

Extraordinary movements of the Denali caribou herd following the perfect storm

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Abstract: Although historic literature is replete with anecdotes about atypical and far-reaching movements of caribou (*Rangifer tarandus granti*) herds in Alaska, very few such events have been described since the late 1970s proliferation of radiotelemetry studies in the region. In September 1992, several herds in Alaska made unusual movements away from their typical year-round ranges as a result of highly unusual weather conditions that affected a broad swath of the state. We describe the movements of 113 radiocollared caribou from the Denali caribou herd during this phenomenon and the subsequent year. The majority of caribou in the Denali Herd left their typical range during 26–28 September 1992, traveling distances up to 221 km and remained out of the area through much of the winter. While the outmigration was highly consolidated and easily noticed, the return was protracted with caribou drifting back to their typical range from October 1992 to early September 1993. All radiocollared caribou that survived the 1992–93 winter ultimately returned to their typical year-round range.

Key words: Alaska, Denali National Park, migration, Mount Pinatubo eruption, range expansion, weather.

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Introduction

Caribou are well-known for their long-distance migrations and understanding of seasonal distribution and movements of populations is commonly sought by caribou managers and researchers (Kelsall, 1968; Skoog, 1968; Valkenburg, 2001). While most caribou populations exhibit relatively predictable seasonal movement patterns, occasionally movements do not fit within those norms and are a fascinating aspect of caribou behavior. Prior to the advent of radiotelemetry, there was conjecture about the regular seasonal movements of caribou populations and substantial focus on their sporadic, atypical movements, primarily because such unusual and unexpected movements were reported widely and well-remembered (Valkenburg, 2001). In his seminal treatise, Skoog (1968) provided an exhaustive summary of the historical record of caribou movements and distribution in Alaska over the preceding century, and concluded that emigration appears to

be the principal means for limiting numbers within any one subpopulation. At the time, unusual mass movements of caribou were viewed as evidence of that emigration.

With the broad use of radiotelemetry over the last 30 years, and the application of molecular genetics more recently, we now recognize that caribou herds are relatively distinct populations and interchange of individuals among herds is uncommon (Valkenburg *et al.*, 2002). However, herd ranges do change over time and overlap among adjacent herds can occur (Valkenburg *et al.*, 2002). While we have abundant information on the normal seasonal movements of many caribou populations, opportunities to document the extraordinary movements have been rare. In September 1992, a highly unusual snowstorm and unseasonal cold temperatures in much of Alaska set in motion a mass exodus of caribou from the Denali Herd out of their normal year-round range.

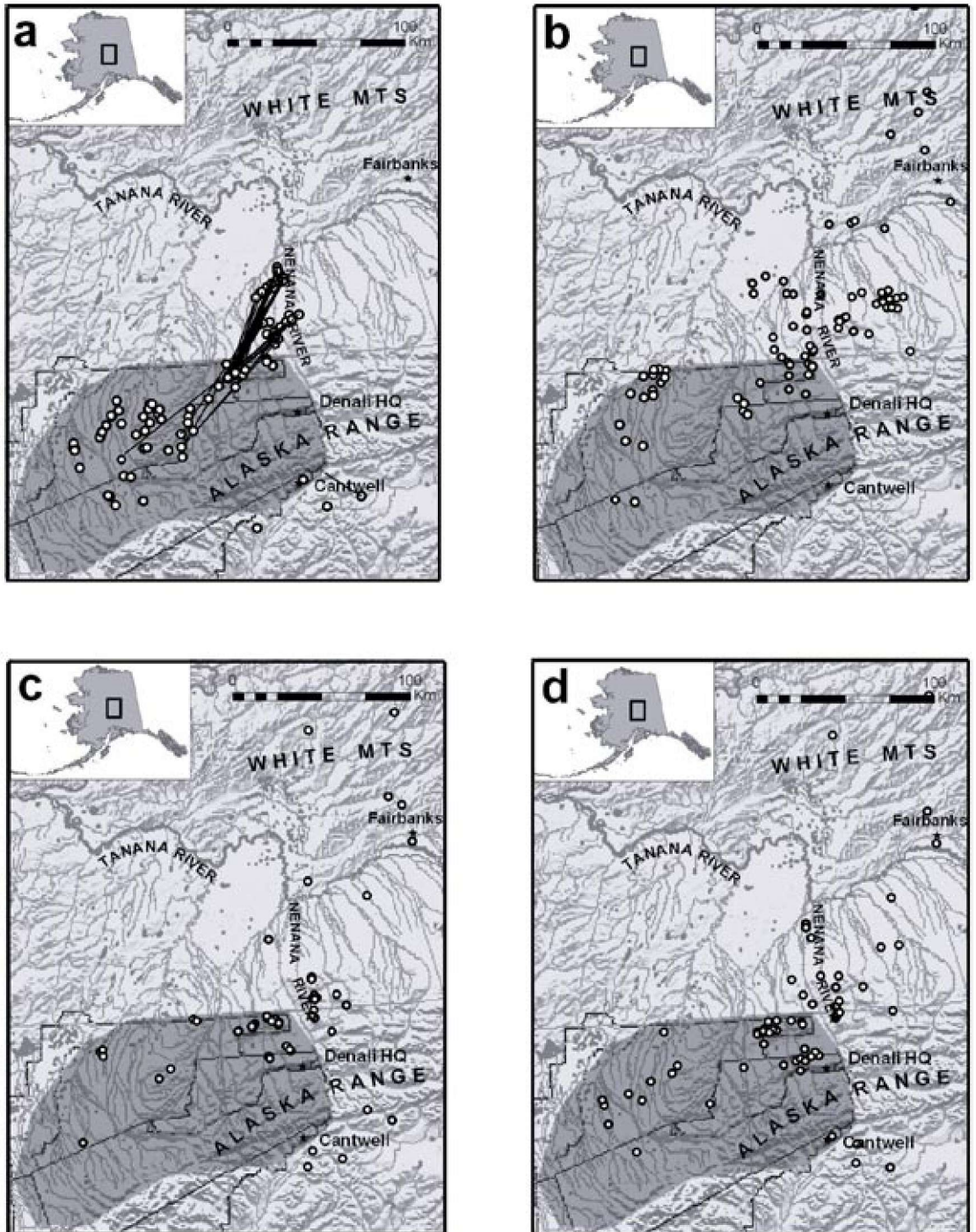


Fig. 1. Distributions of radiocollared caribou from the Denali Herd, Alaska, USA during: a) 22–28 September 1992 (lines indicate movements of caribou from 22–24 September to 26–28 September); b) 2–5 November 1992; c) 8–12 February 1993; and d) 12–22 March 1993. Shading indicates typical herd range.

For this paper, we describe the movements of 113 radiocollared caribou from the Denali Herd during this weather event, the subsequent winter, and their return to the typical year-round range of the herd.

Material and methods

Study area

In September 1992, the Denali caribou herd numbered approximately 2300 animals and normally utilized about 10 000 km² in and adjacent to Denali National Park (Fig. 1; 63°N, 150°W). The area is composed of mountain peaks > 3000 m flanked by lower mountains and broad lowland flats. Areas used by caribou during the year include alpine habitats at higher elevations (800–2200 m elevation) and boreal forest or tussock (*Eriophorum* spp.) tundra habitats below. Approximately 2000 moose (*Alces alces*), and 1700 Dall sheep (*Ovis dalli*) also inhabit the caribou herd's range. Caribou are preyed upon by gray wolves (*Canis lupus*), grizzly bears (*Ursus arctos*), black bears (*Ursus americanus*), wolverines (*Gulo gulo*), coyotes (*Canis latrans*), and golden eagles (*Aquila chrysaetos*) (Murie, 1944; Adams *et al.*, 1995a,b).

The region has a subarctic, montane climate with annual precipitation averaging 38 cm of water deposited primarily as snow during late September to mid-May. Since 1924, winter snowfall has averaged 207 cm, ranging from 86 cm to 441 cm. Snow normally accumulates early in the winter with 50% of the total annual snowfall occurring from late September to mid-December. Snow accumulation on the ground approaches maximum depths by mid-January and remains relatively constant throughout the remainder of the winter until the onset of snowmelt after 15 April.

Weather

We evaluated weather records from Denali National Park to characterize the events of September 1992 compared to average weather conditions for that period. Snowfall and temperature records are complete back to September 1933, except for the 1949–50 winter.

Caribou movements

As of 24 September 1992, 113 caribou ≥1 year old carried radio collars in the Denali Herd, including 78 females and 35 males. Details on capturing and instrumenting caribou can be found elsewhere (Adams *et al.*, 1995a; Adams & Dale, 1998). We located all the instrumented caribou during 22–24 September 1992 in preparation for an aerial composition survey to be conducted by helicopter on 25 September 1992. After detecting the exodus of caribou from their normal range during the helicopter

survey, we conducted additional radiolocation flights during 26–28 September and 5 October 1992 to locate caribou involved in the movements north. We continued to radiolocate caribou throughout the winter, in cooperation with Alaska Department of Fish and Game staff. We completed nearly comprehensive radiolocation efforts 4 times during the winter: 2–5 November 1992, 9–18 December 1992, 8–12 February 1993, and 12–22 March 1993. On 6 May 1993, we initiated efforts to locate all the instrumented females daily as part of an ongoing calf mortality study and most were detected by 10 May 1993. We continued to listen for signals from the remaining females, as well as instrumented bulls, as the calf mortality study progressed through May and early June. By early June, only 1 radiocollared caribou had not returned to the herd's normal range and we monitored her location approximately every month until she was relocated within the herd's range.

Results

Weather

September 1992 began with temperatures that were 2–3 °C lower than average in Interior Alaska (Fig. 2). These cold temperatures were at least in part a result of global cooling from the 15 June 1991 eruption of Mount Pinatubo in the Philippines. The Mount Pinatubo eruption was the largest volcanic eruption on record since the 1912 Mount Katmai eruption in southwestern Alaska (Newhall & Punongbayan, 1996). Mount Pinatubo created a dense aerosol cloud that was slow to penetrate the higher latitudes taking about a year to cover the entire globe (Self *et al.*, 1996). Direct solar shading by the Mount Pinatubo emissions resulted in global cooling of at least 0.5–0.7 °C by September 1992 (Dutton & Christy, 1992; Robock & Mao, 1995).

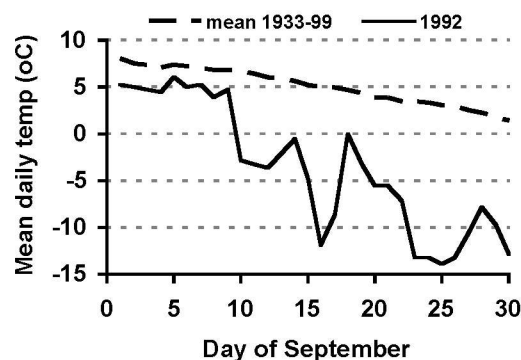


Fig. 2. Mean daily temperatures [(max+min)/2] by date for September 1992 versus September 1933–1999 (no data for 1949), Denali National Park headquarters, Alaska, USA.

With the unusually cool temperatures in place, a powerful winter storm tracking in from the northwest hit Interior Alaska on 12 September 1992. Meteorological events leading to this storm were described by Cole *et al.* (1999) as follows: ... a high-pressure system north of Wrangel Island in Russia set up a northwesterly flow aloft across Interior Alaska. By Saturday, 12 September, at the surface, a warm front stretched in a generally northwest-southeast line across the Fairbanks hills with a strong moisture-laden southwest flow off of the Bering Sea at ground levels. During 12–15 September 1992, 97 cm of wet, heavy snow fell at Denali National Park headquarters (Fig. 3), or nearly half of the snowfall for an average winter. This storm resulted in the third greatest snowfall event (total for consecutive days with measurable snowfall) on record and the only measurable snowpack for mid-September. Snow showers lingered through 22 September and as the skies cleared, temperatures dropped with lows averaging -12 °C through the end of the month (Fig. 2). For the month of September 1992 at Denali National Park, precipitation was 330% of normal and monthly average temperatures were 8.4 °C below normal, the coldest September in 100 years (Cole *et al.*, 1999).

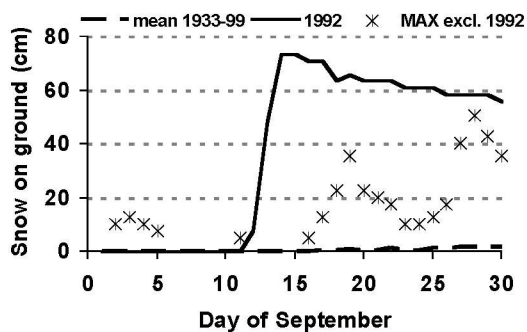


Fig. 3. Snowpack depth by date for September 1992 versus September 1933–1999 average (no data for 1949), Denali National Park headquarters, Alaska, USA. MAX excl. 1992 = maximum snow depth on that date in years other than 1992.

Caribou Movements

During 22–24 September 1992, immediately following the snowstorm, radiocollared caribou were scattered throughout the typical winter range of the herd (Fig. 1a). However, on 25 September during a helicopter composition survey, we encountered >1000 caribou on the northeastern edge of the herd's range headed north en masse down the foothills west of the Nenana River and very few caribou remained on the eastern half of the herd's winter range. Radiotracking during 26–28 September confirmed the movements

Table 1. Status of radiocollared caribou monitored from mid-September 1992 through winter 1992–93, Denali caribou herd, Alaska.

	Cows	Bulls
Total	78	35
Remained in typical range	25	5
- Survived to May 1993	23	3
- Died	2	2
Left typical range	53	30
- Returned to typical range	47	17
- Survived to May 1993	43	15
- Died	4	1
- Dropped collar		1
- Died out of typical range	6	11
- Dropped collar out of typical range		2

north along the Nenana River away from the park (Fig. 1a) and mixing with the adjacent Delta caribou herd, which also exhibited unusual movements away from the Alaska Range (Valkenburg *et al.*, 2002). While nearly all caribou on eastern winter ranges left the area, most of the caribou in the western region (west of the Kantishna Hills) remained on typical winter ranges. A few caribou south of the Alaska Range prior to the storm moved east to join caribou within the range of the Nelchina Herd (Fig. 1a).

Of the 113 radiocollared caribou, 83 left the herd's normal range during late September to early December (Table 1). While the proportion of radioed bulls that left was significantly greater than that for females (86% vs. 68%, respectively; $\chi^2 = 3.91$, 1 d.f., $P = 0.048$), that difference was probably not representative of the population. Most of the bulls (29 of 35) had been captured during 15–24 September 1992 in areas that were subsequently vacated by caribou, and therefore the proportion of bulls in our sample that left the normal range was probably higher than that of the population.

During early October–November, Denali caribou scattered throughout the Tanana Flats and the hills north and east of Fairbanks, where they remained through much of the winter (Figs. 1b, 1c, 1d). Radiocollared caribou were located at distances of 6–221 km from their normal range (median = 50 km; Fig. 4) and mixed with caribou from 3 other herds (Delta, White Mountains, and Nelchina). Denali caribou were scattered throughout nearly 50 000 km², compared to a typical winter distribution of about 6000 km². By mid-March, caribou within 50 km of the Alaska Range generally moved back into the foothills with some returning to the herd's typical

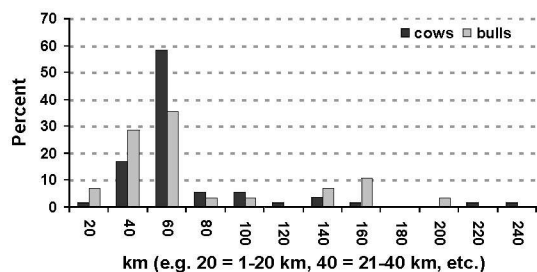


Fig. 4. Maximum distances that radiocollared caribou ($n=53$ cows and 30 bulls) were located from the typical herd range during late September 1992–March 1993, Denali caribou herd, Alaska, USA.

range and the remainder concentrating in areas to the east (Fig. 1d) in the Delta Herd's range. Those near Fairbanks or further north remained at these distant locations.

Movements away from the typical range occurred almost entirely during a 4-day period in late September (Fig. 5). We suspect that many of the individuals that were detected outside of the typical range in early November did in fact leave during or shortly after the main September movement even though we did not confirm their departure until later.

While the movements from the park were consolidated and occurred primarily over just a few days, caribou began returning shortly after the outmigration was detected and continued to drift back in throughout the winter (Fig. 5). In particular, over half of the surviving bulls returned prior to the mid-March radiotracking. Most cows returned between mid-March and early May, the typical period for their movements towards calving areas. Of the 7 cows that returned during mid-May, 4 were still north of the Tanana River in mid-March and the remaining 3 were southeast of Denali National Park. Two of these 7 cows had 1992 calves that survived and both returned with their mothers to the herd's typical range. The final caribou to return was a female that spent its yearling winter southeast of Cantwell in the northern Talkeetna Mountains with resident caribou there, and returned as a 2-year old in late August or early September 1993, almost a year after her departure. With her return, all surviving caribou that had left the herd's typical range had made their way back.

Discussion

The movements we witnessed in early winter 1992 were highly atypical for the Denali caribou herd. The Denali Herd has been the subject of radiotelemetry

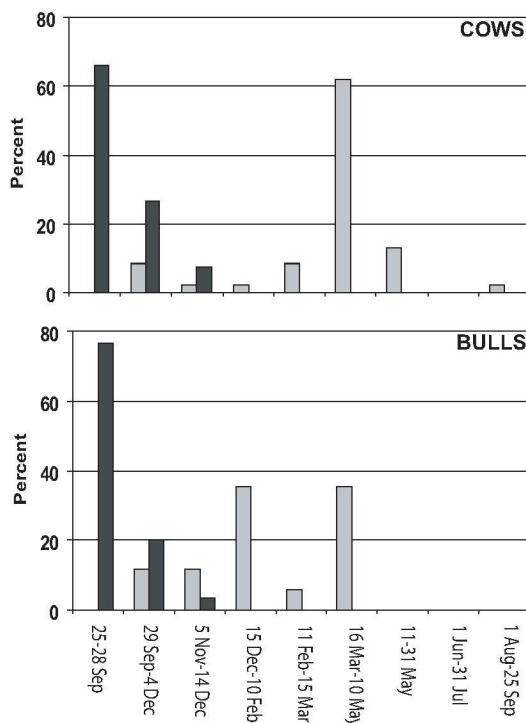


Fig. 5. Timing of departures from (black bars) and returns to (gray bars) the normal range of the Denali caribou herd, Alaska, USA, by radiocollared caribou during late September 1992–September 1993.

studies during 1976–78 (Troyer, 1981) and continuously since 1986 (Adams *et al.*, 1995a,b; Adams & Dale, 1998). In those 21 years of telemetry studies, while some seasonal ranges have shifted, the Denali Herd has stayed within the confines of its typical range except for the events of 1992 described here.

The weather patterns that preceded the September 1992 movements were equally unique. Although the climatic trigger for the unusual movements by caribou was not clear, they did remain within their typical range during the entire period of snowfall and left with the declining temperatures that followed. Their movements, along with similar movements by the adjacent Delta caribou herd, were north out of the mountains and towards lower elevations near Fairbanks, where only about half as much snow fell (Cole *et al.*, 1999). Surprisingly, some caribou continued on into the mountains north of Fairbanks and spent the winter there.

The movements of the Denali and Delta herds out of the Alaska Range occurred over just a few days and were well synchronized and highly noticeable. Nearly all of the Denali caribou on the 2500 km² of their eastern winter ranges converged and exited en masse down the Nenana River Valley, joining the

Delta caribou herd along the way. These caribou traveled near or through rural communities and down the George Parks Highway and Alaska Railroad corridor along the Nenana River. They were subject to great interest in Fairbanks as some continued north through the town's western edge, the first time in nearly 50 years that caribou had been observed there (Valkenburg *et al.*, 2002). Some caribou remained throughout the winter in populated areas along the Tanana River from Fairbanks to Eielson Air Force Base.

While the September movements away from the park were dramatic, returns to their typical range were much more subtle with caribou drifting back immediately following the September exodus and continuing to return for nearly a year. However, a group of about 200 returning caribou did make their way through Fairbanks in mid-April, with the help of a police escort, en route to the Tanana Flats (P. Valkenburg, Alaska Department of Fish and Game, pers. comm.). It is noteworthy that many historical accounts of atypical caribou movements are of mass movements away from typical ranges with no mention of subsequent returns, and these observations served as the basis for claims that mass emigrations were important mechanisms of population change for Alaskan caribou (Skoog, 1968). These purported mass emigrations could have been only the first half of accounts similar to ours where all surviving caribou ultimately returned to their original range, but the return movements were relatively undetected.

Although there was no exchange of individuals between the Denali and Delta herds (this study; Valkenburg *et al.*, 2002) resulting from these atypical movements, it is likely that there was genetic interchange given that the 2 herds mixed together throughout the annual breeding season. A few Denali individuals were also with the Nelchina Herd in the vicinity of Cantwell during the rut.

The propensity to make long-distance seasonal migrations is a defining life history characteristic of many caribou populations in North America (Miller, 2003) and is employed to seasonally exploit high-quality forage resources (Kuropat & Bryant, 1979; Skogland, 1980; Russell & Martell, 1984) and reduce predation risk (Skogland, 1991; Adams *et al.*, 1995a; Hayes & Russell, 2000). However, the sporadic and atypical movement events, such as described here, are more difficult to explain. To the best of our knowledge, in September 1992 Denali caribou traveled into areas where they had never been before, at least for several generations. They faced additional risks by traveling through unfamiliar country and either returned to their typical range during winter or spent the winter in areas that were ostensibly

little improvement over their typical winter range. Further, this was a singular event, and the caribou subsequently returned to the same seasonal cycle of movements they employed prior to September 1992. Such atypical movement events are fascinating in that they largely defy explanation.

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