DISTRIBUTION AND MOVEMENTS OF CARIBOU IN RELATION TO THE KUPARUK DEVELOPMENT AREA

THIRD INTERIM REPORT

by

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SUMMARY

1. The calving grounds of the Central Arctic Herd were surveyed by helicopter in June 1980, and periodic surveys of the West Sak Road were conducted by light truck between mid-July and mid-August 1980.

2. Fewer caribou were observed on the coastal calving grounds in 1980 than 1978 or 1979, apparently in response to late snowmelt and spring flooding; relative density of calving caribou within the coastal area was similar in all 3 years, however. The highest concentration of calving caribou occurred between the West Sak Road and Oliktok Point. Observations from additional survey transects to the east indicated that a second calving concentration may occur east of Bullen Point.

3. The low incidence of calving near the Prudhoe Bay Complex was accentuated in 1980 because of extreme flooding.

4. During midsummer the mean calf percentage among caribou observed from the West Sak Road was approximately representative of caribou in the general region. However, changes in the pattern of calf representation along various sections of the road suggest a net redistribution of cow-calf pairs to the west.

5. The nodal pattern of caribou occupancy noted in previous years was not apparent along the West Sak Road in 1980. Only the Kuparuk floodplain was occupied preferentially; caribou were distributed fairly evenly along the remainder of the road.

6. The distribution of road crossings suggests that many caribou gathered near the Kuparuk River but crossed elsewhere to the west.

7. Variable numbers of caribou observed along the West Sak Road were attributable to weather-induced changes in insect activity.

8. A preliminary analysis relating the occurrence of calves along the West Sak Road to both local disturbance (fixed structures and construction/maintenance activity) and insect activity indicates that heavy disturbance was associated with reduced calf percentages; also, disturbance apparently has a greater effect on local calf representation than insect harassment.

9. Recommendations include strategic regional planning of development. Until such a plan is available, North Slope development should be approached conservatively.

BACKGROUND

Since the discovery of oil at Prudhoe Bay in 1967, much attention has been focused on the effects of oilfield and industrial development on fish and wildlife resources, and on barren-ground caribou (Rangifer tarandus granti) in particular. Wildlife surveys of the Central Arctic Slope conducted in the late 1960's and early 1970's indicated that the Prudhoe Bay region was probably within the peripheral ranges of both the Western Arctic and Porcupine Herds (Hemming 1971), and that some 20-30,000 caribou might occupy the general area during summer (Gavin 1973). After 1970, however, the number of caribou using this area declined rapidly, to an estimated 2,500 in 1972 (Gavin 1973). This apparent withdrawal paralleled a decrease in the size of the Western Arctic Herd, from 242,000 in 1970 (Hemming 1971) to 64,000 in 1976 (Davis and Valkenburg 1978). Since 1975 no large influxes from adjacent herds have been observed and it has become clear that caribou presently ranging in the vicinity of Prudhoe Bay and along the North Slope route of the Trans-Alaska Pipeline (TAP) constitute a separate subpopulation, now known as the Central Arctic Herd (CAH) (Cameron and Whitten 1979a). Although this herd has not been accurately censused, it undoubtedly exceeds 6,000 and has likely been increasing since at least 1977 (Cameron and Whitten 1979b, 1980c).

Caribou occupancy of the Prudhoe oilfield and TAP corridor has declined with sustained petroleum development. This response is primarily a reflection of local avoidance of the area by cows and calves (Cameron et al. 1979, Cameron and Whitten 1980b). In spite of displacement from previously occupied units of range, the herd is very productive. Nevertheless, existing conflicts with industrial development and the potential for progressive disruption elicit a number of concerns for the future well-being of the CAH and other caribou subpopulations on the Arctic Slope. Among the possible consequences is reduced survival of neonatal calves resulting from disturbance-induced displacement of parturient cows from traditional calving grounds. A second major concern is the potential restriction of summer movements in response to insect harassment, specifically the bioenergetic ramifications of reduced access to coastal insect relief areas. The ultimate mitigation of these and other conflicts will require a basic understanding of disturbance mechanisms, including the types and intensities of development that constitute negative stimuli, the threshold levels of disturbance that trigger range abandonment, the amount of displacement tolerable before overuse of remaining range occurs, and whether caribou will accommodate to local disturbance over time. Despite the present dearth of knowledge regarding these fundamental concepts, practical short-term mitigation of existing or imminent problems will become possible as relevant site-specific data are accumulated. Thus, general criteria developed for pipeline design and placement will hopefully maximize physical passage of caribou, and strategic scheduling of construction activity should minimize disturbance-induced displacement. Continued coordinated study, both basic and applied, will likely result in more specific guidelines for petroleum development on the Arctic Slope.

The present research program was initiated in 1978 to address some of these needs in the Kuparuk Development Area (KDA), located immediately west of the main Prudhoe Bay oilfield. This new development unit was known to lie within an active calving area and an important component of summer range. We believed that detailed knowledge of regional caribou distribution and movements would assist in the formulation of development practices which would accommodate caribou, hopefully within established geotechnical constraints. It would also provide an opportunity to identify and quantify the sources of local disturbance and the reactions of caribou to known stimuli. Finally, in conjunction with continued monitoring of CAH status, the present program represents an opportunity to document any related effects on population productivity.

In 1978 and 1979 the distribution of CAH calving activity north of 70°N latitude was examined through systematic aerial surveys, and midsummer ground surveys were conducted along the West Sak Road (Cameron and Whitten 1979c, 1980a). The density of calving caribou was highest north of the KDA and generally lower between Prudhoe Bay and Bullen Point; the incidence of calving was extremely low in the active oilfield near Prudhoe Bay, although parturient cows and neonates were observed south of the main complex. During midsummer of both years, mean calf percentage for groups observed from the West Sak Road was similar to the corresponding regional estimate. Numerical changes in caribou sightings were consistent with observed or predicted variations in insect activity. Areas of highest caribou occupancy along the West Sak Road and the majority of road crossing sites were associated with riparian systems. Relative use of these areas by caribou was seemingly influenced by the distribution and intensity of local disburbance.

This report describes the 1980 results of continued surveys of the CAH calving grounds and along the West Sak Road. These findings and various between-year comparisons are considered in relation to weather-related variables and disturbance within the KDA.

OBJECTIVES

Acceptable baseline data were obtained in 1978, and major study objectives for 1979 and 1980 were to identify and assess changes in:

1. the distribution and density of caribou calving in the vicinity of the Kuparuk Development Area;

2. the distribution, group composition, and movement patterns of caribou within the Kuparuk Development Area during summer; and

3. the overall trends in summer distribution of caribou west of the Kuparuk River.

METHODS

The calving grounds of the CAH were surveyed by helicopter on 11-12 June 1979 using a series of north-south transects (Fig. 1). Coverage and sampling methodology were essentially the same as in previous years (Cameron and Whitten 1979c, 1980a).

Post-calving aggregations were not large enough to accomplish surveys in 1980, and we were therefore unable to obtain midsummer data on herd

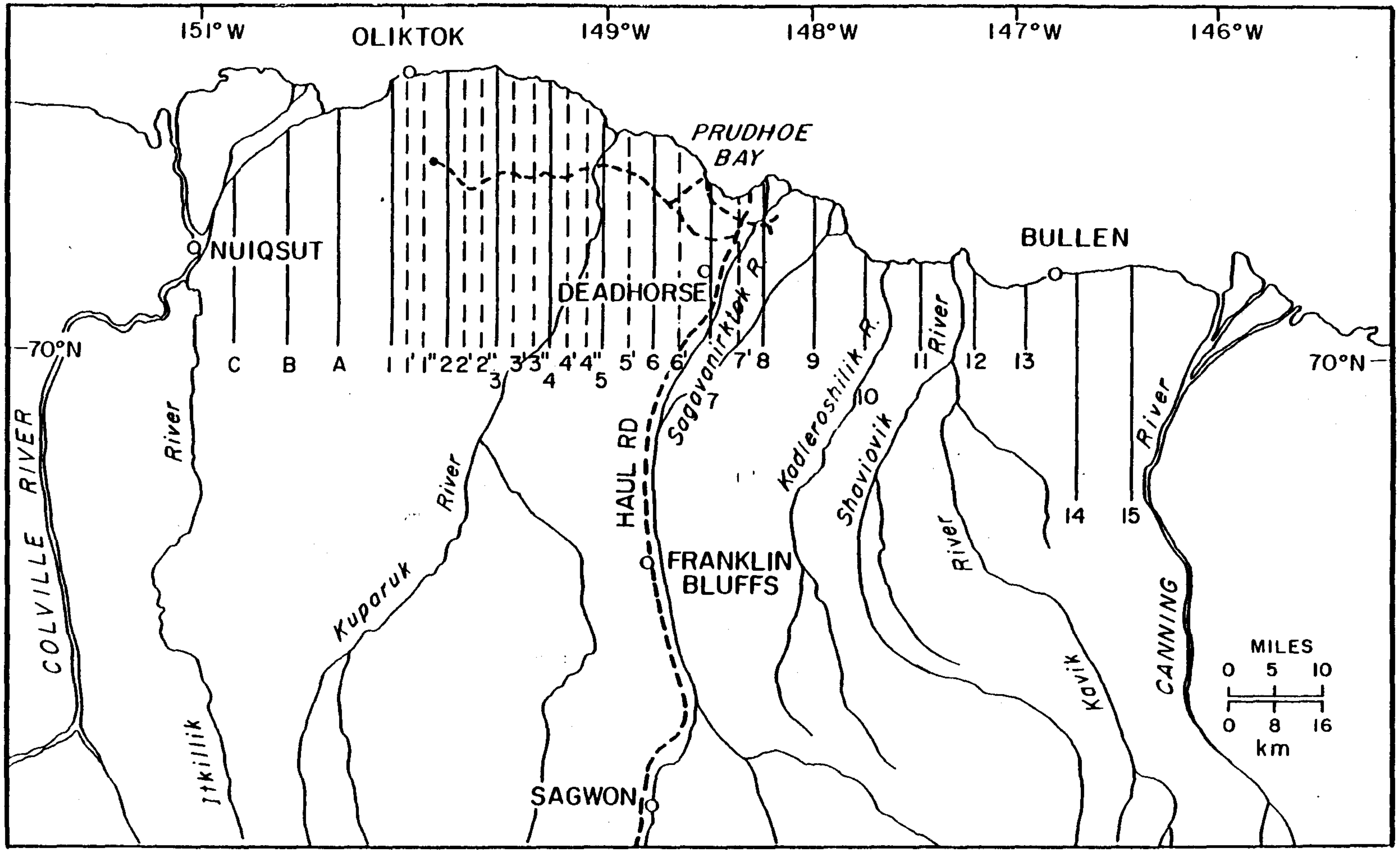

Fig. 1. Map of the study area showing aerial survey transects.

sex/age composition. However, an estimate of regional calf percentage for caribou west of the Kuparuk River was made on 8 August, a few days after inland dispersal had occurred. A north-south grid system was flown low-level by helicopter. Flight lines were at 10 km intervals, corresponding roughly to whole number transects 1 through 4 (Fig. 1) but extending only 30 km inland. We recorded the numbers of calves and adults within approximately 2 km of the aircraft. Additional aerial observations and relocations of radio-collared caribou were made on an opportunistic basis.

The West Sak Road (Fig. 2) was surveyed systematically (Cameron and Whitten 1979c) once or twice daily between 16 July and 8 August. In addition to the standard data recorded for each caribou observation (i.e., location, estimated distance from road, group composition, direction of movement), the location of construction/maintenance activity and the equipment in use were noted. For each survey, the level of insect harassment was estimated by direct observation (i.e., none, light, moderate, or severe), and prevailing weather was summarized. Hourly weather reports for Deadhorse Airport were obtained from the Arctic Environmental Information and Data Center, University of Alaska, Anchorage; mean insect levels were calculated (White et al. 1975) for each 4-hour period. Rates of vehicular traffic along the West Sak Road were estimated from records supplied by an ARCO security checkpoint located on the Kuparuk floodplain.

Caribou data obtained by road survey were entered in a computer file (Honeywell Model 20, University of Alaska) and programmed for the calculation of mean group composition based on the selection of the temporal, position, and/or distance variables. Calf percentages were compared by Chi-square analysis; significance was evaluated at the 95 percent confidence level.

FINDINGS AND DISCUSSION

Distribution of Calving Caribou

Total numbers and group composition of caribou observed during the 1980 calving surveys are listed in Appendix I. Fig. 3 shows the east-west distribution and relative density of caribou within the area surveyed. Even though the area surveyed in 1980 was larger, fewer caribou (787) were observed than in previous years (1923 in 1979, 964 in 1978). However, caribou sighting rates and densities in 1978 and 1980 were actually quite similar, except for the survey area between the Kuparuk and Sagavanirktok Rivers (Table 1).

In 1980, calving caribou west of the Kuparuk River were distributed relatively farther from the Arctic coast than in either 1978 or 1979 (Fig. 4). Nevertheless, in all 3 years of surveys, half or more of all caribou observed in this region were within 16 km of the coast. In contrast, few, if any, calves have been observed within 16 km of the coast in the area corresponding roughly to the Prudhoe oilfield. In both 1978 and 1979, most calving occurred south of the oilfield (Cameron and Whitten 1979c, 1980a). In 1980 very few caribou were observed on any transects between the Kuparuk and Sagavanirktok Rivers and no calves were within the oilfield (Figs. 1 and 3).

A particularly high concentration of calving caribou was observed between the Kuparuk River and Oliktok Point in both 1978 and 1979 (Cameron

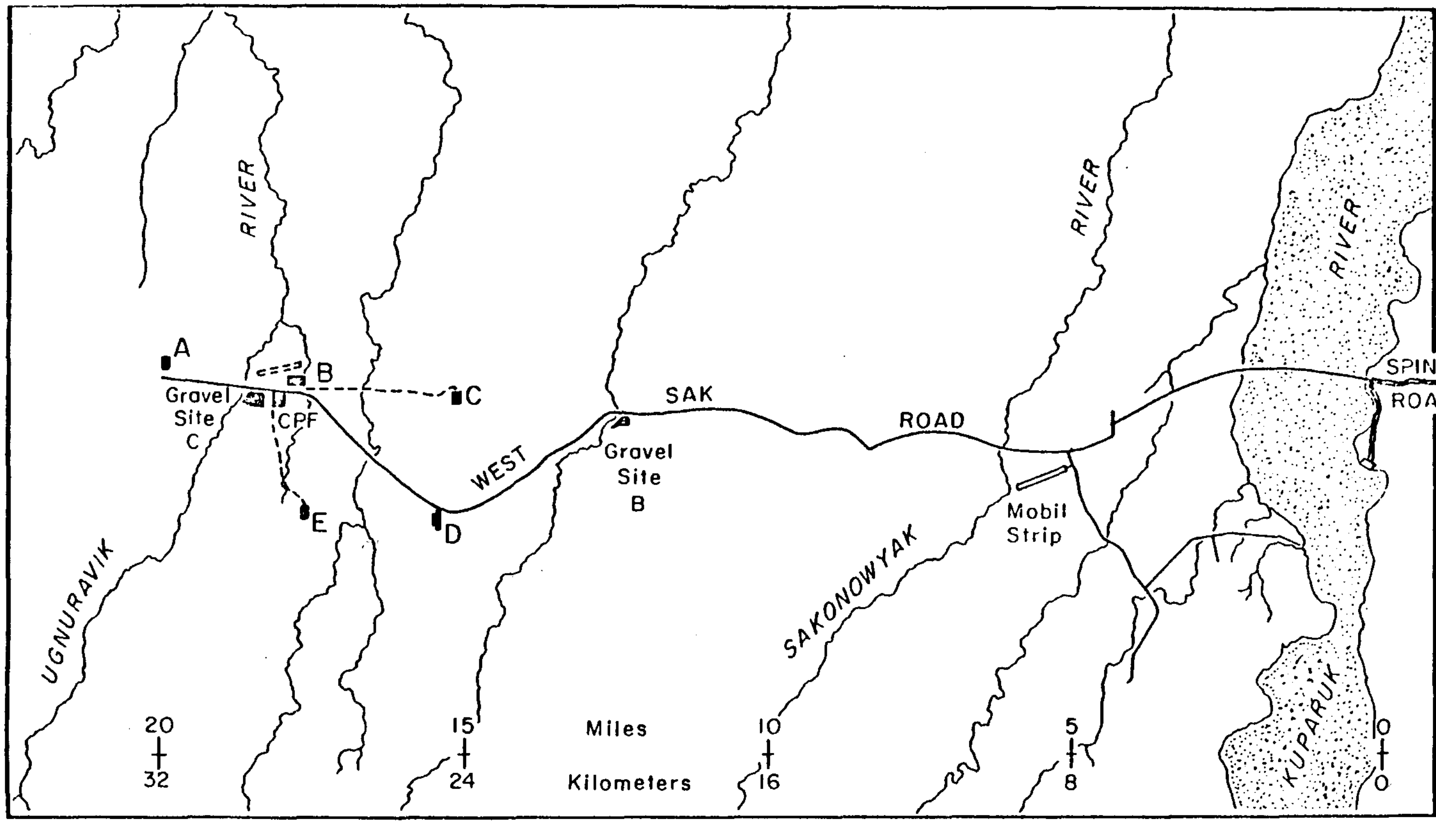

Fig. 2. The West Sak Road and associated facilities.

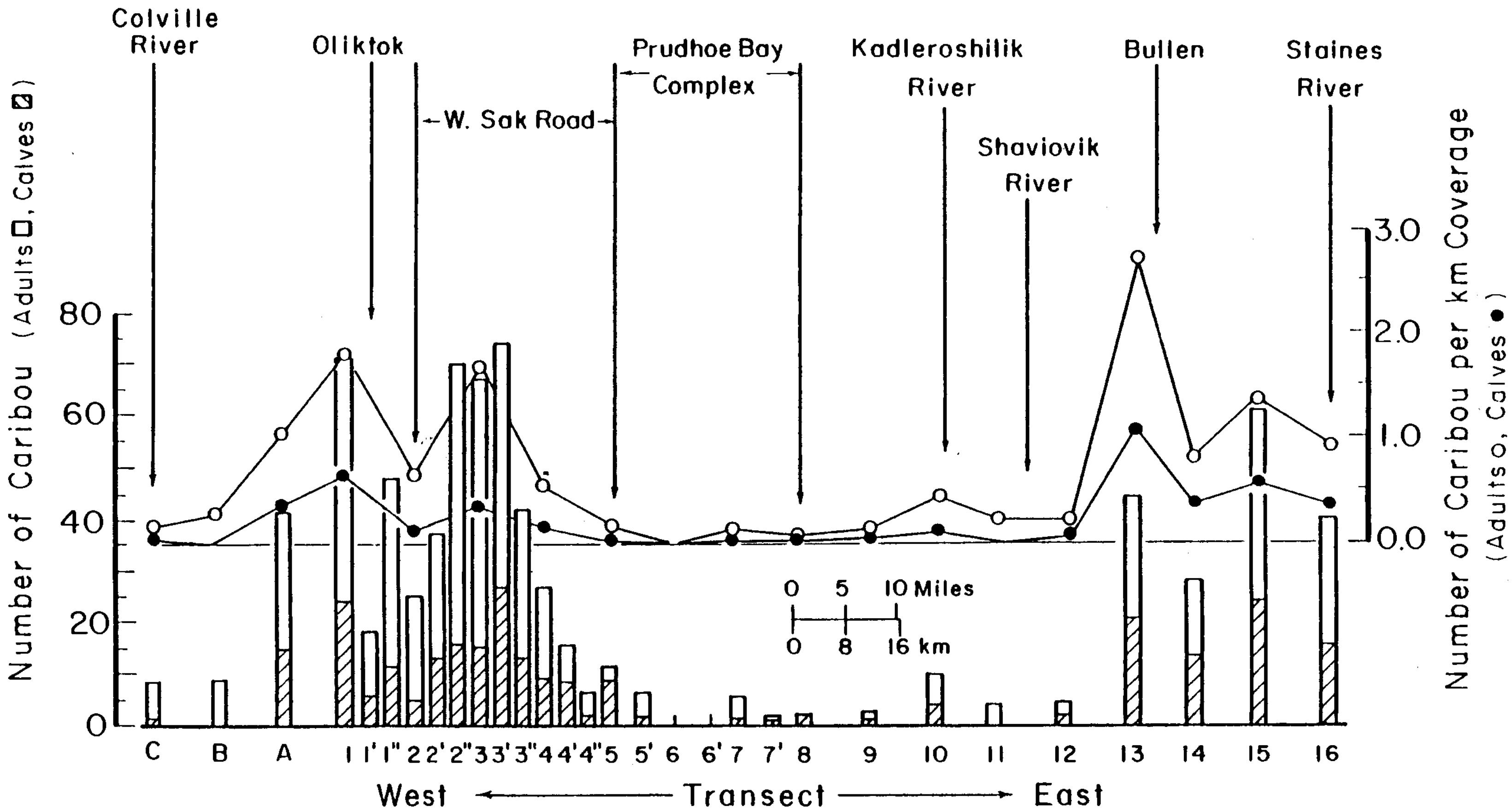

Fig. 3. East-west distribution of caribou during calving, and caribou sighting rate for each whole-number transect (see Fig. 1), 11-12 June 1980.

Table 1. Mean sighting rate and density of caribou on the Central Arctic Herd calving grounds in 1978-80.

Area	Year	Mean Sighting Rate (number/100km)		Mean Density (number/$100km^2$)	
		Total Caribou	Calves	Total Caribou	Calves
West of Kuparuk River	1978	124	44	38	14
	1979	380	152	119	47
	1980	118	34	37	11
Between Kuparuk River and Sagavanirktok River	1978	62	19	19	6
	1979	75	30	23	9
	1980	15	1	4	<1
East of Sagavanirktok River	1978	34	15	11	5
	1979	58	16	18	5
	1980	48	17	15	5
Total	1978	80	29	25	9
	1979	183	71	57	22
	1980	65	19	20	6

Table 2. Caribou densities in the Kuparuk calving concentration area, 1978-80.

Year	Caribou/$100km^2$	Cow-calf Pairs/$100km^2$
1978	281	112
1979	630	279
1980	276	90

Table 3. Group composition of Central Arctic caribou on the calving grounds, 1978-80.

Year	Percent Calves	Calves/ 100 Cows	Bulls/ 100 Cows	Yearling/ 100 Cows
1978	36	82	3	39
1979	37	85	7	26
1980	30	68	4	48

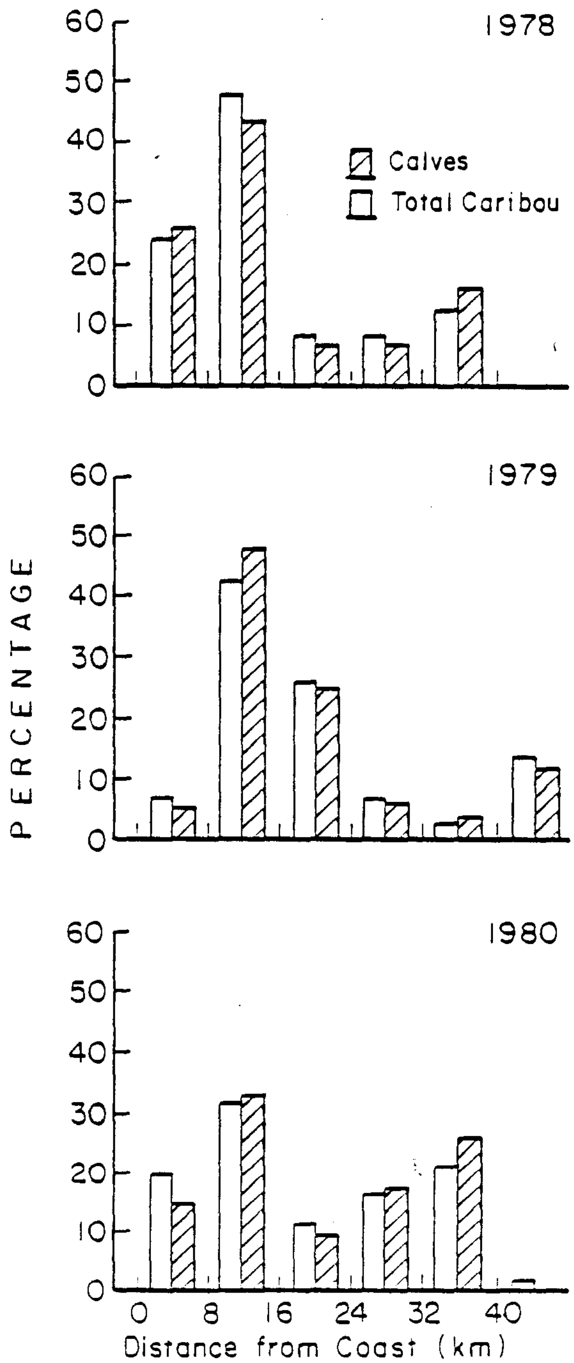

Fig. 4. Relative north-south distribution of caribou west of the Kuparuk River, June 1978-80.

and Whitten 1979c, 1980a). This same area again received heavy use in 1980. Table 2 shows minimum densities of caribou within this "core" area, and Fig. 5 shows its estimated location for all 3 years.

Calf production in 1980 was somewhat lower than in the previous 2 years (Table 3). Harsh winter and spring conditions may have contributed to reduced productivity. However, it is also possible that excellent calf production in 1978 and subsequent high yearling recruitment in 1979 (Cameron and Whitten 1980c) resulted in a large cohort of relatively unproductive 2-year-old cows in 1980. This would have the effect of lowering the calf-cow ratio.

West of the Kuparuk River the percentage of calves among caribou observed within 8 km of the West Sak Road (15%) was significantly lower than that for caribou more than 8 km from the road (34%) (Fig. 6). It is noteworthy that no calves were observed within 4 km of the West Sak Road.

Results of additional survey coverage to the west in 1980 indicated that calving north and west of the KDA extends little beyond the area surveyed previously. In fact, caribou density rapidly declined toward the Colville River (Fig. 3). Also, the higher density of calving caribou observed near Bullen Point was found to extend eastward at least as far as the Staines River (Fig. 3); this confirms earlier suspicions of an eastern calving concentration lying outside the previous limits of coverage (Cameron and Whitten 1979c).

In summary, after 3 years of survey some consistent patterns in calving distribution have begun to emerge. Calving is most concentrated north of the KDA and in the Bullen Point/Staines River area. In the Kuparuk area, most calving occurs within 16 km inland of the coast; the pattern appears to be similar in the Bullen/Staines area, although incomplete coverage precludes a direct comparison. Elsewhere on the central Arctic coastal plain, calving activity is less dense and highly variable. In some years, moderate numbers of calves are born between the Kuparuk and Sagavanirktok Rivers, but south of the Prudhoe Bay Complex (PBC). Within the Kuparuk area, the data on calving distribution suggest some avoidance of the West Sak Road area. This, and the extremely low incidence of calving within the PBC, is consistent with previous reports of avoidance by cow-calf groups (Cameron and Whitten 1979b, 1980b, 1980c; Cameron et al. 1979; Roby 1978).

Total numbers of calving caribou within the study area have varied considerably between 1978 and 1980. We believe that snow depth and the amount of meltwater greatly influence calving distribution on the coastal plain. During a dry spring (i.e., early snowmelt, little or no flooding), the majority of calving occurs in the core calving areas (e.g., 1979). In years of late snowmelt or extensive flooding, however, calving is generally less dense, with considerable dispersal inland, although the core areas remain most heavily used. Thus, flooding resulted in lower densities of caribou in 1978 and 1980; in 1980, particularly severe flooding within and south of the PBC apparently resulted in a near absence of calving between the Kuparuk and Sagavanirktok Rivers. Whatever the effects of weather and development on calving distribution over the past 3 years, productivity of the CAH has been excellent.

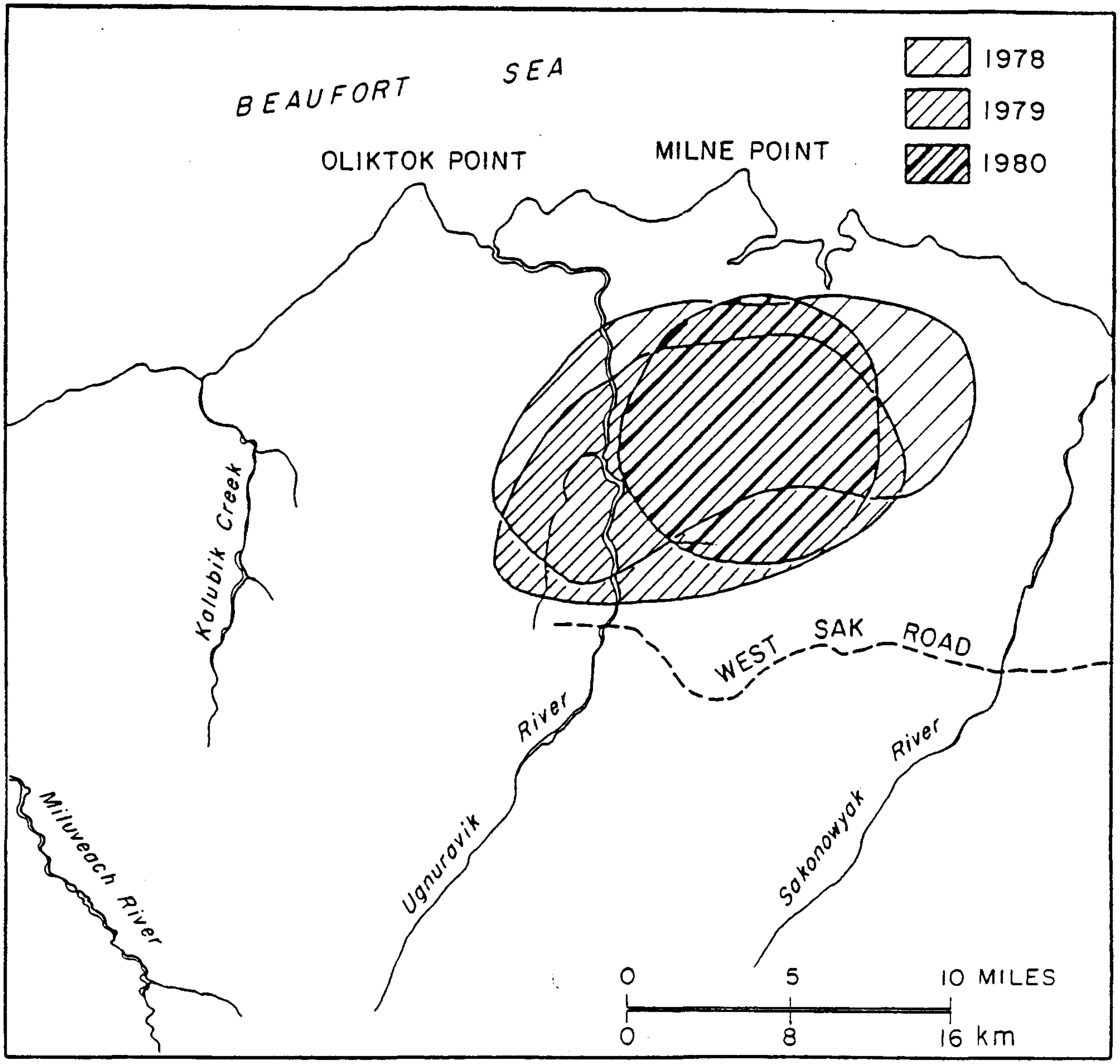

Fig. 5. Calving concentrations of the Central Arctic Herd, June 1978-80.

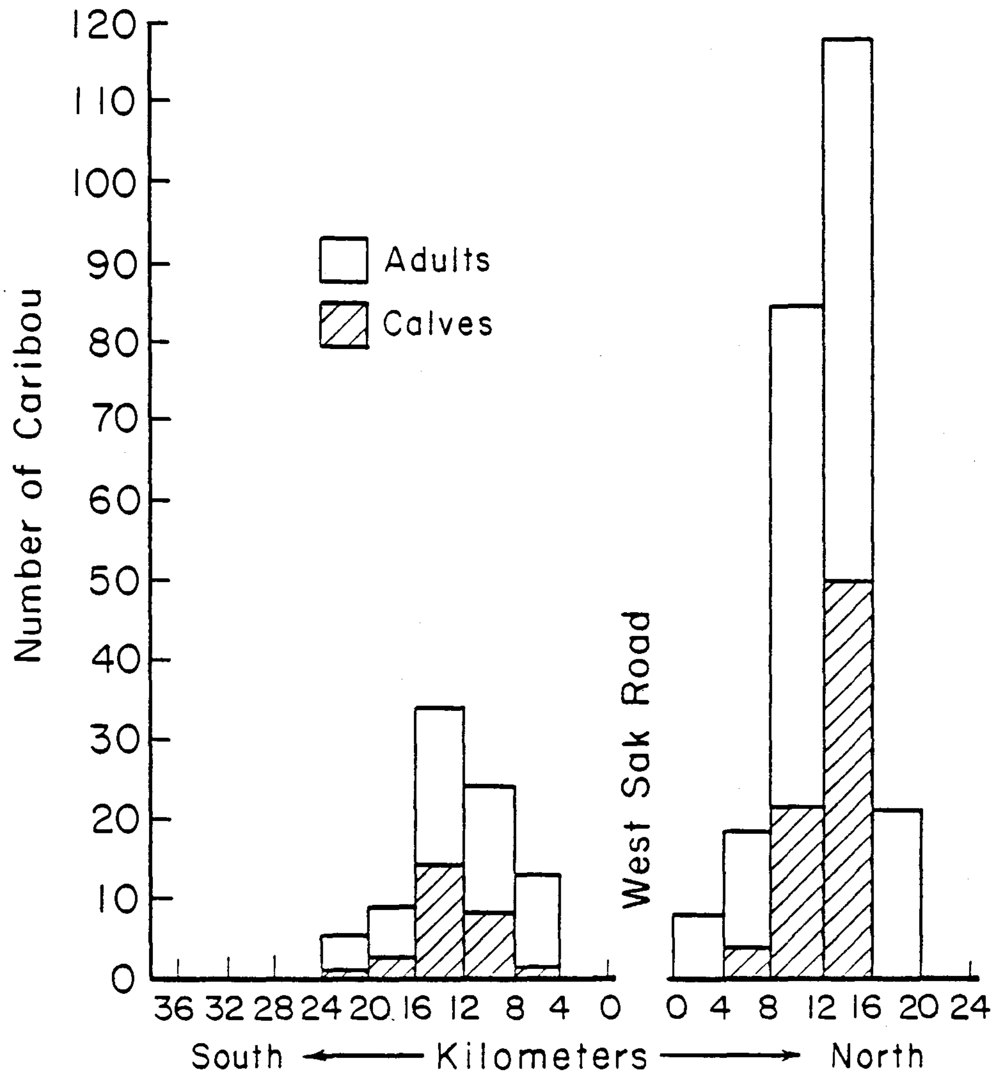

Fig. 6. Distribution of caribou in relation to the West Sak Road, 11-12 June 1980.

Summer Distribution of Caribou West of the Kuparuk River

Regional Group Composition

Aerial transect surveys west of the Kuparuk River on 8 August yielded 570 caribou in 73 separate groups. Overall, calves comprised 28 percent of total caribou observed. This proportion is similar to the corresponding estimate during calving (i.e., 29%; calculated from data in Table 1). In reality, however, the overall percentage of calves in this region would have declined between June and August. Neonatal mortality and the usual post-calving influx of bulls tend to depress relative calf numbers by early summer. Our estimate, therefore, is unrealistically high. However, unpublished results of systematic aerial surveys (see Cameron and Whitten 1979a) in late October 1980 provide a reliable minimum value; west of the Sagavanirktok River and north of 69°30', 21 percent of total caribou observed were calves. Considering the 1978 and 1979 regional estimates of 25 and 23 percent, respectively (Cameron and Whitten 1979c, 1980a), a 1980 value at or slightly above 21 percent calves is not unreasonable. Continued recruitment of numerous yearlings to the adult segment of the CAH (Cameron and Whitten 1980c) and a consequent decline in the proportion of reproductive females would logically result in progressively lower calf percentages, at least in the short term. This calf proportion of 21 percent is our best minimum approximation of regional group composition and will therefore be used as a basis for evaluating similar data obtained along the West Sak Road.

Distribution and Group Composition Along the West Sak Road

Between 16 July and 8 August, 40 complete surveys were conducted from the West Sak Road. A grand total of 4,552 caribou in 347 groups was observed, far more than in either previous year of study (Cameron and Whitten 1979c, 1980a). The number of observations is undoubtedly related to the number of surveys completed, but is probably also a function of between-year differences in patterns of insect harassment (see below). A detailed list of all groups observed is given as Appendix II.

Of the 4,552 caribou observed, 4,093 or 90 percent were classified as either adults or calves. In addition, most adults were classified further as either bulls, cows, or yearlings. However, as in past reports, calf percentage will be used as the only basis for comparing group composition within and between years. Excluding individuals of "unknown" age, 20 percent of the caribou observed from the West Sak Road in 1980 were calves, not substantially different from the corresponding regional estimate of 21 percent (see above). Thus, in 1980, as in 1978 and 1979, overall caribou occupancy was apparently near normal, at least in terms of relative calf numbers.

Figure 7 depicts the 1978-80 distribution of caribou among 4-km segments of the West Sak Road and the calf percentage applicable to each segment. In 1980, 50 percent of total observations were north of the road, 45 percent were south, and 5 percent were west of the road terminus. Thus, relatively fewer caribou were observed to the north, and relatively more were observed to the south and west than in either previous year of study. Aggregate calf proportions north and south of the road were 20 and 18 percent, respectively, not significantly different. It is noteworthy, however, that of

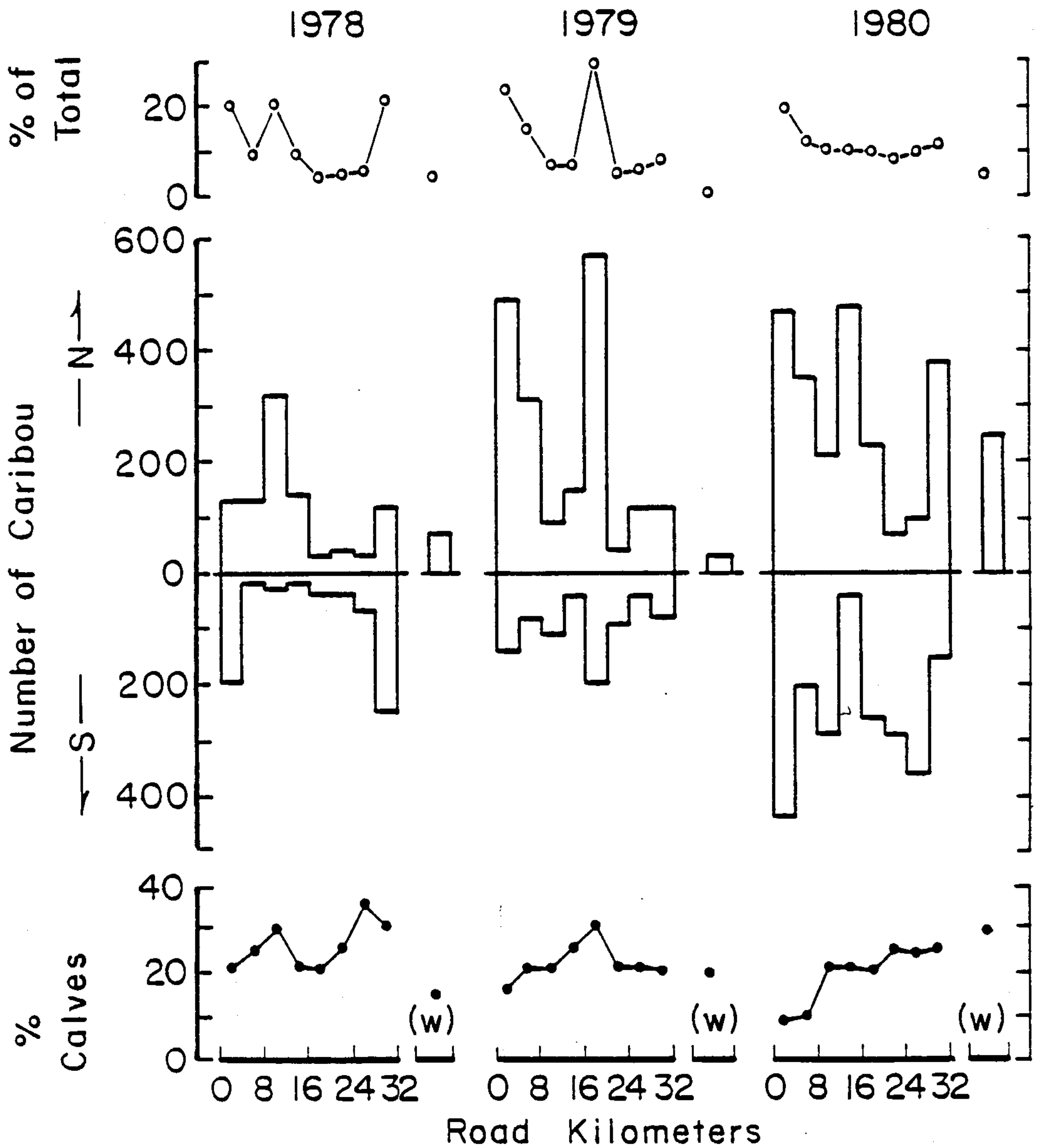

Fig. 7. Distribution of caribou observed from the West Sak Road, summer 1978-80.

the 246 caribou observed to the west, 71, or 29 percent, were calves, the highest percentage calculated for an individual road segment. Unfortunately, corresponding samples for 1978 and 1979 are too small for reliable between-year comparisons.

Calf representation among caribou sightings did not vary detectably with distance from the West Sak Road. Calves comprised a mean of 20 percent of groups observed both within and beyond 1,000 m of the road.

In 1978 and 1979 more than half of all caribou sightings were within three 4-km segments of the West Sak Road (Cameron and Whitten 1979c, 1980a). The majority of calves was also sighted within these segments. In 1980, however, these "nodes" of occupancy were far less distinct. The only area in which caribou were particularly numerous was the 0-4 km road segment encompassing the Kuparuk River floodplain (Fig. 2). Caribou sightings within each of the remaining 4-km intervals were relatively infrequent, each accounting for only 8-12 percent of total observations.

Although caribou were most abundant within the Kuparuk floodplain in 1980, the corresponding calf percentage was the lowest recorded for any 4-km road segment (Fig. 7). A similar pattern was observed in both 1978 and 1979. In fact, calf representation within this segment of the West Sak Road has declined substantially over the last 3 years (i.e., 21% in 1978, 17% in 1979, and 8% in 1980; Fig. 7), far more than the corresponding regional estimates (i.e., 25%, 23%, and 21%, respectively; Cameron and Whitten 1979c, 1980a, and above). Thus, avoidance by cow-calf pairs may have begun as early as 1978, and apparently increased progressively through 1980. Any early abnormalities associated with this particular area, however, are likely not a direct result of KDA-related activities *per se*. The proximity of established production facilities and construction camps on or near the east bank of the Kuparuk River, together with generally increasing traffic along the Spine Road (see Fig. 2), could well be sufficient to influence cow-calf distribution along this portion of the West Sak Road. On the other hand, heavy (KDA-related) construction in the Kuparuk floodplain in 1980 may have contributed to the sharp reduction in relative calf numbers.

Despite abnormally low calf representation in the Kuparuk floodplain, overall calf representation along the West Sak Road was in reasonable agreement with our regional estimate. Obviously, then, disproportionately high calf numbers were present in other areas. Such distributional heterogeneity is, to some extent, a natural phenomenon. For example, in 1978 when only scattered facilities were present along the West Sak Road, caribou distribution and group composition were perhaps most variable. Since that "baseline" year, however, continued local development has apparently resulted in a number of distributional changes, with a trend toward uniformity (Fig. 7). Initially, three peaks of occupancy were apparent, but by 1980 only one remained. Similarly, in 1978 two well-defined peaks in relative calf distribution were identified whereas only one was apparent in 1979; in 1980, calf representation was more evenly distributed, changing from a nodal pattern to one characterized by a net westward shift of cow-calf pairs. In addition, the particularly high calf percentage for groups observed west of the road terminus suggests that relatively more cows and calves detoured around the CPF Complex (Fig. 2) while moving north and/or south.

In 1980, 777 caribou in 27 groups were observed crossing the West Sak Road (including 3 cases in which only part of the group actually crossed during our observation period). Of these, 43 percent (337 caribou, 16 groups) were northbound, and 57 percent (440 caribou, 11 groups) were southbound. Overall, calves comprised 24 percent of the caribou in these crossing groups, slightly higher than both the aggregate value for road observations (20%) and the estimated regional minimum (21%). Further, the calf proportion in northbound groups was higher than for southbound groups (26% vs. 22%).

Thus, despite comparatively low calf percentages along some sections of the road (e.g., 0-8 km, Fig. 7), crossing groups have included a relatively greater number of calves (Cameron and Whitten 1979c, 1980a; Table 4). Although differences are not statistically significant, the trend implies a stronger movement impetus for groups predominated by maternal cows. Also, higher calf percentages for northbound groups is consistent with a tendency for cows and calves to remain nearer the coast than bulls (Cameron and Whitten 1979a), possibly reflecting differences in sensitivity to insect harassment.

The pattern of road crossing location has undergone some obvious changes between 1978 and 1980. Although the majority of crossing activity has occurred within two road intervals of the West Sak Road, different intervals have been involved each summer (Table 4). In addition, the locations of such crossings do not necessarily coincide with nodes of occupancy (Fig. 7). Thus, in 1978, most sightings and crossings were observed within the initial and terminal segments of the road. In 1979 and 1980 most crossings occurred within different road segments; however, in 1979, only one of these was associated with a node of occupancy, whereas in 1980, no interrelationship was apparent.

The significance of this recent change is unclear. It seems reasonable that caribou approaching specific portions of the West Sak Road would cross at or near those positions, given the impetus to continue on. This was clearly the case in 1978, although in 1979 some crossings apparently "spilled over" to an adjacent road segment of relatively low occupancy. In contrast, the 1980 data show that few caribou crossed in the vicinity of the Kuparuk River even though caribou sightings were most numerous in that area. We speculate that moving caribou accumulated near the road within the Kuparuk floodplain, but detoured to the west and crossed elsewhere (if at all), perhaps in response to heavy construction activity.

Caribou frequently move along river courses. Drainages provide relative ease of travel and, in coastal areas, the shortest route to insect relief habitat (i.e., river deltas). Patterns of occupancy and movement during our 1978 "baseline" year were consistent with these premises. We believe that observed changes in local caribou distribution and movements in 1980 reflect some deviation from what may be described as free use of preferred habitat. The extent to which regional density of caribou has been altered cannot be determined from available data, but it is clear that no major abnormalities in group composition have developed. Thus, despite a change toward indistinct areas of caribou occupancy along the road, a few locally depressed calf percentages, and some apparent irregularities in crossing location, overall cow/calf representation in the KDA has remained essentially

Table 4. Observed caribou crossings[1] of the West Sak Road, summer 1980, and the distribution of crossings 1978-80.

		Road Interval (km)							
	From:	0.0	4.1	8.1	12.1	16.1	20.1	24.1	28.1
	To:	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0
No. of Caribou		7	377	142	81	23	46	87	14
Major Direction[2]		N	S	N	N	S	N	N	N
Percent Calves		14	19	25	31	30	28	30	29
% of Total Crossing:	1978	47	2	2	<1	3	1	1	44
	1979	3	6	10	2	55	16	4	4
	1980	1	49	18	10	3	6	11	2

[1] Includes portions of groups that approached but did not actually cross.
[2] Greater than 50 percent.

normal. Indeed, the fact that calves continue to be overrepresented in crossing groups suggests that caribou have reasonable access to various components of their summer range. At what stage continued development might seriously compromise that capability remains conjectural.

Insect-induced Movements

Summer 1980 was unusually cool, windy, and rainy. Conditions were seldom conducive to mosquito activity. Kuparuk Road surveys began on 16 July after a 10-day period of generally light insect harassment. On the 16th, most caribou were south of the road; one group of 129 caribou approached the road, but only four individuals actually crossed, northbound. With higher temperatures and increased insect activity in the afternoon, caribou moved toward the coast. By early afternoon on 17 July, only one caribou was observed from the road. However, with low temperatures and deteriorating weather late that night, large numbers of caribou reappeared to the north of the road. Inclement weather continued through 21 July and caribou numbers remained relatively high along the road through the afternoon of the 19th; and most caribou were south of the road, implying that southward crossings had occurred. After 19 July, the number of caribou sightings generally declined with continued inland dispersal. On 22 July, moderate insect harassment brought some caribou within sight of the road on the south side, followed by redispersal with lower temperatures later that day. With moderate-to-severe insect harassment on 23 July, caribou returned to the vicinity of the road; several northward crossings were observed. Sighting frequency then declined as caribou moved to coastal insect relief habitat. It was again cool on 25 July and moderate numbers of caribou approached the road from the north; some southbound crossings were observed. Insect activity remained low through 1 August; caribou remained widely dispersed and sightings were relatively infrequent. Briefly severe harassment on 2 August followed by moderate harassment on 3 August brought caribou northward across the road. Severe harassment occurred again on 5 and 6 August, but by this time oestrid flies should have replaced mosquitoes as the predominant insect pest. Caribou crossed the road in both directions, but principally to the south. This is consistent with oestrid fly-induced behavior and generally characteristic of August dispersal.

Because of generally poor flying conditions and chronic malfunctions of receiving equipment, very few relocations of radio-collared caribou were made. However, the available information tends to confirm our impressions gained from road surveys. Four collared caribou were located on 18 July; all were in large but loosely aggregated groups between the West Sak Road and the coast. However, only about 1,500 of an estimated 3,500 caribou known to be present in the Kuparuk area were observed north of the road on 18 July. This general observation is consistent with the southward distribution suggested by road survey data (see above). However, on 24 July during a period of severe insect harassment, virtually all caribou estimated to be in the Kuparuk area (and all 5 of the radio-collared caribou in the area) were present in a single coastal aggregation near Beechey Point. Essentially no caribou were present along the road. Collared caribou were again located on 5 August; three were in small groups near the coast, one had moved a few miles south of the West Sak Road, and a fifth could not be found, having presumably moved still farther south and out of tracking range (in October this individual was reloacted far to the south). On 8 August, 3 of the radio-collared caribou were observed by chance during a helicopter survey; only one had remained near the coast while the others had moved well south of the road with most of the unmarked caribou observed.

Summer weather patterns, and therefore insect harassment levels, have differed markedly during the past 3 years. Consequently, caribou movements through, and use of, the Kuparuk region have also been dissimilar (Table 5). Thus, long periods of moderate-to-severe harassment kept caribou near the coast (and away from the road) in 1978, while predominantly light-to-moderate harassment in 1979 allowed caribou to spend more time in preferred feeding areas inland, near the West Sak Road. Similarly, because of generally light harassment in 1980, caribou remained inland for most of the summer, but prolonged periods of little or no insect activity apparently resulted in considerable inland dispersal, more so than in 1979. Thus, caribou sighting rates along the road were lowest in 1978 when insect harassment was generally most severe, and somewhat higher under the more moderate conditions characterizing 1979 and 1980.

Table 5. Caribou sighting rates and insect harassment levels in the Kuparuk area during the period 18 July-4 August, 1978-1980.

	Insect Harassment (no. days)			Sighting Rate (caribou/km)
	Light	Moderate	Severe	
1978	2	9	8	2.7
1979	7	9	3	3.5
1980	11	6	2	3.1

Disturbance and Local Group Composition

Results of studies along the TAP corridor and within the Prudhoe Bay industrial complex indicate that intensive development and related disturbances lead to reduced local occupancy by caribou (Cameron et al. 1970; Cameron and Whitten 1980b, 1980c). Displacement is apparently the result of an avoidance response, particularly by cows and calves. The degree of avoidance has been described by comparing the aggregate percentage of calves observed within or near a given disturbed area with the expected percentage based on corresponding regional observations.

Relative calf representation is probably among the most reliable indicators of conditions that are disruptive to caribou. First, there is considerable evidence that parturient cows and cow-calf pairs are the most sensitive sex/age class of caribou (deVos 1960, Lent 1966, Bergerud 1974, Roby 1978, Cameron et al. 1979); maternal cows apparently view major developments as potentially hazardous. Secondly, calves are easily identified through aerial and ground surveillance, and their relative numbers are described simply and accurately as a percentage of total caribou observed. Hence, in the following analysis of caribou responses to disturbance, calf percentage was used as the dependent variable.

Quantifying disturbance itself was somewhat more difficult. We graded our subjective impressions of severity on the basis of spatial characteristics and relative intensity. Disturbance designations were then calculated and assigned to various locations prior to formalizing the frequency distribution of caribou among various intervals of the West Sak Road. There should have been little or no bias resulting from foreknowledge of differing calf percentages.

Only caribou observed within an estimated 1,000 m of the West Sak Road were used in this analysis. Further, groups within 2 km of a disturbed area were presumed to be potentially affected; this greater road distance criterion was established to compensate (on the liberal side) for minor inaccuracies in the recorded location of caribou.

The disturbance index for a given site was calculated as the arithmetic sum of 2 component indices, those for (1) the occurrence of activity and (2) the presence of structures.

(1) The activity index was determined as the composite of (a) construction/maintenance work, which includes the entire spectrum of site-specific human and equipment activity within the KDA, and (b) routine vehicular traffic along the West Sak Road.

(a) Construction activities were assigned increasing intensity ratings of 1, 2, or 3. Maintenance activity associated with established building complexes was assigned constant values: the CPF was given an activity value of 3 (night, 1) and Well Site D a value of 1 (night, 0); ratings for construction sites within 2 km were increased by, or up to a maximum of, these values.

(b) One-way rates of vehicular traffic (calculated from daily checkpoint records) were given values of 1 (1-10 vehicles/hr), 2 (11-20 vehicles/hr) or 3 (greater than 20 vehicles/hr). Traffic designations were applied to all observations during a given survey.

The sum of the ratings for construction/maintenance and traffic yielded a total activity index of from 1 to 6.

(2) Various structures and structure complexes along the West Sak Road were also rated subjectively from 1 to 6, depending on size, complexity, and spatial characteristics. Again, the 2-km road distance criterion was applied to individual caribou observations. Table 6 gives our numerical classification of structures and specific examples of each, where appropriate, within the KDA.

Table 6. Disturbance ratings assigned to various structures associated with the KDA.

Rating	Description	Example(s)
1	Road only	(self-explanatory)
2	Road + Isolated Structure or Equipment	Mobil Strip, Gravel Site B
3	Road + Pipeline	(N/A in 1980)
4	Road + Pipeline + Isolated Structure	(N/A in 1980)
5	Road and/or Pipeline + Small Complex	Kuparuk River (main channel), Well Site D
6	Road and/or Pipeline + Large Complex	Kuparuk River (east channel), CPF

Thus, each caribou group observation was assigned a final disturbance index ranging from 1 to 12.

These indices were admittedly subjective, and a number of tenuous assumptions are implicit. First, distance criteria (i.e., within 1,000 m and 2 road km) represent little more than guesses as to the visual and/or auditory sensitivity of caribou to disturbance stimuli. Secondly, the numerical system for the individual and combined indices assumes that disturbance is an additive function, whereas the associated behaviorial changes might increase geometrically or exponentially. Thirdly, local structures and physical construction/maintenance activity were considered separately, but given equal status in the final calculation. The broad distinction between these types of stimuli may be meaningless in terms of response patterns; further, such disturbance components may not be functionally equivalent, but synergistic or perhaps even partially compensatory.

In light of these considerations, together with a general lack of precision, final indices were grouped into 3 disturbance levels: 1-4, 5-8, and 9-12. These were designated low, medium, and high, respectively. Table 7 summarizes aggregate calf percentages for groups potentially subject to each level of disturbance and under different degrees of insect harassment. Disturbance classed as low had no apparent effect on calf percentage; an aggregate of 21 percent calves was calculated regardless of insect activity. Within the category of light insect harassment, the mean calf proportion was similar under medium disturbance (19%) but declined to 6 percent under high disturbance.

Groups subject to moderate insect harassment were characterized by a higher proportion of calves under medium disturbance than those under disturbance classed as light (29% vs 21%). This is perhaps an anomaly resulting from an inadequate sample. The mean of 16 percent calves observed under high disturbance levels may be unreliable for the same reason. A net decline in calf percentage with increasing disturbance is intuitively reasonable; further, that the difference was less under moderate insect harassment than under light harassment seems similarly logical. Under severe insect harassment, extremely small samples were obtained for the higher disturbance levels--simply inadequate for any legitimate comparisons.

Table 7. Relationship between observed calf percentage[1] and estimated level of local disturbance.

		Disturbance Level[2]			
		Low (1-4)	Medium (5-8)	High (9-12)	Totals (1-12)
Insect Harassment[3]:					
	Light	N = 1029 21% ca.	N = 624 19% ca.	N = 211 6% ca.	N = 1864 19% ca.
	Moderate	N = 57 21% ca.	N = 90 29% ca.	N = 70 16% ca.	N = 217 23% ca.
	Severe	N = 374 21% ca.	N = 11 --	N = 9 --	N = 394 22% ca.
Totals		N = 1460 21% ca.	N = 725 21% ca.	N = 290 9% ca.	N = 2475 20% ca.

[1] Based on groups observed witin 1,000 m of the West Sak Road and within 2 road km of a given disturbed area.
[2] A range of disturbance indices determined as the sum of numerical ratings (1-6) assigned to both construction/maintenance activity and local structures.
[3] Estimated using the relationship reported by White et al. 1975 or by direct observation.

Despite the lack of data required for a detailed analysis, the categorized totals for each set of insect and disturbance variables (Table 7) provide an interesting overview. Thus, disregarding the effects of varying insect harassment, disturbance greater than "medium" had a clear effect on the calf percentage of associated groups (i.e., decline from 21% to 9% calves). However, the preponderance of observations during light insect harassment might accentuate this apparent difference because of greater sensitivity to disturbance under those conditions. The tendency for coastward movements under moderate/severe insect harassment effectively reduces the number of caribou observed along the West Sak Road. Consequently, our observations may not always be representative of the effects of disturbance elsewhere on the coastal plain. Weather-induced changes in habitat preference would alter the apparent response to similar disturbance conditions. Hence, given a set of disturbance stimuli, one might expect the responses of caribou to attenuate near the coast and intensify with distance inland. Nevertheless, assuming representative sampling along the West Sak Road, the effects of disturbance shown in Table 7 should be a reasonable reflection of the responses of caribou in the immediate area under the insect patterns described for that year (Table 5).

In contrast to the wide range in calf representation associated with varying disturbance, the totals of calf percentage for each class of insect harassment were similar, ranging only from 19 to 23 percent (Table 7). Further, since observations under light disturbance predominated, this might be a minimum range; potential complications associated with massive or widespread disturbance were largely absent. To summarize, overall calf percentages associated with regional insect patterns and KDA disturbance conditions in 1980 suggest that extremes of the latter had relatively more influence than those of the former.

It should be reemphasized that this semiquantitative analysis is strictly preliminary. Many of the conclusions are tentative, numerical classifications questionable, and samples within some categories insufficient. Nonetheless, the analysis does demonstrate that, in broad terms, heavy disturbance effects a substantial change in at least one caribou group variable--calf percentage. For the lack of another approach, we will continue to build on this analytical framework.

OVERVIEW

As of 1980, development of the KDA has not resulted in any discernible changes in calving distribution west of the Kuparuk River. Reported annual variations in the numbers and density of calving caribou are most likely related to the depth of snow, spring weather, and/or melt-off patterns. One specific area of high calving activity north of the KDA has, with minor variations, been occupied repeatedly for a number of years. It remains to be seen, however, whether this calving concentration will remain intact as regional development continues.

Similar considerations apply to future conflicts during summer. Because of the dynamic nature of summer distribution, caribou repeatedly interact with the West Sak Road and its associated facilities. Observations during the past three summers suggest that local caribou movements have changed in response to progressive development. We believe that such changes reflect a trend from a preferred pattern of habitat use to one that is suboptimal but, nonetheless, acceptable to caribou. That local calf percentages have remained representative of regional estimates testifies to that acceptability.

Incremental disturbance associated with the future expansion of oilfield complexes is our major concern. At the current level of KDA development, sufficient habitat options are apparently available to caribou. However, if and when the degree of disturbance on remaining local habitats becomes unacceptable, other, previously unattractive areas may be occupied. We envision this as the basic displacement mechanism. Displacement may occur, for example, when adjacent complexes are sited in close proximity or expand to within some critical distance of each other. At this stage, caribou may perceive them, not as separate entities, but as a single complex that is larger and more disturbing than the sum of the original components. The addition of connecting roads, pipelines, and traffic may contribute to the disturbance effect, perhaps by strengthening the visual link between nodes of activity or building complexes. Thus, with an expanding infrastructure west of the Kuparuk River; with the Kuparuk Pipeline now a reality; with additional wells, flow lines, and processing facilities; with additional support services and air traffic; with an increase in the volume of construction and maintenance-related activity; and with nearby development units emerging; there is good reason to predict that regional habitat options available to caribou will diminish considerably in the near future. In our opinion, substantial displacement of caribou is highly probable.

The most important biological standard for judging the effects of disturbance on caribou is the health and reproductive status of the individuals affected and, ultimately, productivity of the herd itself; that is, the continued ability of a herd to maintain an acceptable balance between reproduction and mortality. Hence, factors that affect dynamic population variables, such as calving success and overwinter survival, are of fundamental importance. The key question is whether or not CAH caribou will continue to have access to habitats which, for a variety of reasons, optimize their physical well-being.

It should also be recognized that abnormal changes in caribou distribution, even in the absence of consequences to herd productivity, may affect caribou users. Thus, substantial displacement of caribou and losses of herd integrity are potentially important to recreational/subsistence hunters and to the nonconsumptive user as well. In addition, the restrictions on access and hunting that frequently accompany petroleum development will effectively reduce public contact with the resource.

Many of the undesirable consequences of industrial activity can be successfully mitigated; others clearly cannot, given the present development philosophy. For example, direct harassment (e.g., helicopter overflights, ATV activity) can presumably be minimized through appropriate regulations, stipulations, and company operating policies. Similarly, improved pipeline designs will hopefully maximize physical passage of caribou. In contrast, past experience suggests that incremental disturbance cannot be adequately controlled to permit optimal use of caribou habitat. In many cases, such restrictions would require major inconveniences to the rather unpredictable progress of petroleum development.

Insufficient knowledge of probable oilfield scenarios precludes strategic planning at a regional level. In fact, site-specific restrictions may have little positive effect if overall regional development is effectively out of control. Nevertheless, until a comprehensive plan is established, the conduct of individual development endeavors should be modified, as necessary, to minimize conflicts with indigenous caribou. Through continued studies of the disturbance behavior and habitat requirements of caribou, as well as improved planning efforts, caribou can hopefully be protected in a manner consistent with orderly--and economically sound--development of Alaska's petroleum resources.

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Appendix I. Survey observations on the calving grounds, 11-12 June 1980.

Obs. No.	Total No.	B	C	ca	Y	Obs. No.	Total No.	B	C	ca	Y
1	3		2	1		46	5		3		2
2	5	2			3	47	2		2		
3	4		2	2		48	2		2		
4	7		3	3	1	49	5		2	2	1
5	4		3	1		50	5		3		2
6	2	1			1	51	2				2
7	1				1	52	8		4	3	1
8	9		4	4	1	53	3				3
9	3		1	1	1	54	1				1
10	6		2	2	2	55	1				1
11	2		1	1		56	6		3	2	1
12	6		3	3		57	2		1	1	
13	2		1	1		58	4		2		2
14	1	1				59	20		9	8	3
15	14		6	5	3	60	3		1	1	1
16	1				1	61	2		1	1	
17	2		1	1		62	1				1
18	22		10	8	4	63	2				2
19	7		4	3		64	1	1			
20	3		1	1	1	65	17		9	7	1
21	1		1			66	11		6	3	2
22	2		1		1	67	17		9	2	6
23	3		1	1	1	68	6		5	1	
24	2		1	1		69	6		4	1	1
25	1		1			70	4		2		2
26	2	1			1	71	2		1	1	
27	1	1				72	3		1	1	1
28	2				2	73	1		1		
29	3				3	74	10		3	3	4
30	3				3	75	8		1		7
31	3		2	1		76	10		4		6
32	2				2	77	2		1	1	
33	1	1				78	26		13	12	1
34	4		2	2		79	3		2		1
35	7		3	3	1	80	6		3		3
36	3		1		2	81	7		3	3	1
37	3		2	1		82	28		12	11	5
38	7		3	2	2	83	15		6	6	3
39	9		3	3	3	84	2		1	1	
40	2		1	1		85	4		2	2	
41	3		1		2	86	7		3		4
42	2	1			1	87	2		1	1	
43	3		2		1	88	3		2	1	
44	13	1	5	5	2	89	2				2
45	2				2	90	4		2	2	

Appendix I. Continued.

Obs. No.	Total No.	B	C	ca	Y
91	1		1		
92	3		2	1	
93	1		1		
94	3		1	1	1
95	25		13	11	1
96	2				2
97	6		3		3
98	1		1		
99	2				2
100	2		1	1	
101	1				1
102	3				3
103	5		2	2	1
104	2		1	1	
105	4		2	2	
106	4		2	2	
107	2		1	1	
108	2		1	1	
109	8		4	4	
110	2		1	1	
111	4		2	2	
112	2				2
113	4		2	2	
114	3				3
115	1				1
116	1		1		
117	6	1	1		4
118	1		1		
119	5		3	2	
120	5	1	1	1	2
121	8		4	4	
122	21		11	10	
123	4		3		1
124	6		3	2	1
125	7		3	3	1
126	5		3	1	1
127	4		2	2	
128	2		1	1	
129	10		6	3	1
130	11		7	2	2
131	12		5	5	2
132	10		6	4	
133	7		4	3	
134	11		5	5	1
135	4		2	2	
136	8		4	4	
137	3		2	1	
138	13		7	6	
139	4		2	2	
140	9		4	4	1
141	18		9	6	3
142	2		1	1	
143	4		2	1	1
144	1	1			
145	4		1		3
146	2				2
147	3		2	1	
148	5		2	2	1
149	2		1	1	
150	3		1	1	1
151	2				2
152	2		1	1	
Totals	787	13	356	247	171

B = bulls, C = cows, ca = calves, Y = yearlings

Note: Some observations include more than one group of caribou.

Appendix II. Caribou observations from the West Sak Road, 16 July-8 August 1980.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[a] (mi)	I.O.D.[b] (yd)	N/S[c]
16 July	1200-1620	1	13	11				2		1.1	1000	N
		2	10	1	5	3	1			5.1	800	N
		3	1	1						6.9	1000+	N
		4	23		9	9		5		11.4	1000+	S
		5	18	4	6	4	1	3		13.2	1000	N
		6	83	5	17	17		44		14.5	1000+	S
		7	2		2					15.2	600	S
		8	20	3	4	4		9		20.0	1000+	W
		9	3	3						15.5	600	S
		10	129	33	45	32	6	13		6.1	1000+	S(X
17 July	1400-1600	1	1	1						18.9	500	S
17 July	2200-2350	1	200						200	4.0	1000+	N
		2	1	1						13.9	1000+	S
		3	7	7						18.9	400	S
		4	2	2						8.2	400	N
		5	48	15	19	13	1			6.7	300	N
		6	59	6	25	19	1	8		6.7	1000+	N
		7	41					41		1.8	1000+	N
18 July	1315-1530	1	44	40	2		2			0.1	400	S
		2	9	8			1			0.9	800	N
		3	11	11						1.1	1000+	N
		4	21	2	4	4	3	8		1.2	1000+	S
		5	1	1						1.7	100	N
		6	117	19		18		80		7.1	1000	S
		7	1	1						12.1	400	N
		8	2	2						16.8	150	S
18 July	2145-0005	1	6	6						0.2	200	N
		2	22	20				2		0.3	1000+	S
		3	8	8						0.3	1000+	S
		4	27	16	4	3		4		0.7	1000+	S
		5	10	9			1			1.4	700	S
		6	19	1		5		13		2.0	1000+	N
		7	9	8				1		3.6	600	S
		8	10	1	5	4				3.6	1000	S
		9	11	1	6	2	2			6.8	1000	S
		10	22			3		19		8.4	1000+	N
		11	9	7	2					8.8	500	N
		12	13			2		11		10.6	1000	N
		13	146	35	37	31		43		15.1	1000+	S
		14	12	12						17.8	900	N
		15	15	2	7	6				11.6	300	N

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[a] (mi)	I.O.D.[b] (yd)	N/S[c]
19 July	1245-1515	1	6	6						0.4	600	S
		2	3	3						0.7	1000+	N
		3	5		3	2				3.4	400	N
		4	43					20	23	3.5	1000+	S
		5	10	1	6	3				7.7	1000+	S
		6	2	2						8.7	800	N
		7	9		4	3		2		14.0	1000+	S
		8	35		14	9		12		15.8	1000+	N
		9	95	18	40	32		5		20.0	500	W
		10	2	2						17.7	800	S
		11	10	1	4	3		2		12.9	1000+	N
		12	2	2						10.5	1000+	N
19 July	2145-2400	1	2	2						0.1	800	S
		2	5	5						0.4	300	N
		3	10	10						1.9	500	S
		4	9	2	4	3				6.7	1000+	N
		5	3	3						7.3	300	S
		6	8	1	4	3				10.5	1000+	N
		7	45	2	26	17				14.4	700	S
		8	1	1						16.8	50	S
		9	10	1	6	3				12.9	1000+	S
20 July	2200-2345	1	6	6						0.1	1000+	S
		2	1	1						1.9	1000+	S
		3	12		7	4	1			11.7	600	N
21 July	1515-1745	1	1					1		1.9	1000+	S
		2	5		3	2				20.0	1000	N
		3	26	1	15	9	1			20.0	1000	W
21 July	2215-0010	1	6	6						0.1	200	S
		2	2	2						1.1	1000	S
		3	1	1						1.9	1000+	S
22 July	1440-	1	16	13	1	1		1		0.6	1000	S
		2	4	4						1.1	1000+	S
		3	1	1						1.8	50	S
		4	3	3						1.6	800	N
		5	2	2						3.1	100	S
		6	12	2	7	3				5.6	800	N
		7	52	9	4	16		23		10.7	1000+	S
		8	18						18	11.5	1000+	S
		9	22						22	12.7	1000+	S
		10	1					1		14.0	1000+	S
		11	4		2	2				14.9	800	S
		12	1	1						17.6	50	N
		13	5		3	2				18.8	1000	N

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[a] (mi)	I.O.D.[b] (yd)	N/S[c]
22 July	2315-0105	1	30	30						1.6	400	S
		2	3	3						1.6	600	N
		3	5	5						1.7	1000+	S
		4	4	4						1.9	1000+	S
		5	2	2						3.6	500	N
		6	8	2	4	2				9.6	1000+	N
		7	2	1			1			13.3	400	S
		8	1	1						13.4	1000+	S
		9	1	1						18.2	300	N
23 July	1130-1430	1	11	11						0.1	100	N
		2	6	6						0.3	400	S(X
		3	89						89	4.7	1000+	N
		4	3	3						5.2	600	S(X
		5	2					2		5.8	1000+	N
		6	14	6		2		6		8.5	1000+	N
		7	1	1						10.9	200	N
		8	11	6					5	12.8	1000+	N
		9	1	1						15.0	1000+	S
		10	43	12	20	11				14.3	1000+	S(X
		11	1		1					6.4	50	S(X
		12	2		1		1			4.6	300	N
23 July	2200-0030	1	1	1						20.0	700	S
		2	1	1						18.3	50	N
		3	2	2						2.3	150	N
		4	3	3						1.4	800	N
		5	1	1						0.5	1000	N
		6	65	61				4		3.5	1000+	S
		7	1	1						11.9	400	S
24 July	1330-1530	1	1	1						0.1	800	S
		2	1	1						9.2	1000+	S
24 July	2130-0135	Poor sighting conditions										
25 July	1430-	1	3			1		2		0.9	30	N
		2	31			7		24		1.6	150	N
		3	25			2		23		1.6	300	S
		4	35			11		24		2.0	600	N
		5	1					1		2.7	300	S
		6	2		1	1				3.9	200	S
		7	9	9						3.9	600	S
		8	2					2		5.3	300	N
		9	26			7		19		7.1	500	N
		10	2					2		9.4	200	S

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[a] (mi)	I.O.D.[b] (yd)	N/S[c]
		11	60			10		50		10.4	1000	S
		12	30			9		21		10.7	150	N
		13	6			2		4		10.7	-	N(X)
		14	48			3		45		11.3	1000	S
		15	7			2		5		11.6	150	S
		16	60			14		46		11.8	800	N
		17	13			4		9		12.1	-	N(X)
		18	8			3		5		12.1	200	N
		19	26			3		23		12.1	1000+	S
		20	9			2		7		12.3	150	S
		21	31			3		28		15.3	400	N
25 July	2215-2345	1	10	10						19.5	600	S
		2	32	8		6		18		20.0	1000+	W
		3	6	4				2		20.0	1000+	W
		4	32	4	6	8		14		19.5	1000+	N
		5	84	15	15	20		34		18.3	1000+	N
		6	10		2	3		5		18.1	1000+	N
		7	102	20	30	28		24		18.0	1000	N
		8	67	4	16	14		33		17.4	600	S
		9	3		1	1		1		17.2	1000+	N
		10	29	1	15	13				16.9	300	S
		11	3	1	1	1				16.9	-	N(X)
		12	5			1		4		16.9	1000	S
		13	4	1	1	1		1		15.3	100	N
		14	5		1	2		2		13.0	300	S
		15	3		1	1		1		13.0	1000+	N
		16	2	1				1		12.2	1000+	N
		17	1	1						9.9	300	N
		18	24	3	7	7	1	6		8.9	700	N
		19	15		8	6	1			8.7	400	N(X)
		20	7		4	3				8.0	100	S
		21	2	2						6.0	100	N
		22	9			4		5		3.3	300	S
		23	15	14			1			1.6	800	S
26 July	1600-1815	1	3	3						1.0	50	S
		2	21	21						1.5	400	N
		3	3	3						1.6	1000+	S
		4	2	2						6.0	400	S
		5	1				1			11.4	500	N
		6	18	2	4	6		6		20.0	1000+	N
		7	1					1		20.0	800	N
		8	4		1	1		2		18.3	1000+	N

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[a] (mi)	I.O.D.[b] (yd)	N/S[c]
26 July	2200-2330	1	23		2	7	2	12		20.0	1000+	S
		2	2	1				1		13.2	300	S
		3	3					3		9.6	1000+	S
		4	1	1						9.6	1000+	N
		5	21	2	1	8	1	9		8.6	600	N(X
		6	5	1	1	1	1	1		1.8	800	N
		7	41	16		4		21		1.6	1000	S
27 July	1230-1320	1	6	6						2.2	100	S
		2	1	1						1.6	1000	S
27 July	2200-0010	1	3	3						16.5	100	S
		2	2	1				1		14.4	1000+	S
		3	6	6						1.6	100	N
		4	11	4		2		5		1.9	1000+	S
		5	4		1	1		2		3.9	800	N
28 July	1305-	1	3	2			1			16.2	500	S
		2	1					1		1.8	1000+	S
		3	7	7						1.3	1000+	S
		4	4					4		0.7	600	S
28 July	2230-	Poor sighting conditions										
29 July	1305-1500	1	15						15	19.8	1000+	N
		2	2					2		18.9	1000+	N
		3	3	2			1			16.0	300	S
29 July	2200-	1	19	1	12	6				20.0	300	W
		2	18			6		12		20.0	1000	W
		3	4		2	1	1			19.5	1000	N
30 July	1300-1345	No sightings										
30 July	2245	1	1	1						1.0	1000+	N
31 July	1310-	1	11			4		7		14.6	1000+	N
		2	1	1						1.8	1000+	S
		3	5	2	3					12.2	1000	S
1 August	1330-1420	No sightings										

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[a] (mi)	I.O.D.[b] (yd)	N/S[c]
2 August	1100-1315	1	6	6						0.1	800	S
		2	4	4						0.2	100	N
		3	7			2		5		4.7	1000+	S
		4	7			3		4		7.0	1000+	N
		5	11	1	4	4	2			8.9	100	S
		6	2		1	1				12.0	800	N(X
		7	2		1	1				14.2	300	N
		8	46	6		16	3	21		15.4	600	S(X
		9	38	5	12	9	3	9		16.5	1000+	S(X
		10	2					2		19.0	800	N
		11	27			7		20		19.9	400	N
		12	2		1	1				20.0	800	W
		13	69	23		17	4	25		20.0	1000+	S
		14	14	2	7	4	1			19.6	600	S(X
2 August	2245-0015	1	2		1	1				0.4	1000+	S
		2	1	1						0.7	400	S
		3	2	2						1.4	900	N
		4	11	4		2		5		1.6	1000	S
		5	1					1		3.3	1000+	S
		6	1	1						6.4	800	S
		7	8	4				4		7.3	800	N
3 August	1100-1330	1	13		5	5		3		19.1	1000+	S
		2	1					1		20.0	800	N
		3	1	1						17.9	700	N
		4	6		3	3				16.1	1000+	S
		5	1	1						14.9	100	S
		6	41	7	15	12	2	5		13.2	800	S(X)
		7	4	3	1					9.0	400	S
		8	7		4	3				5.1	300	N
		9	18	7	7	4				5.0	200	S
		10	11	11						4.3	1000+	S
		11	2		1	1				4.1	600	S
		12	2	2						2.3	600	N
		13	32	32						2.1	1000+	N
		14	14			2		12		2.0	1000+	N
		15	4	2				2		1.9	1000	N
		16	2	1				1		0.2	1000	N
		17	2	2						0.2	50	S
3 August	2130-2350	1	11	1	4	3		3		12.9	400	S
		2	15	13	1	1				4.0	800	N(X)
		3	24	13		4		7		1.6	1000+	N
		4	3	3						1.5	50	N
		5	2	2						1.5	200	S
		6	2	2						1.6	1000+	S

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[a] (mi)	I.O.D.[b] (yd)	N/S[c]
4 August	1115-1245	1	18	11		3		4		20.0	1000+	W
		2	3	2				1		18.0	1000+	N
		3	1	1						16.4	600	S
		4	2		1	1				12.6	1000+	N
		5	17	5		3		9		11.7	1000+	N
		6	1					1		7.5	1000	N
		7	14	2		3		9		1.8	1000+	N
		8	4	4						1.3	800	N
		9	6		2	2	1	1		1.7	1000	S
		10	3	3						0.6	400	N
4 August	2215-0010	1	1	1						20.0	400	W
		2	3	3						1.6	250	N
		3	9	2	2	2		3		1.2	1000+	N
		4	5	5						1.5	800	S
		5	2					2		1.7	1000+	S
		6	10	3	2	2		3		1.9	1000+	S
5 August	1300-1630	1	1			1				20.0	400	W
		2	2		1	1				20.0	1000	W
		3	2					2		20.0	1000+	N
		4	1		1					20.0	-	-
		5	1		1					19.9	-	-
		6	4		2	2				19.5	800	N
		7	2		1	1				19.2	1000	N
		8	1			1				20.0	400	N
		9	18	3		5		10		16.7	1000+	N
		10	1					1		15.8	1000+	N
		11	2	1		1				16.2	200	S
		12	1		1					14.7	100	N
		13	1		1					14.5	100	N
		14	1		1					14.3	400	N
		15	2		1	1				14.0	300	N
		16	1					1		14.0	1000+	N
		17	1	1						13.0	200	N
		18	1				1			12.5	200	N
		19	1	1						12.5	800	S
		20	1				1			12.3	400	N
		21	2		1	1				12.1	1000	N
		22	1	1						11.8	1000	S
		23	1	1						11.8	400	S(X)
		24	1					1		11.7	1000+	S
		25	1	1						10.1	300	N
		26	1					1		10.1	1000+	S
		27	2	1				1		8.8	200	S(X)

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[a] (mi)	I.O.D.[b] (yd)	N/S[c]
		28	338			71		267		8.7	900	N(X
		29	8	2	3	3				6.3	-	S(X
		30	1		1					6.1	-	S(X
		31	1	1						6.0	400	N
		32	1	1						5.7	-	-
		33	1					1		5.8	200	S
		34	2		1	1				5.3	400	S
		35	1			1				2.2	200	S(X
5 August	2215-0040	1	6	3	1	1		1		20.0	600	S
		2	6		2	2		2		20.0	1000+	W
		3	4	2	1	1				19.9	800	N
		4	3	1	1	1				19.2	1000+	N
		5	8	2	3	1	1	1		17.2	600	N
		6	1				1			16.7	400	N
		7	5	1	2	2				14.7	600	S
		8	5	1	2	1	1			12.6	200	N(X)
		9	1		1					12.6	300	N
		10	4		1	1		2		9.9	800	N
		11	2					2		7.5	1000	N
		12	8	4	2	2				3.2	600	S
		13	4		1	1		2		2.6	500	N
		14	2					2		2.4	1000+	N
		15	1					1		2.3	700	S
		16	2		1	1				1.9	600	N
		17	85						85	0.9	1000+	N
		18	13			4		9		1.2	1000	S
		19	4	4						0.2	100	S
6 August	1000	1	1	1						19.7	1000	N
		2	1				1			11.9	200	S
		3	1					1		11.3	800	N
		4	1		1					11.4	200	S(X)
		5	1					1		7.8	800	S
		6	2					2		4.7	400	S(X)
		7	1					1		4.6	200	N(X)
		8	1					1		2.8	200	S
		9	1					1		0.7	200	S
6 August	2130-2345	1	21	19	2					3.7	100	N(X)
		2	3	1				2		3.4	500	N
		3	6	4				2		1.6	800	N
		4	7	7						1.7	1000	S
		5	5	5						1.4	100	S
		6	1	1						2.2	1000	S

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[a] (mi)	I.O.D.[b] (yd)	N/S[c]
7 August	1230-1330	1	25	7	6	6	2	4		19.6	900	N
		2	6	6						11.9	800	N
		3	4		1	1		2		11.7	1000+	N
		4	17	9				8		10.7	1000+	N
		5	2		1		1			10.6	800	N
		6	3	1	1	1				8.2	500	N
		7	1	1						7.0	100	S
		8	3		1	1		1		6.0	1000+	N
		9	12	12						5.2	1000	S
		10	4	4						3.6	1000	N
		11	4		1		3			3.6	500	N
		12	3	2				1		1.3	1000	S
		13	7	5	1	1				1.0	400	N
		14	4					2	2	1.0	1000+	N
8 August	1145-	1	11	1	4			6		8.0	800	N
		2	2					2		6.2	500	N
		3	5	5						6.1	1000+	N
		4	8		5	1		2		2.0	300	N
		5	5	5						1.9	300	S
		6	4		2	2				1.9	600	N

[a] Road mileage.
[b] Initial observation distance (1000+ = more than 1000 yd).
[c] Initial sighting north (N) or south (S) of road; X = eventual crossing; West = west of end of road; - = on road, or position not crossed.

[1] 4 of 129 crossed and then recrossed to join original group of 129.
[2] 33 of 43 crossed at mile 9.4.
[3] Had crossed when seen on return trip.
[4] Crossed during return trip.
[5] Had crossed when seen on return trip.
[6] 140 of 338 crossed at mile 4.0.

B = bulls, C = cows, ca = calves, Y = yearlings, A = adults, U = unknowns.