Reimers, E., Gaare, E. and Skjenneberg, S. (eds.) 1980.
Proc. 2nd Int. Reindeer/Caribou Symp., Røros, Norway,
1979. Direktoratet for vilt og ferskvannsfisk, Trondheim.

# INFLUENCE OF THE TRANS-ALASKA PIPELINE CORRIDOR ON THE LOCAL DISTRIBUTION OF CARIBOU

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## ABSTRACT

The arctic slope route of the Trans-Alaska Pipeline (TAP) and its associated haul road traverse the range of a distinct subpopulation of 5000–6000 caribou (*Rangifer tarandus granti,* Banfield), the Central Arctic Herd (CAH). Seasonal movements are primarily north–south, but intersect the TAP corridor to varying degrees each year. A comparison of results of extensive aerial surveys and ground surveys along the haul road between 1975 and 1978 indicates local abnormalities in caribou distribution and group composition. During summer, aggregate calf percentage along the haul road was consistently lower than that obtained by corresponding aerial survey of the general region; in 1975, 1976, 1977, and 1978 mean calf proportions determined from haul road surveys, respectively, averaged 38, 65, 87, and 86% lower than those determined by air. In fall 1975, calf percentages for aerial and road surveys were identical, but fall road data for 1976, 1977, and 1978, respectively, averaged 41, 50, and 96% lower than comparable observations by air. In general, relatively fewer caribou were observed within the coastal region of the corridor than expected on the basis of aerial survey results. During summer 1976 through 1978 the frequency of caribou sightings from the haul road averaged approximately 30% lower than in 1975, and the rate of corridor crossings was about 80% lower than in 1975; sighting frequency in fall similarly decreased to about 40% of the 1975 level, but corresponding crossing rates were quite variable and demonstrated no consistent trend. The combined results indicate caribou avoidance of the TAP corridor and associated areas of oil development, a response which is strongest for cows with neonatal calves. Annual trends in caribou occupancy are discussed in relation to changes in local disturbance.

## 1. INTRODUCTION

The Trans-Alaska Oil Pipeline (TAP) extends from the coast of the Beaufort Sea to the Gulf of Alaska. From its origin near Prudhoe Bay, the Pipeline parallels a recently constructed haul road, traversing the arctic slope and Brooks Range to the Yukon River, thence south to Valdez along established highways. North of the Yukon River, the TAP corridor borders on or transects the known ranges of 3 caribou herds. The ranges of the Western Arctic and Porcupine herds were described by Hemming (1971) as extending to or slightly overlapping the corridor in this region. Recently, Cameron and Whitten (1979) identified a third subpopulation of 5000–6000 caribou whose range is roughly centered on the arctic slope route of the TAP. Seasonal movements of this "Central Arctic" Herd (CAH) are predominantly north–south between calving grounds near the arctic coast and wintering areas in the northern foothills of the Brooks Range, although lateral movements across the corridor also occur on a regular basis.

By comparing the results of extensive aerial surveys with data obtained from ground surveys along the haul road in 1975, Cameron et al. (1979) described local abnormalities in caribou distribution and group composition. During summer the mean percentage of calves observed within the corridor was substantially lower than the percentage obtained by systematic aerial survey of the adjacent region; corresponding percentages for fall, however, were identical. In both summer and fall, the mean latitudinal position of groups along the haul road was consistently lower than that determined for groups observed by air, indicating a relative paucity of caribou at the northernmost end of the corridor near Prudhoe Bay. The combined results for 1975 indicate avoidance of the corridor during summer by cows and calves with a return to normal group composition during fall, and general avoidance of the Prudhoe Bay development complex during both seasons.

The above response was described for a period of peak construction activity. Since 1975 the level of human activity has declined steadily. As of 1978, essentially all construction had ceased along the TAP right-of-way, with remaining activities primarily attributable to pipeline operations, haul road maintenance, and freight traffic in support of continued petroleum development near Prudhoe Bay. This report summarizes caribou responses to the TAP corridor from 1975 through 1978.

## 2. STUDY AREA

The study area lies between the Itkillik and Canning Rivers and between the arctic coast and the crest of the Brooks Range (Fig. 1). Three physiographic units are apparent (Spetzman 1959). The arctic coastal plain is characterized by poorly drained sedge meadows dominated by *Carex* spp. and rises gradually to an elevation of about 180 m at its southern border (approximate latitude 69°20′N). The foothills continue inland as rolling hills and low linear mountains rising to more than 900 m; *Eriophorum* tussock tundra predominates, but a number of herb, low shrub, and lichen communities are also present. Transition to the mountainous northern slopes of the Brooks Range begins near the southern extreme of the study area. Rugged glaciated peaks extending from northeast to southwest rise to a maximum elevation of 2500 m. Throughout the study area are numerous rivers and creeks which support stands of riparian willow (*Salix* spp.) as well as a variety of grasses, sedges, and forbs.

The TAP and its associated haul road are routed almost entirely along the Sagavanirktok River (Fig. 1), traversing all 3 physiographic regions. Approximately 50% of the 122-cm diameter pipeline is buried, the remainder being supported above ground at heights ranging from about 1 to 5 m.

## 3. METHODS

A series of surveys was conducted along the haul road by light truck from early June through November, 1975–1978. Generally these were scheduled twice monthly, each consisting of 2 trips between Pump Station 4 and

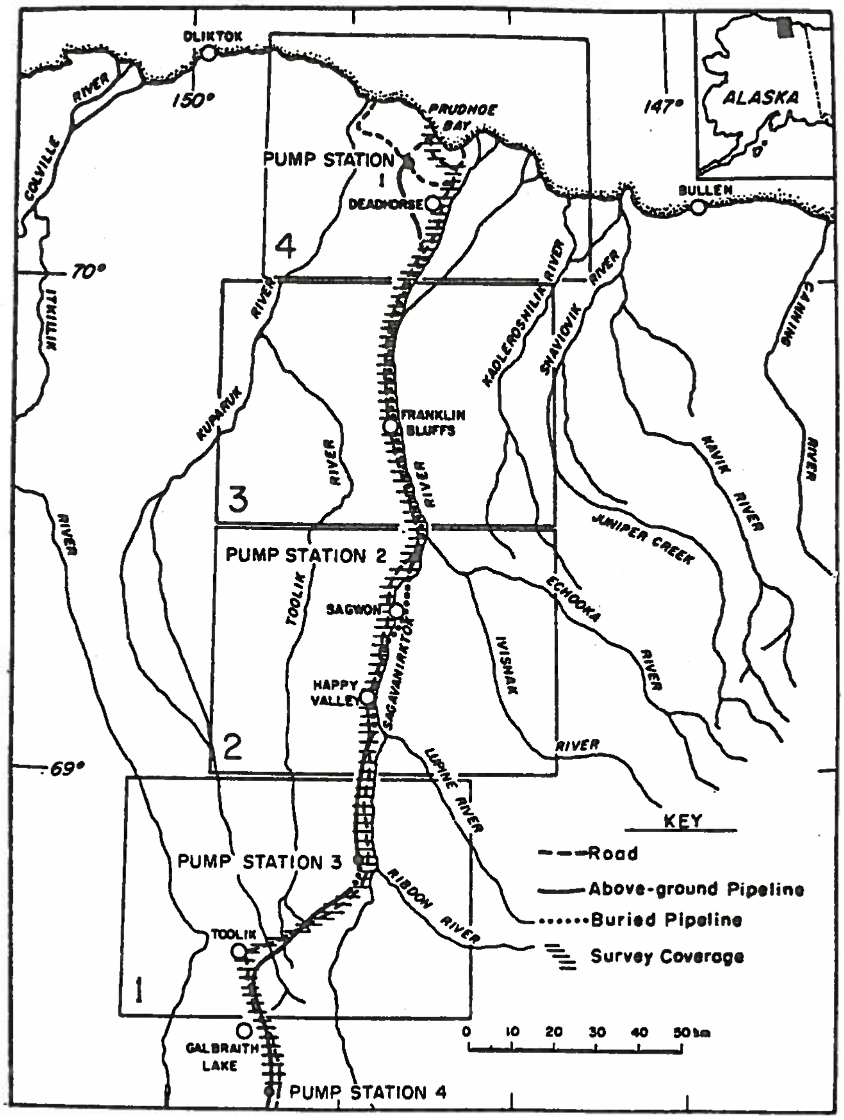


Fig. 1. Survey coverage along the Trans-Alaska Pipeline corridor and regional boundaries established for comparison of haul road and aerial survey results.

the arctic coast, a total of 263 km (Fig. 1); procedural details are given in a previous report (Cameron et al. 1979). At least once each summer and fall the entire study area was surveyed by helicopter or fixed-wing aircraft (Cameron and Whitten 1979). Briefly, caribou within the study area were sampled systematically to determine sex and age composition. For purposes of this report, sex and age identification is limited to 4 categories: calf (less than 1 year old), adult (more than 1 year old, sex unknown), bull (male, more than 2 years old*), and unknown (unclassified as to sex or age).

A mean frequency of caribou sightings within the corridor (number of caribou observed per 100 km) was calculated for summer and fall using aggregate observations from road surveys completed on a single day and/or from the results of paired north/south road segments surveyed on successive days. Corridor crossing rates (number of observed crossings per 100 caribou sighted) were similarly calculated for each season; we assumed that caribou observed crossing either pipeline or haul road would cross — or had crossed — the other.

Records of local air traffic were obtained from Alyeska Pipeline Service Company, Atlantic-Richfield Company, and the Federal Aviation Administration. Employment records were provided by A. Gavin, consultant to Atlantic-Richfield Company.

Statistical significance ($p \leq 0.05$) of paired variates was evaluated using chi-square analysis.

## 4. RESULTS

### 4.1. Local differences in caribou group composition

Observed differences in caribou group composition determined through corresponding aerial and haul road surveys are summarized in Tab. 1 for summer and fall 1975 through 1978. Of the combined total number of caribou observed during all surveys (not given), 93% were classified successfully (i.e. groups with "unknowns" excluded; see Methods); except for road surveys in fall 1975 (56% classified), the proportion exceeded 90%.

Between 1975 and 1978 mean calf percentage obtained by haul road surveys declined substantially for both summer (13% to 3%) and fall (17% to 1%), while bull percentages increased over the same period (65% to 88%, and 43% to 87%, respectively). Clearly, these changes do not reflect a general decline in the percentage of calves in the herd or an increase in the percentage of bulls. Aerial survey data obtained each fall, which should be most representative of herd composition, show a net increase in the proportion of calves, from 17% in 1975 to 23% in 1978; the bull proportion decreased from 44% in 1976 (comparable data not available for 1975) to 34% in 1978 (Tab. 1).

To ensure meaningful comparisons of sex and age composition, calf and bull percentages obtained through haul road surveys were evaluated in relation to corresponding data from aerial surveys, the premise being that the latter are representative of caribou potentially in contact with the corridor, whereas the former indicate actual patterns of local occupancy. Thus, calf and adult percentages obtained through the 2 survey methods were compared for each season using chi-square analysis. Except during fall in 1975 and 1976, such percentages were significantly different.

To demonstrate these temporal changes in local group composition, relative bull and calf numbers were calculated as the ratios of the respective percentages observed from the haul road to those determined through aerial survey. The reference value for bulls in summer was taken as the percentage established during fall aerial surveys (Tab. 1), since summer surveys by air provide only minimum bull estimates (see Methods), and 1975 ratios were estimated using the bull percentage determined from aerial surveys in fall 1976 (44%). Otherwise, ratios were established directly, using the appropriate results of corresponding road and aerial surveys. Annual trends in group composition are summarized in Fig. 2 for each season.

A steady decline in the summer calf ratio is shown between 1975 and 1977, with little subsequent change in 1978. These changes were associated with a linear increase in the bull ratio. Patterns of change for fall were somewhat erratic and differed from summer trends in several respects. As noted above, fall calf percentages obtained from the haul road during the first 2 years were not statistically different from the corresponding estimates made by air, despite the 1976 decrease to approximately 60% of the expected value. However, the calf ratio continued to decline through 1978, reaching the lowest value calculated for either season. In contrast, fall bull percentages observed locally have increased to 2—½ times the proportion estimated for the herd.

### 4.2. Seasonal and annual changes in sighting frequency and crossing rate

Also shown in Fig. 2 are the accompanying changes in caribou sighting frequency along the haul road and the observed rate of caribou crossings of the pipeline corridor; the former variable is an index of local density, and

* Only obvious, mature bulls (i.e. over ca. 4 years of age) were recorded during most aerial surveys.

Tab. 1. Summary of differences in caribou group composition obtained by aerial and haul road surveys on Alaska's central arctic slope, 1975-1978.

| | | | | Total groups classified[2] | | | Groups with calves[3] | | | Groups without calves | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Season | Survey method[1] | Inclusive dates | No. of caribou | Bulls (%) | Calves (%) | No. of caribou | Bulls (%) | Calves (%) | No. of caribou | Bulls (%) |
| 1975 | Summer | Road | 11 Jun-6 Sep | 1856 | 65 | 13 | 614 | 31 | 40 | 1242 | 94 |
| | | Air | 25 Jun-11 Aug | 1209 | (35) | 21 | 721 | (2) | 35 | 488 | (84) |
| | Fall | Road | 20 Sep-25 Nov | 520 | 43 | 17 | 402 | 29 | 23 | 118 | 92 |
| | | Air | 22 Sep-24 Nov | 1597 | (29) | 17 | 1293 | (20) | 21 | 304 | (64) |
| 1976 | Summer | Road | 8 Jun-26 Aug | 891 | 79 | 6 | 155 | 10 | 34 | 736 | 94 |
| | | Air | 30 Jun-12 Aug | 1135 | (27) | 17 | 562 | (1) | 33 | 573 | (54) |
| | Fall | Road | 21 Sep-19 Nov | 42 | 64 | 10 | 14 | 21 | 29 | 28 | 86 |
| | | Air | 12 Oct-15 Oct | 1218 | 44 | 17 | 967 | 34 | 21 | 251 | 81 |
| 1977 | Summer | Road | 8 Jun-28 Aug | 931 | 85 | 2 | 77 | 6 | 32 | 854 | 93 |
| | | Air | 11 Aug-16 Aug | 512 | (44) | 15 | 231 | (10) | 33 | 281 | (73) |
| | Fall | Road | 9 Sep-26 Nov | 355 | 65 | 10 | 137 | 34 | 22 | 218 | 85 |
| | | Air | 10 Oct-16 Oct | 624 | 38 | 20 | 499 | 27 | 26 | 125 | 80 |
| 1978 | Summer | Road | 9 Jun-26 Aug | 1432 | 88 | 3 | 135 | 11 | 33 | 1297 | 96 |
| | | Air | 9 Aug-10 Aug | 287 | (27) | 22 | 191 | (6) | 34 | 96 | (69) |
| | Fall | Road | 13 Sep-13 Oct | 30 | 87 | 3 | 4 | 50 | 25 | 26 | 92 |
| | | Air | 22 Oct-26 Oct | 816 | 34 | 23 | 675 | 24 | 28 | 141 | 82 |

1 Systematic surveys by air (Cameron and Whitten 1979) or along the TAP haul road (Cameron et al. 1979).
2 Groups with no "unknowns" (see Methods).
3 Groups with one or more calves present.
Note: bull percentages in parentheses are minimum estimates (see Methods).

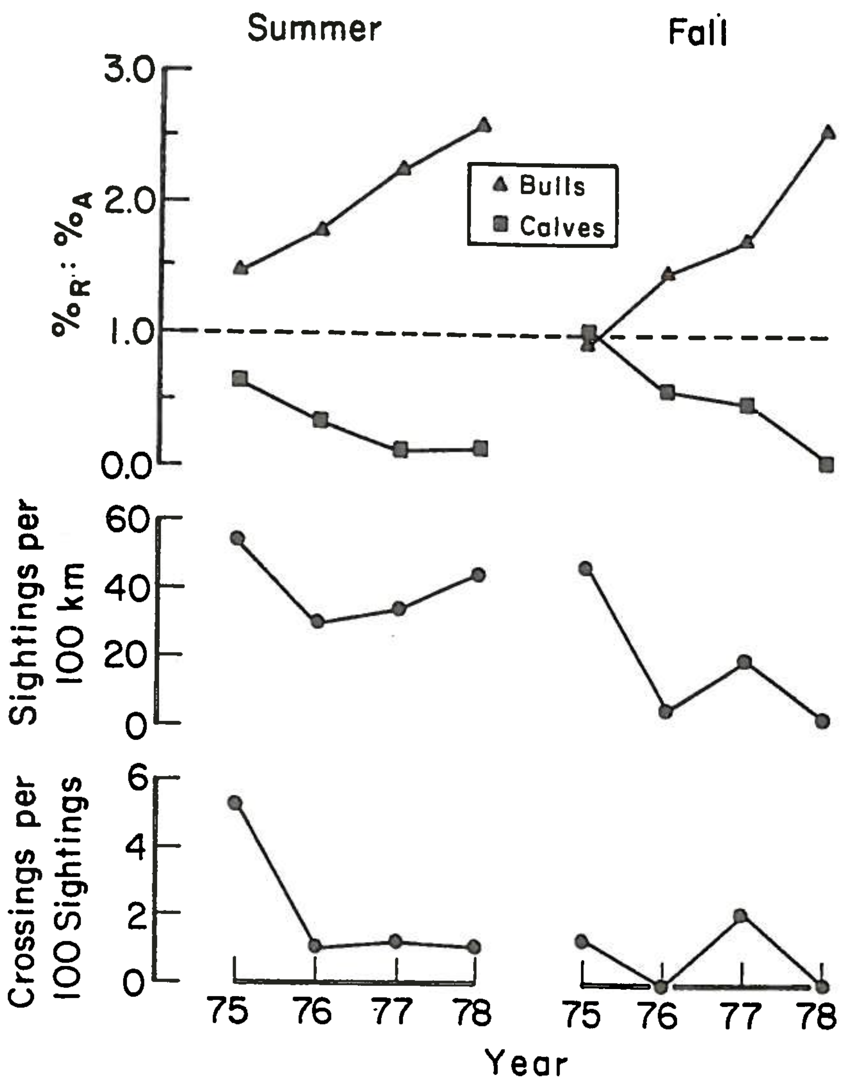


Fig. 2. Changes in relative calf and bull representation, caribou sighting frequency, and crossing rate associated with the Trans-Alaska Pipeline corridor, summer and fall 1975–1978. NOTE: $\%_R$:$\%_A$ = ratio of calf or bull percentages observed from the haul road to those determined by aerial survey.

the latter is essentially the number of corridor crossings expressed as a fraction of caribou sighted. Despite progressive underrepresentation of calves along the corridor in summer, sighting frequency, after an initial decline in 1976, showed a 50% increase thereafter through 1978. Summer crossing rates also declined abruptly in 1976 but, unlike sighting frequency, remained relatively stable through 1978 at approximately 20% of the 1975 value. Fall trends in sighting frequency and crossing rate were similar, declining initially to extremely low values, followed by moderate increases in 1977 with a return to minimum values in 1978.

### 4.3. Local differences in latitudinal distribution of caribou

The latitudinal distribution of caribou present along the TAP corridor was compared with that determined by extensive aerial survey. The percentages of total caribou observed within each of 4 arbitrarily established regions of the study area (Fig. 1) were determined from corresponding results of the 2 survey methods (see Cameron et al. 1979). Those comparisons for 1975 through 1978 are given in Fig. 3 which shows that, in general, fewer caribou were present along the corridor in Region 4 than expected on the basis of aerial survey observations. Caribou avoidance of petroleum-related development near Prudhoe Bay was observed in 1975 by Cameron et al. (1979) who identified such local displacement as a factor contributing to the overall underrepresentation of calves in the corridor, particularly during summer. In the CAH, cows with calves typically occupy coastal habitat in higher numbers than non-maternal adults, and avoidance of the oilfield would necessarily involve relatively more maternal caribou. Conversely, any disproportionate avoidance by cow-calf pairs would, in large part, account for the low relative levels of local occupancy in Region 4. The present results show that disturbance-induced displacement of caribou from the immediate Prudhoe Bay area during summer has continued through 1978 and, in addition, was detectable during fall in 1975 and 1977 (comparable survey data not available for fall 1978). In fall 1976, however, regional percentages of caribou within the corridor agree closely with those determined through aerial survey, an observation that corresponds to statistically insignificant differences in mean calf percentage (see 4.1., above).

## 5. DISCUSSION

### 5.1. Local avoidance

The results indicate that local group composition in summer has not been representative of caribou in the surrounding region; calf and bull percentages clearly differ from comparable estimates for the CAH as a whole, and the disparity has increased since 1975. This trend is apparently attributable to a progressive displacement of cows and calves from areas of vehicular traffic, construction activity, and/or structures along the TAP route. In addition, local avoidance has likely been intensified in the general vicinity of the Pipeline origin near Prudhoe Bay. Here oilfield development is in progress, and disturbance is concentrated spatially. This expanding coastal complex lies within primary calving and summer range, and heightened avoidance during summer would, by implication, involve relatively greater numbers of groups with calves. However, aerial survey observations indicate that the summer range of cow-calf pairs also extends southward into Region 3(see Fig. 1), and the observation

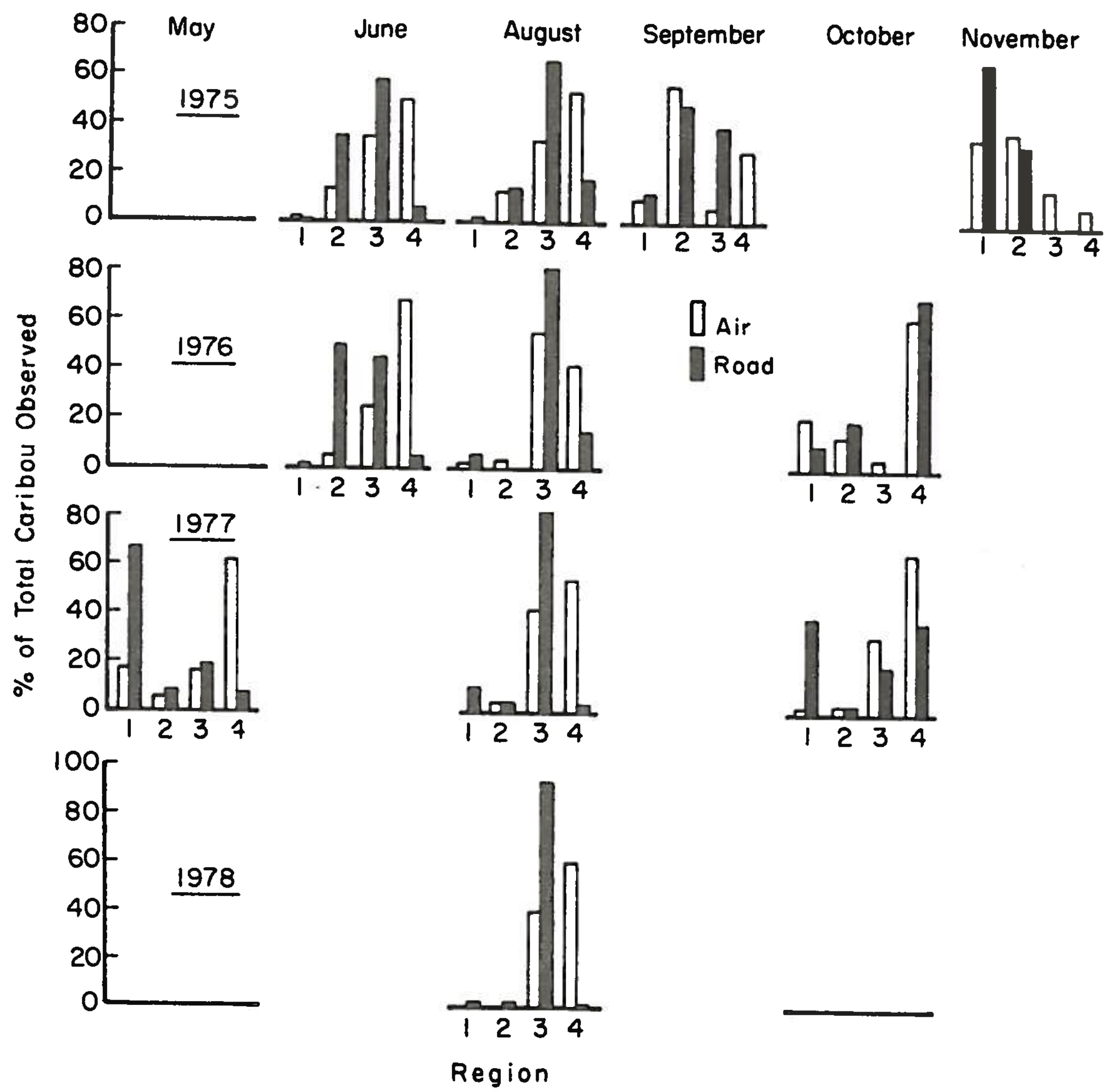


Fig. 3. Regional distribution (see Fig. 1) of caribou determined from corresponding aerial and haul road surveys, 1975–1978.

that few calves are present along the haul road segment within that region indicates that the TAP and haul road with its associated traffic and human activity also constitute an adverse stimulus sufficient to elicit cow-calf avoidance.

The agreement of aerial and haul road calf percentages in fall 1975 (Tab. 1) has been interpreted as desensitization of calves and maternal cows following local avoidance during the summer months (Cameron et al. 1979). Statistically, this seasonal response pattern also applied in 1976, but distinct numerical differences between corresponding calf percentages (see 4.1., above) were probably obscured by extremely small sample size (Tab. 1). After 1976, summer sensitivity of cow-calf pairs clearly extended into fall.

The observed local differences in group composition cannot be attributed to lateral shifts in the range of the CAH. The timing of seasonal movements has varied annually to some extent, but "centers of caribou occupancy" determined periodically within the study area (see Cameron and Whitten 1979) demonstrate that no appreciable redistribution of caribou has occurred in recent years (unpubl. data). This further reinforces the probability of a localized response.

### 5.2. Local group characteristics

Cameron et al. (1979) noted that groups with calves observed during comparable aerial and haul road surveys had similar proportions of calves (Tab. 1) and hypothesized that lower aggregate calf percentages within the corridor were due to the local scarcity of such groups rather than a lower proportion of calves in individual groups sighted. Chi-square analysis shows that, indeed, percentages of total caribou observed from the haul road in groups with and without calves were significantly different from the corresponding results of aerial survey. In addition, calf proportions in groups with calves were not significantly different except for summer 1975. Thus, cow-calf avoidance of the corridor is apparently manifest by different group responses to adverse stimuli rather than local fragmentation into smaller groups with no or fewer calves. A group – rather than individual – response to disturbance is consistent with other reports of the cohesion and leadership characteristic of caribou social units (Miller et al. 1972, Miller 1974).

### 5.3. Seasonal and annual trends in local caribou density

Caribou sighting frequency and crossing rates (Fig. 2) are mean estimates generated by combining all observations within each season. Clearly, variations in weather and habitat may alter the overall pattern of caribou occupancy and thereby affect the validity of comparisons between seasons and years, irrespective of any confounding responses to disturbance. However, consideration of the observed annual changes in local sighting frequency may assist in describing general response trends of caribou to activity and development within summer and fall range between 1975 and 1978.

Since avoidance of the corridor by cows and calves is ostensibly based on a group response, one might speculate that the observed annual differences in sighting frequency for a given season are related to changes in the relative presence of groups with calves, provided that non-calf groups exhibit no negative response. These considerations are demonstrated in Fig. 4 where sighting frequency is plotted in relation to the precentage of total caribou observed locally in groups with calves. Separate baseline relationships were projected for summer and fall using 1975 data; a theoretical Y-intercept was estimated for each season by reducing the initial sighting frequency by an amount equal to the proportion of caribou observed in groups with calves (Tab. 1). Data points for 1976 through 1978 are shown for comparison. The regressions, as shown, predict a decline in mean sighting frequency due entirely to progressive avoidance by groups with calves. Thus, when no calf groups are present, sighting frequencies for summer and fall are projected to be 36 and 11 caribou/100 km, respectively. These intercept values have biological relevance in light of observations during the insect season. Bulls and juveniles, either singly or in small groups, are frequently the only caribou seen on individual road surveys. During fall, when a higher fraction of the herd is found in groups with calves, the total number of caribou along the corridor in groups without calves would be correspondingly lower.

Except for values obtained in summer 1978, all data points fall below the projected regression line (Fig. 4), suggesting that the lower sighting rates in each case were due to additional avoidance of the corridor area by caribou in groups without calves. Further, these disparities, as shown, may be minima. Reliable data on herd status are not available for 1976, but unpublished estimates of yearling recruitment in 1977 and 1978 equaled or exceeded the values reportedly associated with herd growth (Bergerud 1978). Hence, if a recent increase in herd size resulted in higher caribou density within the study area – including the TAP corridor – the points plotted for 1977 and 1978 should be adjusted downward (Fig. 4) to values consistent with the lower density for 1975. This adjustment would bring the summer 1978 sighting frequency nearer the theoretical regression line. On the other hand, if herd growth was accompanied by expansion of range with no increase in overall density, such adjustments would not be necessary and the high sighting frequency obtained in summer 1978 would suggest abnormally high local occupancy by groups without calves. It is noteworthy that in summer

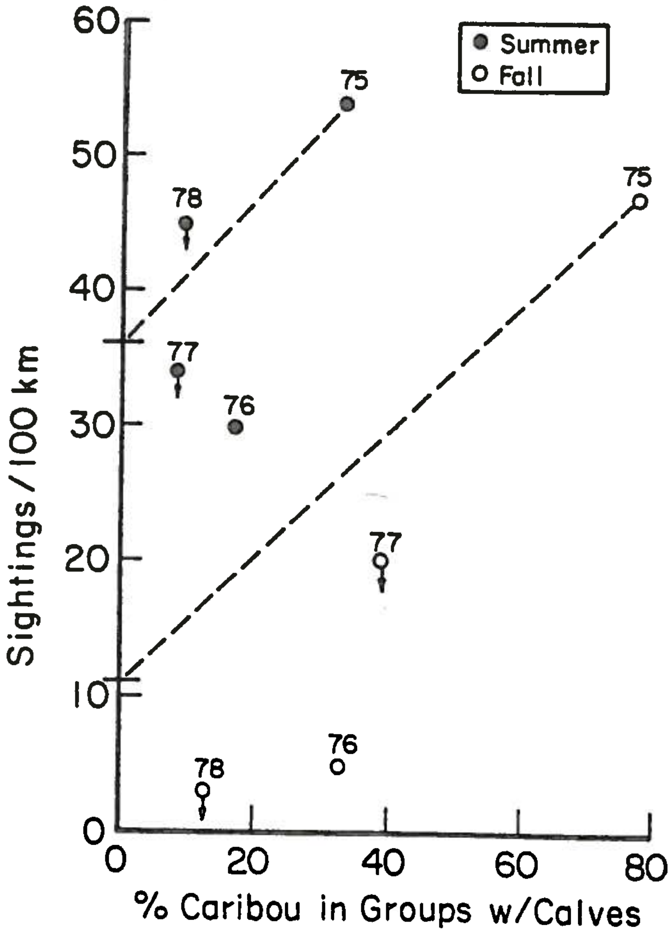


Fig. 4. Caribou sighting frequency along the Trans-Alaska Pipeline corridor in relation to the percentage of total caribou observed in groups with calves. NOTE: Dashed lines are projected from composition data in Tab. 1.

from 1976 through 1978 the increase in sighting frequency was associated with a detectable net decrease in the proportion of caribou observed in groups with calves. Perhaps "normal" summer occupancy by non-maternal groups is gradually being restored locally through desensitization. In contrast, fall sighting frequencies have remained below expected levels and no similar trend of improvement is evident.

### 5.4. Changes in corridor crossing rate

The relatively high crossing rate shown for summer 1975 was associated with maximum sighting frequency (Fig. 2). Local calf representation, although subnormal, was closer to the expected value than during any of the 3 subsequent summers (Tab. 1, Fig. 2), and a higher proportion of crossings involved cows and calves (unpubl. data). However, the summer crossing rate declined abruptly in 1976 and remained fairly stable thereafter through 1978. During the latter interval, bulls represented the majority of local sightings and, not surprisingly, accounted for a commensurately high fraction of the crossings recorded (unpubl. data). Again, this was particularly obvious during the insect season when bulls often occupied roads and construction pads to gain some relief from mosquitos (*Aedes* spp.) and oestrid flies (*Oedemagena tarandi*, L. and *Cephenomyia trompe*, L.). With rare exceptions, crossings were seemingly the result of random local movements of insect-harassed bulls.

In fall 1975, crossing rate was only about 20% of the corresponding summer value despite normal calf representation and relatively high local occupancy (Fig. 2). In general, sighting frequencies and crossing rates in fall followed similar trends. This suggests that caribou present along the corridor in densities exceeding those equivalent to the low 1976 and 1978 sighting frequencies (ca. 4 caribou/100 km) were enroute to winter range. Fall movements occur in response to 1 or more factors, including forage senescence, snow conditions, reproductive drive, and tradition.

### 5.5. Changes in local disturbance

The extent to which elevated pipe per se might restrict caribou movements was a major concern at the inception of this project. In reality, the question of crossing success in relation to any pipe mode has proven largely irrelevant due to the avoidance phenomenon described in this report. Human activity apparently represents the principal impediment to local movement since avoidance of the corridor occurs irrespective of the pipe structure which would otherwise be encountered.

As a means of describing annual trends in disturbance along the TAP corridor and within the Prudhoe Bay complex, airport operations data and employment records were developed as indices of local activity. Relative annual or quarterly changes in these parameters between 1975 and 1978 are given in Fig. 5. Operations data for airports along the TAP corridor are incomplete. However, a steep decline in aircraft activity was obvious during the 2 years following peak levels in 1976; by late 1977 2 of the 3 airports had closed, and we estimate the maximum quarterly level in 1978 for the 1 remaining at only 10% of the highest value recorded. Airport operations in the Prudhoe Bay area were at peak levels in mid-1975, declined by about 50% in 1976, and thereafter increased slightly through 1978. The work force in the Prudhoe area reached a maximum in 1976 and declined progressively through 1978. The relevant point is that all 3 indices reflect highest levels of activity in 1975 and/or 1976, followed by a distinct net decline. By comparison, Fig. 2 shows that group composition along the TAP corridor was least abnormal in 1975 when disturbance levels were at or near maximum, became less representative with continued high local activity, and subsequently deteriorated further, despite a moderation of local disturbance. In addition, annual changes in the response for a given season seem to differ. The onset of cow-calf avoidance in summer was nearly immediate whereas fall abnormalities were not discernible statistically for an additional 2 years. More importantly, neither summer nor fall composition data have indicated any tendency toward a recovery, and latitudinal distribution continues to be biased against the northernmost segment of the corridor near Prudhoe Bay (Fig. 3). The only recent change that resembles a beneficial occurrence is the possible restoration of local bull densities in summer (see 5.3., above).

Seasonal differences in the onset and magnitude of the avoidance response, as well as the rate of change, may be simply a function of maternal sensitivity based on age of calves. Failure to recover following removal or diminution of an adverse stimulus could reflect a finite response lag. However, it is conceivable that altered

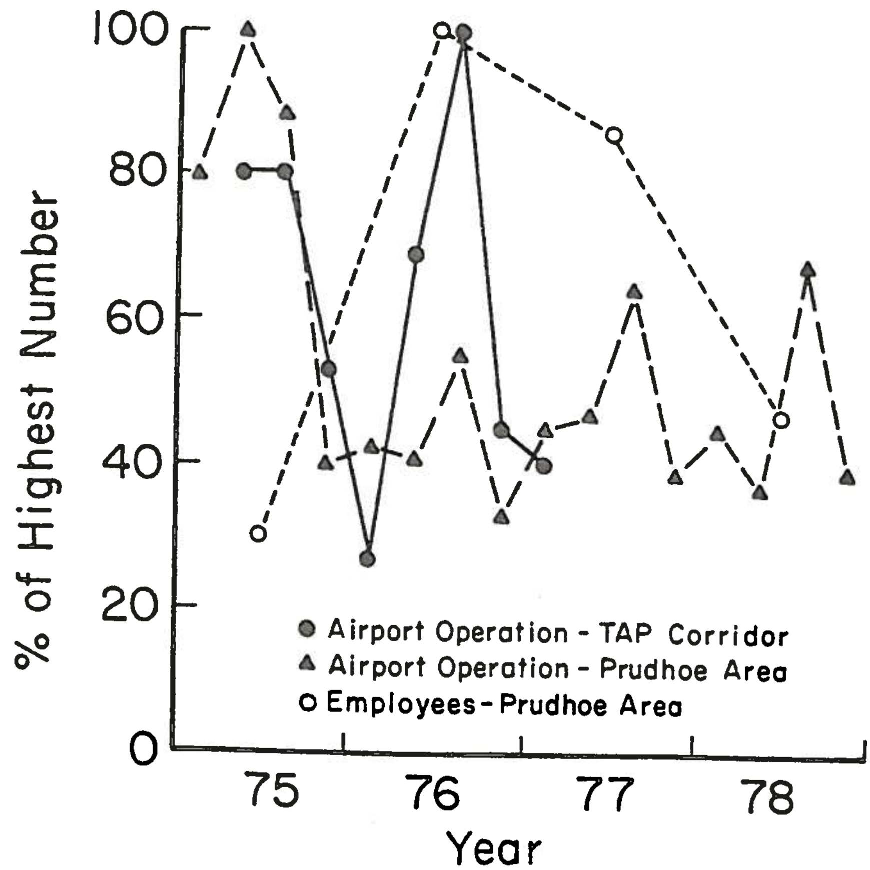


Fig. 5. Relative quarterly changes in total airport operations along the Trans-Alaska Pipeline corridor (Franklin Bluffs, Happy Valley, and Galbraith Lake airports; see Fig. 1) and within the immediate Prudhoe Bay oilfield (Deadhorse and nearby Prudhoe Bay airports; see Fig. 1); and relative annual changes in the number of people employed in the Prudhoe Bay area.

patterns of seasonal occupancy tend to persist as new traditions which are reinforced by previous experience of maternal group leaders and sustained further by their female offspring. Thus, range abandoned by caribou may not be fully reoccupied for many years. This is admittedly conjectural but emphasizes a need to investigate the mechanisms by which movement patterns are established and subsequently sustained or altered. Aslo required is detailed knowledge of the optimal timing, acceptable types, and permissible levels of disturbance within caribou range.

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## REFERENCES

Bergerud, A.T. 1978. Caribou. – In: Schmidt, J.L. and Gilbert, D.L. (eds.), Big Game of North America (Ecology and Management), Stackpole Books, Harrisburg, Pa., pp. 83–101.

Cameron, R.D. and Whitten, K.R. 1979. Seasonal movements and sexual segregation of caribou determined by aerial survey. – J. Wildl. Manage. 43: 626–633.

– Whitten, K.R., Smith, W.T. and Roby, D.D. 1979. Caribou distribution and group composition associated with construction of the Trans-Alaska Pipeline. – Can. Field-Nat. 93: 155–162.

Hemming, J.E. 1971. The distribution and movement patterns of caribou in Alaska. – Tech. Bull. 1, Alaska Dept. Fish and Game, Juneau.

Miller, F.L. 1974. A new era – are migratory barren-ground caribou and petroleum exploitation compatible? – In: Transactions of the Northeast Section, The Wildlife Society, February, pp. 45–55.

– Jonkel, C.J. and Tessier, G.D. 1972. Group cohesion and leadership response by barren-ground caribou to man-made barriers. – Arctic 25: 193–202.

Spetzman, L.A. 1959. Vegetation of the Arctic Slope of Alaska. – U.S. Geol. Surv. Prof. Pap. 302–13.