

JAN 20 1976

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No. 56, December 1975

QUÉBEC

Crashes of muskox and Peary caribou populations in 1973-74 on the Parry Islands, Arctic Canada
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Abstract

Muskox (*Ovibos moschatus*) and Peary caribou (*Rangifer tarandus pearyi*) populations on eastern Melville, Bathurst, and Byam Martin islands declined sharply in the winter 1973-74. A study of caribou from those islands in March and April 1974 revealed that they (1) were in poor physical condition, (2) had an extremely low pregnancy rate, 7.1%, (3) had no indications of debilitating diseases, and (4) were utilizing habitats where the snow was relatively shallow. Fat in marrow from one-half of the femurs from muskox carcasses found on Bathurst Island in the following summer was below 1%. Of 48 recently-dead muskoxen found on Bathurst and eastern Melville islands and whose ages were determined, 27 (56%) were over 10 years of age, one was 9 years old and the rest were less than 3 years old. Males comprised 69% of the 42 muskoxen of identified sex.

Severe snow storms which produced hard dense drifts occurred in September and November of 1973. Meteorological records show a record snow depth for Resolute Bay in early spring 1974, and we believe that extreme winter conditions were the main cause of the crash.

Résumé

Les populations de boeufs musqués (*Ovibos moschatus*) et de caribous de Peary (*Rangifer tarandus pearyi*) dans les îles Bathurst et Byam Martin ainsi que dans l'est de l'île Melville, ont accusé un déclin marqué l'hiver 1973-1974. Une étude des caribous de ces îles en mars et avril 1974 a révélé qu'ils étaient en mauvaise forme physique, ne présentaient qu'un taux de grossesse extrêmement bas, soit 7.1%, que rien n'indiquait qu'ils fussent sujets à des maladies débilitantes et qu'ils utilisaient des habitats où la neige ne comportait que relativement peu d'épaisseur. La proportion de gras dans la moitié des fémurs tirés de carcasses de boeuf musqué trouvées l'été suivant dans l'île Bathurst était inférieure à 1%. De 48 boeufs musqués trouvés peu après leur mort soit dans l'île Bathurst, soit dans l'est de l'île Melville, et dont on a pu établir l'âge, 27 (56%) avaient plus de 10 ans, un avait 9 ans et les autres moins de 3 ans. Des 42 de ces boeufs musqués dont on a pu établir le sexe, 69% étaient des mâles.

De violentes tempêtes de neige survenues en septembre et en novembre 1973 avaient provoqué des accumulations

d'une neige dense et dure. Il ressort des archives météorologiques qu'au début du printemps 1974, la couche de neige à Resolute Bay était d'une épaisseur record et nous croyons qu'un hiver extrêmement rigoureux constitue la principale cause de l'effondrement démographique observé.

Introduction

Aerial surveys by Miller and Russell (1975) showed severe declines in Peary caribou (*Rangifer tarandus pearyi*) and muskoxen (*Ovibos moschatus*) populations during the winter of 1973-74 on Bathurst Island, Northwest Territories. They reported decreases in the numbers of caribou and muskoxen of 62% and about 73% respectively between the summers of 1973 and 1974. Corresponding figures for eastern Melville Island were 68% and 48% (F.L. Miller, pers. comm.). We define eastern Melville Island as lands east of a line between Bridport Inlet and southeast Sabine Bay, i.e., Strata I-IV of Miller and Russell (1974). Bathurst, Byam Martin, and Melville islands comprise part of the Parry Islands. Parry Channel refers to the waters south of the Queen Elizabeth Islands, comprised of McClure Strait, Viscount Melville Sound, Barrow Strait, and Lancaster Sound.

In this paper we report on the physical condition, pregnancy rate, and health of a series of caribou collected on Bathurst, Byam Martin, eastern Melville, and Prince of Wales islands in March and April 1974. Data are also presented on their winter habitats and diet. We include information on the age, sex, and physical condition of dead muskoxen and caribou found on Bathurst and eastern Melville islands in 1974 and attempt to elucidate the circumstances of the population crashes.

Methods

The Canadian Wildlife Service (CWS), Resolute Bay Hunters and Trappers Association, and the NWT Game Management Service co-operated in collecting 25 Peary caribou during the period 28 March-9 April 1974. The specimens obtained included 10, 9, 1, and 5 caribou from Melville, Bathurst, Byam Martin, and Prince of Wales islands respectively.

The Resolute Bay Hunters and Trappers Association provided two hunters, Levi Nungaq and Andrew Iqaluk, who shot the caribou. We used a single-engine Otter to locate the animals and return the carcasses to Resolute Bay, where the meat was distributed to Inuit families. We obtained for each caribou the weight and standard body measurements, and collected ovaries and fetuses, a blood sample, the skull and mandible, long bones from the right hind leg, antlers, and

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rumen and faecal samples. We examined carcasses for obvious signs of pathology and several digestive tracts were frozen and returned to CWS, Pathology Division, Ottawa for detailed examination.

We examined caribou feeding craters (areas where snow is pawed away to expose forage) at collection sites whenever practicable. We recorded plant species in the craters, collected specimens for later identification, noted evidence of grazing, and measured snow depth.

Data and specimen material were collected from dead caribou and muskoxen on Bathurst Island from April to September 1974 in conjunction with continuing studies of muskoxen at the High Arctic Research Station operated by the National Museum of Natural Sciences (Fig. 1). Rumen samples, femurs, and mandibles were also collected from carcasses found on southern Bathurst Island in early August during a survey carried out in co-operation with Renewable Resources Consulting Services Ltd. Femurs from 10 of 30 muskoxen found dead on Bathurst Island did not reach the CWS laboratory.

Data were obtained from caribou and muskoxen found dead on Melville Island in July and August by CWS field parties working near Little Point and Sabine Bay (Fig. 1). Most femurs examined were empty or nearly so and did not warrant femur fat determinations. The appearance and consistency of femur marrow samples was recorded in the field. Femurs from two of three muskoxen found dead near Rea Point in June 1974 were shipped to the laboratory.

In the laboratory, first incisors were sectioned and stained, and cemental layers were counted to determine the age of each specimen. The root of the first molar was sectioned and stained if annulations were not clear in an incisor. Ages are given to the nearest year, with the assumption that caribou were born in June, muskoxen in May.

Rumen samples from each muskox or caribou were examined in a tray following separation of material to particle size by screening through a series of sieves. The percentage of each plant species or species group in each sample was estimated visually. Data for caribou and muskoxen on various islands or island groups were then combined and the means calculated for percent volume and percent frequency of plant species or groups in the combined samples.

The maximum lengths of caribou femurs, tibias, and tarsi were measured with a vernier caliper.

All marrow samples were rated visually into one of four classes similar to those suggested by Cheatum (1949) and adopted by Neiland (1970). Marrow samples which were waxy, firm, and creamy white were labelled class 4. Marrow samples in class 3 were softer and contained tinges of pink and red, and those in class 2 were gelatinous and light red. Marrow samples in class 1 were gelatinous to watery in consistency and red.

Marrow from the femurs was analyzed for percentage fat using the dried weight method (Neiland, 1972). Before initial

weighing, any empty space in the femur was filled with water.

We examined meteorological records from Resolute Bay, Mould Bay, and Rea Point as well as detailed climatological data from central Bathurst Island.

Results

Sex, age, and measurements of samples

Caribou

Body and leg bone measurements, weight, sex, age, collection site, and percentage marrow fat for each caribou specimen obtained in March–April, 1974, are detailed in appendices on file with this report in libraries of the Canadian Wildlife Service⁵. Flight lines and animals observed are recorded on maps contained in a report by Thomas *et al.* (1975) also on file in CWS libraries. Figure 1 shows the location of collection sites 1-9.

Only 3 of the 25 caribou obtained were males, all from Sabine Peninsula on Melville Island. That proportion was about representative of the 89 caribou seen by the collection crew.

Only two calves (ca 9 months), both collected on Bathurst Island, were noted during the collection period. Twelve of the 25 animals were either 5 or 7 years old, perhaps indicating superior productivity in the years 1967 and 1969 relative to later years.

Table 1 gives the means and variances of several body measurements for caribou >2 years of age from three islands.

There was no statistically significant difference in weight or stature between females taken from Melville and Bathurst islands. The females from Prince of Wales Island were significantly heavier than females from Melville Island ($p < 0.02$) or Bathurst Island ($p < 0.02$), although differences in other body measurements were not significant.

Three males taken from Melville Island were significantly heavier than the females from that island ($p < 0.001$), Bathurst Island ($p < 0.02$) or Prince of Wales Island ($p < 0.02$). The males were significantly higher at the shoulder than females from Bathurst Island ($p < 0.05$) or Melville Island ($p < 0.05$), but were similar in height when compared to females from Prince of Wales Island.

Female calves obtained on Bathurst Island weighed 32.5 and 31.0 kg. A yearling (between 1 and 2 years old) collected on the same island weighed 38.0 kg.

Remains of 37 caribou were examined on eastern Melville Island in July and August 1974. Most of them probably died the previous winter, but time since death was difficult to estimate because predators quickly consume and scatter caribou remains. Of the 26 carcasses for which the sex could be determined, 17 were males and 9 were females.

During a brief aerial reconnaissance of Bathurst Island south of Polar Bear Pass in August 1974, we saw 15 carcasses, indicating there had been a high mortality of caribou on the island in 1973–74.

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Figure 1

Locations of sites 1–9 where Peary caribou were collected 30 March to 8 April 1974.

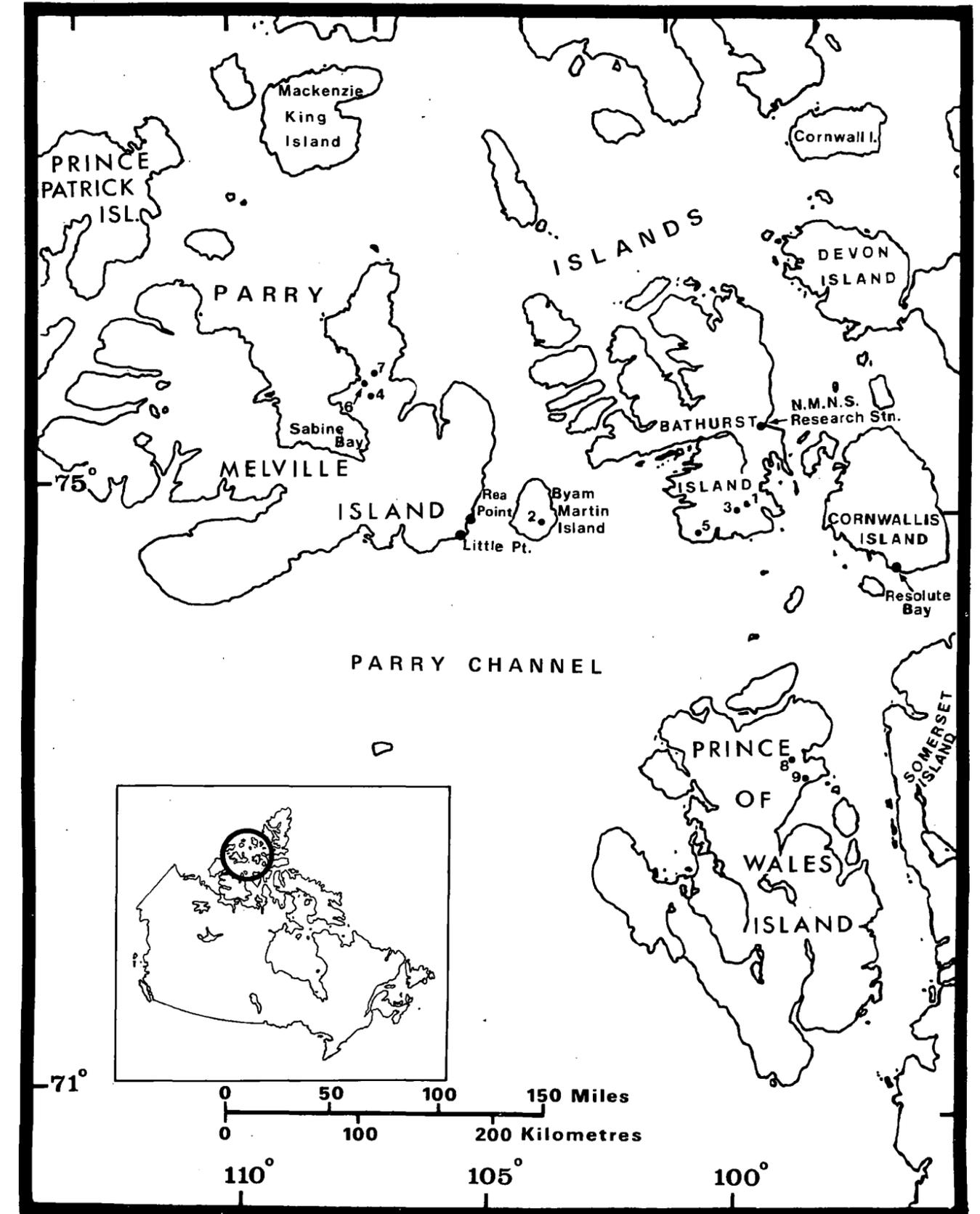


Table 1
Mean measurements (\bar{X}) and variances (s^2) for Peary caribou >2 yr of age collected on Melville, Bathurst, and Prince of Wales islands, NWT, 30 March to 8 April 1974

Island	Sex	N	Weight (kg)		Total length (cm)		Shoulder height (cm)		Girth (cm)	
			\bar{X}	s^2	\bar{X}	s^2	\bar{X}	s^2	\bar{X}	s^2
Bathurst	F	6	50.4	21.6	152.2	24.6	87.7	19.9	113.8	37.0
Melville	F	7	52.7	7.3	151.2	46.5	88.7	12.5	116.4	6.2
	M	3	65.3	10.3	153.3	70.3	95.0	13.0	120.0	39.0
Prince of Wales	F	5	57.7	10.9	156.2	25.7	91.2	36.7	112.0	21.5

Muskoxen

One recently-dead (i.e., <1 year) muskox was found on southern Bathurst Island (south of 78°45'N) on 2 April 1974 and 29 were found the following summer. We could identify 17 as males and 10 as females (Table 2). We obtained mandibles from 19 carcasses; 16 carcasses were >9 years of age and 3 were calves (<12 months) (Table 3). We estimated the ages of four others from size and tooth eruption and wear criteria.

Of 29 recently-dead muskoxen found on eastern Melville Island, 12 were male, 3 female, and 14 could not be sexed (Table 2). Of 26 muskoxen for which age was determined, 12 were over 10 years, and 14 were less than 4 years (Table 3).

During a flight over Cornwallis Island on April 3, we spotted and later examined a dead 2- or 3-year-old muskox located 4 km north of Intrepid Bay. A group of about 10 muskoxen was nearby. Two adult males died on the western side of the island in late March or early April and a calf, which wandered into a mining camp on Little Cornwallis Island, subsequently died.

Caribou reproduction

We collected 19 female caribou >2 years; only three were pregnant. Two of these were from Prince of Wales Island, where a total of five adult females were collected. Only 1 of 14 adult females collected from the Parry islands was pregnant.

Table 2
Number and sex of muskoxen found dead on Bathurst and Melville islands in 1974

Island	Total found dead	Male	Female	Sex unknown	Specimens collected		
					Rumen	Femur	Mandible
Bathurst	30	17	10	3	22	20	19
Melville	29	12	3	14	-	2	26
Totals	59	29	13	17	22	22	45

Rumen contents

Caribou

Mosses comprised an average of 52% of the identifiable contents in rumen samples taken from 20 caribou shot on the Parry Islands, where availability of forage was poor in March and April 1974 (Table 4). Mosses constituted a mean of only 14% of forage in rumen samples from five caribou shot about the same time on Prince of Wales Island, where snow conditions permitted better access to forage. Mosses constituted an average of <1% of rumen samples from six caribou found dead on Bathurst Island in summer 1974. Three of the six caribou were killed by wolves, two in June and one in September.

Luzula nivalis and *L. confusa* were frequent and abundant in all caribou collected (Table 4). They comprised 95%, 90%, and 70% of the contents of rumen samples from the three caribou killed by wolves on Bathurst Island. *Saxifraga oppositifolia* was abundant in rumen samples from caribou shot on Prince of Wales Island, but comprised only 1% of the volume in rumen samples from caribou shot on the Parry Islands. It constituted 10% and 5% of forage in the rumen samples from two caribou killed by wolves in June on Bathurst Island. *Thamnoia* spp. were the most abundant lichens in the rumen samples, but they comprised a relatively low proportion of the rumen contents with the exception of one sample from a caribou shot at site 1 on Bathurst Island. It contained 25% *Thamnoia* spp. Although *Salix arctica* constituted less than 1% of the bulk of rumen contents in caribou

Table 3
Age and sex of 49 of the 59 muskoxen found on Bathurst and Melville islands in 1974

Age (Yr)	Bathurst Is. (23)			Melville Is. (26)			Totals
	Male	Female	Unknown	Male	Female	Unknown	
1	2	1	3*			8	14
2						3	3
3		1*				3	4
9	1						1
11		1		2			3
12	3			1	2		6
13	1	2		3			6
14	2	1		1			4
15	3				1		4
16	1	1		1			3
19				1			1

*Ages estimated from tooth eruption and wear and development of horns.

Table 4

Average volume and frequency (both %) of plant species in rumen samples of 20 and 5 caribou shot on respectively Parry Islands (Bathurst, Byam Martin, and Melville) and Prince of Wales Island, 30 March to 8 April 1974, and of six caribou that died of malnutrition or wolf predation on Bathurst Island, 1974

Plant species	Parry Islands (20)		Bathurst Island (6)		Pr. Wales Island (5)	
	Vol.	Freq.	Vol.	Freq.	Vol.	Freq.
Mosses	52	100	<1	50	14	100
<i>Luzula</i> spp.	36	80	50	83	27	100
<i>Saxifraga oppositifolia</i>	1	75	34	100	36	100
<i>Thamnoia</i> spp.	4	30			4	40
<i>Cetraria</i> spp.	2	20			1	40
<i>Pertusaria</i> spp.	3	2				
<i>Salix</i> spp.	<1	45	5	33	14	80
<i>Papaver radicum</i>	1	60	3	100	<1	40
<i>Draba</i> spp.	1	75	<1	50	<1	20
Unidentified monocots	1	25	8	15	2	20
<i>Cerastium</i> spp.	<1	45				
Unidentified lichens	<1	30				
<i>Dryas integrifolia</i>	<1	10			1	60
<i>Sagina</i> spp.	<1	30				

shot on the Parry Islands, it was the major item, along with mosses, in rumens of many caribou found dead on Melville Island in summer 1974. The latter rumen contents, which were not analyzed as to percentage composition, were mostly from animals that died during the preceding winter. *Salix arctica* constituted 30% of the forage in the rumen samples taken from a caribou killed by wolves on September 3 on Bathurst Island.

Muskoxen

Salix arctica and *Saxifraga oppositifolia* dominated the contents of 22 rumen samples collected from dead muskoxen on Bathurst Island (Table 5). The rumen samples from all the dead muskoxen found on Melville Island also contained a large volume of *Salix arctica*, including many thick stems of that species. Feeding sites used by muskoxen in winter 1973-74 at Little Point and Sabine Bay, Melville Island, were almost denuded of *Salix*.

Table 5

Average volume and frequency (both %) of plant species in rumen samples of 22 of the 30 muskoxen found dead on Bathurst Island in summer 1974

Plant species	Occurrence in rumens	
	Vol.	Freq.
<i>Salix</i> spp.	41	95
<i>Saxifraga oppositifolia</i>	36	86
Unidentified monocots	14	77
<i>Papaver radicum</i>	4	41
Mosses	1	55
<i>Draba</i> spp.	<1	14
<i>Cerastium</i> spp.	<1	5
<i>Dryas integrifolia</i>	<1	5

Winter feeding sites of caribou

Table 6 gives plant species found in feeding craters and in the rumen samples from caribou at collection sites 1 and 5 on Bathurst Island. At site 1 the lichen *Cetraria islandica* was the most frequent plant species in craters, followed by the moss *Hypnum bambergeri*. In contrast, in craters at site 5 the moss *Rhacomitrium lanuginosum*, the rush *Luzula nivalis* and the lichen *Alectoria nigricans* occurred most frequently. Mosses were common in all craters.

We examined smaller numbers of craters at other collection sites. On Byam Martin Island (site 2) several craters examined contained *L. nivalis*, *Cetraria cucullata*, and mosses. At collection sites 4 and 6, both on the Sabine Peninsula, Melville Island, the terrain was more rugged than the flat plains of southern Bathurst Island. There appeared to be a greater ground cover of vegetation than at other sites, and vascular plants made up a greater proportion of the flora. Dominant vascular plants were *L. nivalis*, *Poa arctica*, and *Saxifraga oppositifolia*. Lichens were not abundant but were represented by *C. cucullata*, *C. islandica*, *A. nigricans*, and

Peltigera spp. The only moss identified was *Rhacomitrium canescens*. There was evidence of grazing on both *L. nivalis* and *P. arctica*.

Sites 8 and 9 on Prince of Wales Island were on an extensive plain containing a succession of low-lying sandy beach ridges with wetter intervals. We examined only two craters; vegetation included *Dryas integrifolia*, mosses, *Thamnolia subuliformis*, and an unidentified grass. We found broken willow (*Salix arctica*) twigs at one of the craters. There was no evidence of caribou feeding on *D. integrifolia*.

In April 1974, lowland regions of Bathurst, Byam Martin, and Melville islands were deeply drifted with dense snow. On Melville Island, caribou had moved onto the hills of Sabine Peninsula and were foraging on the windswept slopes and ridges. Snow depths at caribou feeding sites on Bathurst Island ranged from 3-4 cm at site 5 to 15-20 cm at site 1. Snow depth at the one site on Byam Martin Island was 8-16 cm. Snow depths at feeding sites on Sabine Peninsula, Melville Island, were 0-5 cm at site 6 and 3-5 cm at site 4.

In May and June 1974, muskoxen in Polar Bear Pass, Bathurst Island, were feeding on exposed ridge tops and in areas of shallow snow on higher ground rather than in the meadows at the foot of the slopes, the usual late winter grazing areas.

Marrow fat reserves

Caribou

Marrow samples from caribou femurs collected in late winter were rated visually into four classes. They had the following percentages of fat:

- Class 4: $\bar{X} = 74.8\%$; $s = 25.6\%$; $n = 5$
- Class 3: $\bar{X} = 32.2\%$; $s = 20.3\%$; $n = 6$
- Class 2: $\bar{X} = 8.6\%$; $s = 2.7\%$; $n = 6$
- Class 1: $\bar{X} = 3.2\%$; $s = 1.1\%$; $n = 3$

The means were all significantly different ($p < 0.02$).

All marrow samples were low in fat, except for four of the five from adult females collected on Prince of Wales Island, where the average was 80.0% ($s = 23.1\%$). The remaining sample from Prince of Wales Island, from a 14-year-old adult female, was very low in fat (2.7%). The mean fat percentage was lowest for the five adult females from Bathurst Island ($\bar{X} = 12.9\%$; $s = 12.1\%$), while the seven females from Melville Island averaged 22.8% ($s = 23.3\%$) and the three males from that island, 19.7% ($s = 15.8\%$). The mean fat percentage for the Prince of Wales sample was significantly greater ($p < 0.01$) than the mean percentages for any of the other samples. Differences between the means of the other samples were not significant ($p > 0.10$). Three of 12 adult females contained marrow fat percentages below 5%.

The percentage of fat in the marrow of an adult female caribou killed by wolves on Bathurst Island in mid June 1974 was 6.5. Marrow samples from three other caribou found dead in Polar Bear Pass were rated visually as class 1, but they were not saved for fat analyses.

Muskoxen

We analysed marrow for percentage fat in femurs of 22 of 30 muskoxen found dead on Bathurst Island in 1974. All but

Table 6

Frequency (%) of plant species in feeding craters and rumen samples of caribou shot at two sites on Bathurst Island 30 March and 2 April 1974

Plant species	Site 1		Site 5	
	Craters (20)	Rumens (3)	Craters (20)	Rumens (4)
Mosses				
<i>Rhacomitrium</i> spp.			95	
<i>Hypnum</i> spp.	55			
<i>Aulacomnium</i> spp.		100	20	100
<i>Myurella</i>	10			
Lichens				
<i>Cetraria islandica</i>	85		10	
<i>C. cucullata</i>	20			
<i>C. nivalis</i>	5		5	75
<i>C. tilesii</i>			5	
<i>Thamnolia subuliformis</i>	35	100	10	25
<i>Alectoria nigricans</i>			90	
<i>A. ochroleuca</i>			15	
<i>Sphaerophorus</i> spp.			5	
<i>Pertusaria</i> spp.		100		
Vascular Plants				
<i>Luzula</i> spp.		33	90	100
<i>Salix arctica</i>		67	10	75
<i>Saxifraga oppositifolia</i>		100		100
<i>S. caespitosa</i>		33	5	50
<i>S. cernua</i>				25
<i>Potentilla</i> spp.			20	
<i>Draba</i> spp.		33		25
<i>Cerastium</i> spp.		33		75
<i>Sagina</i> spp.				25
<i>Cassiope</i> spp.				25
Unidentified monocot		33		25
<i>Papaver</i>		33		
<i>Stellaria</i> spp.				25

three had marrow fat reserves below 7% and 10 were below 1% (Table 7). The male calf found dead on 2 April 1974 (CWS-#74-M1) had a marrow fat percentage of 1.5. The femurs of two adult male muskoxen (74-1 & 2) killed by wolves on Bathurst Island on 9 May 1974 contained marrow fat percentages of 6.6 (left), 10.1 (right), and 3.2 (left), 2.9 (right). The subadult female (74-3) with femur marrow fat percentages of 2.7 (left) and 1.3 (right) died in Polar Bear Pass on 10 June 1974.

We examined the femurs of 25 recently-dead muskoxen found on Melville Island in July and August 1974, and found that 23 of them were empty, except for a thin layer of non-fatty residue that occupied up to a quarter of the circumference. A thin film of fatty material adhered to the walls of the marrow cavity of some femurs. These observations suggest that all or most of the fat reserves were depleted at the time of death, but the presence of insect larvae and pupae in

several femurs and the possibility of some lipidolysis during the summer precludes definitive statements about marrow reserves. Marrow samples from two of the three adult females found dead on Melville Island were firm and white (class 4). We did not examine femur marrow from the third female.

The femurs of two of three adult male muskox found dead near Rea Point, Melville Island, in June 1974 contained 3.3% and 54.1% marrow fat. Fat reserves of the latter suggest death from wolf predation was more probable than starvation. A femur was not recovered from the third frozen animal.

Pathology and parasitology

Brucellosis tests on 17 serum samples from caribou were negative. No macroscopic pathology was found in any of the caribou examined. We found warble-fly (*Oedemagena tarandi* L.) larvae in two caribou collected from Melville Island.

Table 7
Age, sex, and percentage fat in femurs of 22 of the 30 muskoxen found on Bathurst Island in the summer of 1974

Specimen no.	Age (yr)	Sex	Fat in Marrow (%)
74-9	1*	-	1.5
74-24	1	-	1.8
CWS #74-M1	1	M	1.5
74-3	3*	F†	2.7 (L), 1.3 (R)
74-11	9	M	2.3
74-27	11	F	2.0
74-B	12	M	0.4
74-13	12	M	0.2
74-19	12	M	0.4
74-21	13	F	44.4
74-22	13	M	6.1
74-28	13	F	0.7
74-8	14	F	<0.1
74-17	14	M†	0.4
74-29	14	M	0.5
74-A	15	M	4.4
74-20	15	M	17.0
74-25	15	M	0.4
74-16	16	M†	0.3
74-23	16	F	0.4
74-1	adult	M	6.6 (L), 10.1 (R)
74-2	adult	M	3.2 (L), 2.9 (R)

*Age estimated from tooth eruption and horn development.

†Carcass intact when found.

Autopsy of the 65-kg male calf muskox (CWS-#74-M1) found dead on Bathurst Island on 2 April 1974 revealed mucoid degeneration involving the heart, pancreas, acetabulum, and lower mandible, with excessive fluid in the pericardial sac and abdomen. The lymph nodes were edematous. The lungs revealed an extensive pneumonic involvement. Death was probably caused by the pneumonia, which developed because of malnutrition.

Preliminary examination of the subadult female which died on Bathurst Island on 10 June showed depleted fat reserves but no obvious pathological or parasitological condition. During 30 hours of observations on the 3 days preceding her death, she spent only 24% of the time feeding while the two others in the herd, an adult female and male, spent 38% and 41% of the time feeding.

Climatic data

Standard climatological station records for 1973, maintained by personnel at the High Arctic Research Station on Bathurst Island, extend only to 25 September, but they indicate what may be the primary cause of the severe snow conditions on Bathurst Island during the winter 1973-74. A minimum of 8.4 cm of wet snow fell on 7 and 8 September, accompanied by winds of over 26 kn (30 mph). Temperatures during the 2 days ranged from -4°C (25°F) to +3°C (37°F). On each of the following 3 days, winds of 26 kn (30 mph) were recorded

and the minimum temperature dropped to -8°C (17°F). As a result, snow drifted up to 50 cm deep, even in open areas, and a layer of hard snow covered most of the surface.

Late winter (1974) snow depths on Bathurst Island were greater than normal and temperatures averaged 6°C (10°F) lower than previous records (since 1968) for May and June at the station. Wet snow, freezing rain, and rain in early June with subsequent re-freezing resulted in an ice crust over the accumulated drifts.

Snowfall at Resolute Bay from August 1973 to June 1974 exceeded the 1941-70 average by 58 cm and by June 15 reached a record 43.2 cm compared with the mean of 17.0 cm. A storm in late November 1973 caused extremely high drifts in Resolute Bay.

The geographic distribution of heavy winter snow, as revealed by the weather records and by observations of the authors and others (F.L. Miller and R.H. Russell, pers. comm.), corresponds to regions where muskox and caribou populations crashed.

The severe winter conditions did not appear to affect western Melville and Prince Patrick islands as severely as Resolute Bay. However, snowfall at Mould Bay for the period August 1973 to June 1974 was 37.2 cm greater than the long-term average.

Discussion

Our data combined with those of Miller and Russell (1975) lead to the conclusion that major declines of caribou and muskox populations occurred on Bathurst and eastern Melville islands during and following the winter of 1973-74.

The low fat content of femur marrow samples indicated that the majority of caribou shot on the Parry Islands in late March and early April 1974 were malnourished or starving. Wilkinson and Shank (1974) suggested that Peary caribou on Banks Island with femur marrows containing less than about 55% water (more than 41% fat) by weight were in relatively good physical condition for late March. Caribou with values of 55-90% water (5-41% fat) were malnourished and those with more than 90% water (<5% fat) were starving. Values in parentheses are our conversions using the fat-water regressions of Neiland (1970). About 55% (16/29), 38% (11/29) and 7% (2/29) of 29 caribou obtained 18-20 March 1973 by Wilkinson and Shank (1974) fell in the above categories. Following the same criteria, the numbers of caribou in each category obtained by us on the Parry Islands were 1, 9, and 4. Numbers of caribou obtained on Prince of Wales Island in each category were 4, 0, and 1, and there was no evidence of a die-off on that island.

The extremely low pregnancy rate in caribou shot on the Parry Islands might suggest that the females were in poor condition in the autumn of 1973. However, snow was relatively shallow and soft in the winter of 1972-73 (R.H. Russell and F.L. Miller, pers. comm.), snow melt was early, and the summer temperatures of 1973 were not unusual. Thus, evidence suggests that the caribou should have entered the 1973 breeding season in good physical condition.

Among female Peary caribou collected in recent years, the lightest occurred on the Parry Islands and the heaviest on Banks Island. Females from Prince of Wales Island were

intermediate in weight, all differences being statistically significant. Female Peary caribou collected on Banks Island 18-20 March 1973 (Wilkinson and Shank, 1974) were significantly heavier ($\bar{X} = 62.4$ kg) than those of Bathurst ($p < 0.001$), Melville ($p < 0.001$) and Prince of Wales ($p < 0.05$) islands. Males collected on Banks Island were significantly ($p < 0.01$) heavier ($\bar{X} = 89.2$) than the three obtained on Melville Island. Peary caribou on the Parry Islands have probably had less genetic mixing with the larger barren-ground caribou than have other populations, but nutritional differences could account for some of the reported differences. We require larger numbers of specimens before we can elucidate taxonomic relationships based on morphologic criteria.

Luzula spp., which grow on a wide range of habitats from sea level to exposed ridges of upland regions, appear to be important for caribou survival in winters such as 1973-74. This grass-like rush constituted twice the bulk of all the other vascular plants and lichens in rumen samples of caribou collected in late winter on the Parry Islands.

In our March-April sample, the chief difference in the rumen contents of caribou from Prince of Wales Island and the Parry Islands was the greater proportion of moss and the lower proportion of *Saxifraga oppositifolia* in stomachs of caribou from the Parry Islands. The proportion of mosses ingested by Peary caribou seems to be related to the availability of forage in winter. Mosses are often intertwined with forage species and, when forage was difficult to reach, the animals had difficulty avoiding the ingestion of mosses. Some mosses are nearly indigestible by caribou (Pegau *et al.*, 1973) and if they pass slowly through the digestive tract, they reduce the capacity of the tract for nutritious fodder. The proportion of plant species in the rumen may not reflect the proportion ingested because of different rates of digestion and time to pass through the rumen.

The low proportion of mosses in rumen samples of the six caribou found dead on Bathurst Island in summer 1974, relative to the proportion in March-April samples, suggest that all of them died after the winter of 1973-74. Three of them were killed by wolves in June and September.

Comparisons between crater and rumen contents at a given location (Table 6) must be interpreted with caution. The small sample sizes and the possibility that much of the rumen contents was eaten at places other than the site of death preclude generalization from our data.

Many of the muskoxen found dead on Bathurst and eastern Melville islands starved to death. The male calf muskox found dead on Bathurst Island April 2 weighed 65 kg. Five male muskoxen of the same age collected on Banks Island weighed 84-106 kg (Hubert, 1974). The depleted marrow fat reserves in most muskoxen found dead contrasts with reserves of about 70-90% in muskoxen collected 16-17 March 1973 on Banks Island (Wilkinson and Shank, 1974).

Malnutrition usually affects the young and old members of a population most severely, and in ungulates is more prevalent in adult males than in adult females. Our results add support to those generalizations. Twenty-nine (69%) of 42 recently-dead muskoxen of identifiable sex were males in combined samples from Bathurst and Melville islands. The condition of the marrow in 2 of 22 adult males and in 3 of

7 adult females was more consistent with death by predation than by starvation. Adult females may have become more vulnerable to wolf predation after many of the old males, who guard the groups, died of starvation.

That old muskoxen (mostly males) were affected severely during the winter of 1973-74 is indicated by the preponderance (27/48) of animals over 10 years of age in samples from Bathurst and Melville islands. The relatively low proportion of subadult, recently dead muskoxen on Bathurst Island (6/30) compared with Melville Island (14/29) is explained by the poor recruitment and productivity of muskoxen on Bathurst Island since 1967. Gray (1973), in a 140 km² study area in Polar Bear Pass, recorded late summer populations of 42 to 115 muskoxen in the years 1968 to 1971, with only one calf and no yearlings present. On 23 August 1973, in the same area, 108 muskoxen were seen, including 27 calves and 7 yearlings (Gray, unpub. data). In 1974 the highest number recorded was 13, including two yearlings and two 2-year-olds. Thus the population decline on this important muskox range reflects the widespread population decline.

Malnutrition caused by poor availability of forage was the primary cause of the crash of muskox and caribou populations. The length of the winter, the accumulation of snow, and late winter icing aggravated the situation, but it seems likely that the snow storms of early winter, which caused extensive drifting of wet snow and prevented formation of the usual air spaces at vegetation level, were the most important factors leading to inaccessibility of forage.

The role played by human disturbances in the decline of muskox and caribou populations remains unknown. Seismic work was extensive on southwestern Bathurst Island in late winter 1974 and much of it overlapped known muskox wintering areas. Seismic lines were also noted on Byam Martin Island in March and early April, but no activity was noted near the caribou on eastern Melville Island. The effect of disturbance on animals suffering from malnutrition may be significant, but detailed studies of the role of man's activities on Peary caribou and muskox populations are still to be carried out.

Acknowledgements

We thank E.J. Edmonds for identification of plants in rumen samples and, with D. Van Eyk, for collection of material from dead animals found on Melville Island. For assistance in collecting material on Bathurst Island we thank M. Gauthier, CWS, and L. Rackette and D. Wooley of Renewable Resources Ltd. We thank P.L. Madore for age estimates from dental sections and assistance with other phases of the project. The Polar Continental Shelf Project, Department of Energy, Mines and Resources, provided logistical assistance. L. Nungaq and A. Iqaluk hunted the caribou and assisted in the necropsies. We thank D.R. Flook for supervising the study and improving this report. J.E. Bryant and A.M. Pearson also provided useful comments.

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