Section 4: The Central Arctic Caribou Herd

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From the mid-1970s through the mid-1980s, use of calving and summer habitats by Central Arctic herd caribou (*Rangifer tarandus granti*) declined near petroleum development infrastructure on Alaska's arctic coastal plain (Cameron et al. 1979; Cameron and Whitten 1980; Smith and Cameron 1983; Whitten and Cameron 1983*a*, 1985; Dau and Cameron 1986).

With surface development continuing to expand westward from the Prudhoe Bay petroleum development area (Fig. 4.1), concerns arose that the resultant cumulative losses of habitat would eventually reduce productivity of the caribou herd. Specifically, reduced access of adult females to preferred foraging areas might adversely affect growth and fattening (Elison et al.1986; Clough et al. 1987), in turn depressing calf production (Dauphiné 1976, Thomas 1982, Reimers 1983, White 1983, Eloranta and Nieminen 1986, Lenvik et al. 1988, Thomas and Kiliaan 1991) and survival (Haukioja and Salovaara 1978, Rognmo et al. 1983, Skogland 1984, Eloranta and Nieminen 1986, Adamczewski et al. 1987).

Those concerns, though justified in theory, lacked empirical support. With industrial development in arctic Alaska virtually unprecedented, there was little basis for predicting the extent and duration of habitat loss, much less the secondary short- and long-term effects on the well-being of a particular caribou herd.

Furthermore, despite a general acceptance that body condition and fecundity of the females are functionally related for reindeer and caribou, it seemed unlikely that any single model would apply to all subspecies of *Rangifer*, and perhaps not even within a subspecies in different geographic regions. We therefore lacked a complete understanding of the behavioral responses of arctic caribou to industrial development, the manner in which access to habitats might be affected, and how changes in habitat use might translate into measurable effects on fecundity and herd growth rate.

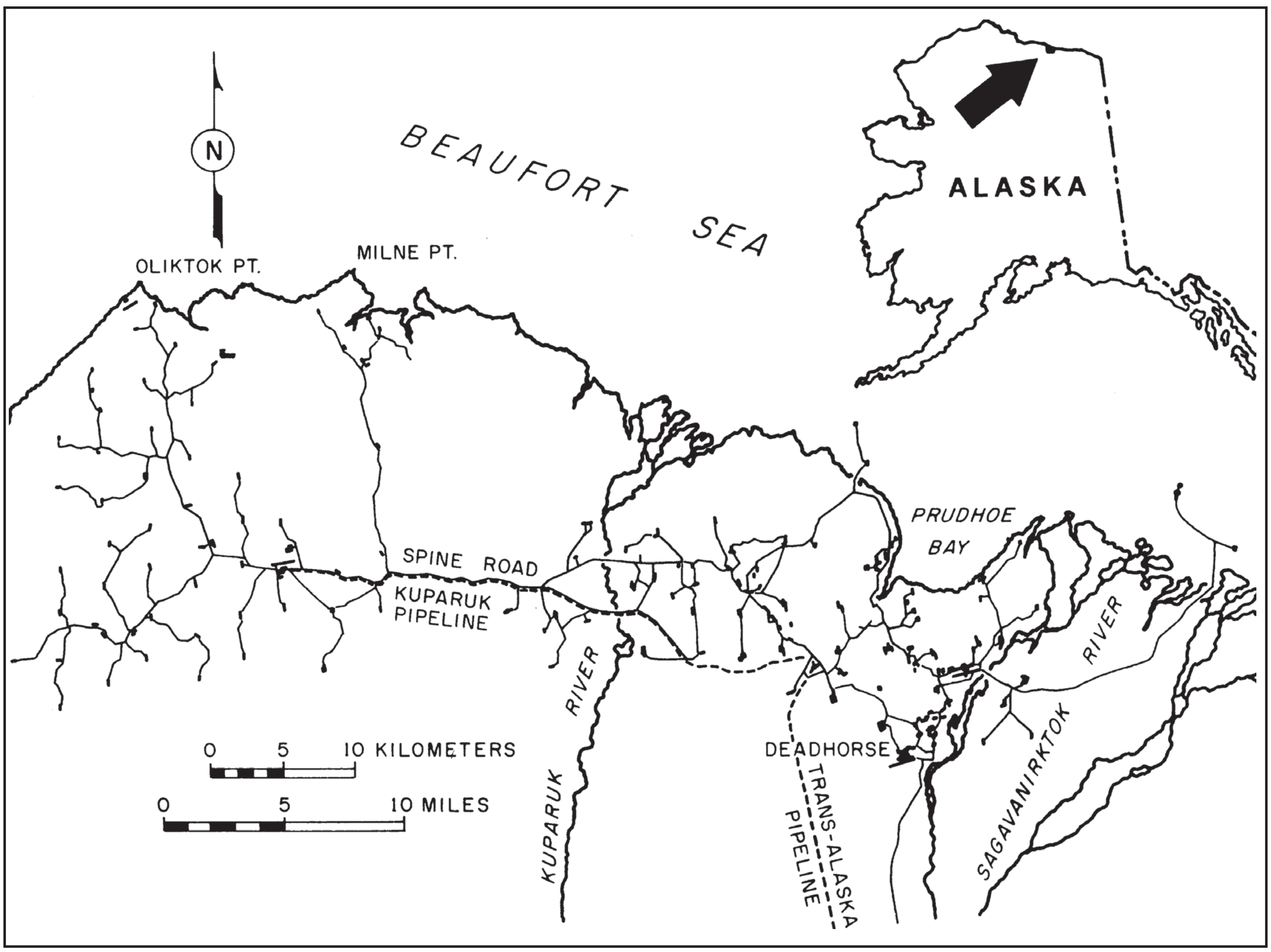

Figure 4.1. Petroleum development infrastructure in the Prudhoe Bay and Kuparuk petroleum development areas, Alaska, showing primary and secondary roads, pipelines, and gravel pads, 1994.

Our study addressed the following objectives: 1) estimate variation in the size and productivity of the Central Arctic herd; 2) estimate changes in the distribution and movements of Central Arctic herd caribou in relation to the oil field development; 3) estimate the relationships between body condition and reproductive performance of female Central Arctic herd caribou; and 4) compare the body condition, reproductive success, and offspring survival of females under disturbance-free conditions (i.e., east of the Sagavanirktok River) with the status of those exposed to petroleum-related development (i.e., west of the Sagavanirktok River).

Status of the Central Arctic Herd

Photocensus results indicate net growth of the Central Arctic herd from 1978 through 2000 (Fig. 4.2). Within that long-term trend, however, there was an abrupt decrease from 1992 to 1995. This decrease coincided with calf production estimates at or below approximately 70%. Steady growth thereafter was associated with productivity estimates consistently exceeding 70%.

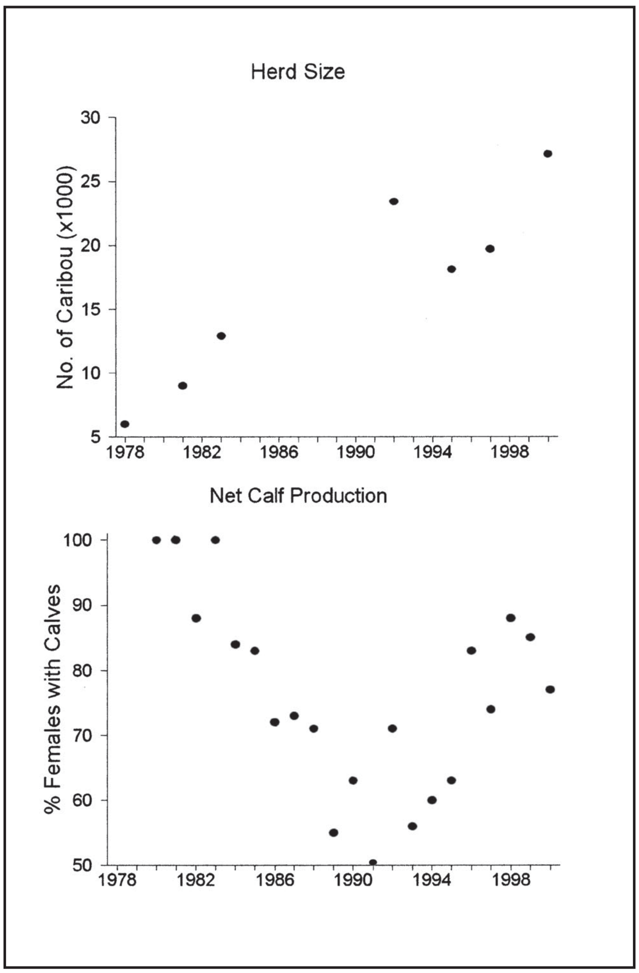

Figure 4.2. Photocensus estimates of the Central Arctic caribou herd, 1978-2000 [Whitten and Cameron 1983*b*; Alaska Department of Fish and Game (ADF&G) files] and net calf production based on observations of radio-collared adult (i.e., sexually-mature) females from 10 June through 15 August (ADF&G files). Note: Productivity data not adjusted for differences in sample sizes east and west of the Sagavanirktok River, Alaska.

Development-related Changes in Distribution

Since 1978, changes in the distribution of calving caribou associated with the Kuparuk petroleum development area, west of Prudhoe Bay (Fig. 4.1), have been quantified using strip-transect surveys flown by helicopter.

After construction of a road system near Milne Point, mean caribou abundance declined by more than two-thirds within 2 km from a road and was less than expected, overall, within 4 km; but nearly doubled 4-6 km from roads (Fig. 4.3) (Cameron et al. 1992*b*). Prior to road placement, caribou were found in a single, more-or-less continuous concentration roughly centered where the Milne Point Road was subsequently built. After construction of the road, a bimodal distribution with separate concentrations east and west of the road was clearly apparent (Fig. 4.4) (Smith and Cameron 1992), indicating avoidance of infrastructure by calving caribou.

These results suggest that roads spaced too closely will depress calving activity within the entire oil field complex. In fact, relative occurrence of caribou in the heavily-developed western portion of the Kuparuk petroleum development area declined significantly from 1979 through 1987, independent of total abundance (Fig. 4.5) (Cameron et al. 1992*b*).

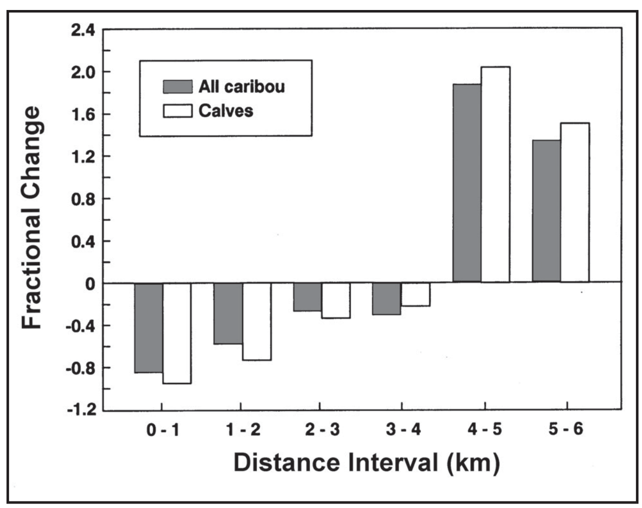

Figure 4.3. Fractional changes in mean density of caribou from the Central Arctic herd between pre-construction (1978-81) and post-construction (1982-87) periods for 1-km-distance intervals from the Milne Point road system in the Kuparuk petroleum development area, Alaska. (*from* Cameron et al. 1992*b*)

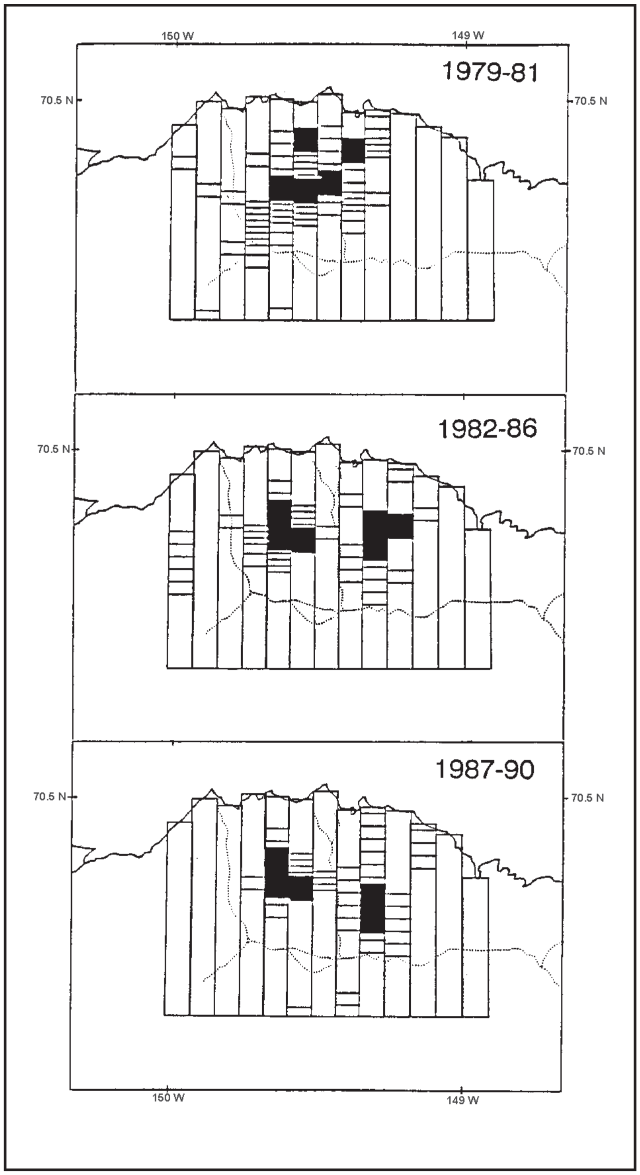

Figure 4.4. Changes in mean relative distribution of caribou from the Central Arctic herd in the Kuparuk petroleum development area, Alaska, during calving: 1979-1981, 1982-1986, and 1987-1990. Shown only are those 10.4-km^2-transect segments in which the occurrence of caribou exceeded the area contribution to total coverage (0.9%). Gradations in line spacing depict multiples of observed use relative to availability: wide = <3X; narrow = >3X-5X; solid = >5X. (*from* Smith and Cameron 1992)

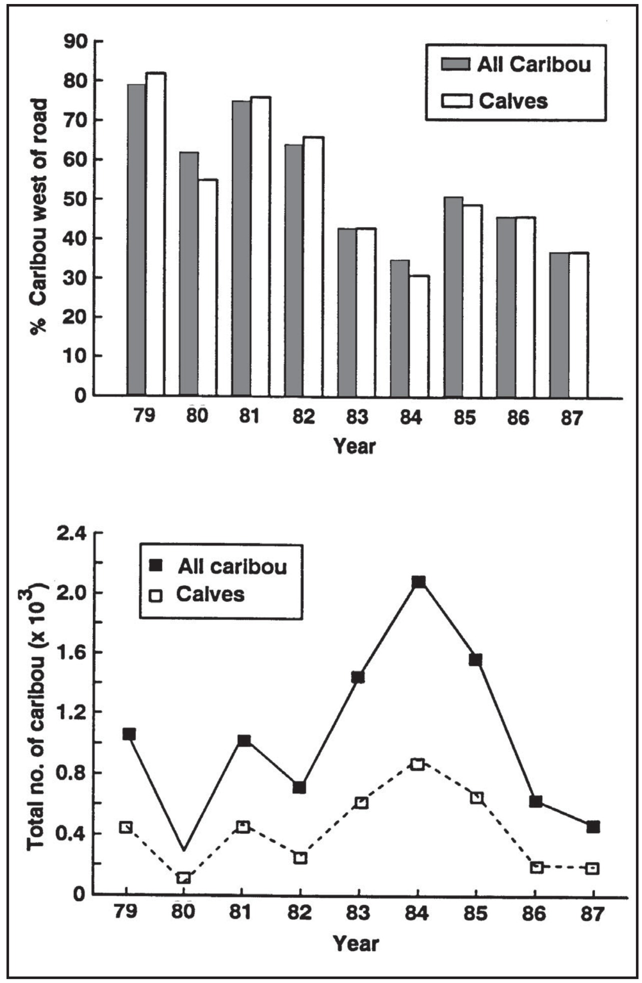

Figure 4.5. Decline in percentage abundance of caribou from the Central Arctic herd west of the Milne Point Road, Kuparuk petroleum development area, Alaska (Spearman's Rank, $P < 0.02$), and changes in total numbers of caribou observed north of the Spine Road (*see Fig. 4.3*), 1979-1987. (*from* Cameron et al. 1992*b*)

An exponential decline in the occurrence of caribou as density of roads increased (Fig. 4.6) (Nellemann and Cameron 1998) underscores the sensitivity of the females during the calving period. The probable consequence is reduced access to preferred habitats (Bishop and Cameron 1990, Nellemann and Cameron 1996, 1998).

Incremental redistribution and local habitat loss within the Kuparuk petroleum development area may have triggered changes on a regional scale. Wolfe (2000) reported an inland shift in concentrated calving activity away from the Milne Point petroleum production unit (Fig. 4.7), apparently in response to the increasing density of infrastructure.

Ground observations within the Kuparuk petroleum development area in 1978-1990 provided additional insights on changing distribution and movements. Caribou increasingly avoided zones of intensive activity, especially during the calving period (Smith et al. 1994), corroborating data from strip-transect surveys. Lower success in crossing road/pipeline corridors by large insect-harassed groups (Smith and Cameron 1985, Curatolo and Murphy 1986, Murphy and Curatolo 1987, Murphy 1988) may have contributed to a general shift from the central Kuparuk petroleum development area to peripheral areas with less surface development and human activity. Routes of summer movement are now primarily south of Oliktok Point and along the Kuparuk River floodplain (Smith et al. 1994).

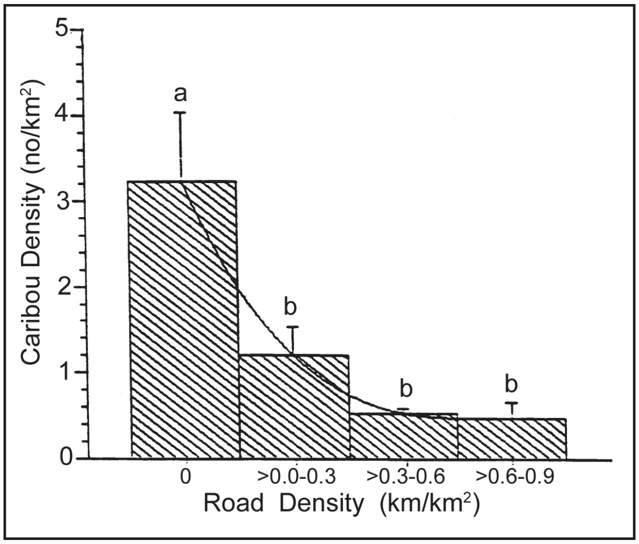

Figure 4.6. Relationship between mean (SE) density of caribou from the Central Arctic herd and road density within preferred rugged terrain, Kuparuk petroleum development area, Alaska, 1987-1992. Different letters indicate a significant difference ($P < 0.05$). (*from* Nellemann and Cameron 1998)

An analysis of the summer distribution of radio-collared females in 1980-1993 (Cameron et al. 1995) suggests that caribou use of the oil field region at Prudhoe Bay has declined considerably from that noted during the 1970s by Child (1973), White et al. (1975), and Gavin (1978). Caribou abundance within the main industrial complex as well as east-west movements through that area were significantly lower than for other areas occupied by caribou along the arctic coast ($P = 0.001$ and $P < 0.001$, respectively). Conservative calculations yielded an estimated 78% decrease in use by caribou and a 90% decrease in their lateral movements (Cameron et al. 1995), all changes apparently in response to intensive development of the Prudhoe Bay to Kuparuk oil field region over the past 3 decades. Occurrence of caribou that use the complex, however, is reportedly unrelated to distance from infrastructure (Cronin et al. 1998).

Body Condition and Reproductive Performance

Reproductive success of caribou is highly correlated with nutritional status. The probability of producing a calf varies directly with body weight and/or fat content of sexually-mature females during the previous autumn (Cameron et al. 1993, 2000; Cameron and Ver Hoef 1994; Gerhart et al. 1997). In contrast, calving date and perinatal survival are more closely related to maternal weight shortly after parturition (Cameron et al. 1993) (Fig. 4.8). The likelihood of conceiving is probably determined by body condition at breeding, whereas parturition date and calf survival reflect maternal condition during late gestation.

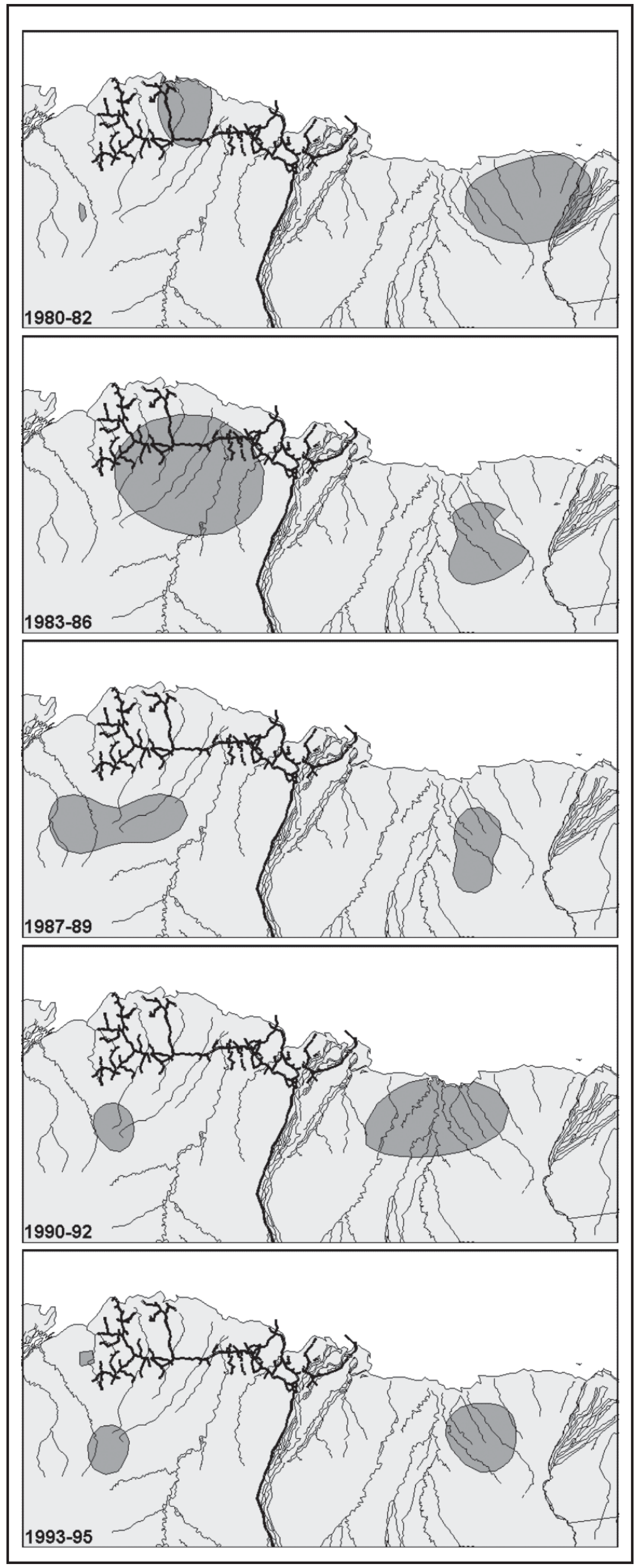

Figure 4.7. Shifts in concentrated calving areas, Central Arctic caribou herd, Alaska, 1980-1995. (*adapted from* Wolfe 2000)

These relationships link the nutritional consequences of changes in distribution to the reproductive success of caribou of the Central Arctic herd. West of the

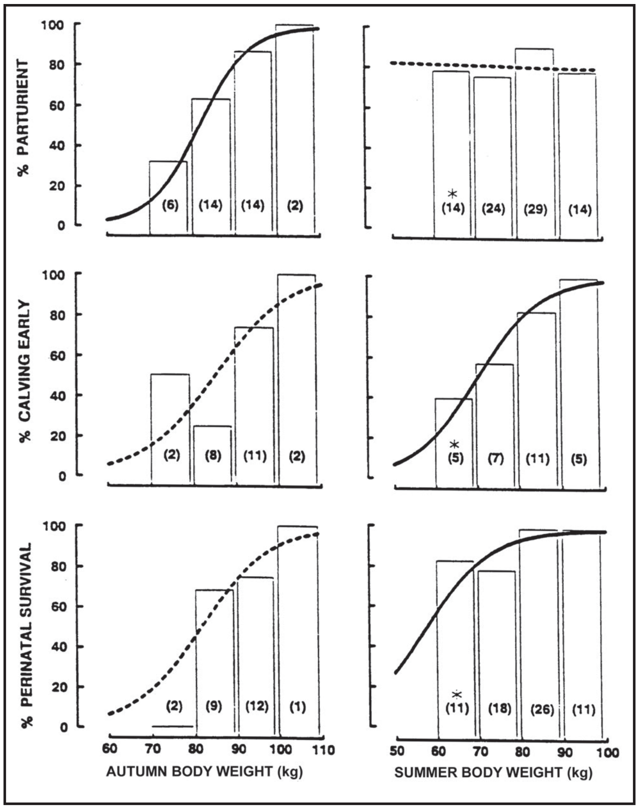

Figure 4.8. Logistic regressions (solid lines are significant at $P < 0.05$) of parturition rate, incidence of early calving (i.e., on or before 7 June), and perinatal (>2 days post partum) calf survival on autumn and summer body weights of female caribou, Central Arctic caribou herd, Alaska, 1987-1991. The empirical percentages are shown at arbitrary 10-kg intervals of body weight. Numbers in parentheses are sample sizes. The asterisk indicates inclusion of one female weighing 57 kg. (*from* Cameron et al. 1993)

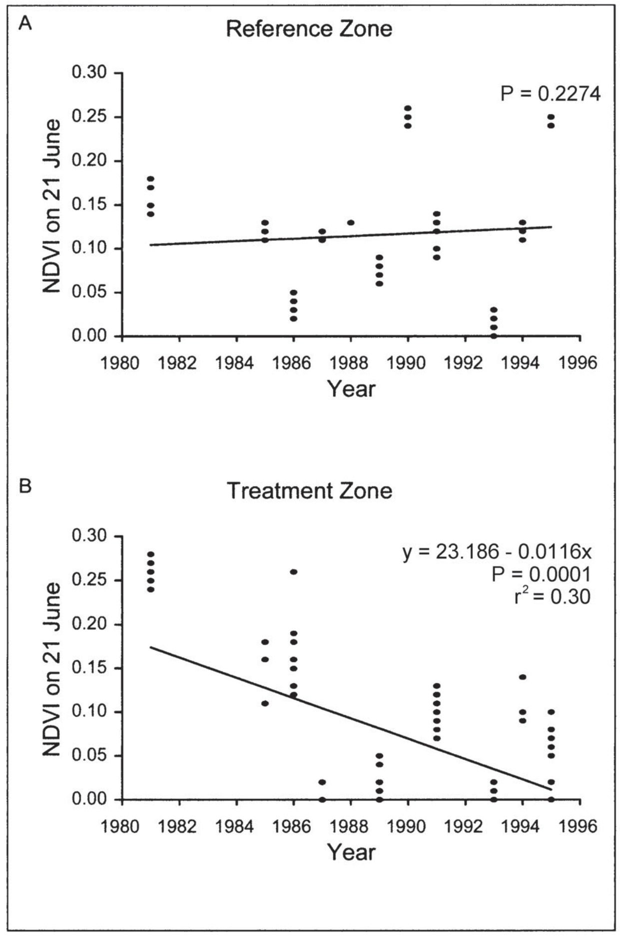

Figure 4.9. Changes in median Normalized Difference Vegetation Index (NDVI) on 21 June for concentrated calving areas of the Central Arctic caribou herd in the study *reference zone* (relatively undeveloped) and *treatment zone* (developed) east and west of the Sagavanirktok River, Alaska, respectively, 1985-1995. (*from* Wolfe 2000)

Sagavanirktok River, in the petroleum development zone, caribou had reduced access to preferred foraging habitats near roads (Nellemann and Cameron 1996) and shifted their concentrated calving area into habitats with lower plant biomass ($P < 0.001$) (Wolfe 2000). In contrast, forage biomass remained constant ($P = 0.23$) within concentrated calving areas east of the Sagavanirktok River where no development was present (Wolfe 2000) (Fig. 4.9).

Repeated use of lower-quality calving habitats may reduce forage intake by females calving west of the Sagavanirktok River. Likewise, impaired summer movements between insect relief habitat and inland feeding areas could depress energy balance (Smith 1996) and, hence, rates of weight-gain.

Indeed, several data sets suggest reduced nutritional status and fecundity of radio-collared females exposed to oil development west of the Sagavanirktok River. Estimates of July and October body weights, over-summer weight-gain, the incidence of 2 successive-year pregnancies, and perinatal calf survival all tended to be lower for females to the west than for those under disturbance-free conditions to the east, although individual differences were not significant at the 95% confidence level (Cameron et al. 1992*a*).

In a more recent analysis of data for 1988-1994, however, mean parturition rate of females calving west of the Sagavanirktok River was less than that of females calving east of the Sagavanirktok River, 64% vs. 83%, respectively ($P = 0.003$, Table 4.1) (Cameron 1995). Corresponding frequencies of reproductive pauses (Cameron 1994, Cameron and Ver Hoef 1994) were significantly higher ($P < 0.02$, *t*-test, ratio method) in the west (36%, 26 of 73 observations) compared with the east (19%, 12 of 64 observations), or approximately one pause every 3 and 5 years, respectively (Cameron 1995).

The key constraint on reproduction is lactation, which exacts a substantial cost on summer weight-gain, in turn influencing the probability of conceiving that autumn. During 1988-1991, weights of all lactating Central Arctic herd females sampled averaged 9 kg less than

Table 4.1. Parturition status of 43 radio-collared female caribou[a], Central Arctic herd, west and east of the Sagavanirktok River[b], Alaska, 1988–1994. West includes the Prudhoe Bay and Kuparuk oil fields; east was generally free of disturbance during that time. (data *from* Cameron 1995)

	% Parturient (*n*)	
Year	West	East
1988	72.7 (11)	100.0 (8)
1989	53.8 (13)	77.8 (9)
1990	83.3 (12)	100.0 (7)
1991	45.5 (11)	75.0 (12)
1992	72.7 (11)	75.0 (12)
1993	55.6 (9)	62.5 (8)
1994	66.7 (6)	87.5 (8)
Mean parturition rate%	64.3** ± 5.0	82.5** ± 5.3

[a] All sexually mature.

[b] Individual locations consistently west or east for 2-7 years during the calving period.

** *t*-test, paired comparisons, P=0.003.

nonlactating females (Fig. 4.10). This resulted in a projected 28% lower parturition rate for the lactating females (Fig. 4.11) (Cameron and White 1992).

Lower parturition rates of females west of the Sagavanirktok River during 1988-94 (Table 4.1) may reflect a failure to compensate for the metabolic burden of milk production (i.e., through increased forage intake or reduced energy expenditure). Hence, those females of the Central Arctic herd that used the development zone were in consistently poorer condition in autumn, experienced more frequent reproductive pauses, and produced fewer calves (Fig. 4.2).

Yet the degree to which lactation constrains weight-gain does vary. An increase in net calf production during

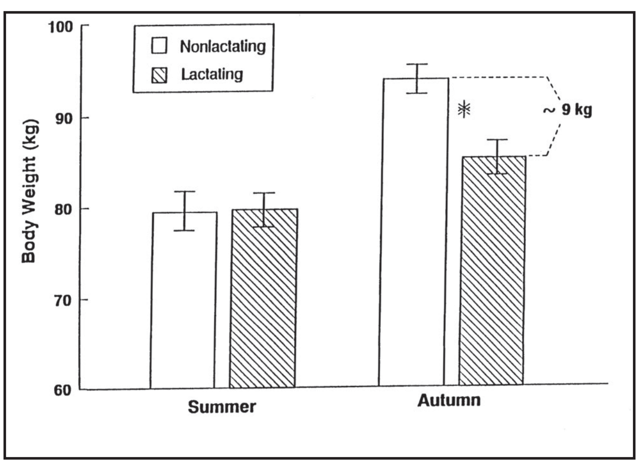

Figure 4.10. Mean (SE) body weights of lactating and nonlactating female caribou from the Central Arctic herd, Alaska, in summer (July) and autumn (October). (*from* Cameron and White 1992) *Significant at $P < 0.001$.

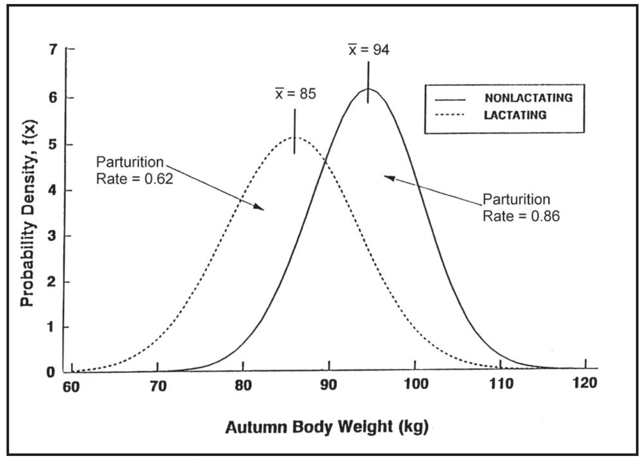

Figure 4.11. Distributions of observed autumn (October) body weights for lactating and nonlactating female caribou from the Central Arctic herd. The associated parturition rates are integrated estimates derived from the logistic model (Fig. 4.8). (*from* Cameron and White 1992)

1996-2000 (Fig. 4.2) suggests the prevalence of forage and insect conditions that enhanced growth and fattening despite the demands of milk production and presence of industrial activity. With the opening of the Badami petroleum development area east of the Sagananirktok River in 1996, however, the undisturbed status of that area was compromised, rendering further comparisons questionable.

Overview

Clearly, anthropogenic impacts on caribou must be identified and assessed within the framework of a variable natural environment. Favorable foraging and insect conditions would attenuate the consequences of disturbance-induced changes in quality of occupied habitats. Conversely, adverse conditions would exacerbate those same types of consequences. Unless analyses are based on multi-year observations of marked individuals and incorporate comparative data on an undisturbed control or reference group, conclusions will be equivocal at best. For example, absent a valid baseline, net growth of the Central Arctic herd (Fig. 4.2) is no better evidence of compatibility with development than a net decline would be evidence of a conflict.

The crucial consideration for the future of the Central Arctic herd and other arctic caribou herds is whether changes in distribution associated with surface development, by depressing reproduction or survival, will either retard an increase in herd size or accelerate a decrease.

Our data, in fact, indicate that productivity can and will decline if the cumulative loss of preferred habitat, when superimposed on natural forces, is sufficient to compromise nutrition.

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