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# EFFECTS OF THE TRANS-ALASKA PIPELINE ON CARIBOU MOVEMENTS

BY

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SUMMARY

The results of continued aerial and road surveys of caribou along the Trans-Alaska Pipeline (TAP) are described and compared with previous data. Local abnormalities in caribou distribution and group composition were already apparent in summer 1975, mainly because of avoidance of the corridor by cows and calves. Summer avoidance has increased each year since 1975, but may have stabilized beginning in 1977. Cow/calf avoidance in fall was not apparent until 1976, but since then it has become even more striking than in summer. Caribou continue to avoid the oil field complex near Prudhoe Bay, the site of heavy construction activity and numerous man-made structures. Frequency of caribou sightings along, and crossings of, the TAP corridor declined sharply after 1975.

Observations of visual- and radio-collared caribou marked from 1975 through 1978 corroborate the avoidance trends established through aerial and haul road surveys. Collared bulls have been sighted more frequently from the haul road and have crossed the TAP corridor more freely than collared cows.

Studies of nutrient composition of caribou forage show a strong correlation between quality (in terms of N and P availability) and plant growth stage. Phenology was shown to progress from south to north on the Arctic Slope. Bulls from the Central Arctic Herd (CAH) follow the progression of phenology closely in their spring/summer movements, but northward movements of cows precede the emergence of new plant growth.

Data on calf production and survival in the CAH are summarized for 1976-78. Rates of yearling recruitment have been high in recent years, and hunting mortality has remained low. The herd is thought to be stable or increasing slowly.

## CONTENTS



## BACKGROUND

The known distribution of caribou (*Rangifer tarandus granti*) on Alaska's central Arctic Slope prior to construction of the Trans-Alaska Pipeline (TAP) and the potential conflicts between caribou and the TAP/haul road complex have been described previously (Cameron and Whitten 1976, 1979b; Cameron et al. 1979). These and other reports also provided interim findings on herd identity, productivity, and seasonal movements, and an analysis of observed abnormalities in caribou distribution and group composition along the TAP corridor from 1975 through 1977 (Cameron and Whitten 1976, 1977, 1978, 1979a; Cameron et al. 1979). This report describes continued progress toward satisfying the principal objectives of this research program.

## OBJECTIVES

In accordance with stipulations 2.5.4.1* and 2.5.3.1 of the Stipulations for the Agreement and Grant of Right of Way for the Trans-Alaska Pipeline, this project is designed to accomplish the following objectives:

To determine herd identity, general numbers, productivity, and seasonal movement patterns of caribou which range in the vicinity of the pipeline corridor.

To characterize movement behavior of caribou which encounter the haul road, pipeline, and construction-related activities.

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* "Leasees shall construct and maintain the pipeline, both buried and above ground sections, so as to assure free passage and movement of big game animals."

To assess the effectiveness of special crossings in allowing for unrestricted movement.

## PROCEDURES

Past reports describe the field methodology and analytical procedures which continue to be applied in aerial surveillance (Cameron and Whitten 1977, 1979), haul road surveys (Cameron and Whitten 1977, Cameron et al. 1979), collaring and radio tracking (Cameron and Whitten 1976, 1978), and sampling for herd productivity (Cameron and Whitten 1977, 1978).

Resighting percentages and frequencies, and crossing rates for collared caribou were compared using chi-square contingency analysis and Student's t-test. Significance was evaluated at the 95 percent confidence level.

## FINDINGS AND DISCUSSION

### Local Caribou Distribution, Forage Quality, and Herd Productivity

Data obtained on the distribution of caribou within the TAP corridor during the 1978 field season, together with the same results from the previous 3 years' work, have been summarized in a manuscript entitled "Influence of the Trans-Alaska Pipeline Corridor on the Local Distribution of Caribou." This paper, which appears as Appendix I, was presented at the Second International Reindeer/Caribou Symposium in Røros, Norway, September 1979, and will be published in the proceedings of that meeting.

A second paper, "Nutrient Dynamics of Caribou Forage on Alaska's Arctic Slope" was presented at the same conference and will also appear in the proceedings; it is submitted as Appendix II. The report provides a quantitative description of temporal and latitudinal changes in the nutrient quality of four key forage species within our North Slope study area and, as such, constitutes a partial assessment of an important habitat variable and its influence on spring/summer movement of the Central Arctic Herd (CAH).

Finally, data on initial calf production, early (ca. 4 months) survival, and yearling recruitment obtained through aerial surveys, together with harvest estimates, were prepared separately as a "Survey and Inventory" report, a copy of which is given as Appendix III.

### Movements of Collared Caribou

Between April 1975 and May 1978, 124 CAH caribou were equipped with numbered neck collars. Seventy-three (59%) of these caribou have been resighted within the study area on one or more occasions, for an aggregate total of 291 resightings, and 31 have crossed the corridor a combined total of at least 75 times. The data demonstrate clear sexual differences in the frequency of contact with the corridor, and are consistent with the local differences in group composition described in Appendix I. Overall proportions of collared bulls and cows resighted (22 of 33 bulls, and 51 of 91 cows) did not differ significantly ($p < 0.05$), but bulls were resighted significantly more often ($\bar{x}$ = 5.4 resightings/bull vs. 3.4 resightings/cow). In addition, a significantly greater proportion of collared bulls resighted were seen at least once from the road (20 of 22 bulls vs. 29 of 51 cows) and road observations accounted for a higher proportion of all bull resightings than of cow resightings (78% vs. 42%, respectively). Also, more bulls crossed the corridor at least once (15 of 22 bulls vs. 16 of 51 cows), and they crossed more frequently ($\bar{x}$ = 2.9 crossings/bull vs. 2.0 crossings/cow). Thus, both the frequency of sightings from the haul road and the rate of corridor crossings were lower for collared cows than for collared bulls.

A total of 37 radio collars were placed on CAH cows between 1975 and 1978. Of these caribou, 34 were successfully relocated, 1 emigrated, and 2 were suspected to have malfunctioning transmitters. Over the 3-year period known or probable mortality and collar shedding eliminated 10 of the 34 caribou with functional radio collars (29%), and five radio-collared cows (15%) have never been sighted without the aid of a tracking receiver but are known to have remained alive within the study area. Thus, the sum of known losses of radio-collared caribou and those not sighted incidental to other surveys (44%) is similar to the proportion of numbered collars not resighted (41%, see above). This indicates that most instances of resighting failure are due to mortality or "sampling error" and cannot be attributed to losses of caribou through emigration. Of the 34 radio-collared cows successfully tracked, 13 crossed the corridor an average of 1.9 times each, a rate not significantly different from that calculated for cows with numbered collars.

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APPENDIX I

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

R. D. Cameron and K. R. Whitten

Presented at the Second International
Reindeer/Caribou Symposium, Røros, Norway
17-21 September, 1979

# 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 5,000-6,000 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 5,000-6,000 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 2,500 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.

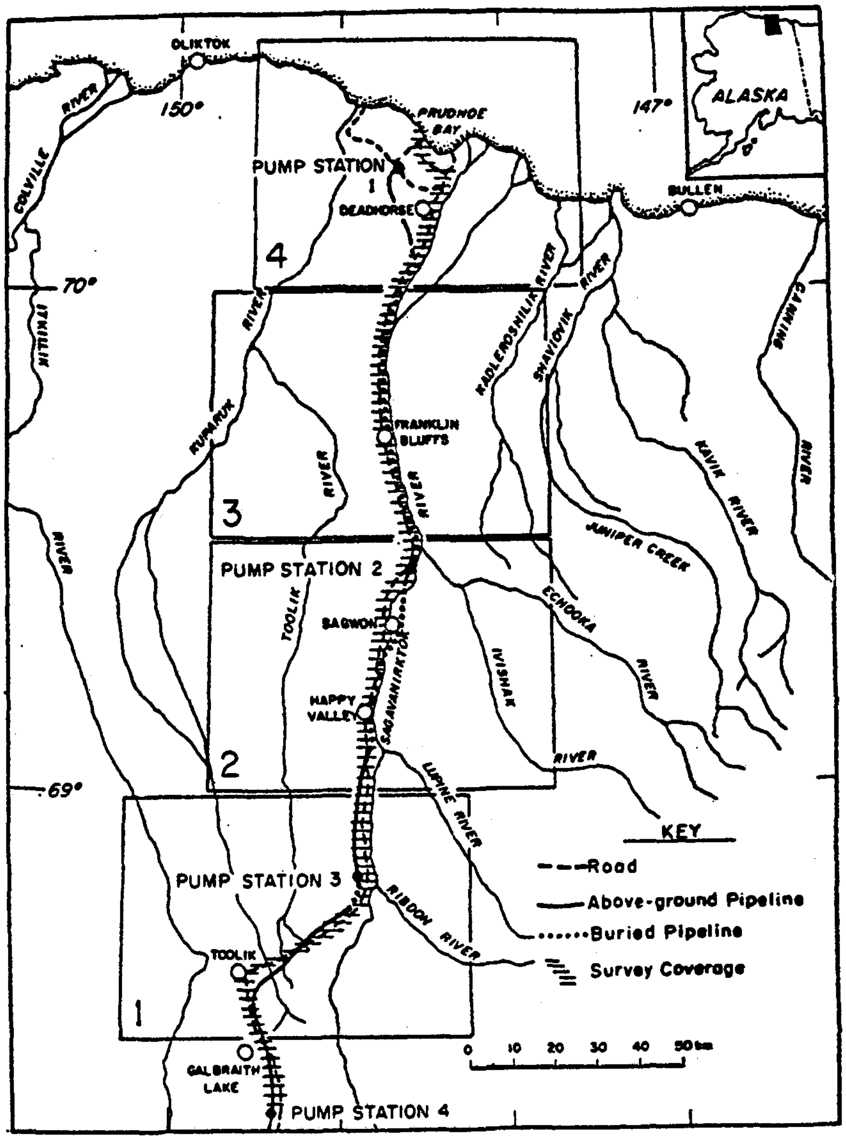


Fig. 1. Survey coverage along the Trans-Alaska Pipeline corridor and regional boundaries established for comparison of haul road and aerial survey results.

## 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 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

* 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 | 1 | 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).

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.

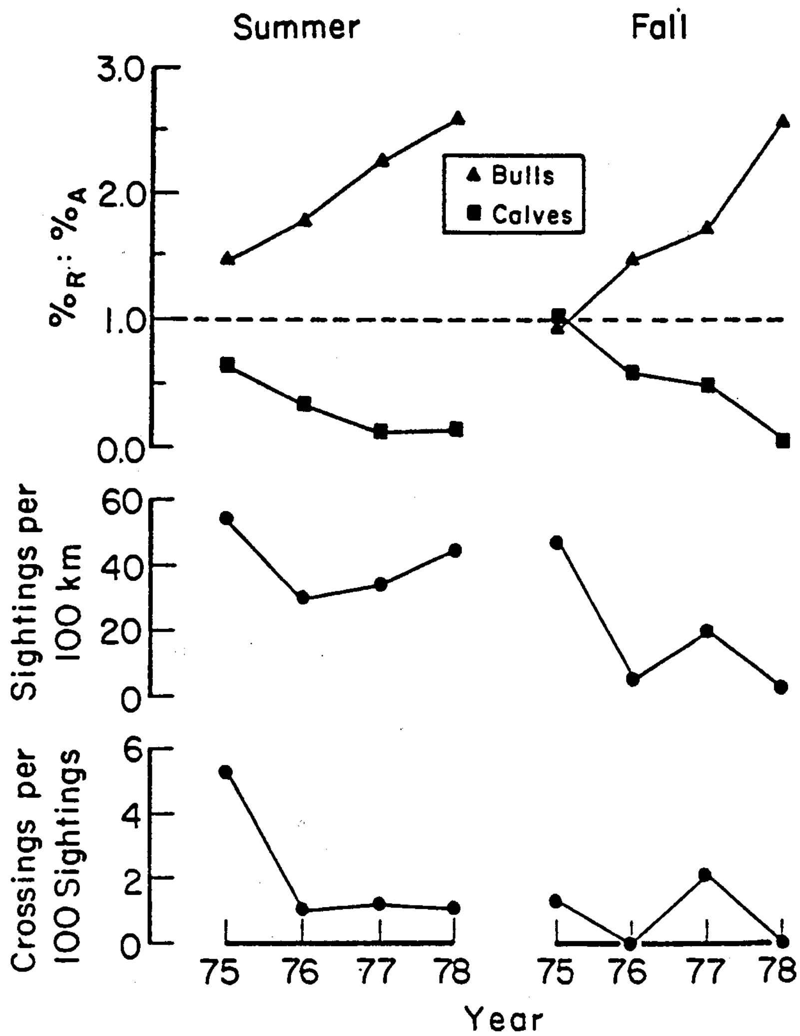


Fig. 2. Changes in relative calf and bull representation, caribou sighting frequency, and crossing rate associated with the Trans-Alaska Pipeline corridor, summer and fall 1975-1978. NOTE: $\%_R:\%_A$ = ratio of calf or bull percentages observed from the haul road to those determined by aerial survey.

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 2-1/2 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 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).

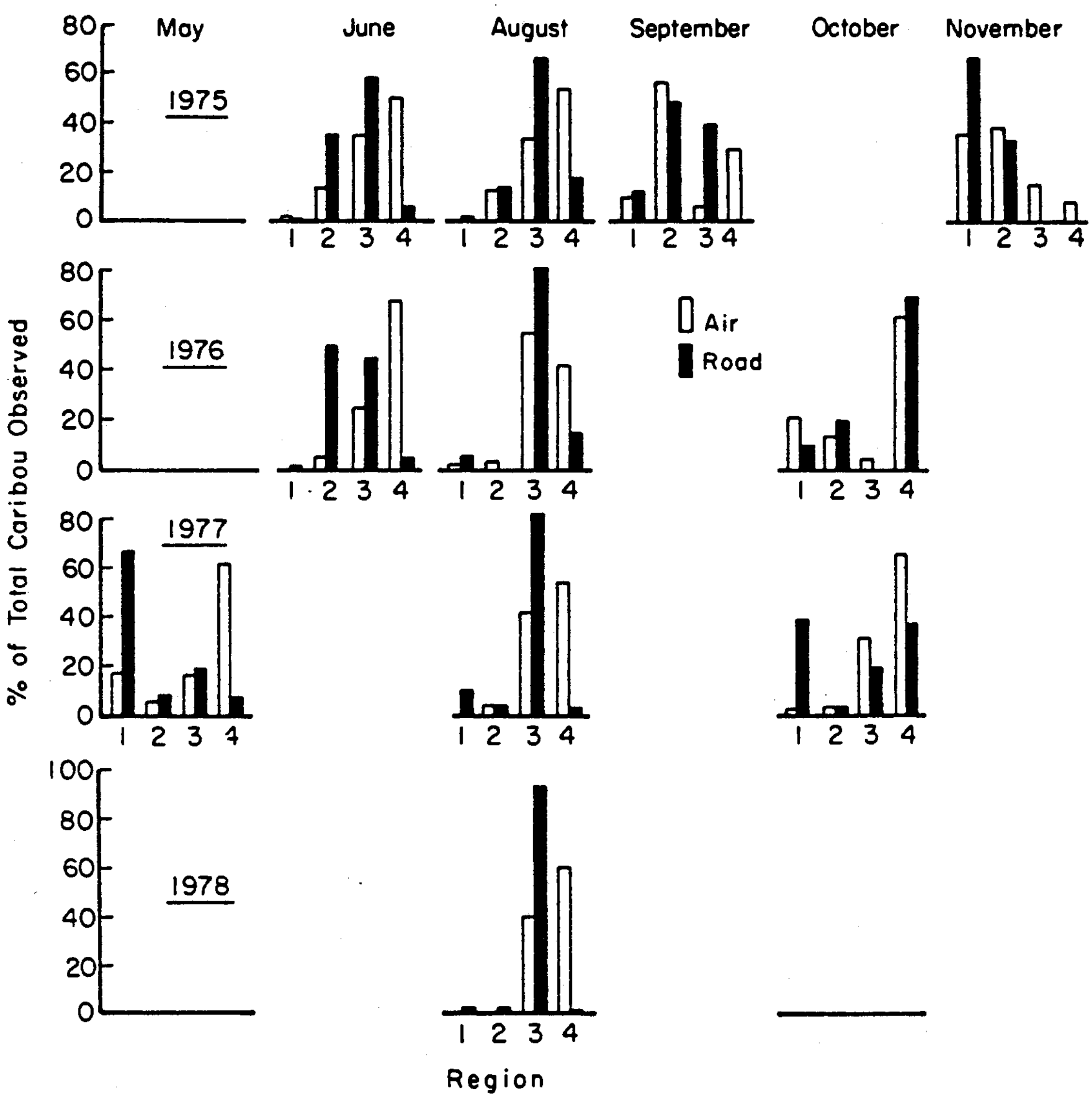


Fig. 3. Regional distribution (see Fig. 1) of caribou determined from corresponding aerial and haul road surveys, 1975-1978.

## 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 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 percentage 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 <u>without</u> 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 <u>high</u> local occupancy by groups <u>without</u> calves. It is noteworthy that in summer 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.

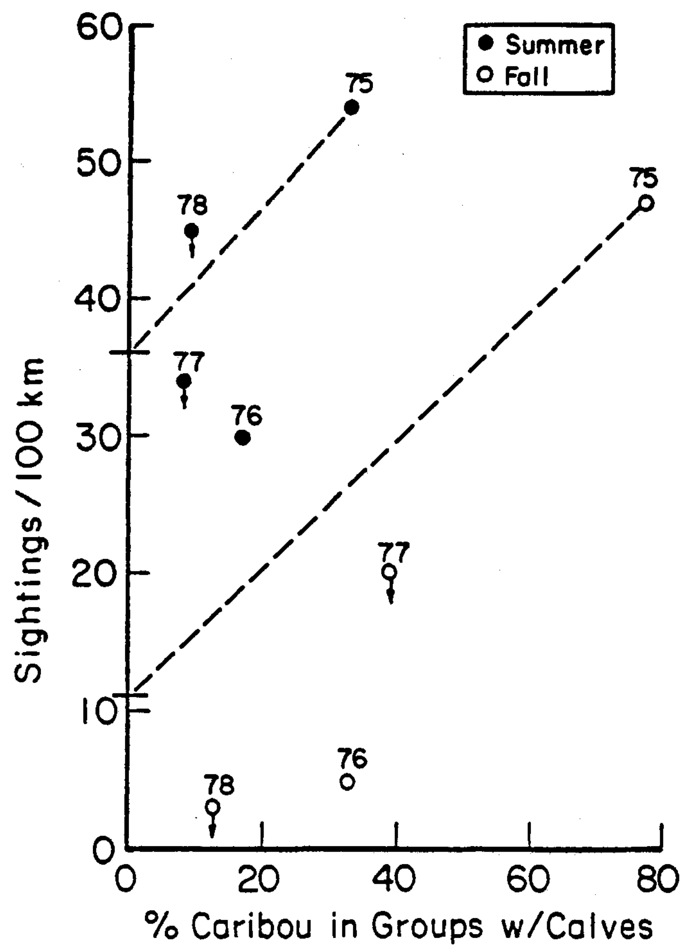


Fig. 4. Caribou sighting frequency along the Trans-Alaska Pipeline corridor in relation to the percentage of total caribou observed in groups with calves. NOTE: Dashed lines are projected from composition data in Tab. 1.

## 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).

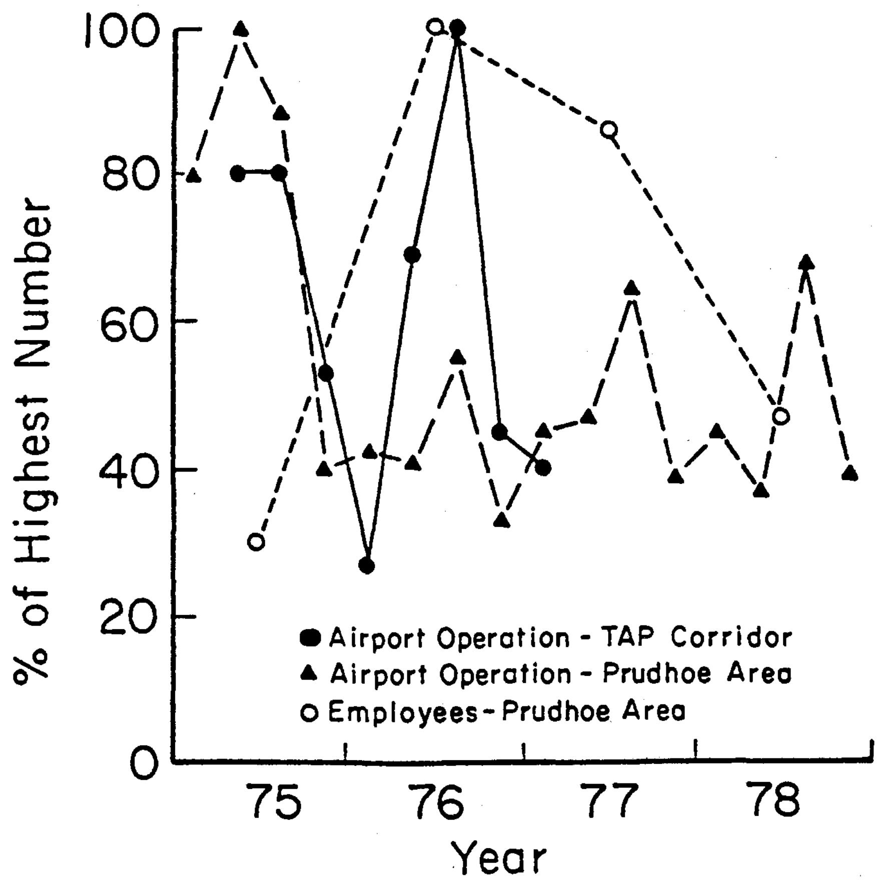


Fig. 5. Relative quarterly changes in total airport operations along the Trans-Alaska Pipeline corridor (Franklin Bluffs, Happy Valley, and Galbraith Lake airports; see Fig. 1) and within the immediate Prudhoe Bay oilfield (Deadhorse and nearby Prudhoe Bay airports; see Fig. 1); and relative annual changes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

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 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. Also required is detailed knowledge of the optimal timing, acceptable types, and permissible levels of disturbance within caribou range.

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APPENDIX II

# NUTRIENT DYNAMICS OF CARIBOU FORAGE ON ALASKA'S ARCTIC SLOPE

K. R. Whitten and R. D. Cameron

Presented at the Second International Reindeer/Caribou Symposium, Røros, Norway
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# NUTRIENT DYNAMICS OF CARIBOU FORAGE ON ALASKA'S ARCTIC SLOPE

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Abstract

Selected forage species (Salix pulchra, Cham., Pedicularis Langsdorffii, Fisch., Eriophorum vaginatum, L., and Carex aquatilis, Wahlenb.) were collected from 9 equally spaced sites on caribou (Rangifer tarandus granti, Banfield) range between the Beaufort Sea and the Brooks Range on the arctic slope of Alaska. Phenological progression was also monitored at these sites by recording flowering dates of conspicuous forbs. Forage samples were analyzed for N, P, K, Ca, Mg, Na, and total nonstructural carbohydrates (TNC), and data from sites within each of 4 latitudinal intervals were combined. Generally, within each region N, P, and K composition decreased steadily for all species through the growing season, while Ca content usually increased; changes in the amounts of other nutrients were less consistent. Phenology progressed from south (initiation of growth ca. 8-10 June) to north (ca. 1 July), and temporal changes in nutrient composition were consistent with the northward delay in phenology. The dicots analyzed were higher in N, P, Ca, and Mg than the monocots. TNC and K also showed consistent differences among species, but Na content was similar for all species. Some sampling sites were apparently deficient in Ca. Caribou have the opportunity to maximize forage nutrient quality during spring and summer by migrating north as phenology progresses and also by selecting among species and among local feeding sites.

## 1. Introduction

During the summer growth season, forage quality for herbivores is usually correlated with nitrogen (N) and phosphorus (P) content. These nutrients are usually most concentrated during the early stages of plant growth. As plant tissues mature, minerals and organic matter of low digestibility (i.e. crude fiber, lignin, etc.) accumulate, thus diminishing N and P levels by dilution. Later, N and P are further reduced in availability to grazers through active translocation to storage tissues in roots and stems. Soluble carbohydrates tend to increase during the plant growing season and then decrease during senescence. After senescence, even some inorganics may be lost from standing dead plant tissues through leaching and bleaching. Thus, N and P availability during the growing period and carbohydrate or total energy content during non-growth periods (e.g. winter), are both related to plant phenology (Stoddart and Smith 1955, Oelberg 1956, Klein 1970).

Factors which affect plant phenology may vary along several environmental gradients, including latitude, altitude, and slope/aspect. On any grazer's range these factors can work in concert or in opposition to determine local plant phenology. A varied topography, or ability to move over long latitudinal distances, provides a wide variation in initiation of plant growth and duration of early growth stages over the range of a grazer (Klein 1970).

Several workers have suggested that caribou follow plant phenological events (Lent 1966, Kelsall 1968), tending to maximize their intake of N and P (Klein 1970). The objective of this study was to determine if this general pattern applies to the Central Arctic Caribou Herd (CAH).

## 2. Description of the study area

The study was conducted along the Trans-Alaska Pipeline haul road from the arctic coast at Prudhoe Bay to the north side of the Brooks Range near Galbraith Lake (Fig. 1). Over this 270-km distance, the road cuts perpendicularly across the major physiographic provinces (Wahrhaftig 1965) on the arctic slope in Alaska. A poorly drained coastal plain of low relief extends 140 km inland. The shallow depth of thaw and flat terrain result in extensive areas of wet meadows and oriented lakes and ponds. Mean elevation is about 180 m where the plain joins the foothills. The foothills consist of a northern section of rolling, rounded hills extending inland to about the mouth of the Ribdon River. Southward, the terrain rises more steeply, with mean elevation reaching 850 m. The mountains rise steeply to over 2,000 m at the southern end of the study area.

Single-stemmed sedges of the genera Carex and Eriophorum dominate the vegetation of the coastal plain, the tussock-forming sedge Eriophorum vaginatum typifies the foothills, and Dryas octapetela, L. characterizes the mountains. Stream margins and outwash plains in the mountains, foothills, and southern portion of the coastal plain are lined by tall willows (Salix spp.). The dense stands of riparian willow give way to scattered low-growing or prostrate willows farther north near the arctic coast.

Within the study area snow melt proceeds from south to north, with windswept ridges and river floodplains in the mountains and foothills generally snow free by mid- to late May. There is a pronounced maritime influence on weather over the coastal plain. Snow-free ground does not usually occur along the coast before 1 June, and snowmelt is not complete until 10-15 June.

## 3. Methods

Nine sampling sites (A-I) were located approximately every 13' of latitude along the haul road from the extreme southern arctic foothills (68°40'N) to the coast at Prudhoe Bay (70°20'N). Most sites were on or adjacent to the Sagavanirktok River floodplain. However, the southernmost site was located on the upper Kuparuk River, and the northernmost site was located on the coast about 12 km west of the Sagavanirktok Delta (Fig. 1). To minimize effects of slope and aspect, only level sampling sites were selected. The sites were visited biweekly on or near the 10th and 25th of each month, beginning in June and continuing through September. However, no visits were made on 10 September, and not all sites were sampled on 25 August.

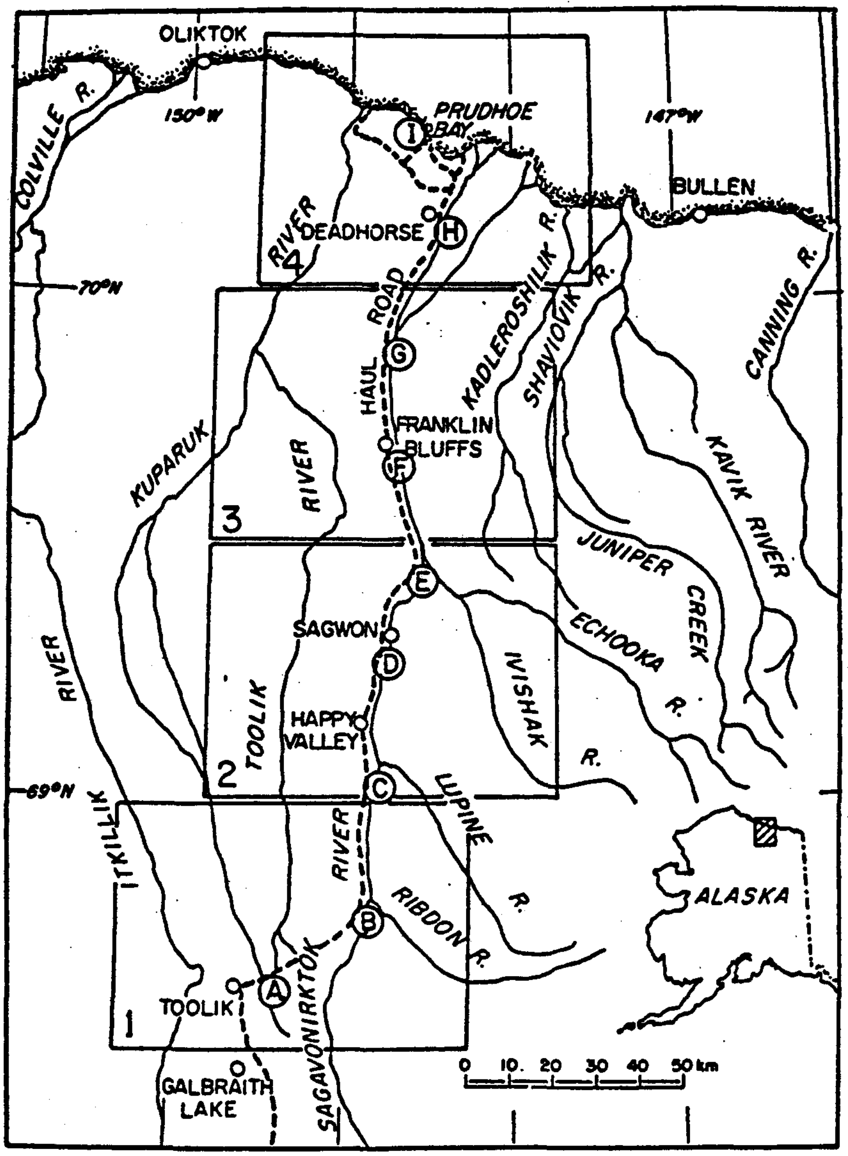


Fig. 1. The study area, with sampling sites (circled letters) and Regions used for analysis of forage nutrient dynamics (rectangles).

Phenology on the sample sites was monitored by observing flowering of forbs. Forb species with conspicuous flowers were noted at each site from when they first appeared in full flower to when all or most individuals with current-year floral parts had ripened (i.e. petals and/or sepals withered or dried). All plants were identified following taxonomy in Hultén (1968). We assumed that a species flowers at the same growth stage regardless of location, and that most species at a given location tend to initiate growth and subsequent flowering synchronously. Only species which occurred on 4 or more sites were included in the analysis of flowering to avoid biasing results with species that might be restricted to microhabitats not present on all sites.

Carex aquatilis, Pedicularis Langsdorffii, Eriophorum vaginatum, and Salix pulchra occur throughout the study area, and were used to investigate nutrient dynamics during the summer growing season. Collections included primarily those tissues eaten by caribou; i.e. stems and leaves of C. aquatilis and P. Langsdorffii, flowering stalks of E. vaginatum, and leaves only of S. pulchra. Samples consisted of the current year's growth, including senescent and dead material late in the season. Either C. aquatilis or E. vaginatum was absent on a few sample sites, but S. pulchra and P. Langsdorffii occurred on all sites. Tissues from several individuals of a species were pooled to form a representative sample for that site. Generally, all species were collected in close proximity to each other, but at site D, about 5 km separated E. vaginatum from the other species, and at site I, C. aquatilis was collected about 1 km from the other species (see Fig. 1).

Samples were stored frozen in plastic bags until analysis. After drying at 65°C for 24-36 hours, samples were sent to the University of Alaska Agricultural Experiment Station, Palmer Research Center, for chemical analysis. Plant tissue digestion followed the method described by Isaac and Johnson (1976), and N and P were measured with a Technicon Autoanalyzer. Potassium (K), calcium (Ca), magnesium (Mg), and sodium (Na) were determined from the digest by atomic absorption. Total non-structural carbohydrate (TNC) was determined using the "Modified Weinmann Method of Removing Total Nonstructural Carbohydrates" (Smith 1969). However, the extract was analyzed for reducing power by the Technicon Autoanalyzer method for "Reducing Sugars in Tobacco Extracts" using ferricyanide reduction rather than copperiodometric titration.

Other studies (Cameron et al. 1979, Cameron and Whitten 1980) have divided the study area into 4 regions for determining caribou distribution in relation to pipeline construction activities. Boundaries of these regions closely follow divisions between physiographic provinces. Sample sites within the southern and northern foothills fall into Regions 1 (sites A and B) and 2 (sites C, D, and E), respectively. The sites on the coastal plain are split evenly between Regions 3 (sites F and G) and 4 (sites H and I) (Fig. 1). Mean nutrient concentrations by species for combined sites within each region were calculated to facilitate comparisons of nutrient dynamics and forage phenology with caribou distribution.

## 4. Results

### 4.1. Flowering phenology

Tab. 1 shows the progression of flowering in selected forbs from the 9 study sites. Numerical scoring was not intended to indicate a "mean flowering date," since actual flowering or senescence could have occurred any time during the 2 weeks between sample dates. Rather, it was intended to order the sites according to progression of flowering. The order correlates strongly with increasing latitude. Only sites D and E, and H and I were reversed in order. Thus, phenology followed a south to north gradient across the study area.

Tab. 1. Flowering phenology of common (occurring at 4 or more sampling sites) dicots.

| SPECIES | SITE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I |
| Anenome narcissiflora | B[1] | AB | AB | B | | C | | | |
| Arctostaphylos alpinum | | | A | B | B | B | | | |
| Pedicularis Langsdorffii | B | AB | ABC | C | BC | C | CD | | CD |
| Andromeda polifolia | BC | BC | B | | C | | | | |
| Rhododendron lapponicum | | BC | B | BC | | C | | | |
| Cardamine hyperborea | | C | | C | D | D | D | D | C |
| Cassiope tetragona | | BC | BC | BC | B | C | | D | |
| Hedysarum alpinum | | C | C | | | D | | | |
| Pedicularis capitata | | BC | B | C | | | D | D | |
| Pyrola grandiflora | | B | C | | D | | | | |
| Valeriana capitata | BC | BC | | C | D | | | | |
| Astragalus umbellatus | | C | BCD | CD | | CD | | | |
| Dryas octopetela | | B | BC | BCE | | C | | CD | CDE |
| Ledum palustre | BC | BC | | C | C | | | | |
| Papaver Macounii | | C | | E | D | CDE | | DE | |
| Polemonium acutiflorum | BC | D | | D | | | | | |
| Polygonum bistorta | BCE | BC | CD | C | C | | | | |
| Saxifraga hirculus | B | CD | | D | DE | | DE | E | DE |
| Minuartia spp. | | | | | | D | | D | D |
| Pedicularis sudetica | | C | | | C | | D | D | D |
| Potentilla fruticosa | | CDE | D | D | | | | | |
| Polygonum viviparum | | D | CD | DE | | DE | DE | | |
| Saxifraga hieracifolia | | | | C | C | | | | E |
| Senecio spp. | | | | D | | D | D | DE | |
| Stelleria spp. | D | | E | C | | | | | DE |
| Parnassia spp. | | E | DE | DE | | | | | |
| Sausseurea angustifolia | | E | D | E | | | | | E |
| SCORE[2] | 2.67 | 2.72 | 2.85 | 3.41 | 3.27 | 3.59 | 4.10 | 4.17 | 4.14 |

[1] Key: A=flowering on 10 June; B, on 25 June; C, on 10 July; D, on 25 July; E, on 10 Aug.

[2] Scoring: 1 pt for each A; 2 for each B, etc. Sum for each site divided by number of entries to give final score.

## 4.2. Nutrient dynamic trends

Fig. 2 shows nutrient dynamics in the 4 selected caribou forage species. N and P dynamics followed a similar trend in all species in all regions.

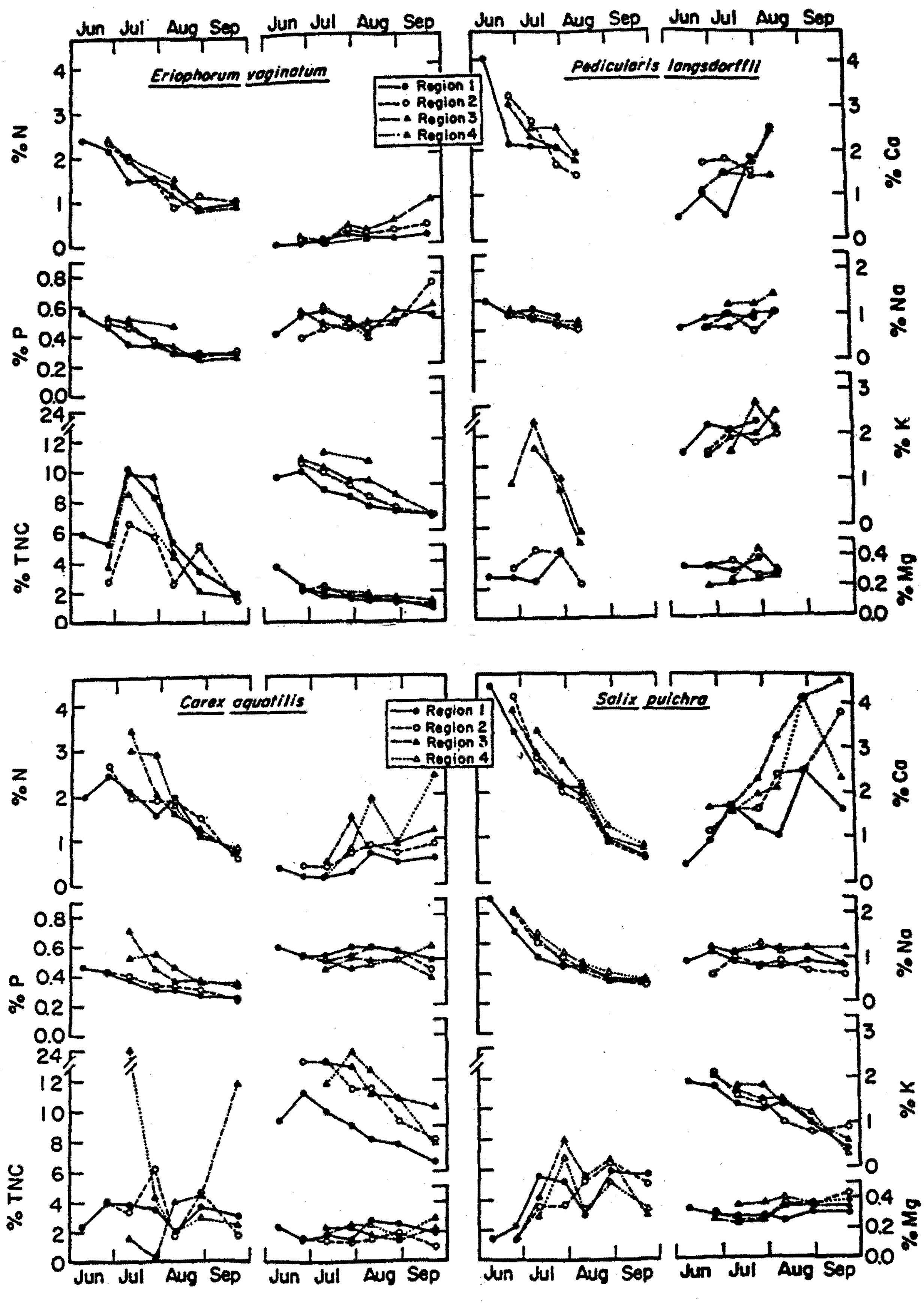


Fig. 2. Seasonal nutrient dynamics of caribou forage plants.

Concentrations were usually highest on the first collection date, representing the period closest to the onset of growth. Thereafter, concentrations declined steadily. In E. vaginatum, C. aquatilis, and S. pulchra, K showed a seasonal trend similar to N and P; however, the initial concentrations were often maintained or even slightly increased in the second collection before a steady decline started. In contrast, K levels in P. Langsdorffii increased throughout the growing season. Ca concentrations usually increased steadily during the study period in all species, with the greatest increases in S. pulchra and the smallest in E. vaginatum. Thus N, P, K, and Ca concentrations were all related to plant growth stage.

Dynamics of other nutrients were far less consistent among either species or regions and showed no regularity among species in relation to plant growth stage. Mg declined slightly through the season in E. vaginatum in all regions, but in the remaining species, Mg generally varied slightly about a mean. The most common trend in TNC concentrations was an increase through the middle of the growing season and then a decrease toward the end of the season. Na concentrations showed little variation through the season in any species or region.

## 4.3. Regional differences in nutrient dynamics

New plant growth was available by 10 June on the southernmost sites (Region 1), but did not appear on the northernmost sites (Region 4) until 10 July. At intermediate sites (Regions 2 and 3), new growth had appeared over a wide area by 25 June. In all regions initial concentrations of N, P, and K were similar within a species, but there were small differences in initial concentrations among regions which may be an artifact of the biweekly sampling scheme. That is, growth may have started any time during the 2 weeks before actual collection. The data show that when first collections were made simultaneously in 2 or more regions the concentrations of N, P, and K from the northern regions were usually higher and thus presumably reflect earlier stages of plant growth (see 4.2, above). The nutrient dynamic curves for N, P, and K clearly show similar seasonal patterns in each region, but there is a displacement toward later dates at the more northern regions (Fig. 2). Regional differences in concentrations of N, P, and K thus appear to correlate closely with date of collection and time since growth initiation (4.1, above).

The regional differences in nutrient concentrations described above for N, P, and K are mainly temporal, reflecting the interrelationship between phenology and latitude. Although TNC concentrations showed no consistent correlation to plant phenology, there was a tendency for TNC concentrations to be higher in Regions 3 and 4. Ca concentration tended to increase during the growing season in all species from all sites, but it showed no clear regional trends. This relationship was probably confused by large intersite differences in Ca concentration (see 4.5, below).

## 4.4. Species differences

The dicots *P. Langsdorffii* and *S. pulchra* were higher in initial N and P concentrations than were the monocots *C. aquatilis* and *E. vaginatum*, and they remained higher until senescence, when concentrations in *S. pulchra* and the 2 monocots apparently stabilized at about the same level. *P. Langsdorffii* was higher in N and P than the other species when it was last collected in early August. Cured stalks were not collected in late August or September, however, so it is not known whether those relatively high N and P levels persisted. N and P concentrations in *P. Langsdorffii* and *S. pulchra* were similar on the last dates on which both species were collected together.

Mg and Ca levels were also consistently higher in the dicots than in the monocots. *E. vaginatum* in particular had very low levels of Ca all season. One exception occurred in Region 4, where *C. aquatilis* had Ca concentrations similar to those in *S. pulchra* and higher than in *P. Langsdorffii*. However, *C. aquatilis* was collected about 1 km from the other species at the northernmost site in Region 4, and there was a possible Ca bias at that particular site (see 4.5, below).

The highest TNC levels were reached in *P. Langsdorffii* and *C. aquatilis* in Regions 3 and 4, but those peaks were of short duration. Otherwise TNC content was generally higher in *E. vaginatum* and *S. pulchra*. Peak TNC concentrations in *S. pulchra* came slightly later than the peak levels in *E. vaginatum*.

K levels were higher in *S. pulchra* and *C. aquatilis* than in *E. vaginatum*. K concentration in *P. Langsdorffii* increased through the summer, while it decreased in the other species. Therefore, K Levels in *P. Langsdorffii* were the lowest of all species early in the season and the highest later. Na concentration was roughly the same for all species, and any differences did not appear to be systematic.

## 4.5. Site differences

Ca concentrations in *S. pulchra* and *P. Langsdorffii* were much lower in sites A, E, and I than in any of the other sites (Tab. 2). Results from *E. vaginatum* and *C. aquatilis* were less conclusive, however. Ca concentrations in *E. vaginatum* at site A were lower throughout the growing season (0.01 to 0.11%) than in the remaining sites (0.1 to 0.95%). Initial Ca concentration in *C. aquatilis* from site A was about 0.4% (possibly due to contamination with standing dead material), but declined to 0.05%, followed by a gradual increase to about 0.2%; all other sites started around 0.3-0.5% and subsequently increased to 0.7-2.7%. At site E, initial Ca levels in *E. vaginatum* were very low, similar to site A, but by senescence Ca levels there fell well within the range of the other sites; no *C. aquatilis* was collected from site E. At site I, no *E. vaginatum* was collected, and *C. aquatilis* did not show lowered Ca concentrations, but it was collected about 1 km from *S. pulchra* and *P. Langsdorffii* and may not reflect the same localized conditions.

Tab. 2. Intersite differences in Ca concentration.

| Species | Ca Concentration (%) Initial A,E,I | Initial All Others | Final A,E,I | Final All Others |
|---|---|---|---|---|
| Salix pulchra | 0.3-0.6 | 1.1-1.7 | 0.6-1.2 | 2.0-4.9 |
| Pedicularis Langsdorffii | 0.5-1.4 | 0.3-3.0 | 0.3-1.1 | 1.6-3.3 |

## 5. Discussion

Observations of flowering in dicots, onset of growth in the species collected for nutrient analysis, and comparison of regional nutrient dynamic curves all indicated a steady progression in plant phenology from south to north on similar sites across the study area. Concentrations of N, P, and, for the most part, K in caribou forage showed clear and consistent trends which were a function of phenology. In spring and early summer, when recovering from winter privation, growing new tissues, or raising young, caribou have high metabolic demands for N and P (Klein 1970). Peak forage N and P concentrations described in this report were comparable to those found in other arctic tundra areas (Tener 1965, Chapin et al. 1975) and they are high compared to most temperate and tropical forages (Klein 1970). They are, however, lower than those reported for some alpine tundra areas (Johnston et al. 1968, Whitten 1975). Assuming the plants analyzed in this study were representative of other plants in the diet of caribou, the peak N and P levels should support rapid body growth. N and P concentrations peaked with or shortly after initiation of growth, but declined rapidly thereafter at any one site. A grazer such as the caribou could theoretically maximize P and N intake and growth potential over a longer time period by following plant phenology from south to north across the study area.

In the CAH, bulls tend to follow the progression of phenology more closely than cows, remaining south longer and traveling north more slowly. On south-facing slopes in the mountains and southern foothills, new plant growth is available in mid- to late May, 2-3 weeks earlier than on the level sites used in this study. By starting in the southern foothills in May and arriving on the coast in early July, most CAH bulls make use of peak quality forage over nearly an 8-week period. In some years, many caribou overwinter on the coastal plain, but proportionately fewer bulls than cows follow this pattern. Most of those bulls which remain on the coastal plain during winter move south in late May, presumably to improved forage conditions. This observation is supported by bull/cow ratios on the coastal plain in May 1977, 1978, and 1979 which averaged 67:100 while in June they averaged 5:100 (Whitten and Cameron unpubl.). Cows arrive on the coastal plain between late April and early June, when little if any new growth is present. Perhaps the survival benefits of moving to the essentially predator-free calving grounds outweigh the loss of some prime forage. Some new growth does become available on the calving grounds shortly after parturition, when nutrient demands of females are highest.

In addition to the phenological/latitudinal trends in N, P, and K concentrations, there were other consistent differences among regions, species, and/or individual sites that presented opportunities for selective foraging. TNC reached its highest concentrations during July on the coastal plain, when most of the CAH occupies that area. Chapin et al. (1975) suggested that during midsummer dicots would be better forage than monocots (assuming similar digestibility), and in the CAH there appears to be selection by caribou for dicots, which are higher in N and P than monocots. Even though dicots make up a small part of the plant biomass in wet tundras (Chapin et al. 1975), such as are dominant on the arctic coastal plain (Regions 1 and 2) where most of the CAH summers, White et al. (1975) found selection for willows by caribou at Prudhoe Bay. While we have no quantitative data on caribou diets from this study, we have observed caribou cropping P. Langsdorffii, P. sudetica, Willd., and prostrate willows (Salix spp.) from Carex and Eriophorum stands. The intersite differences in Ca concentration indicate that even small-scale movements can lead to large differences in intake of this nutrient. However, no data are available to relate this to distribution or movement of the CAH.

Within a species, regional nutrient concentrations tend to converge at senescence, which is induced by widespread frosts in mid- to late August in the range of the CAH. At this point the opportunity for selective foraging by following gross latitudinal trends in phenology, breaks down. CAH caribou disperse over a wider area, but remain in the northern half of the study area (Cameron and Whitten 1979) where N and P concentrations are slightly higher (Fig. 2). In late summer and fall local site differences in microclimate may still provide some variation in plant growth stage, and hence some opportunity for selectivity on a local level. Lake and stream margins, for example, seem to provide a frost shelter and remain green when most vegetation has senesced. Caribou make considerable use of such microhabitats, which are abundant on the coastal plain. Often plants in protected areas may freeze permanently before senescing totally, thus providing a slightly higher source of N and P and perhaps a very good source of carbohydrate during winter. Again, caribou are observed to use such plants.

Hence, caribou movements are not random, but are related in part to forage phenology during spring and early summer. Movements to and from insect relief habitats probably involve optimizing tradeoffs between energy expenditure and nutrient intake (Roby 1978), as do fall and winter movements, whether locally or on a large scale. Hence, reductions in caribou sighting and crossing rates along the haul road from 1975 to 1978 (Cameron and Whitten 1980) are reason for real concern, since they may well represent disruptions in movement patterns that have evolved over long periods of time.

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APPENDIX III

SURVEY-INVENTORY PROGRESS REPORT
ON THE CENTRAL ARCTIC HERD
1976-1979

K. R. Whitten

CARIBOU

SURVEY-INVENTORY PROGRESS REPORT

Game Management Unit 26B - Central Arctic Slope

Period Covered: July 1, 1976 - June 30, 1979

## Population Status and Trend

The Central Arctic Herd (CAH) was identified as a separate subpopulation in 1974. Since that time it has remained relatively stable at 5,000-6,000 caribou. Prior to the early 1970's, large yearly influxes of caribou from the Western Arctic (WAH) and/or Porcupine Herds confounded the separate identity of the CAH. Consequently, early data on trends and productivity are not available.

## Population Composition

Sex and age composition of the CAH has been determined two to three times annually since 1976. All counts were by helicopter or ground observation. Data obtained through May 1979 are summarized in Table 1.

Productivity and survival have been excellent for the past 3 years, with annual recruitment perhaps as high as 15 percent. The high bull/cow ratio (most reliable in fall surveys) is particularly striking. This sexual imbalance may have resulted from a disproportionately high number of bulls remaining with the CAH after the large summer influxes into the area ceased around 1971.

## Mortality

Natural mortality is unknown. However, wolves have been relatively common in the central Arctic compared to the western Arctic. Numerous instances of wolf predation were noted from 1974 through 1977, although the effect on herd productivity was never assessed. Wolf numbers have recently been reduced, through legal and illegal hunting, from at least three active packs in fall 1977 to only two to three individuals in spring 1979.

From 1959 to 1975 there was no closed season or bag limit on the CAH, although big game hunting has been prohibited in the Prudhoe Bay oil field since 1973 and within 5 miles of the Trans-Alaska Pipeline since 1975. Since 1976 the CAH has been included under the WAH permit hunt system. Harvest has always been low, probably never exceeding 50 caribou, and during the past 2 or 3 years annual harvests of the herd are estimated to be less than 20 caribou per year.

No Native villages are within the range of the CAH, although Nuiqsut is on the periphery, and Kaktovik and Anaktuvuk Pass may have occasional access to some CAH caribou. The local subsistence harvest has been

Table 1. Summary of sex and age composition of the Central Arctic Herd, 1976-78.

| Year | Cohort and Season | Cows | | Calves | | | Yearlings | | | Bulls | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | /100C | No. | % | /100C | No. | % | /100C | |
| 1976 | Post-calving (July) | 572 | 41 | 247 | 18 | 43 | 77 | 6 | 13 | 493 | 35 | 86 | 1386 |
| | Rut (October) | 440 | 36 | 204 | 17 | 46 | 40 | 3 | 9 | 539 | 44 | 125 | 1223 |
| | Spring (May) | 430 | 48 | 138 | 16 | 32 | --[a] | -- | -- | 321 | 36 | 75 | 889 |
| 1977 | Post-calving (July) | 1585 | 41 | 886 | 23 | 56 | 227 | 6 | 14 | 1149 | 30 | 72 | 3847 |
| | Rut (October) | 198 | 32 | 127 | 20 | 64 | 64 | 10 | 32 | 239 | 38 | 121 | 628 |
| | Spring (May) | 198 | 56 | 80 | 23 | 40 | -- | -- | -- | 73 | 21 | 37 | 351 |
| 1978 | Post-calving (July) | 1831 | 45 | 997 | 25 | 54 | 302 | 7 | 16 | 913 | 23 | 50 | 4043 |
| | Rut (October) | 293 | 36 | 187 | 23 | 64 | 56 | 7 | 19 | 280 | 34 | 96 | 816 |
| | Spring (May) | 201 | 40 | 121 | 24 | 60 | -- | -- | -- | 177 | 35 | 88 | 499 |

[a] "Long" yearlings classified as adult cows or bulls in May surveys.

minimal, even at Nuiqsut, since most villagers hunt within the range of the WAH.

## Management Summary and Recommendations

The CAH is a small herd with short seasonal migrations. To date, hunting has been a negligible mortality factor due to the remoteness of this herd (discounting access via the haul road, which is currently closed to the public).

Construction and operation of the Prudhoe Bay oil field and the Trans-Alaska Pipeline represent the major concerns for the welfare of the herd. Displacement from portions of traditional calving and summer range has been well documented, as has some disruption of daily and seasonal movements, but no direct effects on productivity or survival have been discernible. The herd is thought to be at low density relative to available range, but future trends are still of concern. Intensive research on the responses of the CAH to petroleum-related development has been in progess since 1974 and will continue (Cameron and Whitten 1976, 1977, 1978, 1979; Cameron et al. 1979). No changes in current management status are recommended (i.e. harvest should remain under the WAH permit system).

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