Responses of Barren-ground Caribou to Petroleum Development Near Milne Point, Alaska

by

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Final Report

to

Conoco, Inc.

and

Continental Pipeline Company

Alaska Department of Fish and Game

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SUMMARY

1. Caribou surveys were conducted from the Milne Point road system by light truck in May, June, and July/August 1982-85.

2. The northern- and southernmost 4-km sections of the road system received relatively high use by caribou.

3. The area 1-2 km north of the West Sak Road was used and crossed frequently by caribou.

4. The mean number of caribou observed per survey varied among seasons and years in response to differences in patterns of snow ablation, insect harassment, and levels of human activity near Milne Point.

5. There was no significant difference among years in the mean distance of caribou groups from the road system during May or June. However, mean distance differed significantly among years during July/August; groups tended to be closer to the road during years when human activity near Milne Point was low (1983 and 1984) than during years when activity was high (1982 and 1985).

6. Mean distance of caribou groups from the road was greater in June than in either May or July/August. During June, the relative number of caribou within 1 km of the road was positively correlated with distance from the road; there was no relationship between number of caribou and distance from the road for either May or July/August.

7. During high traffic years (1982 and 1985), there was no relationship between traffic level and either the proportion of calves per group or the distance of groups from the road.

8. The relative number of caribou, and number of groups, that crossed the road or road/pipeline were variable among years and seasons. The number of caribou that crossed the road was influenced by weather-mediated patterns of insect activity and levels of human activity near Milne Point.

INTRODUCTION

Central Arctic Herd

The Central Arctic Herd (CAH) is a distinct subpopulation of approximately 13,000 caribou (Rangifer tarandus granti) (as of 1983; Smith, unpubl. data) that ranges the Arctic Slope between the Canning and Colville Rivers. Seasonal movements are principally north-south between wintering areas in the Brooks Range and calving/summer range on the Arctic Coastal Plain (Cameron and Whitten 1979).

Pregnant females and some attendant short-yearlings (calves 11 months old) move onto the coastal calving grounds in May (Whitten and Cameron 1985); calving occurs during the first 2 weeks of June. Nonmaternal caribou arrive in this region 2-4 weeks later.

Most CAH caribou remain within approximately 40 km of the Beaufort Sea during the insect season, which extends from late June through mid-August. On warm, calm days when mosquitoes (Culcidae) and oestrid flies (Oestridae) are active, groups of caribou coalesce and move rapidly toward the coast. The area within roughly 1 km of the coast is typically cooler, windier, and more humid than inland areas (unpubl. data), and therefore less conducive to insect activity. During extended periods of insect attack, large aggregations of caribou may move along the coast into the prevailing northeasterly winds. With decreased insect activity, the groups fragment and caribou move inland to feed. Thus, midsummer movements are predictable in some respects but vary considerably depending on the intensity and duration of insect attack and the predominant species of insects present. By mid-August of most years, insect activity declines and CAH caribou disperse inland toward wintering areas.

Petroleum Development

Conoco, Inc., operator of the Milne Point Production Unit, began developing the area near Milne Point during winter 1981-82 with construction of a 29-km gravel road/drill pad complex (Fig. 1). The roads were upgraded nearly continuously during summer 1982. Little or no additional construction occurred during 1983 and 1984; road maintenance was moderate in

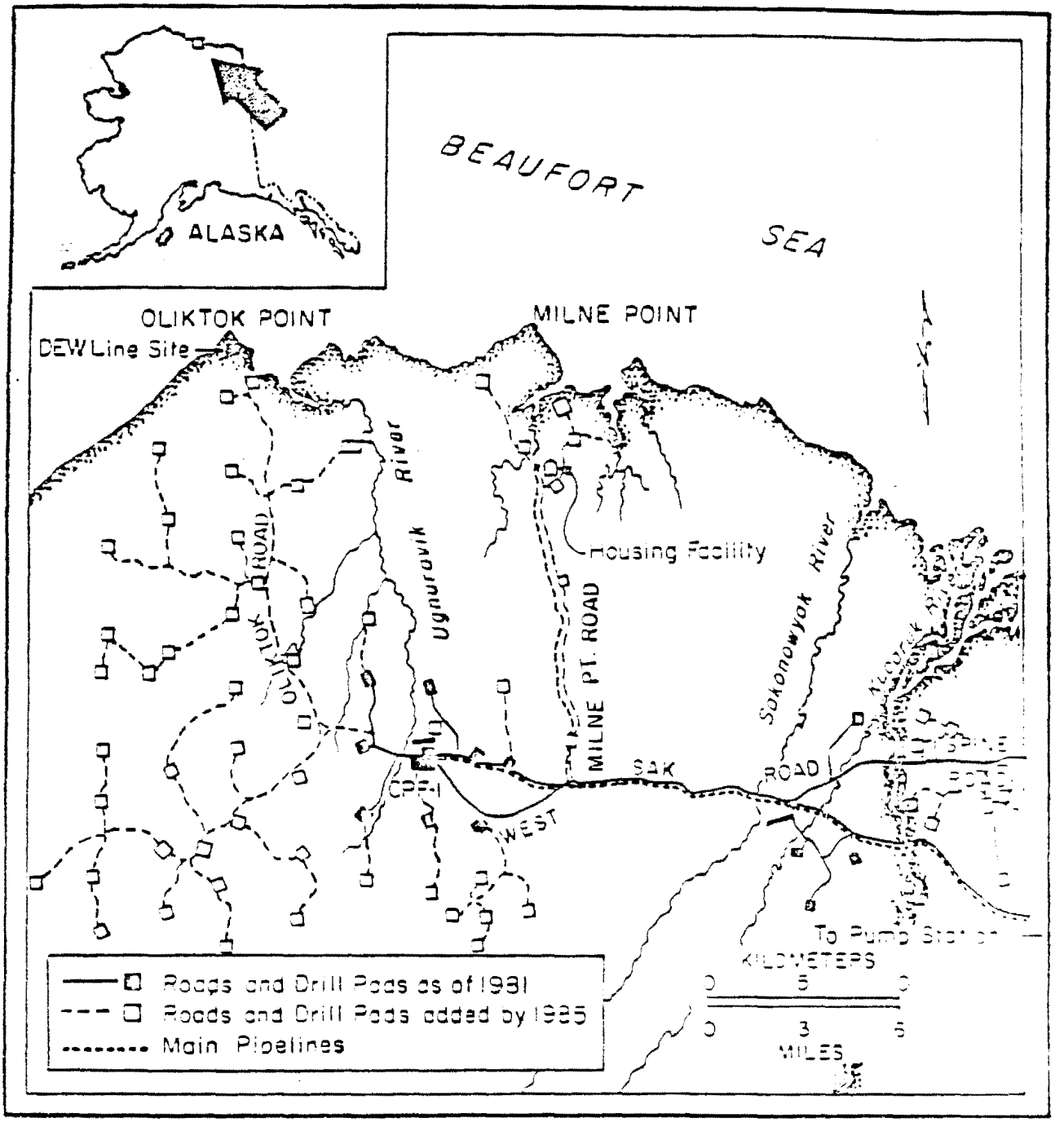

Fig. 1. The Milne Point study area and surrounding region, with roads and gravel pads as of 1981 and 1985.

1983 and minimal in 1984. During winter 1984-85, a central camp facility was built, and a pipeline was erected along the main access road. The pipeline, 45 cm in diameter, is elevated ca. 1.7 m above ground on vertical support members. Levels of human activity in the area during summer were moderate in 1982, low in 1983, extremely low in 1984, and high in 1985.

The Milne Point complex is roughly centered on a high-use portion of the CAH calving grounds (Whitten and Cameron 1985) and an important component of summer range that includes insect-relief habitat. Development near Milne Point raises 2 principal concerns regarding caribou: possible displacement of maternal females from an established calving area, and possible disruption of insect-induced movements.

OBJECTIVES

This research program was designed to describe the distribution of caribou near Milne Point during May-August, to document the effects on caribou of ongoing development, and to develop recommendations for minimizing the impacts of surface development on caribou. In addition, access via the Milne Point road system provided an opportunity for a companion study of an important aspect of caribou summer ecology.

Our caribou research near Milne Point has evolved into 3 discrete areas of investigation, each with a specific set of objectives:

1. Distribution of calving caribou

   a. To describe the distribution of caribou near Milne Point during calving, 1982-85.

   b. To determine the effects of the gravel road/pad complex (and later, a main pipeline) and associated human activity on the distribution of maternal females during calving.

2. Local distribution and movements of caribou, May-August

a. To describe seasonal and annual changes in the distribution of caribou near the road/pad network, and to identify areas of high caribou use and crossing activity.

b. To formulate recommendations to minimize the effects of development near Milne Point on caribou, with particular emphasis on the design and placement of caribou crossing structures (i.e., gravel ramps) in the Milne Point Pipeline (see Dau and Cameron 1984).

— RESULTS —

c. To evaluate the effectiveness of the mitigative measures employed, with special reference to the use of pipeline crossing structures.

3. Weather-insect-caribou studies

a. To determine the relationships between weather variables and the activity of mosquitoes and oestrid flies.

b. To describe the distribution and behavior of caribou in response to the activity of parasitic insects.

Results of the first area of investigation were reported in a paper presented at the Fourth International Reindeer/Caribou Symposium (Appendix I). Objectives addressed under the third study component will be available as Chapters 1 and 2, respectively, of a thesis at the completion of the senior author's M.S. degree program. The second area of investigation is the subject of this report.

METHODS

The study area lies north of the West Sak Road (also known as the Spine Road) between the Oliktok Road and the Kuparuk River (Fig. 1). Physiographic characteristics are typical of the Arctic Coastal Plain (Wahrhaftig

1965). Vegetation is similar to that described for the Prudhoe Bay region (Neiland and Hok 1975, Webber and Walker 1975).

In 1982 and 1983, surveys were conducted twice daily along the East and West Roads (Fig. 2) during 9-27 May, 1-20 June, and 1 July-5 August. In 1984 and 1985, sampling periods were similar, but only 1 survey was conducted per day during May and June, and surveys were terminated on 31 July.

Usually, 1 observer conducted the surveys in a light truck at speeds $\leq$48 km/hr. When caribou were sighted, the vehicle was stopped at the point approximately perpendicular to the group, and the caribou were observed using binoculars or a spotting scope. The following information was recorded for each group of caribou:

1. date and time
2. location along the East or West Road (km)
3. group size and sex/age composition (numbers of bulls, cows, calves, yearlings, adults, unknowns)
4. estimated distance from the road (m)
5. the location of road and pipeline crossings (km)
6. number and sex/age composition of caribou that crossed the road and pipeline

During July 1982 and 1985, a security check station was located at the intersection of the West Road and West Sak Road (Fig. 2). Times of entry and exit of each vehicle that used the Milne Point road system were recorded. From these records, 3 measures of traffic were calculated: (1) the number of vehicle passes during the same hour that caribou were observed; (2) the mean number of vehicles/h for the hour that caribou were observed and the preceding 2 h; and (3) the mean number of vehicles/h over the entire time period encompassing the road survey.

Differences among seasons and years were examined using BMDP-83 statistical software (Dixon 1983). Some of the chi-square analyses were programmed in FORTRAN after Zar (1974). Only complete observations of caribou

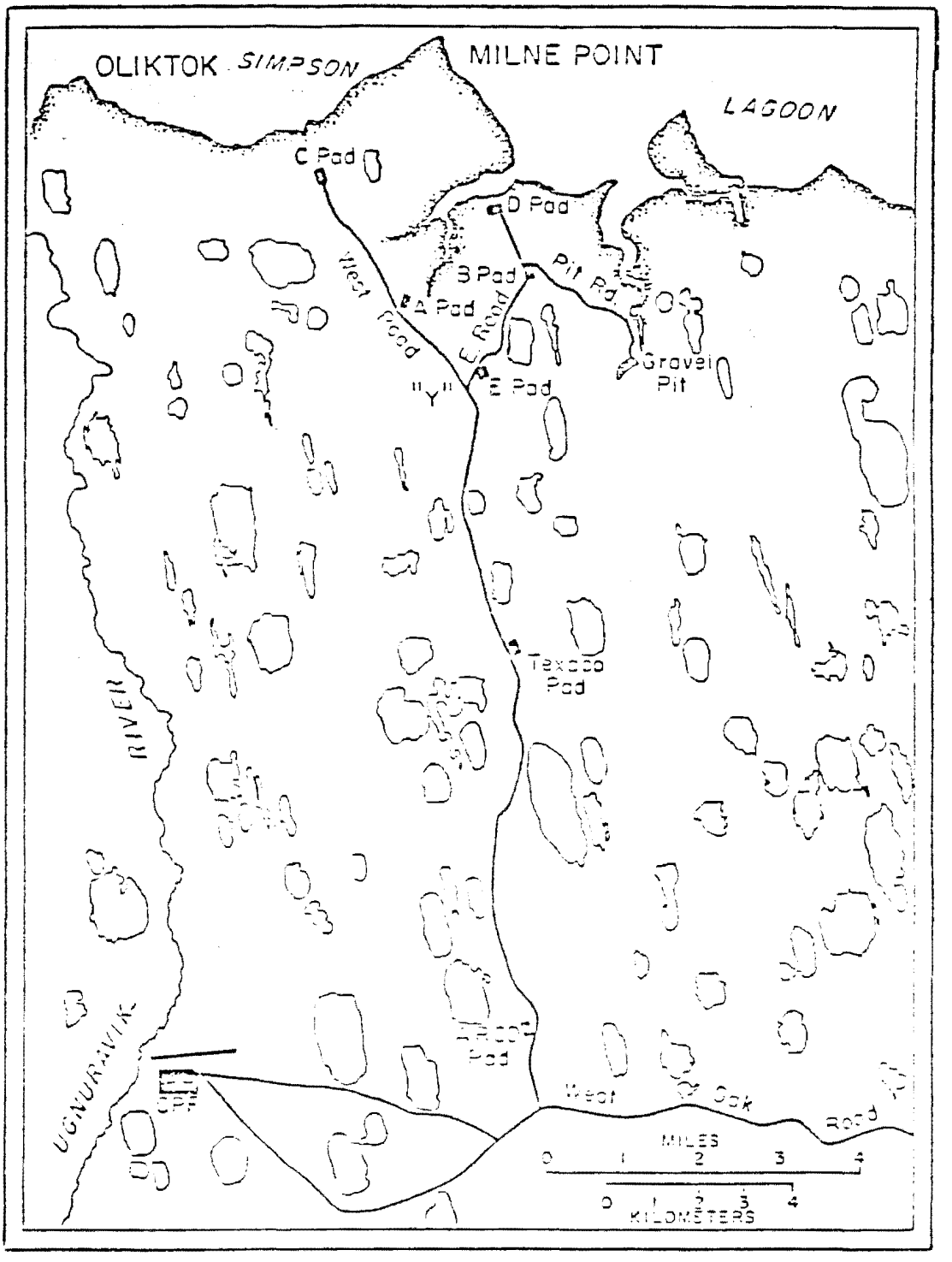

Fig. 2. The Milne Point Development Complex.

(e.g., those for which there were no missing values for any variable) during regularly scheduled surveys were used in the analyses. With one exception (computation of mean distance of caribou groups from roads), the data were restricted to observations of caribou that were within 1 km of the road system. This ensured equal coverage along the road and accurate determination of group sex/age composition. All computer-assisted operations were conducted on a VAX 11 785 (VMS 4.1) computer. Alpha levels (P values) ≤ 0.05 were considered statistically significant.

RESULTS AND DISCUSSION

The northern- and southernmost 4-km sections of the West Road and the East Road received high use and were crossed frequently by caribou (Fig. 3). The observation of numerous caribou from northern sections of road is attributable to the tendency for caribou to aggregate near the coast during periods of insect attack. High use of the southern 4 km of the West Road may have resulted from caribou paralleling the Milne Point and/or West Sak Roads (see Cameron et al. 1983, Smith et al. 1984) into areas near this intersection.

We focused most of our attention on that section of road between the "Y" (i.e., the intersection of the West and East Roads) and West Sak Road (Fig. 2). Maintaining caribou movements through the production complex north of the "Y" would probably require multiple crossing ramps over the flowlines; and even if such ramps were installed, the high levels of human activity likely to be associated with the production complex could greatly reduce or preclude use of the crossings by caribou. Furthermore, the absence of surface development north of C and D Pads provides a natural corridor for east-west movements along the coast.

During each of the 4 years, at least one 1-km section of road, within 4-km south of the "Y" and within 4 km north of the West Sak Road, received relatively high caribou use and crossing activity (Fig. 4). However, when the data from all 4 years were combined, no "nodes" of use or crossing activity were evident within these 4-km sections based on both the intensity of use (i.e., total number of caribou) and the

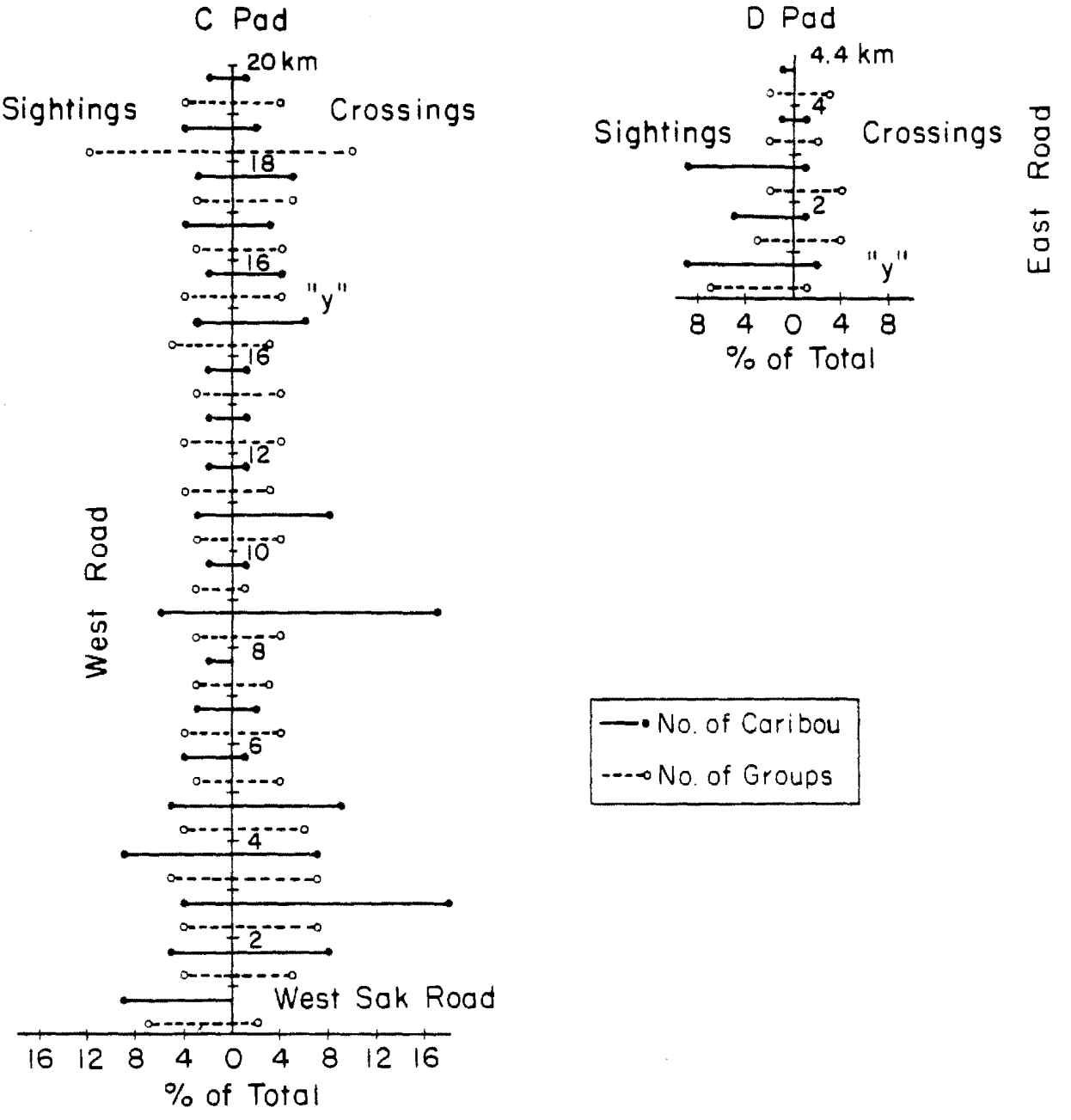

Fig. 3. Distribution of caribou sightings and road crossings along the Milne Point road system (see Fig. 2), 1982-85. Note: percentages <1 are not shown.

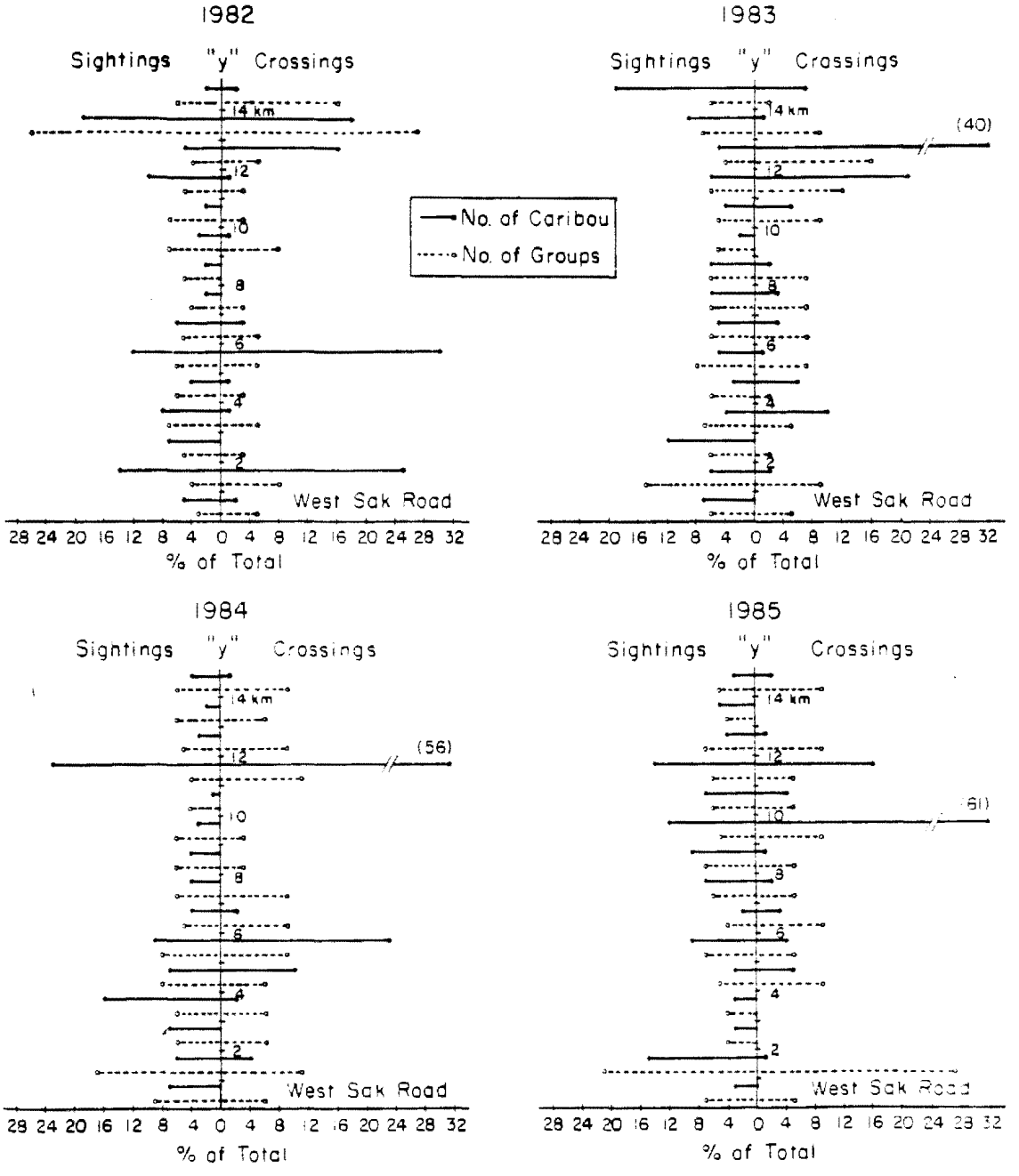

Fig. 4. Distribution of caribou sightings and road crossings along the West Road, between the "Y" and the West Sak Road (see Fig. 2) in 1982, 1983, 1984, and 1985. Note: percentages <1 are not shown.

frequency of use (i.e., the number of groups) (Fig. 5). For example, numerous individual caribou used the area, and crossed the road, 11-12 km north of the West Sak Road, yet this road segment was not used or crossed more frequently (i.e., by groups) than most others. Conversely, groups of caribou often used the area, and frequently crossed the road, 1-2 km north of the West Sak Road, but the number of caribou represented was not appreciably greater than that along most other road segments.

Identifying preferred areas along the road on the basis of total number of caribou may be particularly misleading during midsummer. During July, large groups form in response to insect attack and often travel rapidly over long distances. Assigning preference to areas where these groups happen to be seen is therefore risky. The frequency of use or crossings by groups of caribou may also be biased (Whitten and Cameron, in press), but probably is a more conservative index of preference. Using groups as the sample unit, only 1 area of high use and crossing activity was discernible: 1-2 km north of the West Sak Road (Fig. 5). Although other nodes of use were evident along the West Road during individual years (Fig. 4), the locations were highly variable, suggesting little or no selection of specific movement corridors.

Fewer caribou were observed along the East and West Roads in 1982 than in any other year, despite a reduction in sampling intensity in May and June of 1984 and 1985 (Table 1). This is partly a reflection of differences in herd size. In addition, 1982 was characterized by several brief periods of insect activity, followed by short periods of no insect activity; caribou frequently traveled between coastal and inland areas but did not form large aggregations that remained near the coast at Milne Point. In 1983, however, insects were present on more days, reached higher peak levels of activity, and remained active for longer periods than in 1982 (unpubl. data); oscillatory movements were relatively infrequent, but large groups of caribou formed near the coast in response to insect attack and remained within sight of the Milne Point road system. In 1984, several insect-induced movements between coastal relief habitat and inland foraging areas occurred, but there were essentially no such oscillatory movements in 1985.

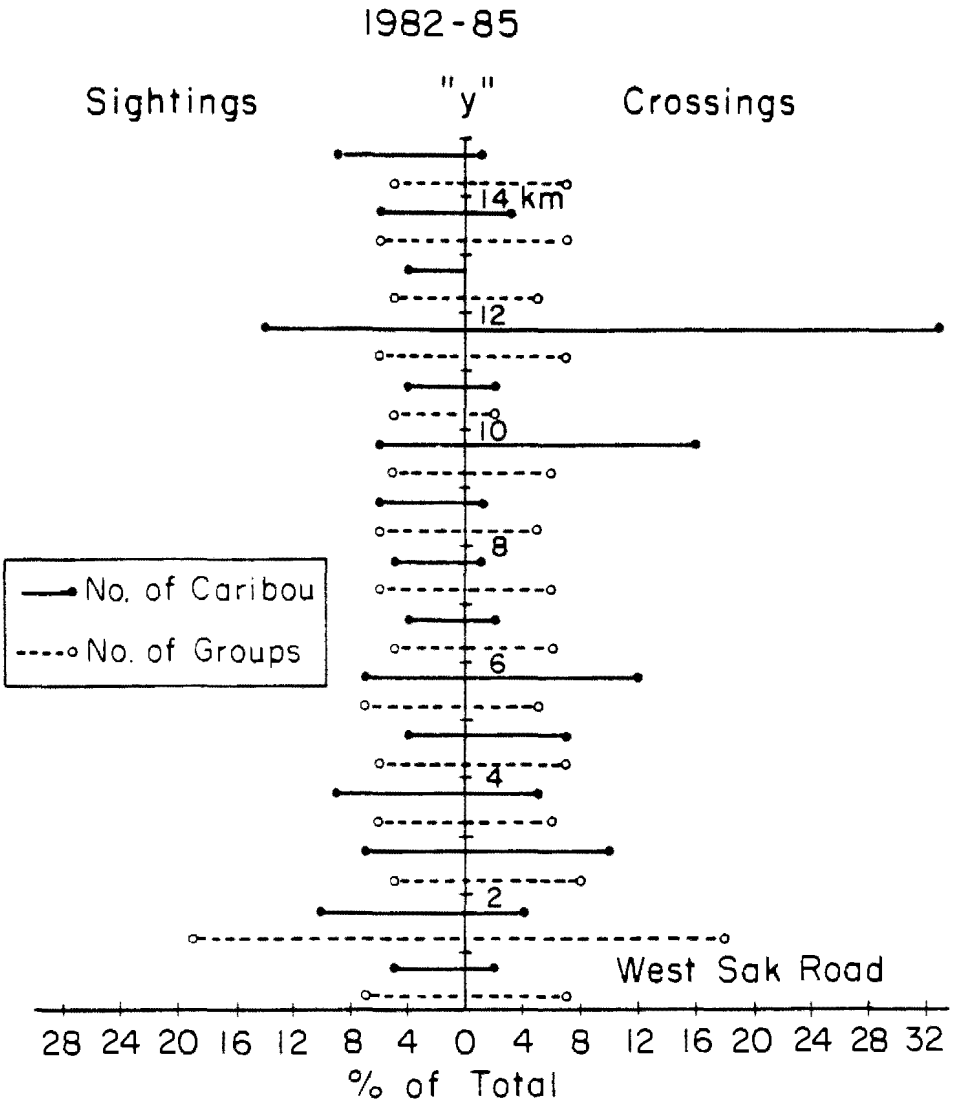

Fig. 5. Distribution of caribou sightings and road crossings along the West Road, between the "Y" and the West Sak Road (see Fig. 2), 1982-85. Note: percentages <1 are not shown.

Table 1. Total number, composition, and mean group size (±SD) of caribou observed within 1 km of the East and West Roads (see Fig. 1) during May, June, and July/August 1982-85.

	No. of caribou							No. of groups	Mean group size	No. of surveys
	Bulls	Cows	Calves	Yearlings	Adults	Unknowns	Total			
1982										
May	55	235	131[a]	1[b]	20	1	443	146	6.08 3 (1.8)	24
Jun	50	242	16	139	82	19	548	168	5.01 1 (3.3)	33
Jul/Aug	767	3,427	1,200	143	1,420	2,368	9,325	299	4.46 31 (191.9)	67
Total	872	3,904	1,347	283	1,522	2,388	10,316	613		114
1983										
May	40	279	260[a]	106[b]	302	30	1,017	243	9.35 4 (2.9)	26
Jun	79	420	236	358	274	0	1,367	356	10.17 4 (5.1)	35
Jul/Aug	2,248	3,209	2,779	1,793	4,625	602	15,256	310	4.77 49 (135.1)	65
Total	2,367	3,908	3,275	2,257	5,201	632	17,640	909		126
1984										
May	15	78	86[a]	4[b]	149	11	343	97	7.46 4 (2.3)	13[c]
Jun	37	172	248	192	674	4	1,327	237	14.81 6 (9.7)	16[c]
Jul/Aug	1,746	671	2,971	113	8,300	2,815	16,616	527	10.33 32 (120.3)	51
Total	1,798	921	3,305	309	9,123	2,830	18,286	861		80
1985										
May	27	228	238[a]	5[a]	280	15	793	167	12.85 5 (3.8)	13[c]
Jun	60	111	111	124	209	0	615	135	6.75 5 (5.8)	20[c]
Jul/Aug	2,034	990	3,055	502	8,054	46	14,681	443	8.53 33 (93.2)	52
Total	2,121	1,329	3,404	631	8,543	61	16,089	745		85

[a] 11 months old.
[b] 23 months old.
[c] 1 survey per day; otherwise, 2 surveys per day.

The mean number of caribou observed per survey was consistently greater in July/August than in either May or June (Fig. 6). Only a portion of all caribou in the region during July are present in May or June (i.e., caribou filter in over a 2-month period). Also, the greater mobility of larger groups during July enhances the likelihood of observing caribou from the Milne Point road system.

Although the CAH has been growing at approximately 13% annually (r=0.12; Whitten and Cameron 1983, 1985), no significant linear or exponential increase in the mean number of caribou observed per survey was noted during May, June, or July/August (Fig. 6). However, there was a significant relationship between the total number of caribou observed during each aerial calving survey and the corresponding mean number of caribou observed per road survey in June ($r = 0.82$, $df = 6$, $0.01 < P < 0.02$). Thus, numbers of caribou observed from the road system were highly dependent upon the abundance of caribou in the study area as a whole, at least during June when comparative data were available. Apparently, annual differences in weather patterns, and possibly disturbance, had more influence on the number of caribou near the Milne Point Complex than the increase in population size. For example, the relatively low numbers of caribou observed during May and June 1982 and May 1984 (Fig. 6) are probably attributable to persistent snow and meltwater on the calving grounds. In contrast, numerous caribou were observed in May 1985, probably because they were attracted to a strip of snowfree tundra adjacent to the newly constructed Milne Point Pipeline. The 1985 decline in numbers of caribou observed during June and July/August was probably a result of unusual weather/insect patterns.

lack of insects would increase numbers.

There was no difference among years in the mean distance of caribou groups from the road system during May or June (Table 2). However, distance was significantly different among years during July/August. Multiple contrasts (Bonferroni technique; Neter and Wasserman 1974) indicate that, during July/August, the mean distance of caribou groups from the road was significantly greater in 1982 and 1985 than in 1983 and 1984 ($P < 0.001$). This difference may be attributable to the lower levels of human activity near Milne Point in 1983 and 1984, as compared to 1982 and 1985.

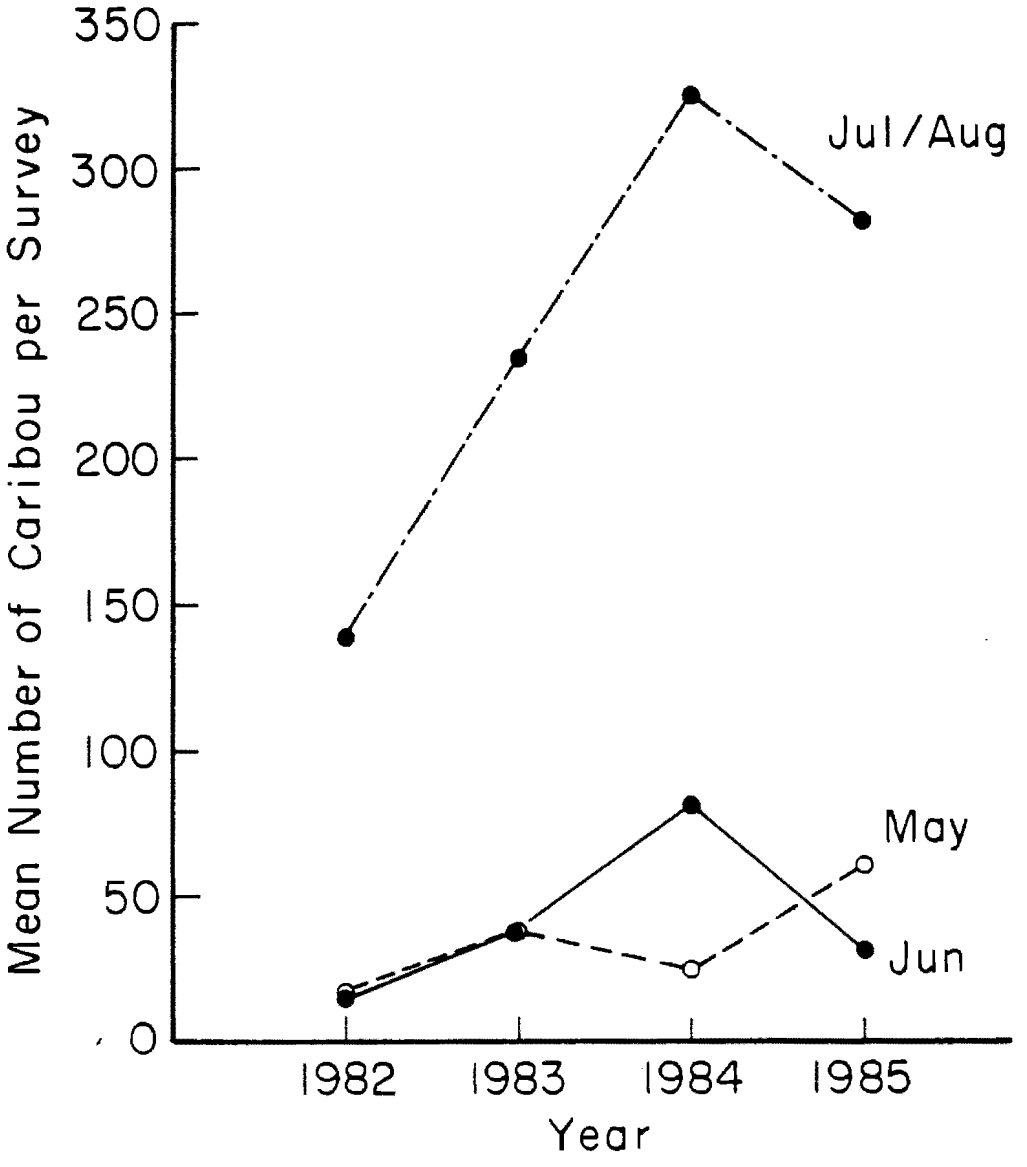

Fig. 6. Mean number of caribou observed per survey (along the East and West Road; see Fig. 2) during May, June, and July/August 1982-85.

Table 2. Mean (±SD) distance to groups of caribou[a] observed from the West Road[b] during May, June, and July/August 1982-85.

	May	June	July/August
1982	1081 (981)	1173 (799)	1029 (902)
1983	1088 (764)	1265 (806)	755 (631)
1984	1050 (516)	1232 (811)	755 (587)
1985	902 (613)	1288 (865)	1025 (713)
F[c]	2.47	0.75	12.66[d]
P(df)	0.06 (3272)	0.53 (3427)	<0.001 (3470)

[a] n = 2643 groups.

[b] Includes only that section of road between the "Y" and a point 2 km north of the West Sak Road (see Fig. 2).

[c] Test statistic for H_o: there is no difference in the means among the 4 years; Welch technique, equal variances not assumed.

[d] Multiple contrasts (Bonferroni technique) showed differences between 1982 and 1983, 1982 and 1984, 1983 and 1985, and 1984 and 1985.

The mean distance of caribou groups from the West Road was consistently greater during June than during either May or July/August (Table 2). Furthermore, in June, the relative numbers of all caribou, and calves, within 1 km of the road were positively correlated with distance from the road; no such relationships were discernible for May or July/August (Table 3).

In summary, the results of ground surveys conducted during June indicate a displacement of cows with calves from the area within 1 km of the road; aerial survey results indicate that this effect extends several km (Appendix I). These observations confirm other reports of the heightened sensitivity of maternal caribou to disturbance (de Vos 1960, Lent 1964, Bergerud 1974, Cameron et al. 1979, Cameron and Whitten 1980, Whitten and Cameron 1985). In contrast, there is no evidence for similar effects during May or July/August. The absence of a response during May suggests a greater tolerance of female caribou for disturbance during the month preceding parturition than during the calving period itself. In addition, some caribou overwinter in or near the oil fields and may be more habituated to roads, pipelines, and human activities than their migratory counterparts that winter in the foothills. Insect activity in July/August strongly influences caribou movements, habitat preference, and their sensitivity to human disturbance. It is therefore difficult to isolate the effects of the road on caribou distribution during summer.

During years of high human activity near Milne Point (1982 and 1985), there was no relationship between any measure of road traffic and either the mean proportion of calves per group, or the mean distance of groups from the road (data limited to that section of the West Road south of the "Y"). Average levels of traffic may have been greater than some critical threshold, above which a functional response of caribou to varying levels of traffic would not be discernible. An alternative explanation for the absence of any pairwise relationship is that disturbance was underestimated because traffic counts did not include road maintenance equipment and other activities along the road (e.g., cleanup crews, survey parties). Finally, as noted above, factors such

Table 3. Percentages of all caribou, and calves, within 100 m distance intervals from the West Road[a] during May, June, and July/August 1982-85.

	May		June		July/August	
	Total	Calves	Total	Calves	Total	Calves
0-100	5	6	7	6	17	19
101-200	10	10	7	6	5	5
	41%		29%		39%	
201-300	12	13	7	2	7	8
301-400	14	12	8	8	10	12
401-500	9	11	12	10	9	10
501-600	8	7	6	7	7	8
601-700	14	14	12	17	19	16
701-800	11	12	14	15	15	12
801-900	8	8	16	18	7	8
901-1000	9	8	12	10	4	3
r	0.10	0.28	0.79	0.76	-0.13	-0.35
n	1,568	417	2,965	546	20,132	3,985
p	>0.50	>0.20	<0.01	<0.01	>0.50	>0.20

[a] Includes only that section of road between the "Y" and a point 1 km north of the West Sak Road (see Fig. 2).

as insect harassment and parturition alter the sensitivity of caribou to disturbance, thereby obscuring any effects of traffic. Nevertheless, some of the between-year differences in distance seem to be partially attributable to annual differences in the levels of human activity near Milne Point, of which traffic is an integral part.

No attempt was made to identify specific locations of high crossing activity during 1985. Instead, we attempted to determine only if free passage of caribou through the area had been maintained with the Milne Point Pipeline in place. Crossing success was evaluated in terms of the total number of caribou, and groups, that crossed the West Road in relation to the total number of caribou and groups observed during each year. There was no difference in the relative number of groups observed crossing the road among years; however, there was a significant difference among years in the relative number of individual caribou that crossed the road or road/pipeline complex (Table 4). Relatively fewer caribou crossed the road in 1983 (11.0% of those observed), a year of low human activity, than in any other year. Long periods of alternating insect harassment and abatement in 1983 apparently reduced the frequency of coastal/inland movements by caribou, resulting in less contact with the road system than in other years. In contrast, 26.2% of all caribou observed crossed the road in 1984. Patterns of insect harassment in 1984 were similar to those in 1982 (see above), and it seems likely that the extremely low levels of human activity in the area facilitated road crossings by caribou. Even though fewer individual caribou and fewer groups crossed the road in 1985 than expected, the effect cannot be attributed specifically to the presence of the Pipeline.

The combined crossing data for all 4 years indicate that the percentage of individual caribou observed crossing the road was substantially lower for May and June (3.1% and 2.3%) than for July/August (20.9%). Therefore, within each season, we compared crossings during each pre-pipeline year with those in 1985 when the Pipeline was in place. Again, there were few differences in the number of groups observed crossing, but there were many differences in the number of individual caribou that crossed the road or road/pipeline complex (Table 5). It

Table 4. Contingency table analyses of the relative numbers of individual caribou, and groups, observed crossing the West Road and/or Milne Point Pipeline[a] May-August, among the years 1982-85.

Year		Individuals			Groups		
		Observed, but no crossing	Observed crossing	Total	Observed, but no crossing	Observed crossing	Total
1982	obs	2526	466 [15.6]	2992	311	22 [6.6]	333
	(exp)	(2464)	(528)		(313)	(20)	
1983	obs	6401	793 [11.0]	7194	487	33 [6.4]	520
	(exp)	(5924)	(1270)		(490)	(30)	
1984	obs	6164	2185 [26.2]	8349	471	30 [6.0]	501
	(exp)	(6875)	(1474)		(472)	(29)	
1985	obs	5220	910 [14.8]	6130	385	18 [4.5]	403
	(exp)	(5048)	(1082)		(379)	(24)	
	Total	20,311	4354	24,665	1654	103	1757
		X^2=676.23[b]	df=3	P<0.001	X^2=2.16[b]	df=3	P>0.05

[a] Includes only that section of road (or road/pipeline) between the "Y" and a point 1 km north of the West Sak Road (see Fig. 2).

[b] H_o: there was no difference in the relative number of individual caribou, or groups, that crossed the road (or road/pipeline) among 1982, 1983, 1984, and 1985.

Note: [ ] = % of total.

Table 5. Yearly pairwise comparisons of crossing success along the Milne Point Road by season, 1982-85.

	Individuals			Groups		
	Crossed	Did not cross	Total	Crossed	Did not cross	Total
May						
1982	4(2)	252(254)	256	2(1)	85(86)	87
1985	0(2)	289(287)	289	0(1)	102(101)	102
	4	541	545	2	187	189
	X^2=4.03	P<0.05		X^2=2.02	P<0.20	
1983	42(28)	531(545)	573	7(4)	117(120)	124
1985	0(14)	289(275)	289	0(3)	102(99)	102
	42	820	862	7	219	226
	X^2=22.07	P<0.001		X^2=5.32	P<0.05	
1984	0(0)	250(250)	250	0(0)	66(66)	66
1985	0(0)	289(289)	289	0(0)	102(102)	102
	0	539	539	0	168	168
	X^2=0.0	n/a		X^2=0.0	n/a	
June						
1982	24(12)	394(406)	418	2(1)	108(107)	110
1985	0(12)	426(414)	426	0(1)	85(84)	85
	24	820	844	2	193	195
	X^2=24.70	P<0.001		X^2=2.02	P<0.20	
1983	45(32)	969(982)	1,014	10(7)	224(227)	234
1985	0(13)	426(413)	426	0(3)	85(82)	85
	45	1,395	1,440	10	309	319
	X^2=18.86	P<0.001		X^2=4.44	P<0.05	
1984	27(19)	1,080(1,088)	1,107	6(4)	166(168)	172
1985	0(8)	426(418)	426	0(2)	85(83)	85
	27	1,506	1,533	6	251	257
	X^2=10.58	P<0.01		X^2=3.07	P<0.10	
Jul/Aug						
1982	438(415)	1,880(1,903)	2,318	18(14)	118(122)	136
1985	910(933)	4,305(4,282)	5,215	18(22)	198(194)	216
	1,348	6,185	7,533	36	316	352
	X^2=2.19	P<0.20		X^2=2.08	P<0.20	
1983	706(837)	4,901(4,770)	5,607	16(15)	146(147)	162
1985	910(779)	4,305(4,436)	5,215	18(19)	198(197)	216
	1,616	9,206	10,822	34	344	378
	X^2=49.46	P<0.001		X^2=0.14	P<0.90	
1984	2,158(1,757)	4,834(5,235)	6,992	24(23)	239(240)	263
1985	910(1,311)	4,305(3,904)	5,215	18(19)	198(197)	216
	3,068	9,139	12,207	42	437	479
	X^2=286.02	P<0.001		X^2=0.10	P<0.80	

should be noted, however, that P-values for the individual comparisons are artificially low because of the lack of independence of observations of individual caribou. This, together with annual differences in patterns of weather, insect activity, and local disturbance, renders the present results equivocal with respect to the effects of the Milne Point Pipeline on caribou crossing success.

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Appendix I

EFFECTS OF A ROAD SYSTEM ON CARIBOU DISTRIBUTION DURING CALVING

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ABSTRACT. In winter 1981-82, a 29-km road system was built in a high-use caribou (Rangifer tarandus granti) calving area near Milne Point, Alaska. Aerial surveys of this area were conducted annually during the calving period for four years before and four years after road construction. Effects of the road system on the distribution of caribou were investigated by comparing survey data obtained during these two periods. The 41 400-ha study area was partitioned into 40 quadrats; after construction (1982-85), significantly fewer caribou were observed within quadrats encompassing the present road system than before construction (1978-81). The area within 6 km of the road system was stratified into six 1-km intervals, and differences in the distribution of caribou among those strata were examined using linear regression analysis. After construction, the density of maternal females was positively correlated with distance, whereas no such relationship was apparent before construction. Density of nonmaternal adults was unrelated to distance during both periods. The results suggest that a local displacement of maternal caribou has occurred in response to roads and associated human activity.

Key words: caribou, calving, roads, disturbance.

INTRODUCTION

The Central Arctic Herd (CAH) is a distinct subpopulation of ca. 13 000 caribou (Rangifer tarandus granti) (as of 1983; W. Smith, unpublished data) that ranges the Arctic Slope of Alaska between the Canning and Colville Rivers. Seasonal movements are principally north-south between wintering areas in the Brooks Range and calving grounds/summer range on the Arctic Coastal Plain (Cameron and Whitten, 1979).

In winter 1981-82, CONOCO, Inc. built 29 km of gravel road as the initial phase of petroleum development within the Milne Point Production Unit (Fig. 1). This complex is approximately centered on one of two known CAH calving concentration areas (Whitten and Cameron, 1985). In winter 1984-85, a single pipeline 35 cm in diameter and approximately 1.8 m above ground was erected adjacent to the Milne Point Road, and a 300-person housing facility was constructed. Human activity and traffic levels near Milne Point were low in June 1983 and 1984 (<10 vehicles per day; 1 active drill rig), moderate in 1982 (10-100 vehicles per day; 2 active drill rigs), and high in 1985 (>200 vehicles per day; 3 active drill rigs).

The objective of this study was to determine the effects of roads and associated activity on the local distribution of caribou, especially maternal females, in this high-use calving area. We compared the distribution of caribou within this region during the four years before construction of the road system (1978-81) with that during the four years after construction (1982-85).

METHODS

The study area is ca. 45 km northwest of Prudhoe Bay, lying north of the West Sak Road between the Oliktok Road and Kuparuk River (Fig. 1). Terrain ranges from sea level to 25 m elevation. Vegetation is typical of the Arctic Coastal Plain (Wahrhaftig, 1965) and similar to that described for the Prudhoe Bay region (Neiland and Hok, 1975; Webber and Walker, 1975).

Aerial surveys of the study area (Whitten and Cameron, 1985; Cameron et al., 1985) were conducted annually between 10 and 14 June 1978-85, within a few days after the majority of CAH calving had occurred. North-south strip transects spaced at 3.2 km were flown by helicopter, and observers searched within 1.6 km of the transect center line. For each group of caribou observed, we recorded map location, group size, and sex/age composition.

The study area was partitioned into 40 quadrats of 1036 ha each (Fig. 2). Median percentages of caribou observed within the seven quadrats that include the present road system (i.e., "road quadrats") were compared between the pre- and postconstruction periods using the Mann-Whitney test; the Z test statistic is reported when ranks were tied (Conover, 1980).

The area within 6 km of the present roads was then stratified into six 1-km distance intervals, excluding portions of strata that were closer to the West Sak Road (Fig. 1), and the data were examined to determine whether the assumptions for linear regression analysis were satisfied (Neter and Wasserman, 1974). Square root transformations eliminated the correlations between means and variances of caribou density within strata. Linear regressions describing caribou density as a function of distance from roads were fit using the full and reduced model approach (Neter and Wasserman, 1974) to examine differences within and between the two four-year periods. Linear models for 1978-81 and 1982-85 were fit simultaneously and compared through analysis of variance (ANOVA).

During the surveys, we did not distinguish between maternal and nonmaternal females. Therefore, to describe the distribution of maternal females, the above analyses based on total number of caribou were repeated using number of calves (i.e., neonates). In addition, stratification and ANOVA were used to compare the responses of maternal groups (i.e., ≥25% calves) and nonmaternal groups (i.e., <25% calves) to roads. It should be noted that the latter is an *a posteriori* analysis, and the results should not be granted the same level of objectivity as other results presented here.

All statistical operations were performed using a Compaq Deskpro computer system and SPSS/PC statistical software (Norusis, 1984). Alpha levels (P values) ≤0.05 were considered statistically significant.

RESULTS

Fewer caribou were near the present road system after construction than before construction. The median percentage of caribou in the seven road quadrats was significantly different between 1978-81 and 1982-85 (8.5 vs. 2.0%; T = 26.0, P = 0.03). Before construction, 17% of all caribou observed in the study area (465 of 2806) were within these seven quadrats, compared with only 2% (90 of 5424) after construction.

Differences between periods for calves were not clear. Even though the median percentage of calves in the road quadrats was higher during 1978-81 (10.5%) than during 1982-85 (0.0%), the difference was not statistically significant (Z = -1.69, P = 0.09). However, the disparity between pre- and postconstruction periods in the percentage of all calves observed in the seven quadrats was greater than that for all caribou. Before construction, 17% of all calves observed (190 of 1150) were within these quadrats, compared with <1% (6 of 2339) after road construction.

Linear relationships between caribou density and distance from roads were significantly different between 1978-81 and 1982-85 for all caribou, and for calves (Table 1). The annual variability in these relationships within each four-year period was not significant for all caribou, but was nearly significant for calves (P = 0.053). The latter may have resulted from yearly differences in levels of human activity in the study area after 1981. Nevertheless, differences in these relationships were greater between periods than among years within periods (Table 1).

During 1978-81, there was no detectable linear relationship between the density of either total number of caribou or number of calves, and distance from roads. In 1982-85, however, both density parameters were correlated with distance (Fig. 3). This further suggests that the between-period difference in the relationship between calf density and distance (see above) was real and not attributable to within-period variation.

The similar results obtained for total number of all caribou and number of calves (Fig. 3) indicate that the distribution of maternal caribou was not appreciably different from the distribution of all caribou. This is not surprising considering that most adult ($\geq$2 years) caribou in the study area during June were maternal females (minimum mean = 69%; SD = 0.15).

The relationships between number of maternal groups per km^2 and distance from roads differed significantly between 1978-81 and 1982-85, a difference that cannot be attributed to within-period variability (Table 2). No such difference was found for nonmaternal groups, either between or within the pre- and postconstruction periods. Furthermore, there was no linear correlation between the number of maternal or nonmaternal groups per km^2 and distance during 1978-81; nor was there any correlation for nonmaternal groups during 1982-85. In 1982-85, however, the number of maternal groups per km^2 was highly correlated with distance from roads (Fig. 4).

DISCUSSION

Results of the quadrat analysis for calves are probably misleading. The absence of a statistically significant difference between 1978-81 and 1982-85 in the percentage of calves in the seven road quadrats may be attributable to the small sample size (n = 8), tied ranks, and the large effect on ranks of the slightly greater percentage of calves observed during 1985 (1%) vs. 1980 (0%).

Linear regression analyses clearly show significant differences between 1978-81 and 1982-85 in the relationships between caribou density and distance from roads, differences that are not artifacts of annual variability. Apparently, displacement of maternal females from areas near the Milne Point road system account for this change.

Extrapolating these local effects to a regional level requires some speculation. The logical implication is that an extensive, dense network of roads will result in widespread, partial displacement of maternal caribou from

calving grounds unless they begin to tolerate these structures and associated activities (Cowan 1974). Unfortunately, there is no evidence for habituation by maternal caribou. On the contrary, numbers of CAH females calving within the Prudhoe Bay oil field have remained consistently low (Whitten and Cameron, 1985, unpublished data), despite nearly a decade of exposure to manmade structures.

The fidelity that most caribou herds show to calving grounds suggests that these areas may be more important than other seasonal ranges which are used less predictably (Skoog, 1968). Bergerud (1974) stated: "The basic question is...why the same areas, limited in extent, are used year after year as calving sites." Valkenburg et al. (in press) discuss some of the factors that could influence the affinity of caribou to calving areas.

The CAH has continued to grow despite the loss of calving habitat. However, this apparent inconsistency does not preclude the possibility that traditional calving areas confer an advantage to caribou. Thus far, displacement of CAH maternal females has been relatively minor, and the low density of this herd on its calving grounds has allowed use of suitable alternative areas (Whitten and Cameron, 1985).

To our knowledge, this study is the first to systematically and quantitatively address the effects of development within a high-use calving area. If petroleum development continues to expand across the central Arctic Coastal Plain, we should have more opportunities to evaluate the importance of calving areas to the CAH. Other seasonal ranges have been only slightly affected by man, losses to predation are thought to be low, and the annual human harvest is small. The absence of these confounding factors provides a unique opportunity to evaluate the consequences of habitat loss to the productivity of a barren-ground caribou herd.

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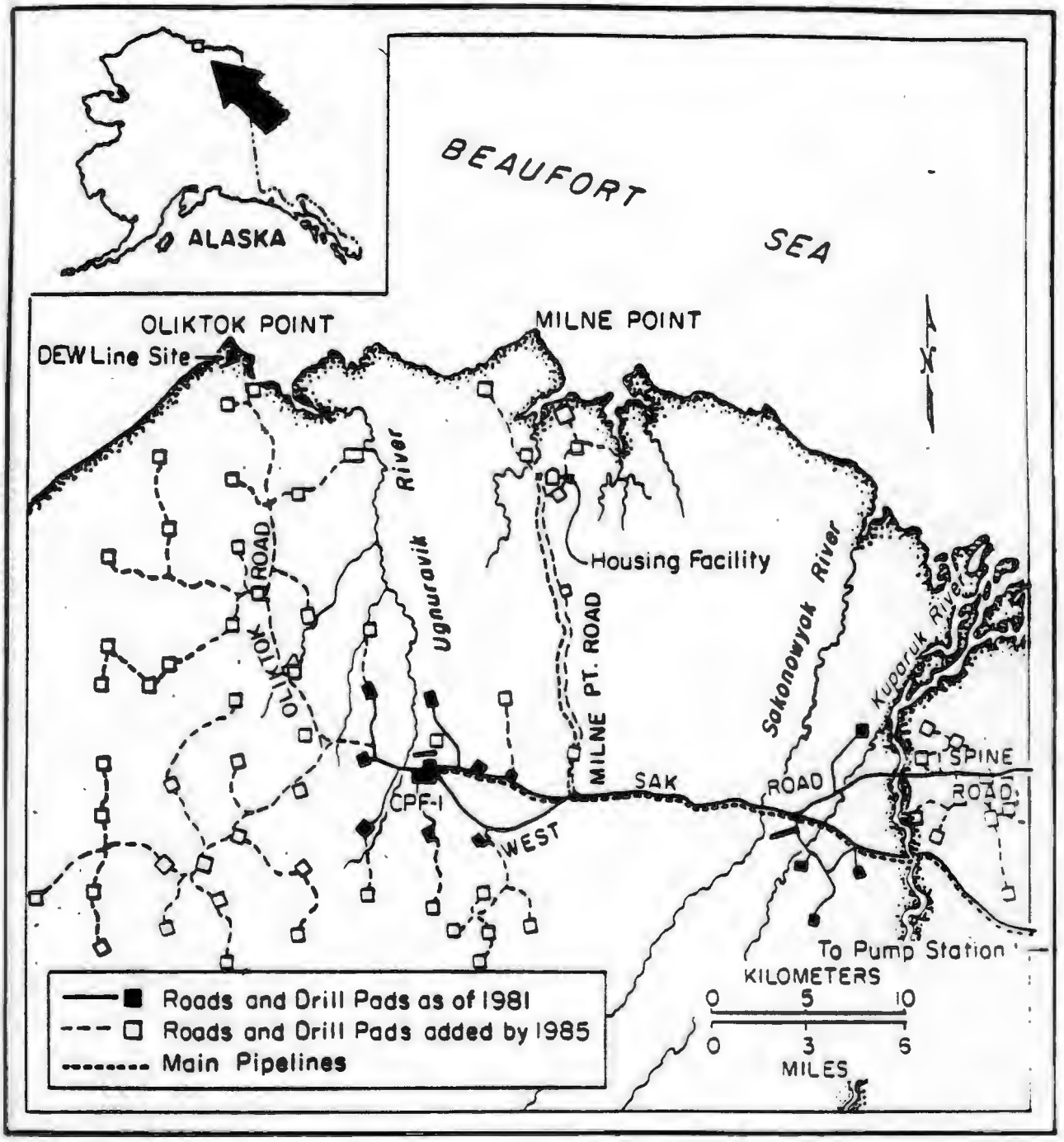

Figure 1. The Milne Point study area and surrounding region, with roads and gravel pads as of 1981 and 1985.

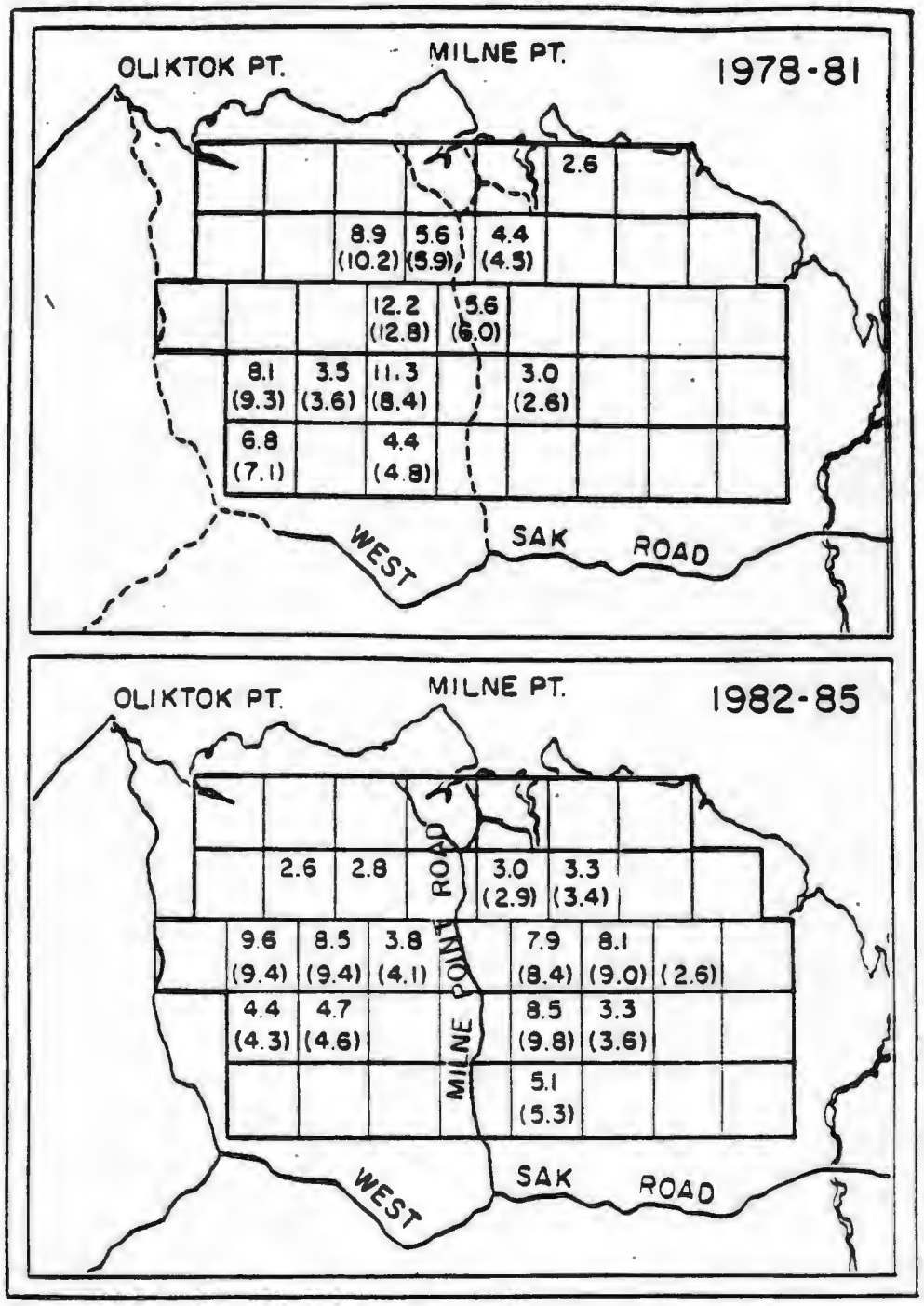

Figure 2. Distribution of 1036-ha quadrats in the study area (see Fig. 1) preferred by caribou (calves, in parentheses) during calving, 1978-81 and 1982-85. The occurrence of caribou is expressed as a percentage of the total observed in all 40 quadrats; only those percentages exceeding 2.5% (the percentage of the total area for each quadrat) are shown.

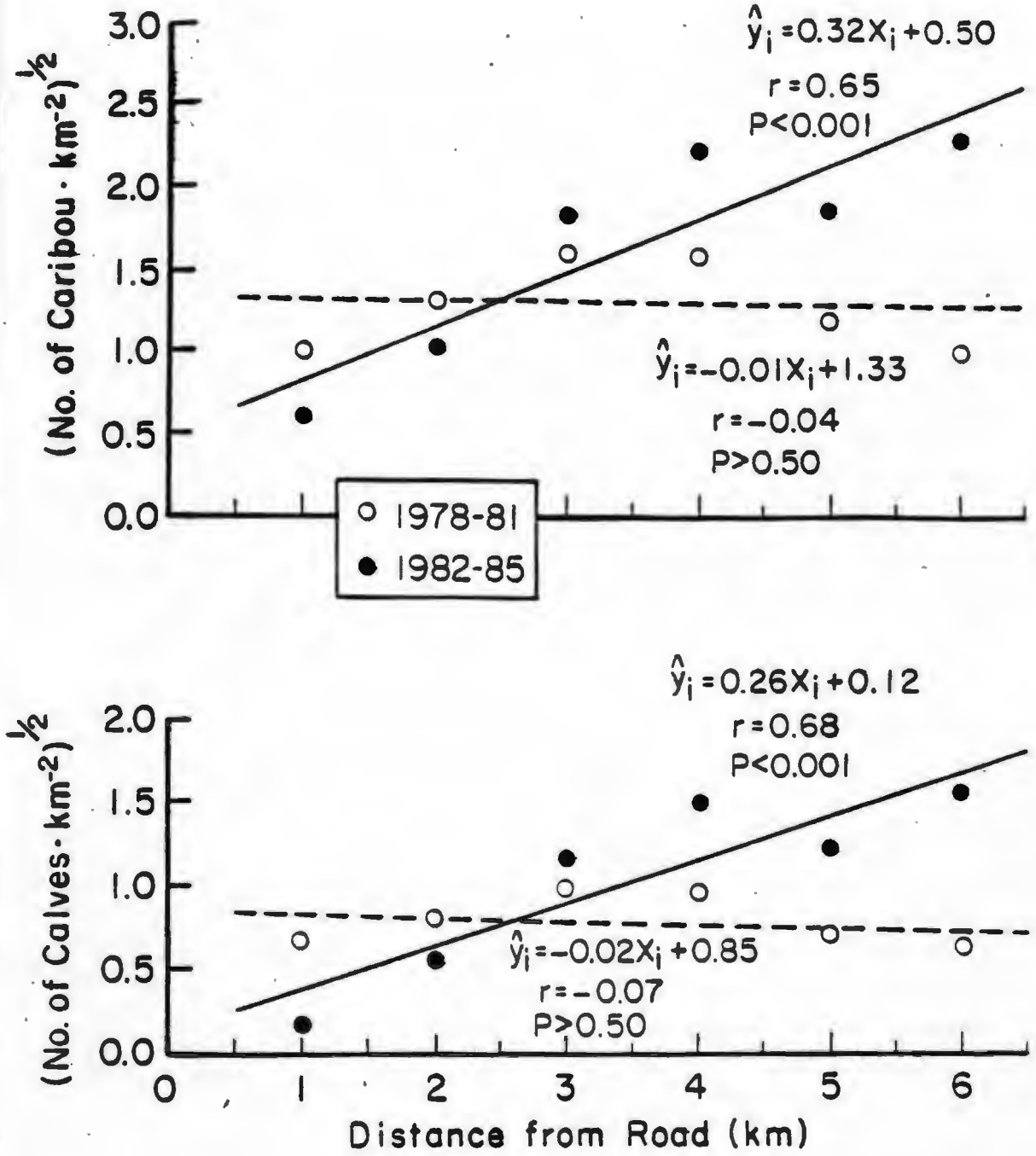

Figure 3. The relationships between caribou density and distance from roads for all caribou, and calves (i.e., neonates), during June 1978-81 and 1982-85, Milne Point, Alaska. Data points shown are strata means for each four-year period; however, linear models were fit using data for individual years.

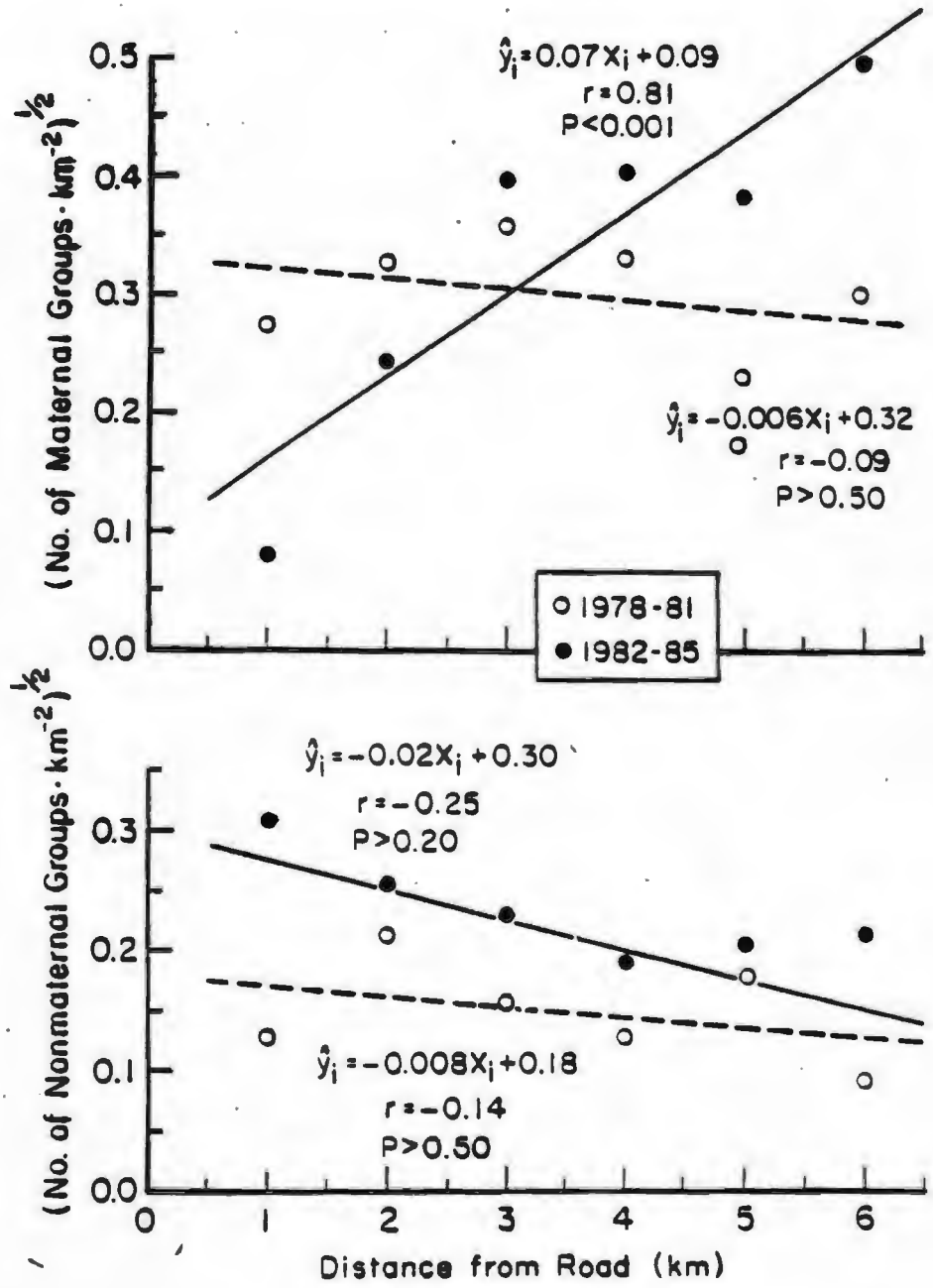

Figure 4. The relationships between the number of maternal groups (i.e., ≥25% calves) and nonmaternal groups (i.e., <25% calves) groups per km^2, and distance from roads during June 1978-81 and 1982-85, Milne Point, Alaska. Data points shown are strata means for each four-year period; however, linear models were fit using data for individual years.

Table 1. Analysis of variance examination of the relationships between numbers of all caribou and calves, per km^2, and distance from roads, Milne Point, Alaska, June 1978-85.

Density parameter	Model[a]	Source of variability	Sums of squares	df	Mean square	F	P	Entering F value	P
All caribou		Total	25.26	47					
	Basic[b]	Regression	3.43	1	3.43	7.23	0.01	7.23	0.01
		Error	21.83	46	0.47				
	Reduced[c]	Regression	8.84	3	2.95	7.89	<0.01	7.24	<0.01
		Error	16.42	44	0.37				
	Full[d]	Regression	15.69	15	1.05	3.50	<0.01	1.91	0.07
		Error	9.56	32	0.30				
	Test[e]	Periods	8.84	3	2.95	5.15	0.02		
		Years/Periods	6.86	12	0.57				
Calves		Total	14.63	47					
	Basic[b]	Regression	2.07	1	2.07	7.58	<0.01	7.58	<0.01
		Error	12.56	46	0.27				
	Reduced[c]	Regression	5.38	3	1.79	8.51	<0.01	7.85	<0.01
		Error	9.26	44	0.21				

Table 1. Continued.

Density parameter	Model[a]	Source of variability	Sums of squares	df	Mean square	F	P	Entering F value	P
	Full[d]	Regression	9.40	15	0.63	3.83	<0.01	2.05	0.05
		Error	5.24	32	0.16				
	Test[e]	Periods	5.38	3	1.79	5.35	0.02		
		Years/Periods	4.02	12	0.34				

[a] Each model tests simple linear relationship(s), where the dependent variable is the square root of caribou density (numbers/km^2) and the independent variable is distance from the road site (km).

[b] Fits a linear model with data pooled across all years; H_o: the eight relationships are not significantly different.

[c] Fits a separate linear model for each period; H_o: the two relationships are not significantly different. The Entering F value tests for the significance of this model beyond the significance of the Basic model.

[d] Fits a separate linear model for each year within each period; H_o: the four relationships are not significantly different. The Entering F value tests for the significance of this model beyond the significance of the Reduced model.

[e] Tests H_o: the variation in linear models between periods is not significantly greater than the variation in linear models among years within each period.

Table 2. Analysis of variance examination of the relationships between numbers of maternal and nonmaternal groups per km^2 and distance from roads, Milne Point, Alaska, June 1978-85.

Density parameter	Model[a]	Source of variability	Sums of squares	df	Mean square	F	P	Entering F value	P
Maternal groups		Total	0.875	47					
	Basic[b]	Regression	0.144	1	0.144	9.09	<0.01	9.09	<0.01
		Error	0.730	46	0.016				
	Reduced[c]	Regression	0.363	3	0.121	10.40	<0.01	9.39	<0.01
		Error	0.512	44	0.012				
	Full[d]	Regression	0.507	15	1.050	2.94	<0.01	1.04	0.44
		Error	0.368	32	0.012				
	Test[e]	Periods	0.363	3	0.121	10.10	<0.01		
		Years/Periods	0.144	12	0.012				
Nonmaternal groups		Total	0.742	47					
	Basic[b]	Regression	0.026	1	0.026	1.66	0.20	1.66	0.20
		Error	0.716	46	0.016				
	Reduced[c]	Regression	0.111	3	0.037	2.58	0.07	2.97	0.06
		Error	0.631	44	0.014				

Table 2. Continued.

Density parameter	Model[a]	Source of variability	Sums of squares	df	Mean square	F	P	Entering F value	P
	Full[d]	Regression	0.273	15	0.018	1.24	0.29	0.92	0.54
		Error	0.469	32	0.015				
	Test[e]	Periods	0.111	3	0.037	2.74	0.10		
		Years/Periods	0.162	12	0.013				

[a-e] See footnotes to Table 1.