Abundance and movements of caribou in the oilfield complex near Prudhoe Bay, Alaska

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Abstract: We examined the distribution and movements of 141 radiocollared female caribou (*Rangifer tarandus granti*) of the Central Arctic Herd during summer, 1980–1993. Numbers of caribou locations within each of 5 quadrats along the arctic coast were totalled separately for days during which insects were active and inactive, and numbers of east-west and west-east crossings of each quadrat mid-line were determined from sequential observations. Both abundance and lateral movements of radiocollared females in the quadrat encompassing the intensively-developed Prudhoe Bay oilfield complex were significantly lower than in other quadrats ($P < 0.001$ and $P < 0.00001$, respectively). Avoidance of, and fewer movements within, the complex by female caribou are ostensibly in response to the dense network of production and support facilities, roads, above-ground pipelines, and the associated vehicular and human activity. Impaired access to this area constitutes a functional loss of habitat.

Key words: arctic, disturbance, pipeline, *Rangifer tarandus*

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Introduction

Barren-ground caribou (*Rangifer tarandus granti*) of the Central Arctic Herd (CAH) inhabit the Arctic Slope between approximately the Colville and Canning Rivers. Seasonal movements occur between calving and summer ranges on the coastal plain and wintering areas in the northern foothills of the Brooks Range (Cameron & Whitten, 1979).

Summer distribution and movements of CAH caribou are influenced strongly by insects. During warm, calm days in July when mosquitoes (*Aedes* spp.) and oestrid flies (*Hypoderma* (= *Oedemagena*) *tarandi, Cephenemyia trompe*) become active, caribou aggregate and move to the coast of the Beaufort Sea; when cooler conditions prevail, insect activity abates, and caribou return inland (Dau, 1986). These oscillatory movements periodically bring numerous caribou into contact with oilfields in the coastal zone (e.g., Smith & Cameron, 1985a, 1985b; Murphy & Curatolo, 1987; Smith *et al.*, 1994).

Petroleum-related activity near Prudhoe Bay spans nearly 25 years. Following the discorvery of oil there in 1968, development increased steadily, from little more than a staging are near Deadhorse Airport to a large, dense network of roads, pipelines, processing facilities, and assorted commercial enterprices. The present complex occupies much of the coastal zone between the Kuparuk and

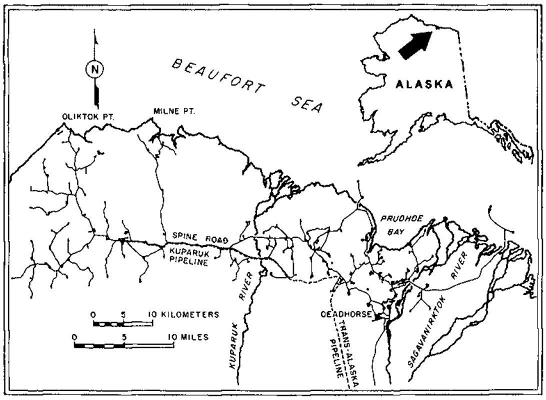

Fig. 1. Roads and facilities in the Prudhoe Bay region, Alaska, ca. 1990. Note: One or more pipelines (stippled) are adjacent to most roads.

Sagavanirktok Rivers. During the 1980s, additional oilfields were developed west of the Kuparuk River and in the Sagavanirktok Delta (Fig. 1).

For 14 summers, we monitored the distribution and movements of radiocollared caribou, in part to identify any changes that might occur with increasing development in the Prudhoe Bay region. In this paper, we test the following hypothesis (H_0): Neither overall abundance nor frequency of east-west and west-east movements of radiocollared females within the area encompassing the Prudhoe Bay oilfield complex differed from similar areas elsewhere within the summer range of the CAH.

Methods

From 1980 through 1993, we relocated 141 different radiocollared female caribou (range, 6–40 caribou/yr) by fixed-wing aircraft at least once each during the period 25 June – 10 August. Locations were marked on topographic maps (U.S. Geological Survey, 1:250,000) and later converted to UTM coordinates, or coordinates were recorded directly from a LORAN or GPS receiver; most were accurate to < 2 km, and all < 5 km, judging from our ability to relate caribou observations to identifiable map landmarks or based on position errors of airborne navigation equipment.

Analyses were restricted to locations within ca. 20 km of the coastline. The area was subvided at 1° intervals of longitude from 146°W. to 151°W, yielding 5 quadrats, each ca. 850 km². The central quadrat encompassed the Prudhoe Bay oilfield complex north from Deadhorse Airport, while the other quadrats included less-developed areas west of the Kuparuk River and undeveloped areas east of the Sagavanirktok River (Fig. 2).

Insect activity was classified as present or absent for each survey day by applying hourly temperature and wind data recorded at Deadhorse Airport to the

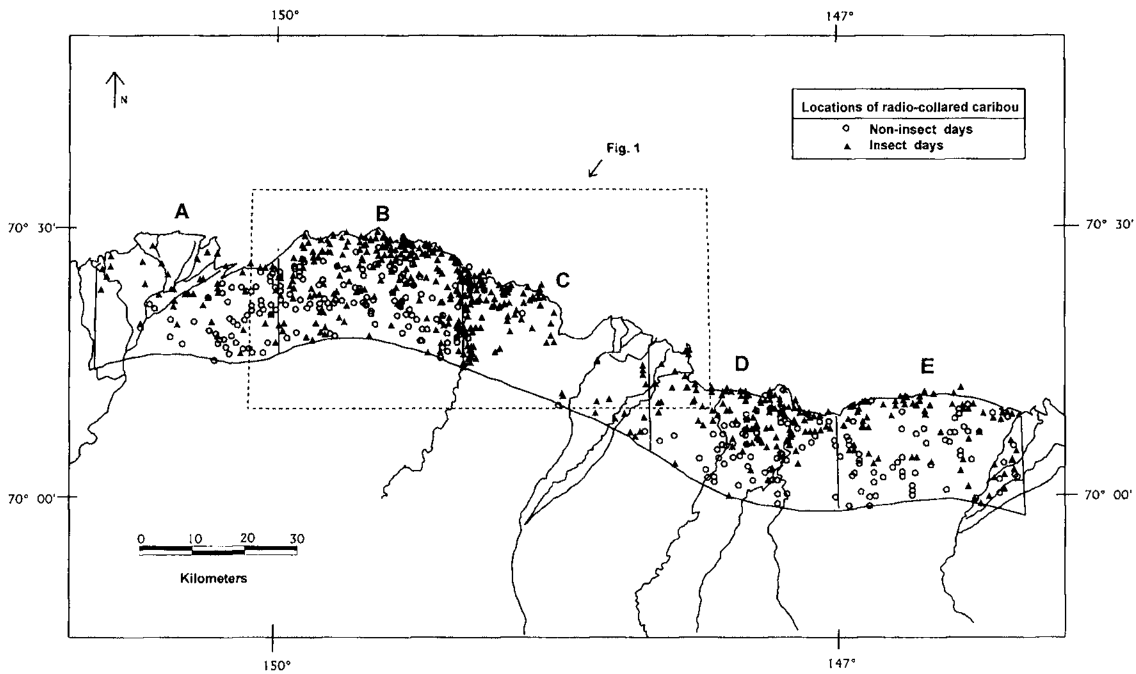

Fig. 2. Locations of radiocollared female caribou within ca. 850-km² coastal quadrats in relation to insect activity. Central Arctic Herd, Alaska, summer 1980–1993. Note: Some points represent > 1 female in a single group.

predictive models of Russell *et al.* (1993). If temperature and wind velocity met the criteria for predicted mosquito or oestrid fly activity for ≥ 4 hours, that entire day was classified as an «insect» day; all other days were classified as «non-insect.»

The entire summer range of the CAH seldom was surveyed for radiocollared females on a single day, and, in some years, coverage of quadrats (Fig. 2) to the west (A and B) or east (D and E) was not equal. Quadrat C, however, was overflown regularly during departure and arrival in the Deadhorse area, our base of operations. Nonetheless, bacause radiotracking effort was not always spatially uniform, we assessed distribution of radiocollared females among quadrats by comparing ratios of non-insect: insect observations. We compared east-west movements of females within quadrats from a subset of sequential locations of 115 individuals, from which ratios of inferred: potential crossings of each quadrat midline were calculated. Standard errors were computed (ratio formula; Cochran, 1977), with female-year as the sample unit, and differences between ratios of means were evaluated using *t*-tests. *P*-values < 0.05 were considered significant.

Results

We obtained 1220 point locations for radiocollared females within the study area. Despite use of a simple categorical estimate of insect activity for each full day, there was a clear tendency for caribou to be nearer the coast on insect days than on non-insect days (Fig. 2), a direct reflection of movements that occur in response to changing mosquito and oestrid fly harassment.

The ratio of non-insect:insect observations of female caribou within Quadrat C was significantly lower than those for the other 4 quadrats ($P < 0.001$, Table 1). Similarly, the relative frequency with which radiocollared females crossed the midline of Quadrat C was significantly lower than for other quadrats ($P < 0.00001$, Table 1).

Table 1. Ratios of non-insect:insect observations of radiocollared female caribou within each quadrat (Fig. 2), and inferred:potential crossings of quadrat mid-lines, Central Arctic Herd, summer 1980–1993.

Quadrat	Observations, non-insect:insect (*n*)	Crossings, inferred:potential (n^a)
A	0.60 (154)	0.46 (192)
B	0.35 (382)	0.43 (408)
C	0.08[b] (186)	0.05[c] (222)
D	0.43 (305)	0.41 (269)
E	0.61 (193)	0.49 (168)

[a] Number of potential crossings based on sequential locations, including those assumed for interjacent quadrats.

[b] Significantly lower than ratios for Quadrats A, B, D, and E (*t*-test, $P < 0.001$); all other differences not significant, except for Quadrats B vs. E ($P < 0.01$).

[c] Significantly lower than ratios for Quadrats A, B, D, and E (*t*-test, $P < 0.00001$); all other differences not significant.

Discussion

Abundance

The data indicate reduced use of Quadrat C by radiocollared female caribou, at least during non-insect days, apparently in response to the presence of the Prudhoe Bay oilfield complex. An inspection of caribou locations (Fig. 2, with reference to Fig. 1) clearly demonstrates that few were in the general area of the complex. Even during insect harassment, most females were along or near the Kupurak floodplain, a major movement corridor for caribou (Smith *et al.*, 1994), or within a few kilometers east of the Kuparuk Delta, an area of little surface development. Clearly, avoidance is far more extensive than reported previously for the central portion of the oilfield (Cameron *et al* , 1979; Smith & Cameron, 1983).

The comparative paucity of female caribou in Quadrat C during non-insect vs. insect days (Table 1) cannot be attributed to a unique habitat composition, specifically, a greater occurrence of sparsely-vegetated riparian areas used principally for insect relief. Figure 2 shows that Quadrat C comprised more riparian habitat than Quadrat B, D, or E, but less than Quadrat A, yet the non-insect:insect ratio for the latter was among the highest computed (Table 1).

Determining the exact area that female caribou avoid is difficult, owing to the gradual progress of oilfield development and the accompanying net growth of the CAH from ca. 9000 in 1981 (Whitten & Cameron, 1983a) to ca. 23,000 in 1992 (Whitten, unpubl. data). A *minimum* area, however, can be estimated. Assuming, conservatively, that abundance of radiocollared females during insect days did not decline, reduced use of Quadrat C can be calculated as the product of the total number of locations there during insect days (171) and the second lowest ratio reported (0.35, Quadrat B; Table 1). Thus, at least 60 females should have been present in Quadrat C, whereas only 13 were observed, a decrease of 78 % or an equivalent area of 660 km².

Movements

Our observation of infrequent lateral movements of female caribou within Quadrat C reinforces earlier evidence for low rates of crossing the Trans-Alaska Pipeline corridor, including its extension through the complex (Whitten & Cameron, 1983b). In contrast, caribou apparently were abundant, and major movements were not uncommon, in this same area during the 1970s (Child, 1973; White *et al.*, 1975; Gavin, undated).

Obvious attempts by large groups of caribou to penetrate the oilfield complex have been observed in recent years. On several occasions (e.g. Smith *et al.*, 1994), insect-harassed aggregations moved eastward across the Kuparuk Delta, contacting the roads and pipelines west and south of Prudhoe Bay (Fig. 1), but apparently were unable to continue to the west channel of the Sagavanirktok River. Moreover, in our 14 years of radiotracking, not a single collared caribou is known to have passed entirely through the main oilfield in either direction. The 10 inferred crossings of the Quadrat C mid-line (Table 1) may have occurred near Deadhorse Airport, the southern boundary of the complex.

Although predevelopment data are unavailable, there is no reason to believe that previous movements of caribou in Quadrat C were substantially different from those in similar areas of the CAH summer range. Insect-induced movements are ostensibly more opportunistic than repetitively site-specific. Given unimpeded access, the exact routes caribou take to and from the coast depend largely upon their location at the onset and cessation, respectively, of insect harassment; although riparian areas, when available, are selected as corridors (Smith *et al.*, 1994). Hence, just as weather events tend to be random, so are the associated movements. If mid-line crossing ratios for Quadrats A, B, D, and E accurately reflect a random process, then the frequency of lateral movements within Quadrat C has decreased by nearly 90 % (Table 1).

Implications

Underuse of, and reduced movements within, the Prudhoe Bay oilfield by caribou are apparently due to the cumulative effects of intensive and extensive surface development, high levels of vehicular traffic, and widespread human activity. Very likely, avoidance is exacerbated by numerous pipelines < 1.0 m above ground level, which constitute physical barriers to movement.

By comparison, more recent oilfields west of the Kuparuk River (i.e. within Quadrat B) have a lower densitiy of production-related facilities (Fig. 1), and nearly all pipelines are elevated ≥ 1.5 m. Numerous caribou continue to occupy these areas in summer, albeit with notable shifts in distribution (Smith *et al.*, 1994). Nevertheless, as development within the Kuparuk region continues to expand and intensify, additional changes can be anticipated.

The avoidance process, we suspect, is quite subtle and therefore difficult to detect. Unlike the extreme sensitivity noted during calving (Dau & Cameron, 1986; Cameron *et al.*, 1992), female caribou evidently will tolerate considerable surface development in summer, especially when passage under (or over) pipelines is possible (Smith *et al.*, 1994). However, if structural complexity increases to a point at which the environment becomes unacceptable, caribou may largely abandon an area, perhaps abruptly. Withdrawal is probably sustained by new movement patterns that emerge through learning and trial-and-error. Both rate of egress and the eventual level of use might also vary to an unknown degree, depending upon local habitat types and regional landscape features. Our inability to quantify this complex interaction of man-made and natural stimuli renders critical levels of disturbance elusive and accurate predictions of the timing of abandonment virtually impossible.

Barren-ground caribou are indeed adaptable (Bergerud *et al*, 1984), but there are limits. Exceeding their tolerance for adverse stimuli will influence distribution and may preclude access to an area. And inaccessible habitat is habitat lost.

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