. U.S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR-2002-0001, pp. 8–37
- Gunn, A. & Miller, F. L.** 1986. Traditional behavior and fidelity to caribou calving grounds by barren-ground caribou. – *Rangifer* Special Issue 1: 151–158.
- Jorgenson, J. C., Udevitz, M. S. & Felix, N. A.** 2002. Forage quality and quantity. – In: Douglas, D. C., Reynolds, P. E. & Rhode, E. B. (eds.). *Arctic Refuge coastal plain terrestrial wildlife research summaries*. U.S. Geological Survey, Biological Resources Division, Biological Science Report USGS/BRD/BSR-2002-0001, pp. 46–50.

- Kelleyhouse, R. A. 2001. *Calving ground selection and fidelity: Teshekpuk and Western Arctic caribou herds*. M.S. Thesis, University of Alaska Fairbanks, Alaska, USA. 124pp.
- Kelsall, J. P. 1968. *The migratory barren-ground caribou of Canada*. Department of Indian Affairs and Northern Development, Canadian Wildlife Service. Ottawa, Ontario, Canada. 340pp.
- Klein, D. R. 1970. Tundra ranges north of the boreal forest. – *Journal of Range Management* 23: 8–14.
- Lawhead, B. E. & Prichard, A. K. 2002. *Surveys of caribou and muskoxen in the Kuparuk-Colville region, Alaska, 2001*. Final Report, prepared for Phillips Alaska, Inc. Anchorage, Alaska, by ABR, Inc., Fairbanks, Alaska, USA. 37pp.
- Lawhead, B. E. & Prichard, A. K. 2003. *Mammal surveys in the greater Kuparuk area, Northern Alaska*. Final report for ConocoPhillips Alaska, Inc., Anchorage, Alaska, prepared by ABR, Inc., Fairbanks, Alaska, USA. 45pp.
- Mahoney, S. P. & Schaefer, J. A. 2002. Hydroelectric development and the disruption of migration in caribou. – *Biological Conservation* 107 (2): 147–153.
- Muller, S. V., Racoviteanu, A. E. & Walker, D. A. 1999. Landsat-MSS-derived land-cover map of northern Alaska: extrapolation methods and comparison with photo-interpreted and AVHRR-derived maps. – *International Journal of Remote Sensing* 20: 2921–2946.
- National Research Council. 2003. *Cumulative environmental effects of oil and gas activities on Alaska's North Slope*. 452pp.
- Nelleman, C. & Cameron, R. D. 1996. Effects of petroleum development on terrain preferences of calving caribou. – *Arctic* 49: 23–28.
- Noel, L. E. & George, J. C. 2003. Caribou distribution during calving in the northeast National Petroleum Reserve – Alaska, June 1998–2000. – *Rangifer* Special Issue 14: 153–161.
- Noel, L. E., Parker, K. R. & Cronin, M. A. 2004. Caribou distribution near an oil field road on Alaska's North Slope, 1978–2001. – *Wildlife Society Bulletin* 32: 757–771.
- Philo, L. M., Carroll, G. M. & Yokel, D. A. 1993. *Movements of caribou in the Teshekpuk Lake Herd as determined by satellite tracking, 1990–1993*. North Slope Borough Department of Wildlife Management Report. Available from North Slope Borough Department of Wildlife Management, Box 69, Barrow, Alaska 99723, USA. 60pp.
- Prichard, A. K., Murphy, S. M. & Smith, M. D. 2001. *Analysis and mapping of satellite telemetry data for the Teshekpuk caribou herd 1990–1999*. Available from North Slope Borough Department of Wildlife Management, Box 69, Barrow, Alaska 99723. 89pp.
- Reynolds, H. V. 1989. Units 24, 25A,B,D, and 26A,B,C brown/grizzly bear management report. – In: Morgan, S. O. (ed.). *Annual report of survey and inventory activities 1 January 1987–31 December 1987*. Volume XIX, Part V. Alaska Department Fish and Game. Study 4.0. Juneau, Alaska, USA, pp. 174–184.
- Russell, D. E., Martell, A. M. & Nixon, W. A. C. 1993. Range ecology of the Porcupine caribou herd in Canada. – *Rangifer* Special Issue 8.
- Russell, D. E., Kofinas, G. & Griffith, B. 2002. *Barren-ground caribou calving ground workshop report of proceedings*. Technical Report Series Number 390. Canadian Wildlife Service, Ottawa, Ontario. 39pp.
- Schaefer, J. A., Bergman, C. M. & Lutlich, S. N. 2000. Site fidelity of female caribou at multiple scales. – *Landscape Ecology* 15: 731–739.
- Silva, J. B., Adams, L. G. & Gal, R. (eds.). 1985. *Habitat evaluation for the Teshekpuk Lake special area study*. Bureau of Land Management. Arctic Resource Area. Fairbanks, Alaska. 183pp. + appended al.
- Stone, R. S., Dutton, E. G., Harris, J. M. & Longenecker, D. 2002. Earlier spring snowmelt in northern Alaska as an indicator of climate change. – *Journal of Geophysical Research* 107: 1–27.
- White, R. G., Thomson, B. R., Skogland, T., Person, S. J., Russell, D. E., Holleman, D. F. & Luick, J. R. 1975. Ecology of caribou at Prudhoe Bay, Alaska. – In: Brown, J. (ed.). *Ecological investigations of the tundra biome in the Prudhoe Bay region, Alaska*. Biological Papers, University of Alaska, Special Report Number 2: 151–202.
- Whitten, K. R. 1995. Antler loss and udder distension in relation to parturition in caribou. – *Journal of Wildlife Management* 59 (2): 273–277.
- Whitten, K. R. & Cameron, R. D. 1980. Nutrient dynamics of caribou forage on Alaska's arctic slope. – In: Reimers, E., Gaare, E. & Skjenneberg, S. (eds.). *Proceedings of the 2nd International Reindeer/Caribou Symposium*. Røros, Norway, 1979, pp. 159–166.
- Wolfe, S. A. 2000. *Habitat selection by calving caribou of the Central Arctic Herd, 1980–95*. Thesis, University of Alaska Fairbanks, Alaska, USA.
- Young, D. J. & McCabe, T. R. 1998. Grizzly bears and calving caribou: what is the relation with river corridors? – *Journal of Wildlife Management* 62 (1): 255–261.
- Zar, J. H. 1999. *Biostatistical Analysis*. Prentice-Hall, Inc. Upper Saddle River, New Jersey, USA. 663pp.