BEVERLY CALVING GROUND SURVEYS

JUNE 5-16 1993

AND

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ABSTRACT

I estimated the number of caribou on the Beverly herd's calving ground in June 1993 and 1994 where caribou were counted on aerial photographs taken along strip transects flown over the calving grounds. The 1993 and 1994 surveys respectively resulted in estimates of 52,500 ± 6,100 and 151,000 ± 48,700 caribou one year old and older on the calving grounds. Based on the proportion of breeding females in each stratum, the number of breeding females on the calving grounds in 1993 and 1994 was estimated to have been 37,700 ± 5,700 and 120,000 ± 43,100. This extrapolates to estimates of total population size of 87,000 ± 17,900 and 276,000 ± 106,600. The 1993 estimate was inconsistent with other data collected between 1988 and 1993 that indicated consistently high spring recruitment rates, low wolf sighting rates on the winter range, and relatively low levels of harvest of Beverly caribou. There is no evidence that technical problems with the survey were responsible for the lower estimate in 1993. The most likely explanation for the low estimate in 1993 is that not all breeding females aggregated on the calving ground that year. The peak of calving occurred before 12 June and on 14 June in the two strata surveyed in 1993, and before 9 June in both strata in 1994. Overall rates of neonatal mortality in 1993 and 1994 were 11.4% and 7.2%, respectively. Wolf predation was the primary cause of neonatal mortality in both June 1993 and 1994, causing 70% (n=33) and 61% (n=28) of mortalities, respectively. Results obtained in 1994 are consistent with other data, and indicate that the Beverly herd has remained stable in size since 1984. At current levels the herd is above the 150,000 level identified by the Beverly and Qamanirjuaq Caribou Management Board as the level below which emergency management action will be considered.

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ᓇᓚᐅᑦᑖᑭᑕᐅᓯᒪᓕᖅᑐᑦ ᖃᓄᑎᒥ ᐅᓄᕐᓂᖏᑦ ᑐᒃᑐᐃᑦ Beverly-ᐅᓂᕋᖅᑕᐅᔪᑦ ᑎᒃᓴᓕᐅᑉ ᑐᒃᑐᖁᑎᖏᑦ ᓄᕐᓕᐅᕐᕕᒋᕙᒃᑕᖏᓐᓂ ᔫᓐ 1993-ᒥᑦ 1994-ᒧᑦ ᑕᒪᑐᒪᓂ ᖃᖓᑕᓲᒃᑯᑦ ᐊᔾᔨᓕᐅᖅᑕᐅᑲᑕᒃᒍᑎᒃ ᓈᓴᐃᕕᐅᓚᐅᖅᑐᒥ ᓄᕐᓕᕕᒋᕙᒃᑕᖓᓂ. 1993 1994-ᒥ ᓈᓴᐃᔪᑕᐅᔪᔪᑦ ᓇᓚᐅᑦᑖᑭᑕᐅᓯᓚᐅᖅᒥᔪᑦ ᐅᓄᕐᓂᖏᓐᓂᒃ 52,500 ± 6,100 ᐊᒻᒪᓗ 151,000 ± 48,700 ᓄᑲᑐᒐᐃᑦ ᐊᖏᓂᖅᓴᐃᓪᓗ ᑕᒫᓃᔪᔪᑦ ᓄᕐᓕᕕᒋᕙᒃᑕᖓᓂ. ᐃᓱᒪᒋᓪᓗᒋᑦ ᐅᓄᕐᓂᓕᕙᒃᑕᖏᑦ ᓄᕐᓕᒍᓐᓇᖅᑐᑦ ᐊᕐᓇᕕᒐᐃᑦ ᐊᑐᓂ ᓈᓴᐃᕕᐅᔪᓂ, ᐅᓄᕐᓂᓕᔪᓴᖏᑦ ᓄᕐᓕᒍᓐᓇᖅᑐᑦ ᐊᕐᓇᕕᒐᐃᑦ ᓄᕐᓕᕕᒋᕙᒃᑕᖏᓐᓂᒃ 1993-ᒥᑦ 1994-ᒧᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᔪᑦ 37,700 ± 5,700 ᐊᒻᒪᓗ 120,000 ± 43,100 ᓇᓚᐅᑦᑖᑭᑕᐅᔪᔪᑦ ᐅᓄᕐᓂᓕᓇᓴᖅᑕᖏᑦ 87,700 ± 17,900 ᐊᒻᒪᓗ 276,000 ± 106,600. 1993-ᒥ ᐊᔾᔨᒥᓴᐅᔪᖏᓪᒪᑕ ᓈᓴᐃᔪᑕᐅᔪᔪᓂᑦ 1988-ᒥᑦ 1993-ᒧ ᐊᑯᓐᓂᖓᓂ ᑕᐃᒪᖓᓂᑦ ᐅᐱᕐᖔᒃᑯᑦ ᐊᒥᓱᖕᒍᖅᑐᑦᑖᕈᖅᖃᑦᑕᖅᒪᑕ, ᐊᒥᓲᖕᖏᓐᓂᖅᓴᐅᖃᑦᑕᖅᒪᑕᓗ ᐊᒪᕈᐃᑦ ᑕᑯᔭᐅᔪᔪᑦ ᐅᑭᐅᒃᑯᑦ ᓇᔪᖃᑦᑕᖅᑕᖓᓂ, ᐊᒻᒪᓗ ᐊᒥᓲᖑᑦᑐᓄᑦ ᐊᖑᓇᓱᒃᑕᐅᓚᐅᖅᑐᑎᒃ. ᓴᓇᖅᑯᑎᓄᑦ ᐃᓗᐊᖏᔪᑎᖃᐅᓗᐊᓚᐅᖏᓐᓇᑦᑕ ᓈᓴᖅᑕᐅᑎᓪᓗᒋᑦ ᓱᖕᒪᑦ ᐅᓄᖏᓕᖅᐹᓪᓕᕈᑕᐅᓚᐊᖑᓗᐊᕐᒪᖔᑕ ᓇᓗᓇᖅᑐᑦ 1993-ᒥ. ᐃᓱᒪᒋᔭᐅᔪᑦ ᐊᓄᖏᔪᑕᐅᓚᐅᕐᓂᖑᓄᑦ ᓇᓚᐅᑦᑖᑭᑕᐅᔪᔪᑦ 1993-ᒥ ᑕᒪᐃᑕᓕᒫᖅ ᓄᕐᓕᐅᑭᓐᓇᖅᑐᑦ ᐊᕐᓇᕕᒐᐃᑦ ᑲᑎᖅᓯᓚᐅᖏᓪᒪᑕ ᓄᕐᓕᕕᐅᕙᒃᑐᒥ ᑕᒪᑐᒪᓂ ᐅᑭᐅᖑᓂ. ᓄᕐᓕᐅᔪᑦ ᐅᓄᕐᓂᖅᐹᖑᓕᖃᑦᑕᖅᒪᑕ ᔫᓐ 12-ᖑᓚᐅᖏᓐᓂᖑᓂ 14-ᒥᓗ ᑖᒃᑯᓇᓂ ᒪᕿᐃᓕᖑᔪᓂᒃ ᓈᓴᐃᕕᐅᔪᔪᓂ 1993-ᒥ, ᐊᒻᒪᓗ ᓯᕗᓂᖑᓂ ᔫᓐ 9 ᑕᒪᐃᓐᓂ ᓈᓴᐃᕕᐅᔪᔪᓂ 1994-ᒥ. ᑕᒪᐃᑎᒍᑦᑕ ᓄᕐᓕᔭᐅᖄᖅᑐᑦ ᑐᖁᒐᔪᖕᓂᖅᐹᖑᔪᔪᑦ 1993-ᒥ ᐊᒻᒪᓗ 1994-ᒥ 11.4-ᐳᓴᖕᒋᑦ ᐊᒻᒪᓗ 7.2-ᐳᓴ ᑖᒃᑯᓇᓂ ᐅᑭᐅᓂ. ᐊᒪᖅᑯᓄᑦ ᓄᕋᐃᑦ ᑐᖁᓴᖅᑕᐅᒐᔪᖕᓂᖅᐹᖑᔪᔪᑦ ᔫᓐ 1993-ᒥ ᐊᒻᒪᓗ 1994-ᒥ, ᑕᒪᐃᓐᓂᒃ 70-ᐳᓴᖕᒋᑦ (n=33) ᐊᒻᒪᓗ 61-ᐳᓴᖕᒋᑦ (n=28) ᑐᖁᑕᐅᔪᔪᑦ ᑖᒃᑯᓇᓂ ᐅᑭᐅᓂ. ᓈᓴᖅᑕᐅᔪᔪᑦ 1994-ᒥ ᑕᒪᐃᓐᓄᑦ ᐅᑭᐅᓄᑦ ᓇᓕᒧᓚᒃᑐᑦ ᓇᓴᐃᕕᐅᔪᔪᓄᑦ, ᐊᒻᒪᓗ ᓇᓗᓇᐃᖅᓯᔪᑕᐅᓪᓗᑎᒃ ᑎᒃᓴᓕᐅᑉ ᑐᒃᑐᖁᑎᖏᑦ ᐅᓄᕐᓂᖏᑦ ᑕᐃᒪᖓᓄᑦ ᓈᓕᒧᐃᓐᓇᑭᔪᖕᒪᑕ 1984-ᒥ. ᒫᓐᓇᓕ ᐅᓄᕐᓂᓕᓴᖏᑦ ᑐᒃᑐᐃᑦ 150,000 ᐅᖓᑖᓃᖕᒪᑕ ᓇᓗᓇᐃᔭᖅᑕᐅᔪᑎᓪᓗᒋᑦ ᑎᒃᓴᓕᐅᑉ ᐊᒻᒪᓗ ᖃᒪᓂᖅᔪᐊᒥ ᑐᒃᑐᓂᒃ ᐊᐅᓚᖅᑦᑎᔨᑦ ᑲᑎᒪᔨᖏᓐᓄᑦ ᐊᑖᓃᓕᖅᓂᖅᐸᑕ ᑕᐃᒪᓕ ᐊᐅᓚᑦᑎᔪᑎᓕᐅᖅᑕᐅᒋᐊᖃᕐᒫᖅᐳᑦ ᐊᑖᓄᖅᓂᖅᐸᑕ ᐃᓱᒪᒃᓴᖅᓯᐅᕈᑎᖃᓕᖅᓴᖅᐳᑦ.

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INTRODUCTION

The Department of Renewable Resources' calving ground census technique is designed to estimate the number of breeding females on a herd's calving ground. Before 1980 estimates were based on visual sample counts along strip transects on the calving ground (Heard 1985). Since 1980 we have used aerial photographs taken along strip transects to reduce observer bias (the number of animals missed by observers in visual surveys) and more accurately estimate herd size.

A review of caribou research in the Northwest Territories indicated that the most efficient interval between population censuses to detect changes in herd size is six years (Heard and Williams 1991). Previous estimates indicated that the Beverly herd increased between 1982 and 1984 (Williams and Heard 1986), and declined between 1984 and 1988 (Heard and Jackson 1990). The objective of these surveys was to estimate the number of breeding females on the Beverly calving ground in June 1993 and 1994.

The 1993 population estimate was below 150,000 caribou. Below the level of 150,000 caribou, the Beverly and Qamanirjuaq Caribou Management Board considers emergency management options. Consequently the Board requested that Renewable Resources repeat the survey in June 1994 to confirm the 1993 results. This report describes the results of the 1993 and 1994 photographic censuses of the Beverly caribou herd and discusses the differences between the 1993 and 1994 estimates of herd size.

METHODS

We conducted unsystematic reconnaissance flights on 5 and 6 June 1993 and 2 and 3 June 1994 in Cessna 185 aircraft over the previously recorded calving grounds (Figures 1 and 2). On 6 June 1993 and 4 and 5 June 1994, we followed transects systematically spaced at 10 km intervals over the calving distribution to determine relative densities of caribou within the calving area. Two observers counted all caribou aged one year old or older within a 400 m strip on each side of the aircraft. We surveyed transects at 120 m above ground level at approximately 170-180 kph. Transect end points were determined during the flights when no breeding females had been observed for approximately 10 km.

Caribou densities determined from the systematic transects were used to divide the calving ground into two strata, where densities within each stratum were similar. Stratum density estimates were also used to determine the optimal allocation of survey effort (km of flight lines) within each stratum that would maximize the precision of the population estimate (Heard 1987a) for the subsequent photographic survey. On 11 June 1993, while conducting classification flights with a Bell 206B helicopter, I observed that caribou that had occupied the southern areas of the high density stratum (stratum 1, Figure 3) had moved into the central part of the stratum. To reduce the number of photographs with 0 caribou, I moved the southern border of the high density stratum northwards.

On 11 and 12 June 1993 and 7 and 8 June 1994 the strata were resurveyed using aerial photography. In 1993 and 1994, respectively, the photo plane took 2,644 and 2,387 photographs (to produce black and white prints, 230 cm X 230 cm in size, using XX2405 film) with a Zeiss RMK A 15 camera with a forward motion compensator from 600 m above ground level to provide an image scale of 1:4000. Photographs had 60% forward overlap. H.P. Roy and Associates of Ottawa, Ontario used a stereoscope to count caribou on the photographic

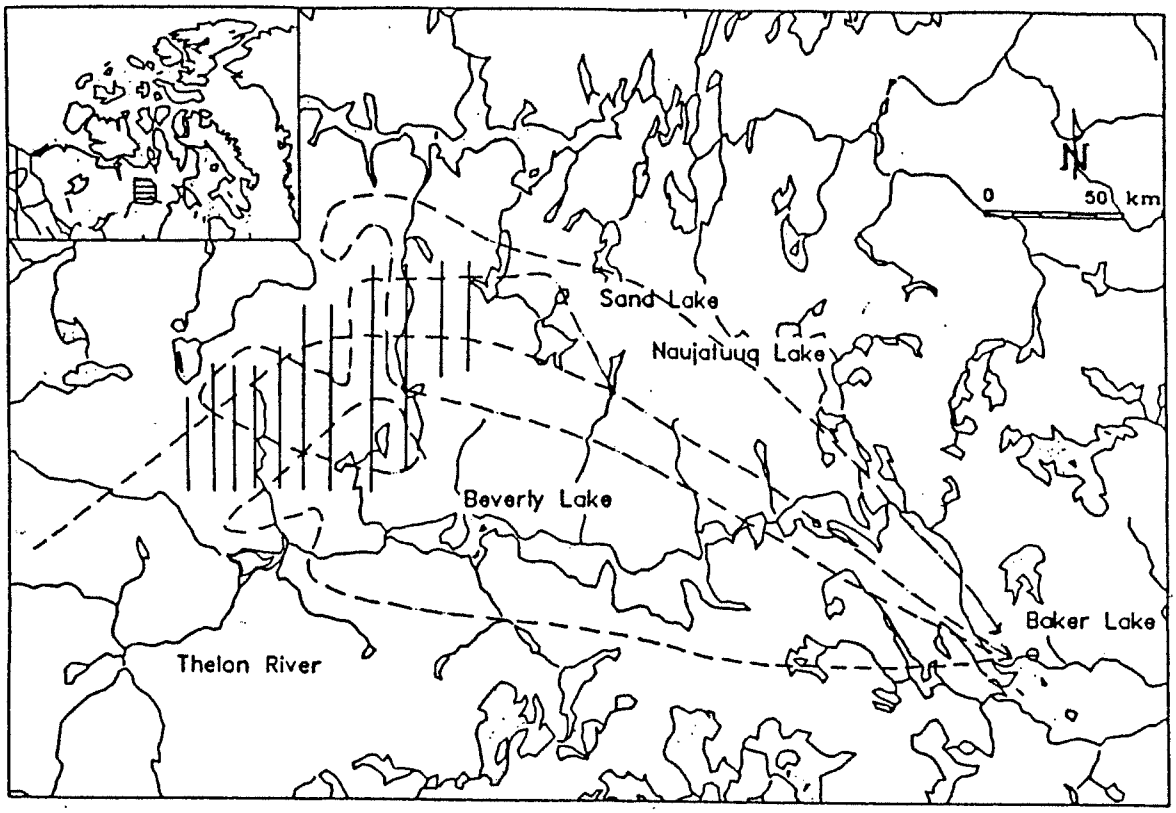

Figure 1. The location of survey strata and reconnaissance flight lines on the Beverly calving grounds in June 1993.

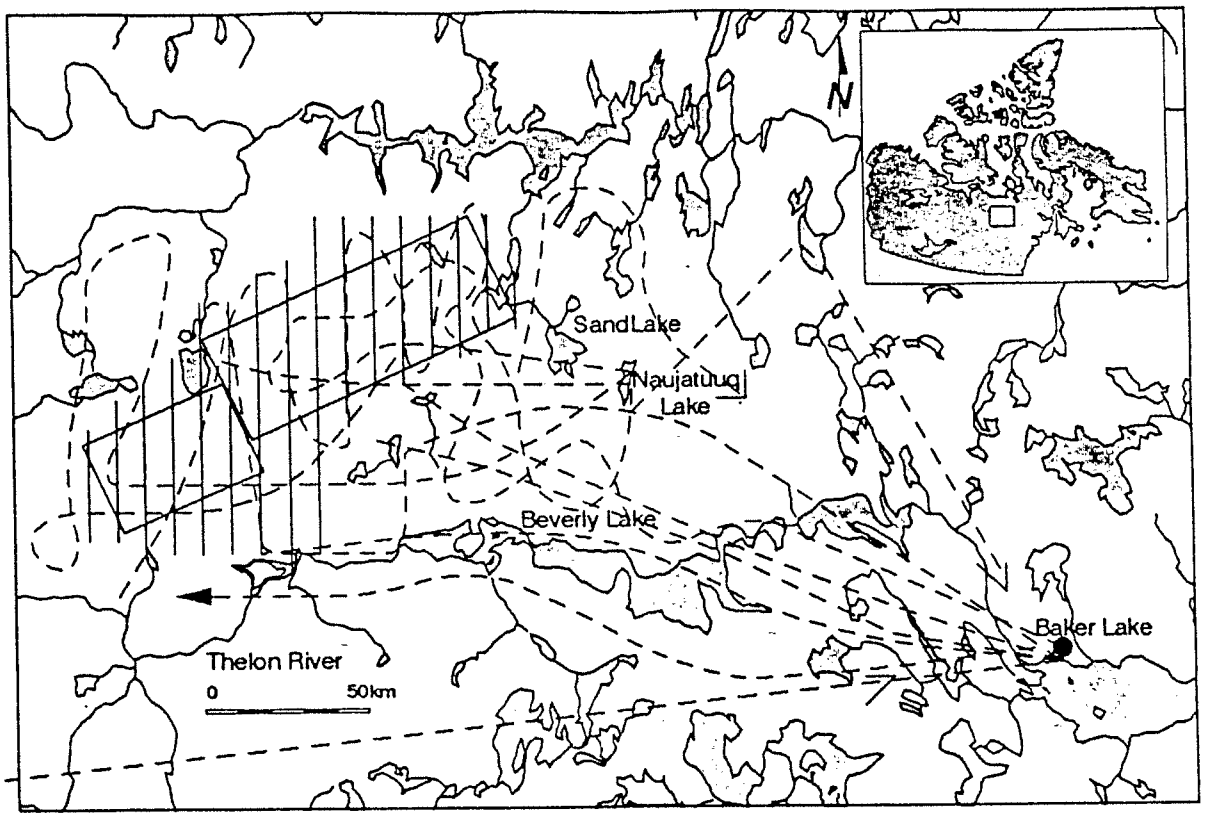

Figure 2. The location of survey strata and reconnaissance flight lines on the Beverly calving grounds in June 1994.

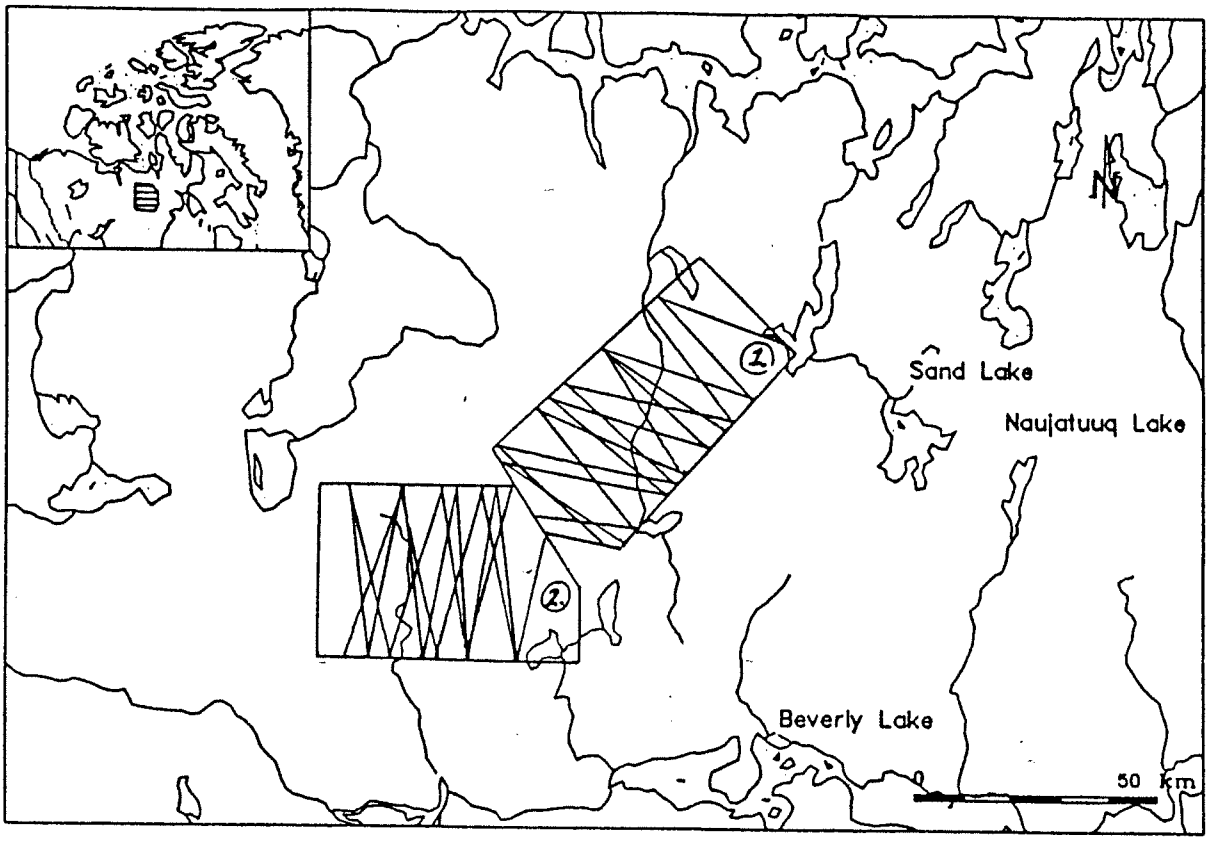

Figure 3. Systematic transects followed over the calving grounds in a helicopter between 11 and 16 June 1993 to determine the proportion of breeding females and the cause and extent of neonatal mortality.

contact prints. Based on the number of adult caribou recorded on photographs, Jolly's (1969) method 2 was used to calculate an estimate of number of caribou and associated variance in each stratum.

Between 11 and 16 June 1993 and 9 and 13 June 1994, the age, sex and reproductive condition of all caribou observed were recorded from a Bell Jet Ranger 206B helicopter while flying along lines systematically spaced within each stratum (Figures 3 and 4). The helicopter was flown at about 50 m above ground level and 100 kph, although speed and altitude varied. Caribou were classed as neonates, yearlings, two year old and older males, and two year old and older cows. Breeding females (pregnant and post-partum cows) were identified by the presence of hard antlers and/or an udder. Cows that were without hard antlers but with distended udders were considered to be breeding cows that had lost their calves. Barren cows were those without hard antlers and without an udder.

The proportion of breeding females in each stratum was the weighted mean and its variance was calculated using the binomial formula (Snedecor and Cochran 1967:514).

The proportion of breeding females in each stratum was multiplied by the population estimate for that stratum in order to estimate the number of breeding females. Total herd size was calculated by dividing the estimate of total number of breeding females on the calving ground by the sex ratio of the population (66 males: 100 females; the mean of 6 fall composition estimates available from different NWT caribou herds) and by the proportion of females in a caribou herd that are usually pregnant (72%), based on data collected from 1966-1968 from the Qamanirjuaq herd (Dauphine 1976) and from the Beverly herd between 1980 and 1987 (Thomas and Barry 1990). Variance of the estimate of total herd size was calculated after Heard (1987b).

Gross field necropsies were conducted on calf carcasses found during the systematic classification flights. Calves were aged according to hoof wear and condition of the umbilicus as described by Miller et al. (1988). Calves with canine puncture wounds to the body and/or skull, with associated

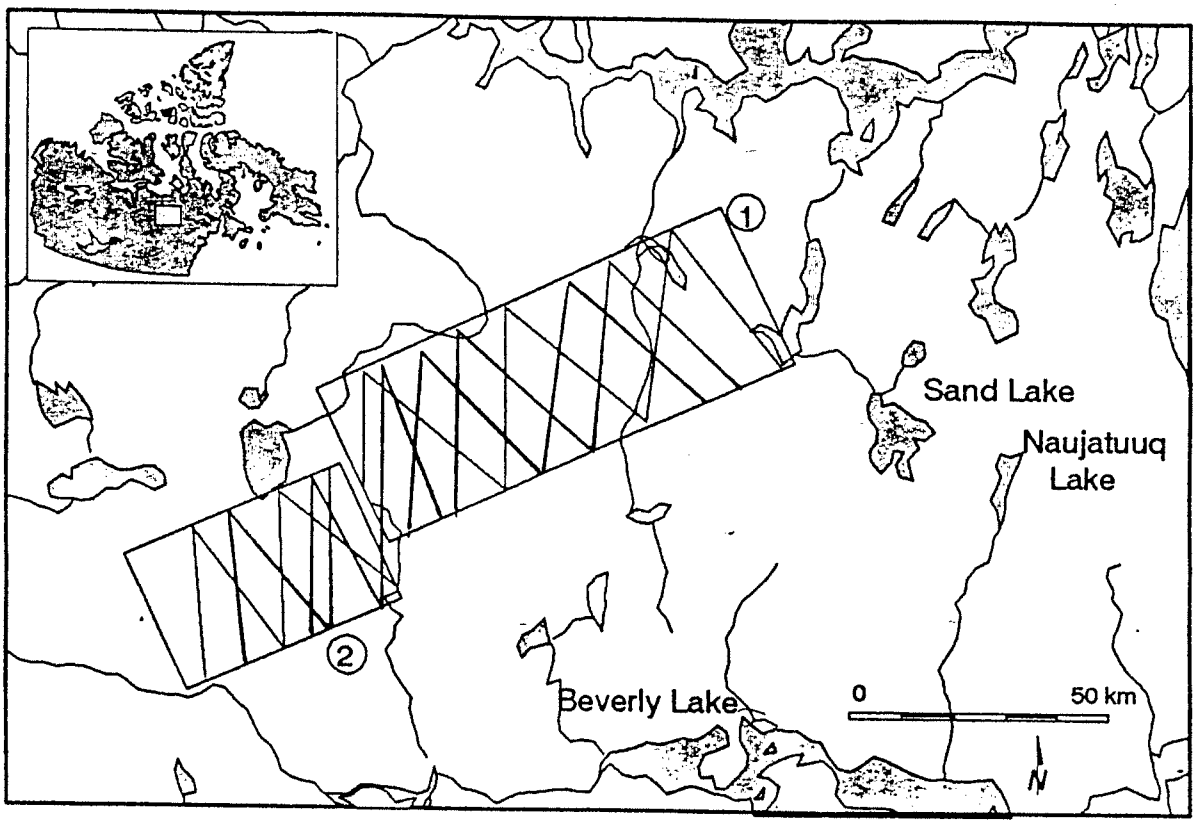

Figure 4. Systematic transects followed over the calving grounds in a helicopter between 9 and 13 June 1994 to determine the proportion of breeding females and the cause and extent of neonatal mortality.

hemorrhage were considered to have died as a result of wolf predation. Cause of death for calves that appeared physically normal (had walked based on wear on the cartilaginous hoof tabs, lungs properly inflated, etc.), but that died with no milk curds in their stomachs, was classified as abandonment/starvation. Extensive hemorrhaging with no evidence of puncture marks was considered evidence of death from non-predator induced trauma. Causes of death that could not be identified due to extensive scavenging of the carcass were classified as unknown.

RESULTS

Herd Size

I located the Beverly herd's calving grounds north of Beverly Lake in roughly the same area as reported in previous surveys. Calving caribou had occupied a similar area in 1993 (3,200 km^2) and 1994 (3,300 km^2) and a smaller area than had been recorded in June 1988 (6,200 km^2), 1984 (4,100 km^2) and 1982 (4,200 km^2).

The survey intensity, or area photographed, in 1993 was 23% in stratum 1 (high density) and 18% in stratum 2(low density). In 1994, the survey intensity was 25% in stratum 1 and 13% in stratum 2. The photo interpreter counted 12,384 and 26,194 caribou in the photographs in 1993 and 1994, respectively. To determine the level of accuracy of the initial interpretation, samples of 60 (2%) photographs in 1993 and 300 (12.6%) in 1994 were checked by a second interpreter, who spent approximately 1.5-2 hours intensively scanning each picture to ensure that all caribou had been counted. Results of the intensive checking indicated accuracies of 94% and 99% in the initial interpretation in 1993 and 1994, respectively.

The number of caribou estimated to have been on the calving grounds from the 1993 and 1994 photographic surveys was 52,700 ± 6,200 and 151,000 ± 48,700, respectively (Tables 1 and 2). The proportions of breeding females in the two strata were 83% and 57% in 1993, and 88% and 21% in 1994 (Tables 3 and 4). Estimates of the number of breeding females on the calving ground were 37,700 ± 5,700 in 1993 and 120,000 ± 43,100 in 1994 (Tables 5 and 6). The total herd size was estimated to be 87,000 ± 17,900 in 1993 and 276,000 ± 106,600 in 1994 (Tables 7 and 8).

Table 1. The number of caribou estimated in strata 1 and 2 of the Beverly caribou herd's calving ground in June 1993 based on the photographic strip transect survey.

Stratum	Estimate	Density (caribou /km^2)	Variance	SE	CV
1	29,716	20.65	32304960		.191
2	22,790	12.97	5095681		.099
Total	52,506		37400641	6166	.116

Table 2. The number of caribou estimated in strata 1 and 2 of the Beverly caribou herd's calving ground in June 1994 based on the photographic strip transect survey.

Stratum	Estimate	Density (caribou /km^2)	Variance	SE	CV
1	131,743	71.02	2361852000	48599	.369
2	19,288	13.41	8267593	2875	.149
Total	151,031		2370119600	48684	.322

Table 3. Number of caribou one year old and older classified in strata 1 and 2 of the Beverly caribou herd's calving ground 11-14 June 1993.

Classification	Stratum 2 11 June	Stratum 2 13 June	Stratum 1 12 June	Stratum 1 14 June	Total Number
Breeding Cows					
calf + 2 antlers	131	131	434	321	1017
calf + 1 antler	1	0	5	6	12
calf + 0 antlers	10	17	46	95	168
udder + 2 antlers	157	179	289	163	788
udder + 1 antler	5	15	13	14	47
udder + 0 antlers	20	62	31	43	156
no udder + 2 antlers	104	31	24	6	165
no udder + 1 antler	34	18	6	3	61
Barren Cows					
no udder + 0 antlers	198	127	67	66	458
Yearlings	220	115	120	61	516
Bulls	12	3	4	1	20
Total	892	698	1039	779	3408
Propn breeding cows in stratum	.57		.83		
SD	.048		.093		
CV	.084		.112		

The number of antlers refers to dry antlers grown the summer of 1992.

Table 4. Number of caribou one year old and older classified in strata 1 and 2 of the Beverly caribou herd's calving ground between 9 and 13 June 1994.

Classification	Stratum 1 9 June	Stratum 1 11 June	Stratum 1 13 June	Stratum 2 9 June	Stratum 2 11 June	Stratum 2 13 June	Total Number
Breeding Cows							
calf + 2 antlers	125	312	285	14	17	13	766
calf + 1 antler	17	15	41	2	2	1	78
calf + 0 antlers	197	627	1233	24	28	62	2171
udder + 2 antlers	75	90	97	22	19	22	325
udder + 1 antler	5	9	8	2	3	0	27
udder + 0 antlers	32	81	85	10	23	34	265
no udder + 2 antlers	3	0	0	3	0	0	6
no udder + 1 antler	1	0	0	0	0	0	1
Barren Cows							
no udder + 0 antlers	42	38	100	278	157	92	707
Yearlings	56	92	128	175	286	114	851
Bulls	0	0	1	20	34	2	57
Total	553	1264	1978	550	569	340	5254
Propn breeding cows in stratum		.88			.21		
SD		.137			.123		
CV		.042			.188		

The number of antlers refers to hard antlers grown the summer of 1993.

Table 5. The number of breeding female caribou on the Beverly herd's calving ground in June 1993 based on composition counts and the photographic transect strip estimates.

Stratum	Estimate	Proportion Breeding Females	Number of Breeding Females	Variance[a]	SE
1	29,716	.83	24,664	29552449	
2	22,790	.57	12,990	2733758	
Total	52,506		37,654	32286207	5682

[a]. Variance in each stratum is equal to the number of breeding females (the product) squared, times the sum of the squares of the CVs of the estimates that were multiplied together to get that product (Heard 1987b).

Table 6. The number of breeding female caribou on the Beverly herd's calving ground in June 1994 based on composition counts and the photographic transect strip estimates.

Stratum	Estimate	Proportion Breeding Females	Number of Breeding Females	Variance[a]	SE
1	131,743	.88	115,934	1853358000	
2	19,288	.21	3,993	917500	
Total	151,031		119,927	1854275500	43061

[a]. Variance in each stratum is equal to the number of breeding females (the product) squared, times the sum of the squares of the CVs of the estimates that were multiplied together to get that product (Heard 1987b).

Table 7. Extrapolation of the 1993 Beverly caribou calving ground survey data to an estimate of total herd size.

Survey Data	Estimate	SE	CV
Total number of breeding females on calving ground	37,654	5682	0.151
Proportion of females in the entire herd[a]	0.603		0.10[b]
Average proportion of yearling and older females that breed[c]	0.72		0.10[b]
Total population[d]	86,728	17,943	0.207

[a]. based on the mean of 6 fall composition estimates from several herds.
[b]. no data; value only a guess
[c]. from Qamanirjuaq (Dauphine 1976) and Beverly (Thomas and Barry 1990) data
[d]. total population = number of breeding females on calving ground/proportion of females in the population/proportion of females pregnant. e.g., 37,654/.603/.72
for SE calculations see Heard (1987b)
CV=SE/total population.

Table 8. Extrapolation of the 1994 Beverly caribou calving ground survey data to an estimate of total herd size.

Survey Data	Estimate	SE	CV
Total number of breeding females on calving ground	119,927	43061	0.36
Proportion of females in the entire herd[a]	0.603		0.10[b]
Average proportion of yearling and older females that breed[c]	0.72		0.10[b]
Total population[d]	276,000	106,600	0.39

[a]. based on the mean of 6 fall composition estimates from several herds.
[b]. no data; value only a guess
[c]. from Qamanirjuaq (Dauphine 1976) and Beverly (Thomas and Barry 1990) data
[d]. total population = number of breeding females on calving ground/proportion of females in the population/proportion of females pregnant. e.g., 37,654/.603/.72
for SE calculations see Heard (1987b)
CV=SE/total population.

Peak of Calving

The peak of calving (the day on which one half of the calves have been born) occurred before 12 June 1993 in stratum 1, as 61% of breeding females were post-partum on that day (Table 9). On 13 and 15 June 1993, 46% and 60% of females in stratum 2 were post-partum, respectively, indicating that the peak of calving occurred on 14 June.

The peak of calving occurred before 9 June 1994, because on that date 82% and 65% of breeding females were post-partum in stratum 1 and 2, respectively (Table 10).

Table 9. The proportion of breeding females that were pre and post-partum and percentage of neonatal calf mortality on the Beverly herd calving ground based on classification flights conducted between 11 and 16 June 1993.

	Post-partum cows		Pre-partum cows			
	Cows with calves	Antlerless cows with udders	Antlered cows without udders	Antlered cows with udders	Prop'n Breeding Females Post-Partum	% Neonatal Calf Mortality
Stratum 2 (West)						
11 June	142	20	138	162	.351	12.3
13 June	148	62	49	194	.464	29.5
15 June	139	23	28	76	.609	14.2
Stratum 1 (East)						
12 June	485	31	30	302	.608	6.00
14 June	422	43	9	177	.714	9.20
16 June	291	18	12	55	.822	5.80

Table 10. The proportion of breeding females that were pre and post-partum and percentage of neonatal calf mortality on the Beverly herd calving ground based on classification flights conducted between 9 and 13 June 1994.

	Post-partum cows		Pre-partum cows			
	Cows with calves	Antlerless cows with udders	Antlered cows without udders	Antlered cows with udders	Prop'n Breeding Females Post-Partum	% Neonatal Calf Mortality
Stratum 1 (East)						
9 June	339	32	3	80	0.817	8.60
11 June	954	81	0	99	0.913	7.80
13 June	1559	85	0	105	0.940	5.20
Stratum 2 (West)						
9 June	40	10	3	24	0.649	16.2
11 June	47	23	0	22	0.761	32.9
13 June	76	34	0	22	0.833	30.9

Extent and Timing of Neonatal Mortality

Based on 1875 cows classified on transect, 7.1% of 24,664 breeding females in stratum 1 (high density) had lost calves by 16 June 1993, which represents about 1751 calves (Table 9). Breeding females are identified as cows without antlers, but with distended udders and no calves. Based on 1181 cows classified on transect, 19.7% of the estimated 12,990 breeding females in stratum 2 (low density) had lost their calves by 15 June, which represents approximately 2,559 calves. A loss of 4310 calves from 37,654 breeding females results in an estimate of 11.4% neonatal mortality.

In 1993, calf losses recorded in stratum 2 underestimated total neonatal mortality rates relative to stratum 1 because classification flights were conducted right at the peak of calving in stratum 2, at a time when only one half of calves had been born, but several days after the peak of calving in

stratum 1. Despite that bias, roughly twice as many cows had lost calves in stratum 2 as in stratum 1.

Classification flights started on 9 June 1994. Approximately twice as many breeding cows had lost calves in stratum 2 (16%-low density) as in stratum 1 (9%-high density) (Table 10). The proportion of cows in stratum 2 that had lost calves increased to 33% and 31% on 11 and 13 June, respectively. In contrast, the proportion of cows in stratum 1 that had lost calves decreased to 8% and 5% on 11 and 13 June, respectively.

Based on 3,337 cows classified on transect, 6.5% of the estimated 115,934 breeding females in stratum 1 had lost their calves by 13 June, which represents approximately 7,526 calves. Based on 301 cows classified on transect, 29.1% of the estimated 3,993 breeding females in stratum 2 had lost their calves by 13 June, which represents approximately 1,163 calves. Overall, an estimated 8,689 calves were lost from 119,927 breeding females on the calving ground, which represents 7.2% calf mortality within several days of the peak of calving.

DISCUSSION

Herd Size

The number of breeding females on the Beverly herd calving ground in June 1994 (120,000 ± 43,100) is approximately three times greater than the number estimated in June 1993 (37,700 ± 5,700) and is similar to the number of breeding females estimated in June 1984 (114,000 ± 31,000). This indicates that the herd has remained stable in size since 1984.

The 1993 estimate was inconsistent with other data that had indicated consistently high spring recruitment rates, low wolf sighting rates on the winter range, and relatively low levels of harvest of Beverly caribou between 1988 and 1993 (unpubl. data). There is no evidence that technical problems with the survey were responsible for the lower estimate in 1993. There was a four day delay between the systematic reconnaissance and photographing; however, it is unlikely that large-scale movements off the calving grounds occurred in the interval between systematic reconnaissance and photographic survey. A reconnaissance flight around the periphery of the calving ground, and systematic classification flights on 11 June with a 206B helicopter, indicated that the only movement of caribou between the reconnaissance and photographing was a northward shift of the southern distribution of caribou into the center of stratum 1. There were no breeding females observed outside the calving ground boundaries, and results of the photographic survey indicated that the strip transects extended beyond the boundaries of the calving distribution. The likelihood of caribou having moved off the calving ground is reduced by the tendency for caribou to move relatively little over the peak of calving. While the possibility cannot be ruled out, there is no evidence that the discrepancy in the 1993 estimate resulted from movement of caribou off the calving grounds.

Extensive reconnaissance prior to the survey did not locate any other areas occupied by breeding females. However, the most likely explanation for the low estimate in 1993 is that not all breeding females aggregated on the calving ground that year. While snowmelt occurred later in 1993 than in 1994, the timing in 1993 was similar to that observed during previous surveys. Classification flights did not locate bands of breeding females moving onto the calving grounds over the calving period. Had this movement occurred, it would have indicated that the cows had been delayed in their migration to the calving grounds.

The 1994 estimate is consistent with recruitment rate, wolf abundance and harvest data collected between 1984 and 1988. There was only one day between the systematic reconnaissance and photographic survey, and results of the photography indicated that the transects extended beyond the calving distribution. I believe both the 1993 and 1994 results provide accurate estimates of the number of breeding females on the calving grounds in those years. The 1994 estimate of total herd size (276,000 ± 106,600) places the Beverly herd above 150,000 caribou. Above this level, the Beverly and Qamanirjuaq Caribou Management Board does not consider emergency management options.

Peak of Calving

With survey intervals increased to six years, there is increased potential for rapidly expanding populations to reach high densities that reduce range quality through overgrazing. Reduced range quality may lead to the under nutrition of caribou, reduced pregnancy rates in cows (Crete et al. 1993) and the production of small, weak calves that are born late (Couturier et al. 1990). Calves born earlier or later may have higher mortality than those born at the peak of calving, depending on environmental conditions (Adams et al. 1989).

The calving ground survey technique requires systematic classification flights over the calving grounds to determine the proportion of breeding females in each stratum. Those data, and analysis of the cause of death of calf carcasses observed on transect, provide measures of peak of calving and an estimate of the rate of neonatal mortality from causes other than predation; measures sensitive to range condition and nutritional status of caribou.

Systematic classification flights over Beverly calving grounds were not conducted prior to the 1988 census. However, non-systematic classification counts were conducted from the ground and air during previous surveys and earlier authors subjectively estimated peak of calving. In 1978, based on observations during survey flights, most calving was thought to have occurred between 5 and 9 June, with the peak on 7 June, although classification counts did not begin until 30 June (Heard and Decker 1980). In 1980 calving peaked before the onset of classification counts on 13 June (Gunn and Decker 1982). In 1981 calving was thought to have peaked between 2 and 5 June in eastern sections (Jingfors et al. 1982), but between 7 and 9 June in southwestern sections (Miller et al. 1988). In 1982 Stephenson et al. (1984) reported that calving peaked 9-10 June in central, high density areas and 11-12 June in eastern, low density areas, so that peak of calving in the combined strata was between 10 and 13 June. In 1983 calving peaked between 8 and 14 June (Miller et al. 1988). About half of the calves were born in 3 of 4 strata by 10 June 1987 (Heard et al. 1990). Most cows in the high density stratum had given birth by 8 June 1988 (Heard and Jackson 1990). In 1993 calving peaked before 12 June in the high density stratum, and on 14 June in the low density stratum. Calving peaked earlier in 1994, as more than half of breeding females in both strata had had calves by 9 June.

Variability in the percentages of breeding females post-partum in stratum 1 and 2 in both 1993 and 1994 suggests that peak of calving occurred earlier in high density strata than low density strata. This is consistent with previous surveys where peak of calving varied by several days amongst

areas within the overall calving ground (Heard and Decker 1980, Jingfors et al. 1982, Stephenson et al. 1984 and Miller et al. 1988).

Extent and Timing of Neonatal Mortality

The size of udders rapidly decreases after the loss of a calf, so that it becomes increasingly difficult to determine barren cows from breeding cows that have lost their calves based solely on udder counts. However, by the peak of calving, barren cows have approximately 10-15 cm of new antler growth, whereas breeding cows have just recently shed their antlers and have no new growth.

The lack of systematic searches for calf carcasses during previous studies has resulted in few data from NWT populations to compare to June 1993 and 1994 calf mortality rates. Overall rates of neonatal mortality in 1993 and 1994 were 11.4% and 7.2%, respectively. This is within the range of rates reported on the Porcupine calving and post-calving grounds (6.6%-15.4%) (Whitten et al. 1984, 1985 and 1986). In contrast, Heard and Decker (1980) reported that 30% of calves born in June 1978 had died within three weeks of birth.

The lack of a trend in proportion of cows that had lost calves between subsequent classification flights within each stratum in 1993 may result from small sample sizes of caribou classified relative to the total number of caribou within each stratum. It may also reflect increased difficulty in detecting receding udders in cows that had lost calves several days previously.

Causes of Neonatal Mortality

Wolf predation was the primary cause of neonatal mortality in both June 1993 and 1994, causing 70% (n=33) and 61% (n=28) of mortalities, respectively (Appendices 3 and 4). The 1993 and 1994 results are consistent with previous

studies on the Beverly herd where at least 61% of calf carcasses examined in 1978 (Heard and Decker 1980) and 68.5% of calf carcasses examined in June 1981, 1982 and 1983 (Miller et al. 1988) showed evidence of wolf predation as the cause of death. Those results indicate that a high proportion of neonates die from wolf predation on the Beverly calving grounds relative to the Qamanirjuaq and Porcupine herds. Wolves killed 31.6% of calves on the Qamanirjuaq calving grounds in 1970 (Miller and Broughton 1974). Relatively few calves are killed by wolves on the Porcupine herd calving grounds, where wolves killed 0%, 12.5% and 20% of calves in 1983, 1984 and 1985, respectively (Whitten et al. 1984, 1985, 1986).

Bear predation accounted for a lower proportion of calf mortality on the Beverly calving ground, where 0.4% of calf mortality between 1981 and 1983 (Miller et al. 1988) and 3% in June 1993 was attributed to bears, than on the Porcupine calving ground and summer range, where bear predation accounted for 18%, 6.25% and 10% of mortalities among radio-collared neonates in 1983, 1984 and 1985, respectively (Whitten et al. 1984, 1985 and 1986). Many instances of bear predation probably go undetected because of the tendency for bears to consume entire calf carcasses.

Unknown causes (non-predation) of calf mortality in June 1993 accounted for 15% of mortalities, followed by abandonment/starvation (9%) and non-predation related trauma (3%). In 1994 abandonment/starvation caused 14% of calf mortalities, followed by non-predation related trauma (14%), unknown causes (non-predation) 7% and stillbirth/atelectasis 4%.

Three of 33 (9.1%) and 1 of 20 (5%) carcasses with sufficient amounts of lung remaining to determine whether the lungs had been properly inflated prior to death had fetal atelectasis in 1993 and 1994, respectively. Small sample sizes in 1993 and 1994 make it difficult to determine whether rates observed in recent years reflect a significant change in the rate of atelectasis relative to that reported by Miller et al. (1988) who found fetal and neonatal atelectasis in 14.2% of mortalities.

Weather over the calving grounds in both 1993 and 1994 was characterized by mild temperatures (-5°C to +25°C) with variable snow and rain showers. Spring was early in 1994, with no snow remaining on the ground when the survey began. There was no evidence from calf necropsies in both years that any of the calves had died as a result of exposure. Miller et al. (1988) also found no evidence for calves dying from exposure to extreme weather.

Other Wildlife Sighted

We observed 16 wolves and 5 grizzly bears in 64.2 hours and 28 wolves and 6 grizzly bears in 52.2 hours of survey flying in 1993 and 1994, respectively. This gives hourly sighting rates of 249 wolves and 78 bears observed per 1,000 hours flown in 1993, and 536 wolves and 115 bears observed per 1,000 hours in 1994. Sighting rates from both surveys are higher than reported in 1987, when 137 wolves and 17 bears were observed per 1,000 hours (Heard et al. 1990), and in 1988, when no wolves and 19 bears were observed per 1,000 hours (Heard and Jackson 1990).

Because a relatively small number of hours are spent flying during each calving ground survey, sighting rates of wolves and bears are greatly influenced by a few observations and, therefore, provide only a crude estimate of absolute abundance. Accordingly, small changes in sighting rates must be interpreted cautiously. However, it appears that the sighting rate of both wolves and bears on the Beverly calving grounds has increased since 1987. In 1994 we located two active wolf dens on the Beverly calving grounds.

In 1993 we observed 75 adult muskoxen in 14 groups (mean group size = 5.4 ± 6.64 SD) and 2 muskox calves. Single calves were observed in groups of 6 and 8 adult muskoxen. In 1994 we observed 648 adult and 43 calf muskoxen in 61 groups (mean group size = 10.6 ± 13.87 SD), and saw two moose along the Thelon River at Ursus Islands.

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In 1994 Billy Shott (Uranium City, Saskatchewan) and Pierre Robillard (Black Lake, Saskatchewan) assisted with the reconnaissance and visual surveys. Robert Mulders (Regional Biologist, Renewable Resources, Arviat) assisted with all aspects of the survey. Joe LaRose (Renewable Resources Officer, Baker Lake) assisted with logistics in Baker Lake and participated as an observer in the Qamanirjuaq survey when the observer from Baker Lake was unable to fly. Judy Williams checked a sample of photographs to determine accuracy of counts. Assistance with fuel caching from Baker Lake, and funding for the systematic classification survey flights with a Bell 206B Jet Ranger was provided by the Polar Continental Shelf Project, Department of Energy, Mines and Resources Canada.

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Appendix 1. Personnel and itinerary, June 1993.

Personnel: Mark Williams (MW), Wildlife Management Division, Renewable Resources, Yellowknife.
Robert Muldurs (RM), Regional Biologist, Renewable Resources, Arviat.
Edwin Evo (EE), Baker Lake.

Itinerary
June 5. Weather clear.
Total flying hours 7.8. 4.6 hours ferry Yellowknife (YK) to Baker Lake (BL). 3.2 hours survey.
MW departed YK in C185 (Arctic Sunwest, pilot Bernard Piquet) to BL. Reduced altitude to 2,000 agl approximately 120 km SW of calving ground to record %snow cover and look for caribou sign. Refuelled Naujatuuq L. (NL) Spaghetti reconnaissance E of calving ground then to BL. After dinner, flew spaghetti reconnaissance RM and EE observing, over calving ground.

June 6. Scattered clouds in BL. Variable over calving ground, cloud cover ranging from broken-overcast with rain showers.
Total flying hours 10.1.
Spaghetti reconnaissance in a.m. with MW, RM and EE observing. Refuelled NL. Drew up flight lines for systematic reconnaissance, and set strip width markers on airplane. Checked strip widths with fuel drums placed 400 m apart on ground. Completed systematic reconnaissance in p.m.

June 7. Weather variable overcast.
Requested photo plane from Edmonton. Analyzed systematic reconnaissance results, drew up flight lines for air photo plane. Photo plane arrived BL at 19:00 (Geographic Air Survey 5, Marv Hengen and Dennis ?).

June 8. Low overcast all day, not suitable for photography.

June 9. Scattered cloud, layer of broken cloud on deck over calving ground. Not suitable for photography. Helicopter crew (Mark Hutcheson and Terry Lariviere in Canadian Helicopters FBQH) arrived at 23:00.

June 10. Clear in BL, overcast, rain and snow showers over calving ground.
5.1 hours flown in 206B.
C185 returned to YK. MW and RM flew classification surveys and necropsied calves. Re drew flight lines for photo plane based on classification flights.

June 11. Ceilings broken-scattered in BL.
8.5 hours flown in 206B.
MW and RM conducted classification counts over calving ground and necropsied calf carcasses. Photo plane completed 9 transects in Stratum A and 5 in Stratum B.

June 12. Ceilings scattered over BL, broken over calving ground.
7.5 hours flown in 206B.
MW and RM conducted classification counts over calving ground and necropsied calves. Photo plane completed remaining transects. Photo plane returned to Edmonton.

June 13. Broken ceilings in BL. Overcast over calving ground with snow and rain showers all day.
5.9 hours flown in 206B.
MW and RM conducted classification counts and necropsied calves.

June 14. Clear over BL in a.m. Low, broken ceilings with snow showers over calving grounds.
5.5 hours flown in 206B.

MW and RM conducted classification counts and necropsied calves.

June 15. Low, broken ceilings in BL and over calving ground.
5.8 hours flown in 206B.
MW and RM conducted classification counts and necropsied calves.

June 16. Low, broken ceilings in BL and over calving grounds.
4.8 hours flown in 206B.
MW and Sarma Liepins conducted classification counts and necropsied calves.

Appendix 2. Personnel and itinerary, June 1994.

Personnel: Mark Williams (MW), Wildlife Management Division, Renewable Resources, Yellowknife. Robert Muldurs (RM), Regional Biologist, Renewable Resources, Arviat. Billy Shott (BS) Uranium City, Saskatchewan. Pierre Robillard, (PR)Black Lake, Saskatchewan.

Itinerary

June 2. MW delayed in Yellowknife because of complications with aircraft charter. BS and PR flew up from Saskatchewan in C185 (pilot Glen Ferguson) to Baker Lake. RM met them in Baker Lake. Flew a spaghetti reconnaissance in evening. 6.9 hours flown.

June 3. Weather clear. MW flew in C185 (Arctic Sunwest, pilot Bert Storvold) from Yellowknife to Baker Lake. Reduced altitude to 1,000 agl when crossed the Thelon River, to record % snow cover and look for caribou SW of expected calving ground. 4.1 hours ferry. RM, BS and PR flew 6.1 hours of spaghetti reconnaissance. Drew up flight lines for systematic reconnaissance. Spring early, all snow has melted. Lakes clear of snow and the ice has risen, edges of large lakes open.

June 4. Broken ceilings, moderate N winds. Set strip width markers on airplane. Checked strip widths with fuel drums placed 400 m apart on ground. MW, BS, PR flew 10 km systematic reconnaissance with BS and PR observing. 6.7 hours flown.

June 5. Broken ceilings, moderate N winds. MW, BS, PR completed 10 km systematic reconnaissance. 7.6 hours flown. Helicopter crew (pilot Lance White and engineer Wojtek Slupek) arrived in Baker Lake. Called Edmonton to request photo plane. Drew up flight lines for air photo plane.

June 6. Weather clear. C185 from Saskatchewan returned with BS and PR. Helicopter unserviceable. Photo crew arrived at 16:40 (Marv Hengen and Dennis ?, Geographic Air Survey Ltd.)

June 7. Broken ceilings, showers in a.m. Strong winds and thunderstorms in p.m. Photo plane off at 8:30, skies clear over calving grounds. Helicopter unserviceable. Bert Storvold returned to Yellowknife with second C185. Photo plane completed stratum 2 and 1/2 of stratum 1 before low level cloud obscured ground.

June 8. Overcast, fog in a.m. Clear by 13:00. Photo plane off at 14:00. Completed photographs over stratum 1. Began Qamanirjuaq census. Helicopter unserviceable.

June 9. Weather clear. Record high temperatures (+24°C) today. Photo plane off at 8:30 to take pictures over Qamanirjuaq. Began systematic classifications from 206B, calf necropsies, MW and RM observing. 8.2 hours flown.

June 10. Weather variable overcast in BL. Photo left Rankin returning to Edmonton without completing 3 lines in low density, because forecast for overcast, rain and snow showers over calving ground. RM picked up David Abernethy (Wildlife Technician, Arviat) in Rankin, and conducted systematic classification counts over the Qamanirjuaq calving grounds.

June 11. Overcast in BL. Snow and rain showers over calving grounds. MW and RM conducted classification survey over Beverly calving grounds. 7.2 hours flown.

June 12. Fresh snow on ground, variable broken ceilings over BL, variable broken over calving ground with rain and snow showers. MW and RM conducted classification counts over Qamanirjuaq calving grounds. 9.6 hours flown.

June 13. Overcast in BL. Variable broken over calving ground with snow and rain showers all day. MW and RM conducted classification counts and necropsied calves Beverly calving grounds. 7.6 hours flown.

June 14. Broken ceilings over BL in a.m. Low, broken ceilings with snow showers over calving grounds. MW and RM conducted classification counts and necropsied calves over Qamanirjuaq calving grounds. 8.8 hours flown in 206B.

June 15. MW returned to Yellowknife on sched. RM returned to Arviat on sched. Helicopter crew waiting for floats to reposition to Cambridge Bay.

Appendix 3. Results of necropsies of caribou calf carcasses found on the 1993 Beverly calving ground.

Date	No.	Description	Cause of Death
12 June	C1	0-1 day old ♂ (no wear on cartilaginous hoof tabs, wet umbilicus >5cm) most abdominal, some thoracic organs missing. Remaining lung pink, skull intact, some hemorrhage under skin	unknown
	C2	3-4 day old ♀ (tabs worn off, but little wear on hooves). all abdominal, thoracic organs missing, muzzle chewed off, brain case shattered.	wolf predation
	C3	1-3 day old ♂ (tabs only slightly worn). stomach, all abdominal organs missing, lungs pink, muzzle chewed off, skull punctured and broken with hemorrhage around punctures.	wolf predation
	C4	3-4 day old ♀ (tabs off, little wear on hooves). stomach, all organs, eyes, tongue missing. Numerous punctures into brain case, skull shattered with extensive hemorrhage.	wolf predation
	C5	>4 day old ♀ (tabs off hooves, some wear on hooves, umbilicus dry). stomach, abdominal organs missing, lungs pink. puncture through top of brain case and behind right eye, hemorrhage on muzzle.	wolf predation
	C6	0-1 day old ♀ (hoof tabs not worn). stomach, brain, tongue, throat and most abdominal organs missing. lungs pink. hemorrhage on one side of back of skull.	wolf predation
	C7	3-4 day old ♂ (hoof tabs worn off, no wear on hooves). Found near cow. Not scavenged, skull intact, lungs pink and normal in appearance, stomach empty but for lichen.	abandonment/ starvation
13 June	C8	1-3 day old ♀ (tabs present, but worn). thoracic, abdominal organs, shoulder missing. skull intact.	unknown
	C9	1-3 day old ♂ (hoof tabs present, some wear). thoracic, abdominal organs missing, skull crushed.	wolf predation
	C10	1-3 day old ♀ (hoof tabs present, some wear). thoracic, abdominal organs missing, skull crushed.	wolf predation
	C11	1-3 day old ♂ (hoof tabs present, light wear). extensive hemorrhage around head, eye and throat. one eye scavenged. lungs pink. only lichen in stomach.	abandonment/ starvation (kicked in throat?)

	C12	>4 days old, sex unknown (tabs worn off, hooves worn). found in snow bank with bear tracks. extensively scavenged, skull intact.	bear predation
14 June	C13	3-4 day old ♀ (tabs off hooves, no wear on hooves). all thoracic and abdominal organs missing. hole in right flank, meat eaten. back of skull punctured with associated hemorrhage.	wolf predation
	C14	>4 day old ♀ (tabs worn off, some wear on hooves). not scavenged, skull intact, no hemorrhaging, lungs pink, stomach empty.	abandonment/ starvation
	C15	1-3 day old ♂ (hoof tabs present but worn). all abdominal, thoracic organs missing, back of skull crushed, skull severed from vertebral column.	wolf predation
	C16	3-4 day old ♀ (tabs worn off hooves, no wear on hooves). found in water. all abdominal organs missing, skull intact, no hemorrhage, lungs pink, heart normal.	unknown (drowned?)
	C17	1-3 day old ♂ (tabs worn, no wear on hooves, umbilicus dried up). 1 eye missing, hemorrhage around eye, throat, shoulders, back. skull intact, no hemorrhage around skull, lungs pink. stomach full of milk curds.	trauma (kicked?)
	C18	3-4 day old ♀ (tabs off hooves, light wear on hooves). skull crushed.	wolf predation
	C19	1-3 day old ♂ (wear on tabs, no wear on hooves, umbilical cord dried up). skull crushed.	wolf predation
	C20	1-3 day old ♀ (wear on tabs, no wear on hooves). all thoracic, abdominal organs missing, skull crushed.	wolf predation
	C21	3-4 day old, sex unknown (tabs worn off, light wear on hooves). all abdominal, thoracic organs missing, skull intact, but extensive hemorrhaging under skin.	wolf predation
	C22	3-4 day old ♀(tabs worn off, light wear on hooves). skull crushed.	wolf predation
15 June	C23	1-3 day old ♀ (tabs worn, no wear on hooves, < 5 cm of wet umbilicus). all abdominal, thoracic organs missing, skull intact, no hemorrhaging.	unknown
	C24	unknown age, sex. extensively scavenged. skull severed from spine. skull intact with no hemorrhage.	unknown
	C25	>4 day old, sex unknown (tabs worn off, wear on hooves). extensively scavenged, skull crushed.	wolf predation

	C26	>4 day old ♀ (tabs worn off, wear on hooves). all abdominal, thoracic organs missing, lungs pink, skull crushed with extensive hemorrhaging.	wolf predation
	C27	1-3 day old ♀ (tabs worn, no wear on hooves). all abdominal, thoracic organs missing, remaining piece of lung pink, skull crushed.	wolf predation
16 June	C30	1-3 day old, sex unknown (tabs worn, no wear on hooves). abdominal organs missing, lungs pink. canine puncture through skull, associated hemorrhage.	wolf predation
	C31	>4 day old ♀ (tabs worn off, wear on hooves). all abdominal organs missing, throat scavenged, lungs pink. canine puncture above eye socket with associated hemorrhage.	wolf predation
	C32	1 day old ♂ (slight wear on tabs, umbilicus 7.5 cm long and wet). abdominal organs, one eye and tongue missing. lungs pink. canine puncture, hemorrhage on both sides of back of skull.	wolf predation
	C33	3-4 day old ♀ (tabs worn off hooves, light wear on hooves). abdominal, thoracic organs missing. skin taken from neck and shoulders but no flesh removed. skull crushed.	wolf predation
	C34	1-3 day old ♀ (tabs worn, no wear on hooves). abdominal and thoracic organs missing, remaining lung pink. skull punctured at back with hemorrhage.	wolf predation
	C35	>4 day old ♂ (tabs worn off, wear on hooves). abdominal organs missing, lungs pink. skull crushed with hemorrhaging.	wolf predation

Appendix 4. Results of necropsies of caribou calf carcasses found on the Beverly herd calving ground in June 1994.

Date	No.	Description	Cause of Death
9 June	C1	1-3 day old ♀ (little wear on cartilaginous hoof tabs, umbilicus dry). mother still near carcass. no scavenging. no milk, bits of lichen, bile in stomach. jaw broken with hemorrhage	trauma
	C2	1-3 day old ♂ (tabs slightly worn). skull crushed, abdominal cavity opened, otherwise carcass intact.	wolf predation
	C3	1-3 day old ♀ (tabs only slightly worn, umbilicus off). canine puncture in front of ear right side, puncture left side under jaw in throat. no scavenging, carcass intact.	wolf predation
	C4	<1 day old ♀ (tabs not worn, umbilicus dried, 5 cm long). mustard yellow fluid around anus, lungs purple, not inflated, sank in water, stomach empty. no sign of trauma.	stillbirth/atelectasis
	C5	>4 day old ♂ (tabs off hooves, some wear on hooves, umbilicus dry). carcass intact. blood on r side, skull intact, broken rib on l side with hemorrhage above ribs, puncture through skin with hemorrhage.	trauma
	C6	1-3 day old ♂ (light wear on hoof tabs). skull crushed with hemorrhage, abdominal cavity opened, stomach eaten.	wolf predation
	C7	unknown age ♀ . blood around neck, punctures with hemorrhage under jaw, skull intact but bruised.	wolf predation
	C8	1-3 day old ♂ (hoof tabs present, but worn, umbilicus dried up). thoracic cavity scavenged, canine puncture marks and hemorrhage on top of skull	wolf predation
	C9	1-3 day old ♂ (hoof tabs present, some wear, umbilicus wet for 2.5 cm, dry for 5 cm). carcass not scavenged, small red spots along stomach lining. stomach empty. lungs dark with hemorrhage on lobes, but had been inflated.	abandonment/starvation
	C10	1-3 day old ♂ (hoof tabs worn off, but only slight wear on hooves). 3 punctures and hemorrhage on top of skull, central puncture through brain case. no milk in stomach, which contained lichen.	abandonment/starvation
	C11	1-3 day old ♀ (hoof tabs present, umbilicus dried, 10 cm long). blood around muzzle, carcass not scavenged, canine puncture and hemorrhage at back of skull, skull crushed.	wolf predation

11 June	C12	1-3 day old ♂ (hoof tabs slightly worn). all abdominal, thoracic organs scavenged. single puncture in top of skull with hemorrhage.	wolf predation
	C13	>4 day old ♂ (hoof tabs worn off, hooves lightly worn, umbilicus dried 5 cm long). stomach full of milk curds, lungs normal. hemorrhage under skin across top of back, puncture through skin on back.	wolf predation
	C14	>4 day old ♀ (tabs worn off, no wear on hooves, no umbilicus). matted blood on hair in front of ear and across muzzle. skull punctured forward of left ear with hemorrhage. skull cracked.	wolf predation
	C15	1-3 day old ♂ (hoof tabs present but worn). canine punctures in top of skull, which is crushed.	wolf predation
	C16	>4 day old ♂ (tabs worn off hooves, no wear on hooves, umbilicus dried, 3cm long). carcass intact. blood from mouth and around eye. hemorrhage under skin above shoulders and in muscle in middle of back.	trauma
	C17	1-3 day old ♂ (tabs worn, no wear on hooves). abdominal, thoracic cavities opened, stomach scavenged. skull crushed with hemorrhage.	wolf predation
	C18	1-3 day old ♀ (hoof tabs worn). stomach scavenged. back of skull crushed with massive hemorrhage. canine puncture on top of skull.	wolf predation
	C19	>4 day old ♂ (tabs worn off, light wear on cartilaginous sheaths, umbilicus dried up). skull crushed with hemorrhage.	wolf predation
	C20	>4 day old ♀ (tabs worn off, cartilaginous sheaths worn, some wear on hooves. umbilicus dried, 5 cm long). lungs normal. stomach empty, no sign of trauma.	starvation/abandonment
	C21	1-3 day old ♂ (tabs present). all thoracic, abdominal, organs missing, skull intact, no hemorrhaging. lungs ok.	unknown
13 June	C22	>4 day old ♂ (tabs worn off, light wear on cartilage). all internal organs scavenged. skull intact. no hemorrhage.	unknown
	C23	1-3 day old ♀ (hoof tabs present but worn, umbilicus dry, 2.5 cm long). left side opened, all abdominal, thoracic organs missing, small portion of lung looks ok. skull intact, hemorrhaging along top of spine, puncture on side of ribs.	trauma

C24	1-3 day old ♂ (hoof tabs present but worn) extensively scavenged. no abdominal or thoracic organs remaining. canine puncture on top of skull. hemorrhage in front of right ear.	wolf predation
C25	1-3 day old, sex unknown (hoof tabs present). extensively scavenged, all abdominal, thoracic organs missing. skull crushed.	wolf predation
C26	>4 day old ♂ (tabs worn off, wear on cartilaginous sheaths over hooves). all abdominal, thoracic organs missing, meat pulled off back. blood on side of head, ear, down side of neck. hemorrhage on throat, canine puncture on back of neck with hemorrhage.	wolf predation
C27	1-3 day old ♀ (hoof tabs worn). badly decomposed. skull crushed.	wolf predation
C28	1-3 day old, ♀ (hoof tabs worn, umbilicus gone). cow still protecting carcass. carcass intact. skull intact, lungs, heart, ok. stomach empty.	abandonment/ starvation