NUMBERS, DISTRIBUTION, AND PRODUCTIVITY OF CARIBOU IN NORTHEASTERN KEEWATIN DISTRICT NORTHWEST TERRITORIES IN 1976

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ABSTRACT

This study was conducted to determine numbers, distribution and calf production of caribou (Rangifer tarandus groenlandicus) in two previously unstudied areas of northeastern Keewatin District, Northwest Territories. Aerial surveys were conducted north of Chesterfield Inlet between 15 and 25 June 1976 and north of Wager Bay between 29 June and 2 July 1976. The caribou north of Chesterfield Inlet (the Lorillard herd) were considered a social unit because they used a distinct calving ground. The observed calf to cow ratio in this area was 60:100 and the number of animals over 1 year of age was estimated to be 13,780 ± 3,357 (S.E.). A distinct calving ground north of Wager Bay (the Wager herd) could not be delineated because cows and calves had moved to join the bulls prior to the surveys. The observed calf to cow ratio north of Wager Bay was 58:100, and the population was estimated to be 9,369 ± 1,064 (S.E.).

ACKNOWLEDGEMENTS

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1. INTRODUCTION

Information on caribou occupying the vast areas north of Chesterfield Inlet and Wager Bay was virtually non-existent at the beginning of this study. The objective of our surveys was to determine, by means of aerial census techniques, numbers, distribution, and productivity of the caribou in this area.

Both the north and south shores of Wager Bay are steep, rocky and barren, rising quickly to elevations as high as 600 m above sea level (asl.). Most of the study area is undulating with abundant rock outcrops. Vegetated areas are strewn with boulders. The relatively well-drained grass-heath communities predominate over soggy sedge meadows. The study area covered 122,000 km^2 (Figs. 1 and 2).

2. METHODS

We divided the region into two study areas. The Lorillard area, occupying 65,000 km^2, was bounded by Chesterfield Inlet on the south, Hudson Bay to the east, Wager Bay and the 66th parallel on the north, and 94° W (Fig. 1). Twenty-one north-south transect lines were established at 16 km intervals and surveyed between 15 and 25 June, 1976.

The Wager Bay area, bounded by the Gulf of Boothia and the Arrowsmith River to the north, Hudson Bay to the east, Wager Bay to the south and 94° West, covered approximately 57,000 km^2 (Fig. 2). On the basis of a reconnaissance flight completed on 29 June to determine general caribou density and distribution, we divided the area into four strata. Stratum 1 with the lowest caribou density received 5% coverage from 16 transects. Seven transect lines established over stratum 2 and eight over stratum 3 gave 10 and 20% coverage respectively. We attempted to count all caribou in stratum 4 because of the dense aggregations of caribou and rugged topography in that region. In strata 1, 2 and 3, transect lines were spaced at 32, 16 and 8 km intervals respectively to obtain the desired coverage (Fig. 2). The surveys were completed on 2 July 1976. Two additional strata were distinguished after the survey. Stratum 1a was treated as a distinct unit because no caribou were seen in this area. Stratum 1c was omitted from the analysis because it was within the range of the Melville Peninsula population (Calef and Helmer 1980).

Transect lines were flown at an altitude of 120 m agl. at 192 km/hr in either a Cessna 185 aircraft (15 - 23 June) or a Cessna 337 aircraft (25 June - 2 July). Observers were the same (Heard and Cooper) throughout the survey. All caribou within a 0.8 km strip on each side of the plane were counted and classified as cows, calves, bulls or unknowns. Calves were easily recognizable by their small size and bulls were distinguished by the presence of antlers. All non-bull caribou in groups containing calves were considered to be cows. The pilot navigated and plotted the location of each sighting on 1:250,000 scale topographical maps while the observers recorded the corresponding data on tape; thus the observers never had to look away from the transect strip.

Population estimates were calculated using Jolly's Method 2 for unequal-sized sampling units (Jolly 1969) and Norton-Griffiths' method for integrating the results from different strata (Norton-Griffiths 1975). These calculations are based on statistical theory requiring transects to be spaced randomly (Siniff and Skoog 1964, Jolly 1969, Norton-Griffiths 1975, Caughley 1977). However, transects were spaced systematically in this survey because: 1) the evaluation of distribution and the estimate of production (calf to cow ratios) were more accurate when sampled systematically; 2) non-surveying flying time was reduced; 3) navigation was simpler; and 4) the resulting population estimate was not biased (Norton-Griffiths 1975, Pennycuick et al. 1977). Moreover, a variance estimated from evenly spaced samples, especially where stratification is employed, is seldom much different from a variance based on random samples (Caughley 1977, Cochran 1977, Pennycuick et al. 1977). If anything, the true variance will be slightly less than that of a random sample (Pennycuick et al. 1977). So long as systematic samples do not correspond to a periodic clumping of animals, the assumptions of the statistical model based on random sampling are not grossly violated (Caughley 1977).

3. RESULTS

3.1 The Lorillard Survey

3.1.1 Distribution

We observed 1,748 caribou on 21 transects resulting in an average density of 0.212/km^2 (Table 1). Cows and calves were concentrated on the high plateau south of Wager Bay; a few calves were observed over the entire study area. We delimited a calving ground of 12,250 km^2 within which 88% (326/370) of the calves were observed (Table 2, Fig. 3). Bulls, yearlings, and non-breeding cows occupied areas off the calving ground (Table 2).

The calving ground differed in physical characteristics from the rest of the study area. It occupied a high rocky plateau between 240-480 m asl. The rest of the census zone was approximately 150 m asl. The calving ground appeared to be cooler than the lower areas because newly fallen snow persisted longer at the higher elevations. These characteristics are typical of the calving grounds of most Canadian mainland caribou (Parker 1972).

Caribou density was much higher on the calving ground (1009/1213 = 0.83 caribou/km^2), than off the calving ground (739/5296 = 0.14 caribou/km^2; Table 2). Cows comprised 80.2% (548/683) of the caribou over 1 year of age that were found on the calving ground (Table 2). Group size on the calving ground, excluding calves, averaged 7.9 + 1.3 (S.E.) (683/87, with a range of 1-100). It was necessary to estimate the numbers in two groups because they were too large to count accurately.

3.1.2 Productivity

The calf to cow ratio based on data from the whole study area, using only those groups containing calves, was 56 calves to 100 cows (370:655). The calf-cow ratio in the high density area of the calving ground, 64:100 (272:423, Fig. 3), was significantly higher than over the rest of the study area, 42:100 (98:232, $X^2 = 8.64$, $p<0.01$, df = 1). This relationship did not change when the two largest groups were dropped from the analysis.

The ratio of calves to adult females provides the most accurate index of production and calf mortality. Unfortunately, unless the number of yearlings in groups that contain calves is equal to the number of non-parous adult females not in groups containing calves, the calf - cow ratio expressed here is biased. Since it is not possible to distinguish between yearlings and non-parous cows during aerial surveys, no indication of the magnitude or direction of this bias can be obtained. The most frequently used method for expressing calf production in caribou is the percentage of calves in the total population. In the Lorillard study area, calves comprised 21.2% (370/1748; Table 1) of the herd.

3.1.3 Population Estimate

By multiplying caribou density, determined from the aerial transects over the whole area, by the size of the study area, the population (excluding calves) was estimated to be 13,780 ± 3,357 (S.E.) (Table 3). As a result of the high variation in the number of caribou observed per transect (e.g. transects 11, 13, 18, Table 1), 95% confidence limits were high, 50.8% (Table 3).

3.2 The Wager Bay Survey

3.2.1 Distribution

We observed 2,313 caribou in 4 strata within the Wager Bay study area (Table 4). The distribution of bulls and cows with calves overlapped more in the Wager Bay study area than in the Lorillard study area. Calves in the Wager herd were distributed over the entire region surveyed (Fig. 4). Ninety-five percent of the bull caribou were within 16 km of the coast (Fig. 5). The observed distribution of bulls was not biased by transect orientation because the transects were perpendicular to the coast (Fig. 2). The highest density of calves occurred in stratum 4 (Table 5), but the number estimated in each stratum was similar: stratum 1b - 565 calves, stratum 2 - 744, stratum 3 - 455 and stratum 4 - 488. As with calves, the highest density of bulls was observed in

stratum 4. As predicted from the preliminary survey, the density of both adult and calf caribou increased with sampling intensity (Table 5).

The average group size (including calves) in strata 1b, 2, and 3 was 7.8 ± 1.4 (Table 6). The density was so high in stratum 4 that it was impossible to distinguish individual groups even though some clumping did occur.

The relatively large post-calving caribou concentrations in stratum 4 were moving south down the river valleys toward the coast of Wager Bay. Their direction of movement indicated that they calved further north, presumably on the rocky plains south of Curtis Lake (Fig. 4). It is unlikely that they had come from further away because calving had occurred only about 2 weeks earlier. Cows and calves observed in the other strata also could have come from a Curtis Lake calving ground. Alternatively, caribou north of Wager Bay could have given birth while in medium-sized groups distributed throughout the study area.

Bulls in the Kaminuriak herd were distributed around the coastal plain in early summer as were bulls in the Wager herd. However, bulls and post-calving groups of Kaminuriak caribou do not usually come together until later in the summer (Parker 1972). The early mixing of bulls and post-calving groups at Wager Bay probably results from the calving area being close to the coast, rather than from the social organization being different to that of the Kaminuriak herd.

3.2.2 Productivity

The calf to cow ratio was 58:100 (Table 7). In calculating the data for Table 7, two groups in which the calves were not counted accurately were omitted from strata 2 and 3. In stratum 4, we concentrated on obtaining accurate counts of adults, thus the number of calves counted was low (Table 4). In most groups only the adults were enumerated and the number of calves was estimated. The result was probably an underestimate of the calf-cow ratio, since groups with the fewest calves would have been the easiest to count. If data from only strata 1b, 2 and 3 are used to calculate the calf-cow ratio, the result is 60 calves:100 cows. Calves comprised 18.0% (152/843) of the population in strata 1b, 2 and 3 (Table 4).

3.2.3 Population Estimate

The number of caribou over 1 year of age was estimated to be 9,369 ± 1,064. The number of caribou in each of stratum 1b, 2 and 3 was estimated by multiplying the average density in each stratum by the area (Table 3). A complete count was achieved in stratum 4. Approximately half the herd was located in stratum 2. No caribou were observed in stratum 1a (Table 4). Ninety-five percent confidence limits on the population estimate were 23.6%.

When complete counts are undertaken, sampling error is zero. However, there may still be some error in the form of observer bias. It is possible that in stratum 4 the numbers of caribou in large groups were estimated incorrectly, and some groups were missed while others were counted more than once. To examine potential counting bias, we compared the results of the survey and reconnaissance flights. The close similarity between the two counts (Table 4) was encouraging. It would have been unreasonable to assume that the results would be identical because: 1) many caribou could have moved in or out of the area in the 2 days between these surveys, and 2) the boundaries, although similar, were not identical on both days. The similarities between counts suggested that there was little bias resulting from over-counting or missing large numbers of caribou. Bias in the estimation of group size would not show up in this comparison if we were consistent in our estimates on each day.

4. DISCUSSION

Caribou in the Lorillard herd south of Wager Bay used a distinct calving ground that was avoided by bulls, yearlings, and non-productive cows. This is typical of most herds (Kelsall 1968, Parker 1972). A distinct calving ground was not apparent north of Wager Bay. It is possible that cows gave birth on a calving ground around Curtis Lake and had dispersed by the time of these surveys.

The calf to cow ratios in this study (56:100 in the Lorillard herd, and 58:100 in the Wager herd) were slightly lower than the ratio of 69:100 observed among the Kaminuriak caribou (Parker 1972). Similar results of 62:100 were obtained for the Melville Peninsula herd (Calef and Helmer 1980) and of 62:100 (average from 1955 to 1962) for the Nelchina herd (Skoog 1968). The relatively high calf-cow ratio in the high density area of the Lorillard calving ground suggests higher survival of calves in this area than over the rest of the study area. Increased survival could be related to reduced wolf predation at higher densities (Holling 1959) and/or some favourable physical/climatic attribute of the habitat that reduced density-independent mortality (Parker 1972). It is also possible that calf-cow ratios were biased by our sampling methods. If there had been a relatively high proportion of non-breeding cows on the edges of the calving ground, we would have obtained the same results. Ground surveys, where barren cows (those without a distended udder) were distinguished from breeding cows whose calves had died (those with a distended udder), would have been required to distinguish between these two explanations.

Parker (1972) found that calves made up 30.0% of the Kaminuriak population just after calving in mid-June, and by mid-July had declined to 14.7%. The percentages of calves in the Lorillard and Wager herds were lower (21 and 19%, respectively) than those observed by Parker (1972). This, coupled with the lower calf-cow ratios, indicates that these areas did in fact have a lower production of caribou than the Kaminuriak population in 1968. The Wager survey took place approximately 2 weeks after calving was assumed to have occurred. Low production of the Wager herd may be partly a result of

the high mortality which reportedly occurs during this period (Parker 1972).

A second estimate of size of the Lorillard herd can be obtained by extrapolating the data from the calving ground. The number of caribou over 1 year of age on the calving ground was estimated at 6,830 (Table 3). If the Lorillard herd is distributed in the same way as the Kaminuriak herd, then 80% of the caribou over 1 year of age on the calving ground should be breeding females. Those breeding females should comprise 43% of the population (Parker 1972). Adult females did make up 80.2% of the non-calf segment on the Lorillard calving ground. If those females made up 43% of the Lorillard herd, then the population estimate would be 12,739 animals $\frac{(6830 \times 0.802)}{(0.43)}$.

The estimated size of the Wager herd was within the precision range normally obtained in surveys of large mammals (95% confidence limits):

22% - Siniff and Skoog 1964

30% - Evans et al. 1966 (mean from 3 surveys, range 25 - 38%)

21% - Sinclair 1972 (mean from 7 surveys, range 11 - 40%)

16% - Calef and Helmer 1980

This is very close to the previous estimate of 13,780 and suggests that the population estimate obtained in this study is more accurate than the broad confidence interval indicates.

Undoubtedly, some animals within the transect strips were overlooked. Other authors suggest that observers usually miss about 20% of the caribou (Thomas 1969, Parker 1972). If our bias was similar, the revised estimates would be

17,225 ± 4,196 (1.25 x 13,780 ± 3,357) and 11,711 ± 1,330 (1.25 x 9,369 ± 1,064) caribou for the Lorillard and Wager herds respectively. However, the error associated with the Lorillard population estimate was high. That error could be reduced in future surveys without any increase in cost (flying time) if the study area was first divided into two or more strata. Two obvious strata would be the calving ground and the surrounding area. If two such strata had been recognized at the outset of this survey, the 95% confidence limits would have been reduced by optimizing the sample size in each strata (Snedecor and Cochran 1967). The optimal allocation of sampling effort would be to fly 12 transects off the calving ground and 39 transects over the calving ground. If that had been done, the 95% confidence limits would have been only 28.9% of the population size. Thus stratification and optimization of sampling effort would have reduced the 95% confidence limits from 50.8% to 28.9% with the same amount of flying time.

Sampling error could also be reduced by increasing the sampling intensity over the whole area. Fifty-four transects would have to be flown to reduce the 95% confidence limits to 28.9%. This is 2.6 times the number of transects actually flown, and is clearly less efficient than dividing the survey zone into strata.

The Wager survey design led to a precise population estimate. We flew seven transects in each of strata 1b and 2, and eight transects in strata 3. If seven transects were flown in stratum 1b, six in stratum 2, and 12 in stratum 3, the 95% confidence limits would have been reduced only 1.2%, from 23.6% to 22.4%.

5. CONCLUSIONS

The 25,000 caribou estimated on the two study areas described here substantially increase the estimates of the number of caribou in northeastern Keewatin. Those two caribou groups appear to be distinct herds since they calve in separate areas. They also appear to be distinct from the Melville herd to the north (Calef and Helmer 1980) and from the Kaminuriak herd to the south (Parker 1972; Hawkins and Calef 1980).

The data presented here, and those of Calef and Helmer (1980) are the first to provide information on the density of caribou living year-round north of the tree line on the mainland.

It is impossible to say whether more or fewer caribou have previously inhabited this region since no previous surveys have been done. In recent years, the Kaminuriak herd has declined by approximately 20,000 animals (32%; Hawkins and Calef 1980). It is possible that some of the Lorillard caribou are emigrants from the Kaminuriak herd. However, the best explanation for the decline of the Kaminuriak herd is that the combination of hunting deaths and natural mortality have exceeded recruitment at least since 1968 (Heard 1980). The existence of a distinct calving ground suggests that the Lorillard and Wager animals must currently be considered a separate population.

Table 1. Numbers of caribou observed per transect on the Lorillard study area in June 1976.

Transect number	Transect length (km)	Transect area (z) (km^2)	Cows	Calves	Bulls	Unknown	Total	Caribou over 1 yr of age	Density of caribou over 1 yr of age (caribou/km^2)
1	233	372	4	4	1	8	17	13	0.035
2	227	364	1	1	0	6	8	7	0.019
3	227	364	7	7	0	1	15	8	0.022
4	228	366	0	0	0	23	23	23	0.063
5	242	387	5	1	0	43	49	48	0.124
6	247	396	10	5	0	96	111	106	0.268
7	240	383	3	2	0	37	42	40	0.104
8	250	400	25	13	11	19	68	55	0.138
9	246	393	17	8	12	12	49	41	0.104
10	256	409	25	12	19	34	90	78	0.191
11	256	409	109	78	41	60	288	210	0.513
12	246	393	64	49	36	55	204	155	0.394
13	225	360	0	0	1	1	2	2	0.006
14	172	276	53	32	5	12	102	70	0.254
15	155	248	21	8	8	15	52	44	0.178
16	147	235	3	0	9	35	47	47	0.000
17	145	232	9	5	16	12	42	37	0.160
18	133	213	256	122	11	41	430	308	1.444
19	72	115	40	22	0	13	75	53	0.461
20	81	130	3	1	12	15	31	30	0.230
21	40	64	0	0	0	3	3	3	0.047
Totals	4,068	6,509	655	370	182	541	1,748	1,378	0.212

Table 2. The proportion of caribou in each age and sex class on and off the Lorillard calving ground in 1976.

Age or sex class	On the calving ground	Off the calving ground	Total	Percent on the calving ground
Cows	548	107	655	84
Calves	326	44	370	88
Bulls	36	146	182	20
Unknowns	99	442	541	18
Totals	1,009	739	1,748	58
Transect area (km^2)	1,213	5,296	6,509	—

Table 3. Calculations of population size and variance for both the Lorillard and Wager caribou populations in 1976[p].

Area surveyed	Number of transects surveyed (n) *1	Maximum number of transects possible (N) *1	Area (Z) km^2	Density of caribou (R)*2 per km^2	Population estimate (Y) *3 (caribou over 1 year of age)	Pop. variance (VAR (Y))*4	Standard error S.E. of the population *5	95% confidence limits on the pop. est. *6
Lorillard herd:								
Whole area	21	210	65,000	0.212	13,780	11,269,125	3,357	50.8
Calving ground only	13	-	12,250	0.558	6,830	-	-	-
Wager herd:								
Stratum								
1a	9	-	19,288	0.0	0	-	-	-
1b	7	140	19,950	0.119	2,374	414,736	644	66.0
2	7	74	15,083	0.262	3,952	313,494	560	35.0
3	8	51	2,908	0.639	1,858	402,944	635	81.0
4	-	-	181	6.536	1,185	0	0	0
Total	31	-	57,389	-	9,369	1,131,174	1,064	23.2

[p] after Jolly (1969) and Norton-Griffiths (1975).
(see next page for Notes *1 - *6)

Table 3. (cont'd)

NOTE:

*1 N is the total number of transects possible that can be established over the area from which a sample of n of these are selected and surveyed.

*2 R = y/ z = total animals counted/total area searched (from Tables 1 and 4 as appropriate).

*3 Y = R x Z.

*4 VAR $(\hat{Y})$ = [(N) (N - n)/(n) $((S^2y)$ - (2) (R) (Szy) + $(R)^2$ $(S^2$ z))].

*5 S.E. $(\hat{Y})$ = $\sqrt{\text{VAR.}}$

*6 95% C.L. = (100) $(t_{.05})$ (S.E.)/$(\hat{Y})$; where t is for n-1 degrees of freedom.

Table 4. Numbers of caribou observed per stratum and per transect on the Wager study area in June 1976.

Stratum	Transect number	Length (km)	Transect area (z) (km^2)	Cows	Calves	Bulls	Unknowns	Total	Caribou over 1 year of age	Density of caribou over 1 year of age (caribou/km^2)
1a	1 to 9	-	-	0	0	0	0	0	0	0.00
1b	1	158	252	4	2	2	9	17	15	0.060
	2	40	64	28	18	-	6	52	34	0.531
	3	78	125	-	-	1	5	6	6	0.048
	4	61	99	2	2	-	10	14	12	0.122
	5	93	150	6	1	5	5	17	16	0.107
	6	72	116	3	2	1	17	23	21	0.181
	7	46	74	-	-	1	-	1	1	0.014
Totals		548	880	43	25	10	52	130	105	0.119
1c	1	38	61	-	-	1	25	26	26	0.426
	2	67	108	16	8	4	29	57	49	0.454
	3	7.6	12.2	-	-	-	5	5	5	0.409
	4	67	108	12	10	-	1	23	13	0.120
	5	42	67	-	-	-	79	70	70	1.047
Totals		221.6	356.2	28	18	5	130	181	163	0.458

Table 4. (continued)

Stratum	Transect number	Length (km)	Transect area (z) (km^2)	Cows	Calves	Bulls	Unknown	Total	Caribou over 1 year of age	Density of caribou over 1 year of age (caribou/km^2)
2	1	84	136	18	11	-	2	31	20	0.148
	2	84	136	7	1	-	3	11	10	0.074
	3	132	213	19	6	29	19	73	67	0.314
	4	55	89	4	1	-	-	5	4	0.045
	5	146	236	15	8	24	25	72	64	0.271
	6	153	247	51	25+	10	19	105	80	0.324
	7	35	57	12	3+	10	25	50	47	0.828
Totals		689	1,114	126	55	73	93	347	292	0.262
3	1	33	53	-	-	-	6	6	6	0.113
	2	35	56	10	9	12	8	39	30	0.536
	3	35	56	4	2	5	-	11	9	0.161
	4	37	59	-	-	-	14	14	14	0.237
	5	38	62	1	1	-	-	2	1	0.016
	6	40	65	45	25	4	-	74	49	.756
	7	43	69	32	21	9	64	126	105	1.522
	8	25	40	25	14	-	55	94	80	2.000
Totals		286	460	117	72	30	147	366	294	0.639
4	Survey	-	-	921	104[1]	75	189	1,289	1,185	6.536
	Reconnaissance	-	-	976	445	84	321	1,826	1,381	7.618

[1] low; see text (page 6) for explanation.

Table 5. The density of adult and calf caribou in each stratum of the Wager study area in 1976.

Stratum	Adult density$_2$(R) (caribou/km^2)	Calf density$_2$ (caribou/km^2)	Percent of stratum surveyed
1b	0.12	0.03	4.4
2	0.26	0.05	7.4
3	0.64	0.16	15.8
4	6.54	2.69[1]	100.0

[1] assuming a calf to cow ratio of 53:100.

Table 6. Average group size in 1976 in the Wager study area.

Stratum	Number of groups	Mean group size	S.E.	Range
1b	25	5.2	1.8	1-46
2	53	6.5	0.7	1-23
3	31	11.8	2.0	1-48
Combined	109	7.8	1.4	-

Table 7. Calf to cow ratios in the 1976 Wager study area.

Stratum	Number of calves	Number of cows	Calves per 100 cows
1b	25	43	58
2	50*	100	50
3	64*	90	71
4	44*	83	53
Combined	183	316	58

* estimated group sizes omitted from the analysis.

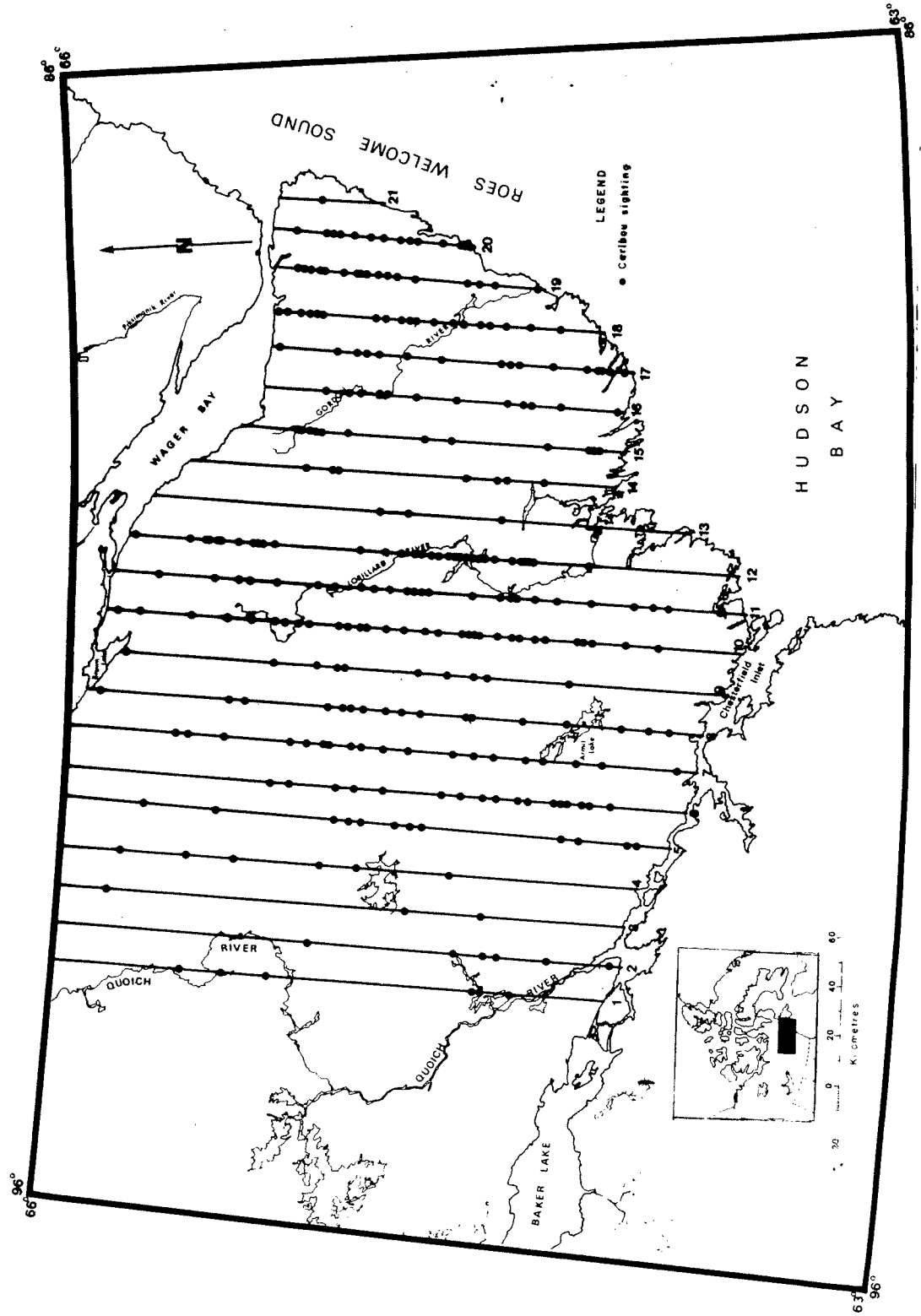

Figure 1. The 1976 Lorillard study area showing the location of the 21 transect lines and the observed caribou.

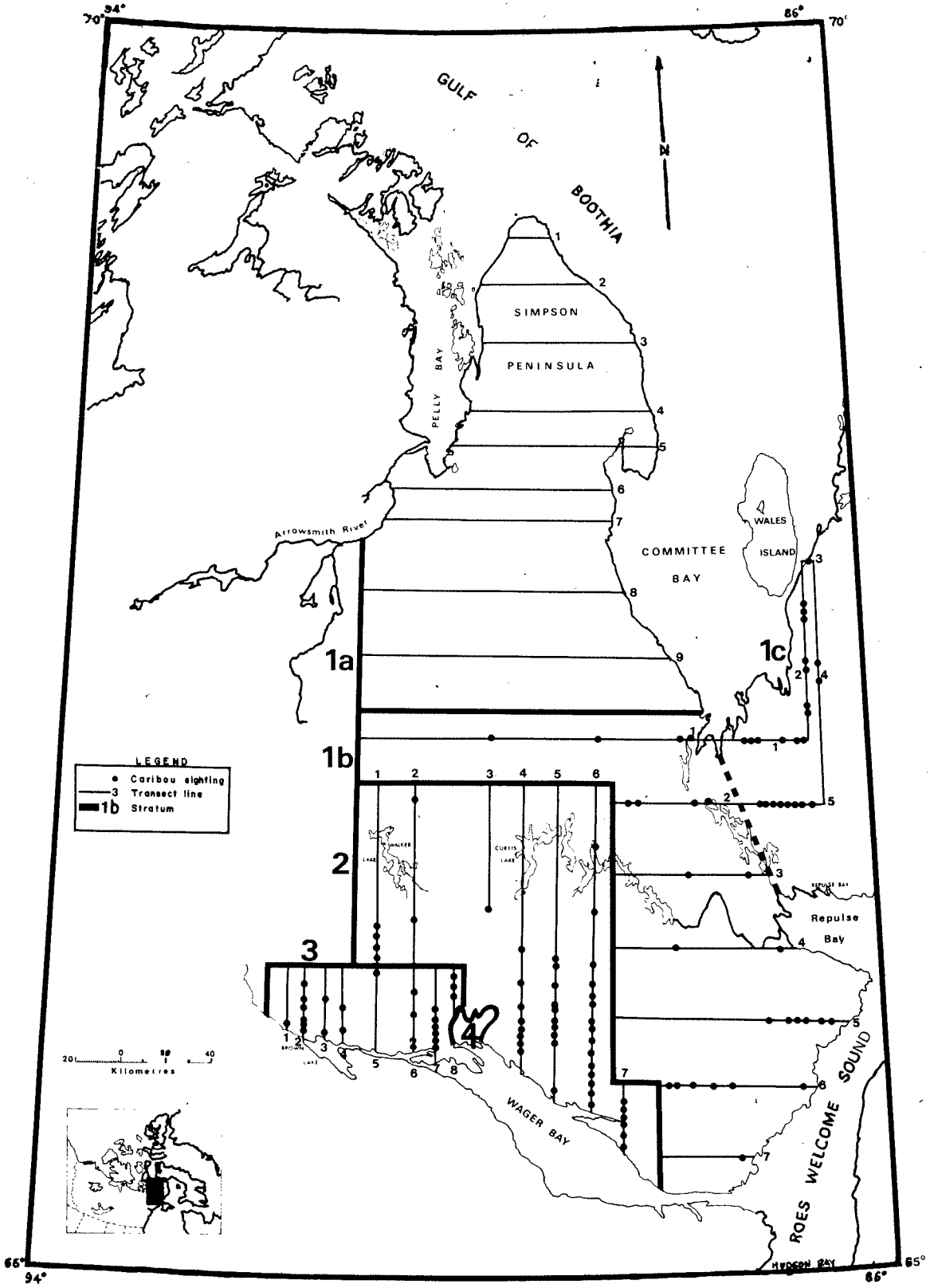

Figure 2. The 1976 Wager study area showing the strata, transect lines and the location of observed caribou.

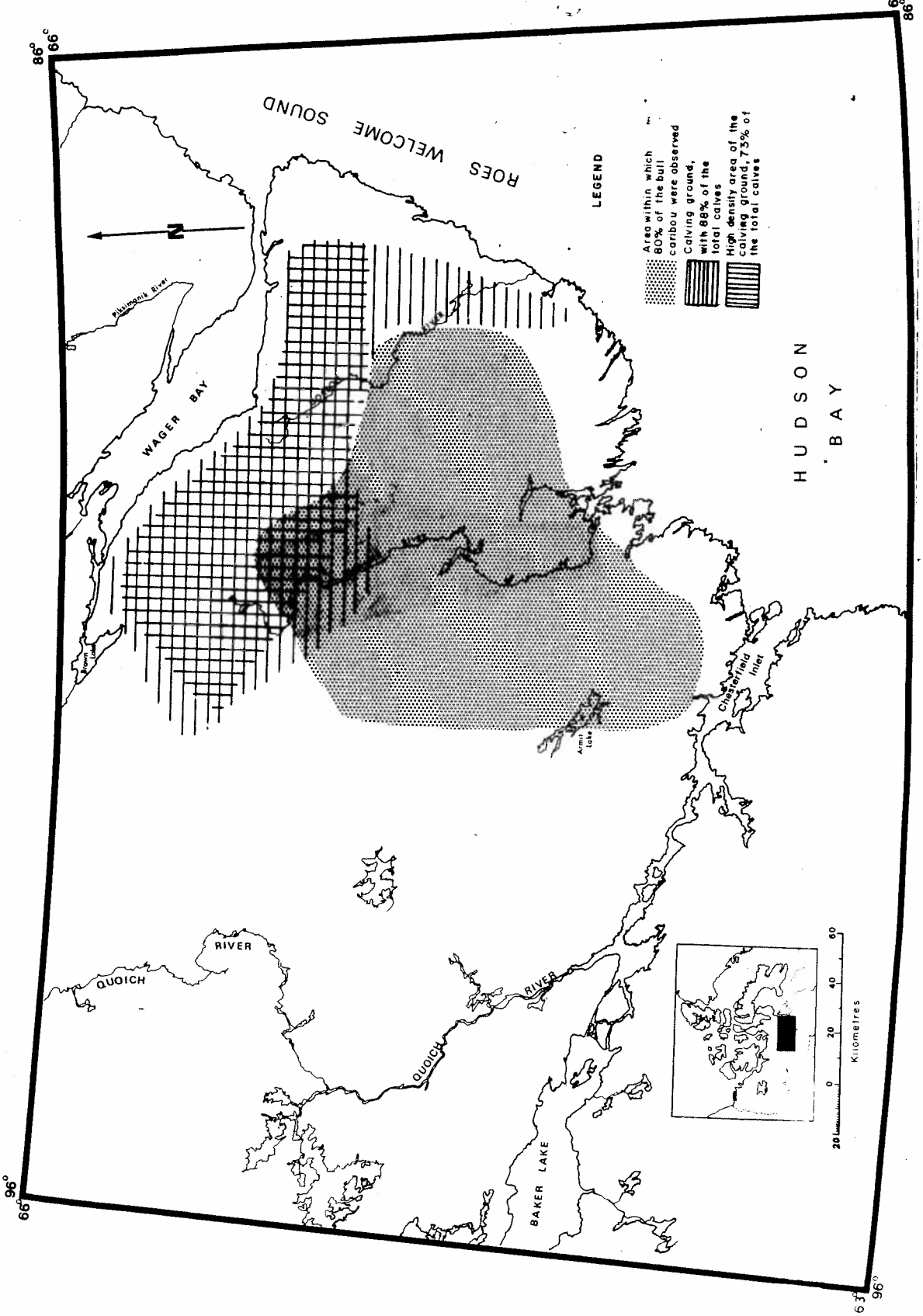

Figure 3. The 1976 Lorillard study area showing the calving ground and the distribution of bull caribou.

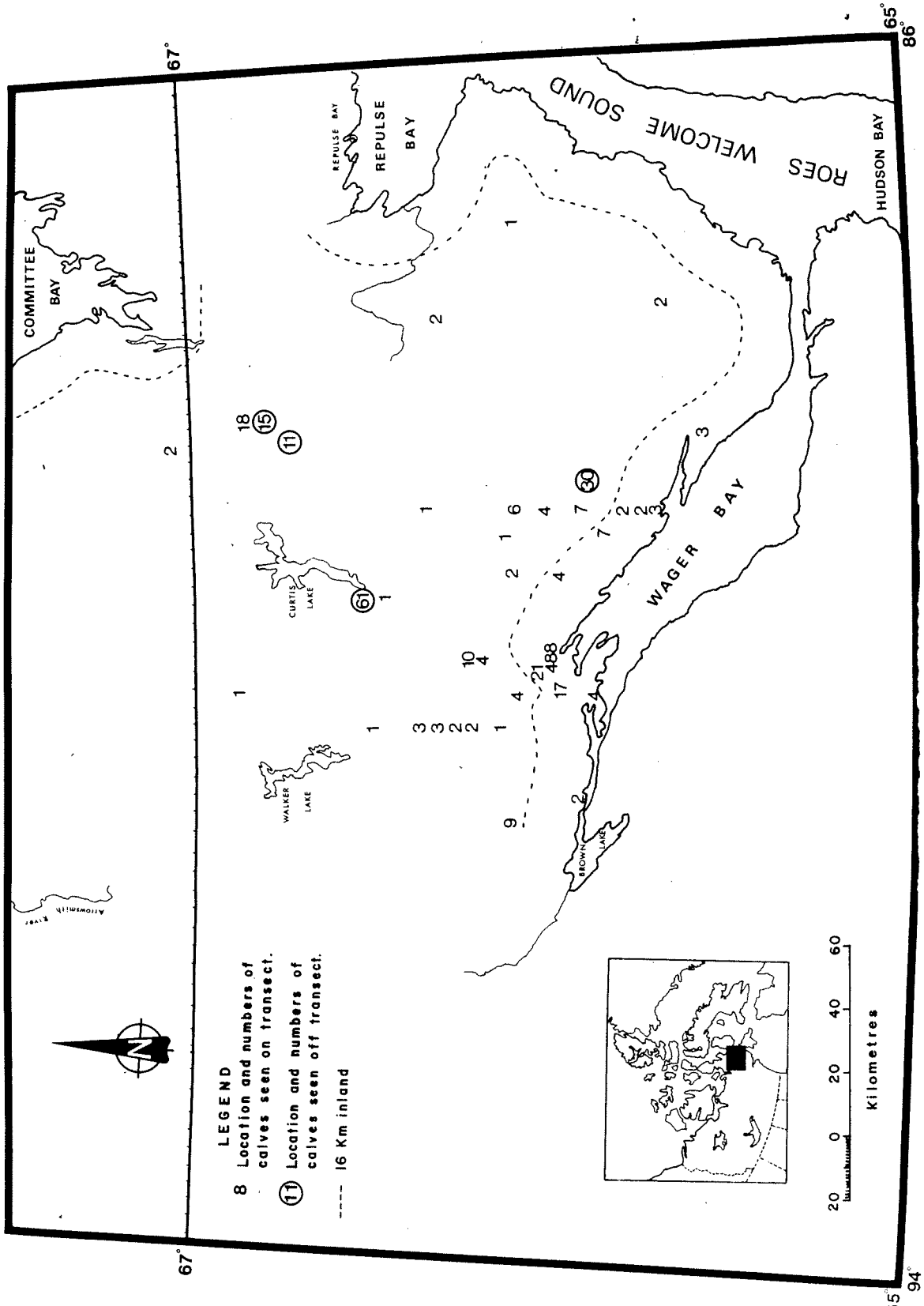

Figure 4. The 1976 Wager study area showing the distribution of caribou calves.

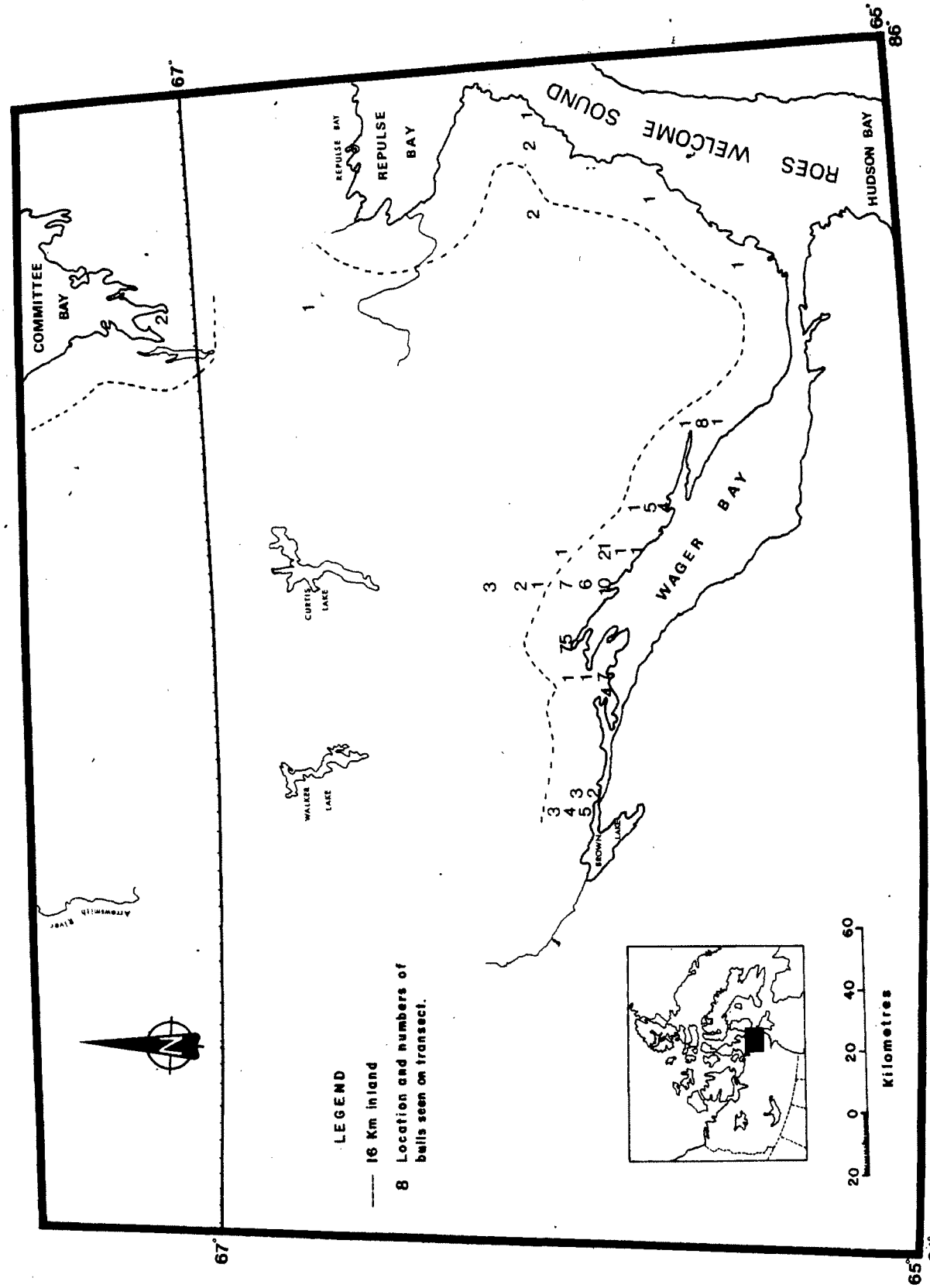

Figure 5. The 1976 Wager study area showing the distribution of bull caribou.

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