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Barren Ground Caribou - Calving Grounds In The Northwest Territories
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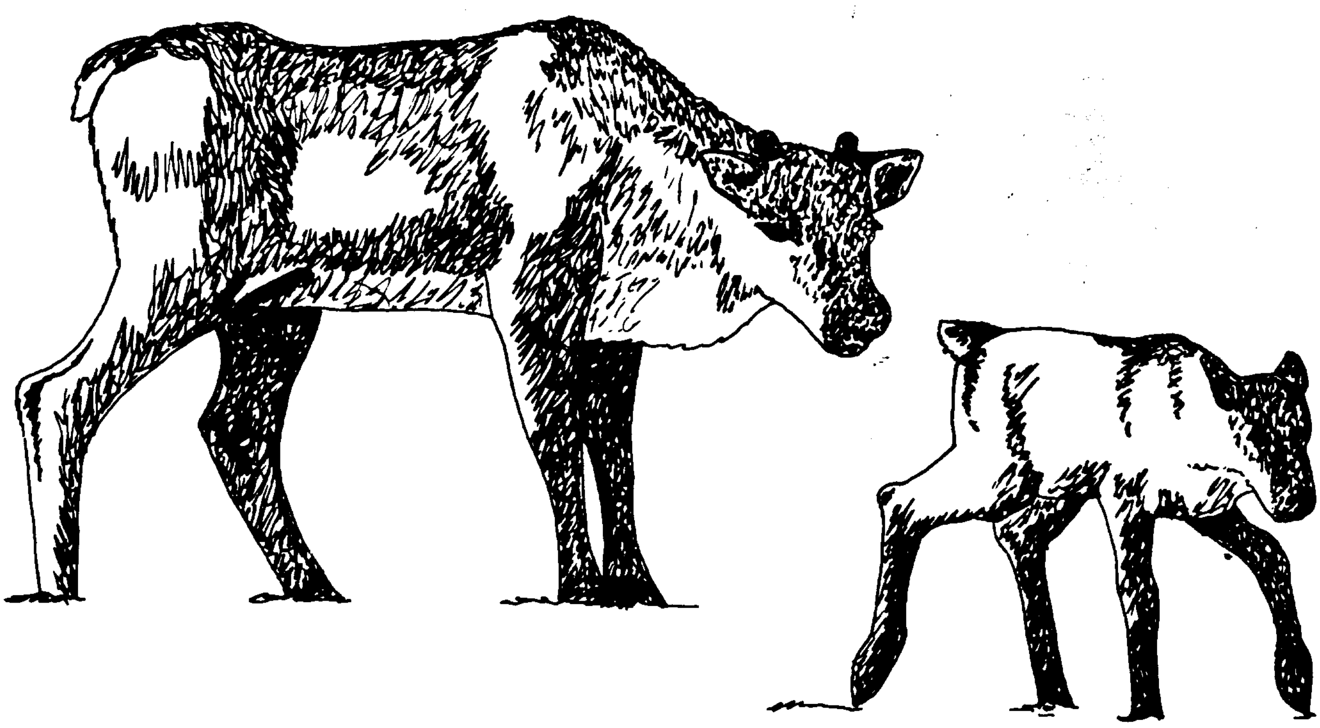
Barren Ground Caribou

Calving Grounds in the Northwest Territories



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ories Wildlife Service

Progress Report Number 7

CHARACTERISTICS OF THREE BARREN-GROUND CARIBOU CALVING GROUNDS IN THE NORTHWEST TERRITORIES

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N.W.T. WILDLIFE SERVICE

YELLOWKNIFE, N.W.T.

1982

Progress Report No. 7

ABSTRACT

Potential effects of human activities on barren-ground caribou on the Bathurst, Beverly and Kaminuriak calving grounds are unknown. In April, 1980, DIAND sponsored the N.W.T. Wildlife Service in a 3-year disturbance study on calving grounds. The first year of the study concentrated on histories of the use of calving grounds, topography, snowmelt patterns, vegetation and abundance of predators. Historically, the general location of the calving grounds has not changed . Varied topography is a characteristic of al 1 three calving grounds. The geographical limits of the more varied topography approximatel y align with the horders of the Beverly and Kaminur iak calving grounds. The three calving grounds are located in the northern portion of each herd's range and remain snow-covered longer than more southerly port ions of their ranges. Snowmelt begins and ends earl ier on the Kaminur iak and southern portion of the Beverly calving grounds (early June) than on the Bathurst and northern portion of the Beverly calving grounds (mid-June) . Willows and dwarf birch shrubs characterize the vegetation on the Kaminuriak and southern portion of the Beverly calving grounds. Lichen communit i es dominate the vegetation on the northern portion of the Beverly calving grounds. The number of wolf dens is low on the calving grounds compared to areas near treel ine. None of the environmental characteristics examined clearly isolate the calving grounds from their surrounding areas. The general location of traditional calving grounds is likely the influence of several interacting factors including plant phenology and predator avoidance. Traditional behaviour is likely important in explaining the choice of specif ic location of calving ground.

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INTRODUCTION

During the 1 %0's it became clear that the pregnant cows of barren-ground caribou herds return each year to a specific area to give birth (Lent 1%6, Skoog 1968). In the N.W.T., four major calving areas were described (Kelsall 1%8, Thomas 1%9). Results from tagging studies verified the assumption that all caribou associated with a particular calving area belong to one herd and the herds were named after the location of the calving grounds (Parker 1972a). The affinity of cows to their calving ground appears to be strong. In 1%7, 1976 and 1980, portions of the Kaminuriak herd reached the calving ground wel 1 before the onset of calving (Parker 1972b, Fischer et al. 1977, Heard 1980b). Instead of moving off the calving ground, the cows slowly circled within the boundaries. Lent (1%6) documented similar observations with the western Arctic herd in Alaska.

The annual migration to the calving ground begins in late March or April. Frequently cows and juveniles aggregate on the late winter range a few weeks prior to the onset of spring migration. The cows and juveniles migrate at an average rate of 10-21 km/day (Kelsall 1%8) and reach the calving ground near the end of May. Barren cows frequently associate with the bulls who move north at a slower rate, and are usually south or west of the calving grounds during calving (Kelsall 1968, Parker 1972b). The cows disperse over the calving ground during calving while the juveniles frequently are concentrated along the southern borders of the calving ground. The proportion of yearlings and subadults on the calving ground varies each year.

Calving of caribou is highly synchronized. The calving period is the time between the earliest and latest births within a herd. Within the calving period, most cows calve during a 5-7 day peak. In the central and eastern Arctic, the calving period is approximately 31 May - 15 June with peak occurring around 4-10 June. The calving ground of a herd in any 1 year is the area where pregnant cows concentrate during calving. The location of the cal ving ground of a herd varies between years, but in most years there is overlap among the locations. Therefore, in theory, the term calving grounds indicates al 1 areas where pregnant cows of a herd have been known to concentrate. However, for each herd, there are fewer than 15 years data documenting the extent of a calving ground during calving. In addition, as methodology among calving ground surveys has varied, definitions of the boundaries of each calving ground have been inconsistent. Thus, in practice, the boundaries of the calving grounds of each herd presented in this report must be viewed as dynamic. It is expected that future surveys will expand the boundaries of the calving grounds depicted in this report.

Within a calving ground, the density of cows varies greatly (0.4 - 24 cows/km^2). During calving, the group size of cows is usually less than 10; however, after the calving peak, cows and calves begin to aggregate into nursery bands which may number several hundred animals. Near the end of June, many cows and calves may form large postcalving groups which vary in size from 1000-30,000 animals. These postcalving groups may be encounter throughout late June and July; however, during August, large groups of cows and calves are rarely observed.

Concern about consequences of human activities on caribou calving grounds has been widely and repeatedly expressed. Cows on the calving grounds are approaching the nadir of their annual physiological cycle dus to the stresses of migration and late term pregnancy and, almost immediately, have to face the added stresses of birth and lactation. Since the calf remains with the cow during its first year, the formation of a strong cow-calf bond is critical to the survival of the calf and may have an important influence on the success of female calves as mothers. Thus, any disturbance that disrupts or weakens the fostering of the cow-calf bond has the potential to be detrimental to the caribou population.

Recognition of the traditional use of the calving grounds and the vulnerability of cows and calves caused concern about the consequences of human activities on calving grounds. The need for research into the behaviour of the caribou and the characteristics of calving grounds was recognized (Klein 1970, Klein and White 1977) . At the same time as biologists were expressing their concerns, the Hamlet of Baker Lake, N.W.T. , forced an examination of the possible disturbances to caribou by industrial activities in the District of Keewatin. The subsequent court hearing precipitated the Department of Indian Affairs and Northern Development (DIAND) to develop and implement the Caribou Protect ion Measures. These measures were developed to restrict land-use operat ions in the areas used during calving and postcalving by the cows of the Beverl y and Kaminur iak herd. In those areas between 15 May and 31 July, a Land-use Inspector will not release an area to activities uncle r Land-use Permit until it has been determined that no cows and calves are nearby. Land-use regulations as applied by land-use permits restrict human activities on the calving grounds of other N.W.T. caribou herds during the calving period.

DIAND also recognized the need for research into the potential effects of human activities on caribou. In April 1980, DIAND funded the NWT Wildlife Semite "to conduct caribou disturbance studies". The studies were on calving grounds and traditional water crossing sites in the Districts of Keewatin and Mackenzie. Winter roads were also to be studied.

In this study we took the approach that before we could evaluate and refine the Caribou Protection Measures for caribou on calving grounds, we would have to attempt to understand how, and if possible why, caribou use certain areas for calving as well as the envi ronmental character isti cs of the calving grounds. Of the four object ives in our initial proposal in 1980, we addressed objectives 1 and 2 during the first year:

1. To describe the a) topography b) abundance of predators c) vegetation and d) snowmelt characteristics on the calving areas and to compare these with adjacent regions.

2. To evaluate the feasibility y of testing the hypotheses that have been advanced to explain the traditional use of calving grounds.

3. To describe a) the behavioral patterns and b) the use of characteristic features of the calving areas by caribou and to attempt to relate this use to calf survival.

4. To evaluate land-use regulations for calving grounds by using descriptions of the potential and actual types of industrial activities on calving areas in conjunction with an understanding of those features critical to calf survival.

The primary objective in 1980-81 was to conduct a literature review on the envi ronmental character istics of the calving grounds of the Bathurst, Beverly and Kaminuriak herds and briefly sample the vegetation of the Beverly calving grounds. Various ideas have been advanced to explain the traditional use of calving grounds. Those research hypotheses were useful in focusing on factors that may affect the use by cows of specific areas as calving grounds. However, the discussion of environmental characteristics of calving grounds was not restricted to only those characteristics mentioned in the research hypotheses. Evaluation of the research hypotheses was a secondary object ive.

HISTORICAL REVIEW OF THE CALVING GROUNDS

Ten thousand years ago, the calving grounds and summer ranges Presently used by the Bathurst, Beverly and Kaminuriak herds were under ice (Craig and Fyles 1%0) . Over the next 3,000 to 4,000 years, the ice retreated, the postglacial lakes formed and drained and the land rebounded to emerge from the postglacial marine floods. Thus the charact eristics of the terrestrial envi ronment original ly influencing the location of the calving grounds and summer ranges of the Bathurst, Beverly and Kaminur iak herds may have changed during the past 6,000 to 7,000 years.

Biological information concerning the location of Bathurst and Beverly calving grounds has only teen gathered since 1950 (Kelsall 1953) ; biologists did not visit the Kaminuriak calving grounds until 1963 (Malfair 1%3) . During this relatively brief time, the location of all three calving grounds has remained similar. In addition, indirect evidence suggests that car ibou movement patterns have been relatively stable with time. This evidence is from the native peoples who depended on caribou andwhoadaptedtheir lifestyle to the rhythms . of the caribou.

The frequent association of tent rings, inukshuks, stone caches and other artifacts with water crossing sites and calving grounds attest to the consistency between past and present movement patterns of barren-ground herds (Harp 1%1, Gorden 1975) . Archaeologists have determined that a site on the southeast shore of Aberdeen Lake has been seasonally occupied more or less continuously for the past 7,000 years (Wright 1972) . The first occupants were late paleo-Indian hunters (5000 - 4000 B.C.) who were followed by a second Indian culture, the early, mid and late Shield Archaic peoples (3000 - 1000 B. C.) . Around 1000 B. C., the climate cooled and an Inuit culture, the Arctic Small Tools or pre-Dorset people (1000 B.C. - 0 A.D.), replaced the Indian who followed the southern retreat of the treeline. The climate improved around O A.D. and various groups of Athabascan-speaking peoples occupied the Aberdeen site (O - 1800 A.D.) until the early 19th century. At this time, the Chipewyans, the last group of Athabascan-speaking people to use the Aberdeen site, moved south to maintain their fur trade with the Europeans. Caribou Eskimos from the Hudson Bay coast then moved inland and have made use of the Aberdeen area since then. All cultures were attracted to the site because of the abundant caribou resource (Gorden 1975) . The pattern of sequential occupation by different cultural and linguistic groups appears to be representative of the central and south Keewatin (Wright 1972, Gorden 1975) .

Prior to 1948, there are only occasional anecdotal observations of the barren-ground caribou herds. Combining the knowledge gained since 1948 of the movements of cows before and after breeding with the historical information, we can sketch the histories of the three calving grounds concerned. These histories reveal three conclusions. First, there are annual variations in the length and onset of spring migration. Second , locations of the calving ground overlap in successive years. Third, the amount of time spent on the calving ground by the caribou varies annually.

Bathurst Calving Grounds

Caribou of the Bathurst herd migrate north and northeast in spring from the major wintering areas to reach the calving grounds east of Bathurst Inlet (Fig. 1). In any one year, spring migration may be less than 100 km if a group of caribou overwintered around Bathurst Inlet or it may be more than 80 0 km, if the winter range south of Great Bear Lake was used.

There are some historical records documenting pre-calving migrations across Bathurst Inlet (Rasmussen 1932, Banfield 1954) . There is no historical information on the current Bathurst calving grounds, but inf ormation in Rasmussen (1932) suggests that calving was east of Bathurst Inlet.

The first scientific investigation concerning the location of the calving ground of the Bathurst herd began in 1950 (Kelsall 1953) . That year, caribou overwintered in coastal areas between Coppermine and Perry River as well as in the taiga. On 13 May and 25 May 1950, two migrations crossed lower Bathurst Inlet heading west into the surrounding high count ry. On 28 May and in early June there were two movements east across Bathurst Inlet. Kelsall (1955) could not determine if different groups of animals were migrating and he did not observe any calving. Females with calves had returned to Bathurst Inlet to feed on the lowlands by mid-July 1950. On a flight on 29 May 1951, Kelsall observed three trails crossing Bathurst Inlet and the Western River. The first two movements had come from Gorden Bay and the headwaters of Ellice River; caribou were scattered adjacent to and east of the Burn side River. The third trail moved north from the Western River, continued north and east to cross Bathurst Inlet where

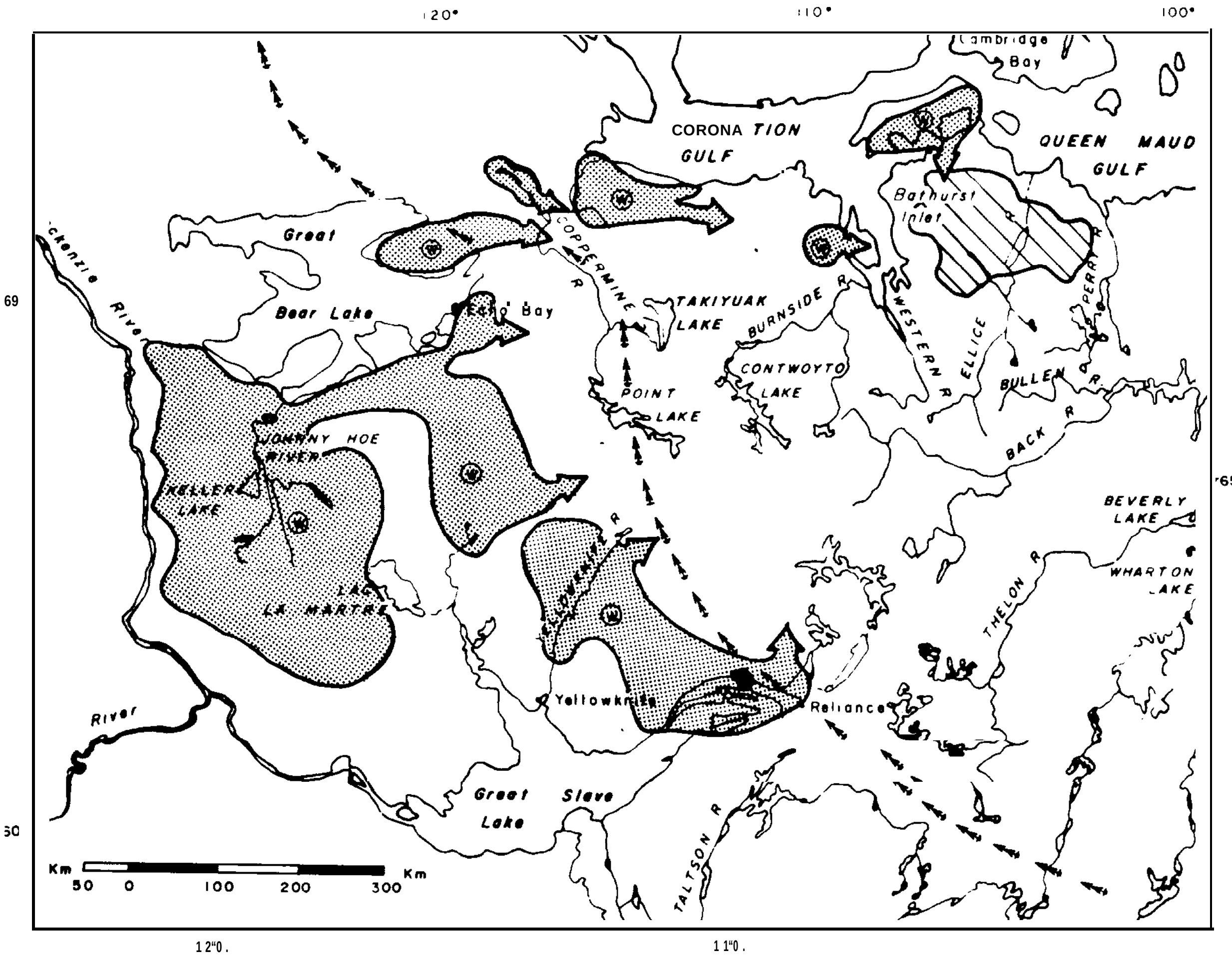


Figure 1. Known winter ranges and direction of spring migration used by Bathurst barren-ground caribou herd, 1950-1977.

Legs-ld

calving ground

Winter range used 2 or more years

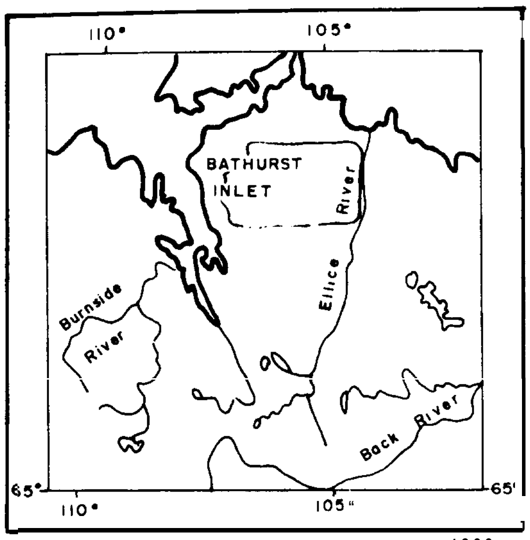
Direction of spring migration f rom winter range

Treeline

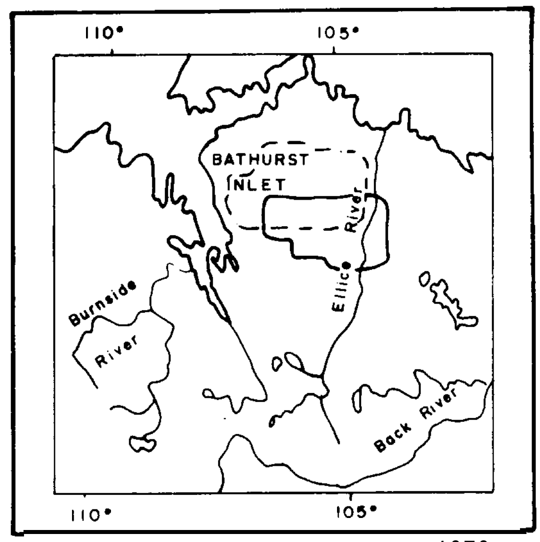
the trail split into two. It left many animals moving east along the east shores of Bathurst Inlet and around the headwaters of the Ellice River. From 12-20 June, 1950, Kelsall camped in the hills west of Bathurst Inlet among a group of calving caribou. There was no aerial reconnaissance to determine the distribution or numbers of calving caribou east and west of Bathurst Inlet. Kelsall (1953) concluded that caribou calved within 10-15 km of either side of Bathurst Inlet and later (1955) suggested that, in most years, calving occurs east of Bathurst Inlet. Since then, records kept at BurnSide Harbour indicate cows frequently migrate east across Bathurst Inlet during late May (Kelsall 1953) ; however, there has been no accurate documentation of the number of cows using this pre-calving migration route nor have there been aerial surveys to document other pre-calving migration routes directly south and southeast of the calving grounds.

Between 1952 and 1965, there was no survey conducted during June delineating the Bathurst calving grounds. Williams (1%5) observed that in 1%5, the area northeast of Bathurst Inlet was a calving ground for the Bathurst cows. Since 1965, the location of the calving ground of the Bathurst caribou herd was establ ished during seven surveys (Williams 1%6; Boxer 1970, 1971, 1974; Calef and Boxer 1977; N.W.T. Wildlife Service Files; Heard 1980a) . Each year, the location has been east of Bathurst Inlet and moving progressively further east towards Perry River (Fig. 2) .

The extent of the Bathurst calving grounds (Fig. 1) was determined by superimposing the seven calving grounds delineated during those aerial. surveys between 1966 and 1980. Calving caribou have also been reported in the hills west of Bathurst Inlet in 1951, 1977 and 1979 (Kelsall 1953, G. Calef pers. comm. , R. McKillop pers.

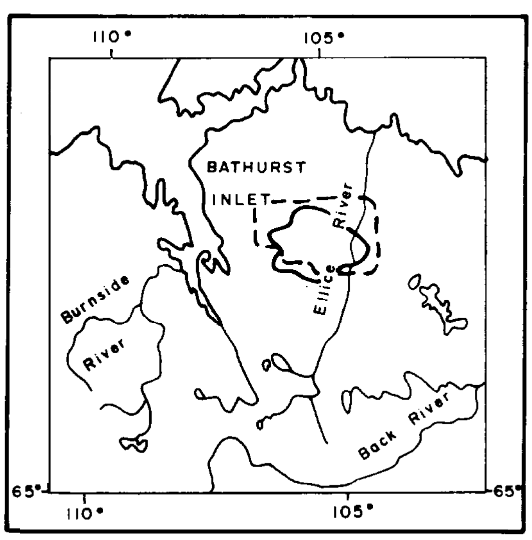


1966



1970

Km 50 0 100 200 Km



1971

Legend

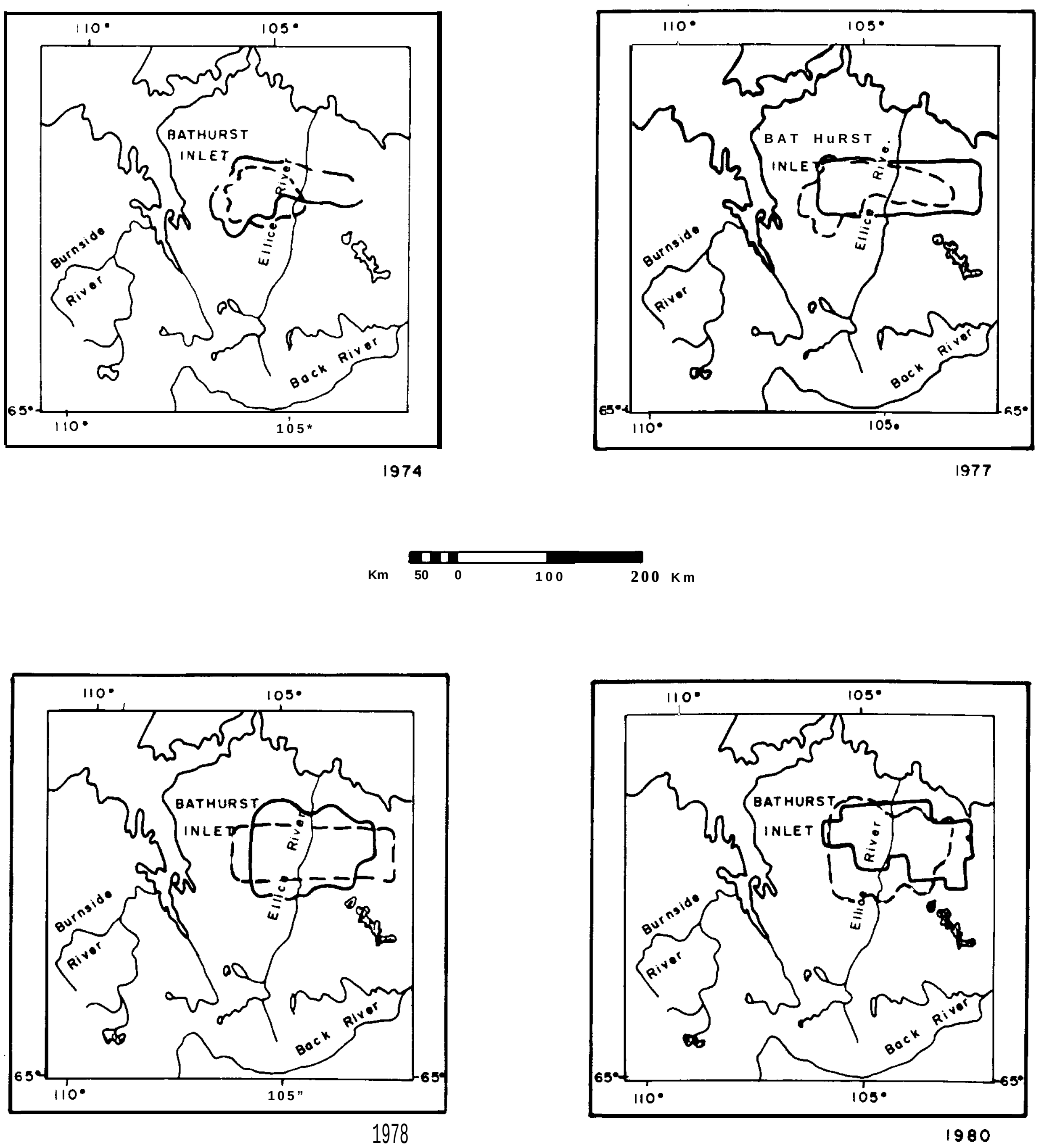
——— Calving ground bounds.y

------ Previous location of calving ground location

1966 Year calving ground Location

Figure 2. The location of Bathurst calving ground in 1966, 1970, 1971, 1974, 1977, 1978 and 1980.

Figure 2 continued



comm.) and on the Kent Peninsula in 1936, 1937 and 1938 (Banfield 1980) . It has never teen documented how many caribou use this area for calving.

Since 1974, the population of 1+ year old caribou on the calving ground has declined (Table 1). There appears to be an increase in the size of the calving ground; however, the inconsistent definitions of the boundaries of the calving ground among surveys render this observation tentative.

By mid-June, cows with calves are forming nursery bands, but we do not know when they leave the calving ground. Postcalving aggregations can be found on the lowlands around Bathurst Inlet by early July (Kelsall 1955) . Rasmussen (1932) also documented such observations. In sane years, there are few or no caribou at Bathurst Inlet throughout the summer (Kelsall 1955, Bird and Bird 1961) . We do not know which other areas are used by postcalving groups.

Beverly Calving Grounds

The Beverly herd migrates north and northeast in spring to the calving grounds north and south of Beverly Lake (Fig. 3) . Animals that overwintered near the east arm of Great Slave Lake must migrate about 500 km, while those who winter south of Lake Athabasca migrate over 800 km to a calving ground.

Prior to 1948, there are no anecdotal observations of the Beverly calving grounds. Lawrie (1948) did not observe calving, but his records imply that the calving occurred north of Beverly Lake.

The location of the Beverly calving ground has been documented for 11 years between 1957 and 1980 (Fig. 4); however, the population

Table 1. Estimated number of 1+ year old caribou and size of Bathurst calving ground, 1%6-1980.

Year	1+ year old caribou on calving ground *	Size of calving ground (Km^2)	Reference
1966	65,180	8,200	Williams 1966
1970	99,500	7,526	Boxer 1970
1971	87,145	4,239	Boxer 1971
1974	%,435	6,799	Boxer 1974
1977	61,729	7,688	Calef and Boxer 1977
1978	48,924	10,070	N.W.T. Wildlife Service files
1980	34,240	10,195	Heard 1980a

* Population estimates revised by Heard 1980c.

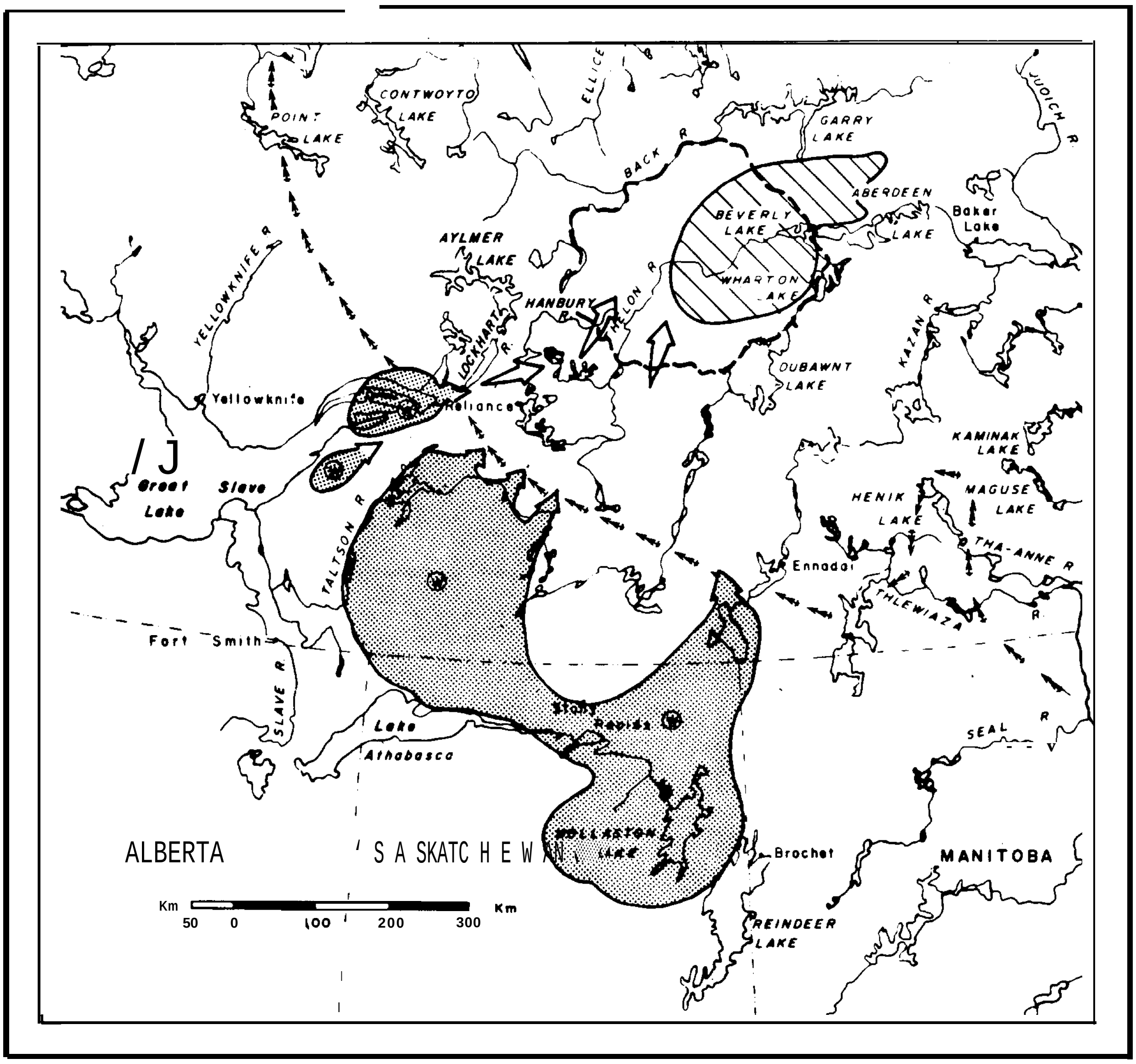


Figure 3. Known winter ranges and direction of spring migration, Beverly barren-ground caribou herd, 1950-1979.

Legend

- calving ground
- Winter range used 2 or more years
- Direction of spring migration from winter range
- Spring migration route
- Treeline

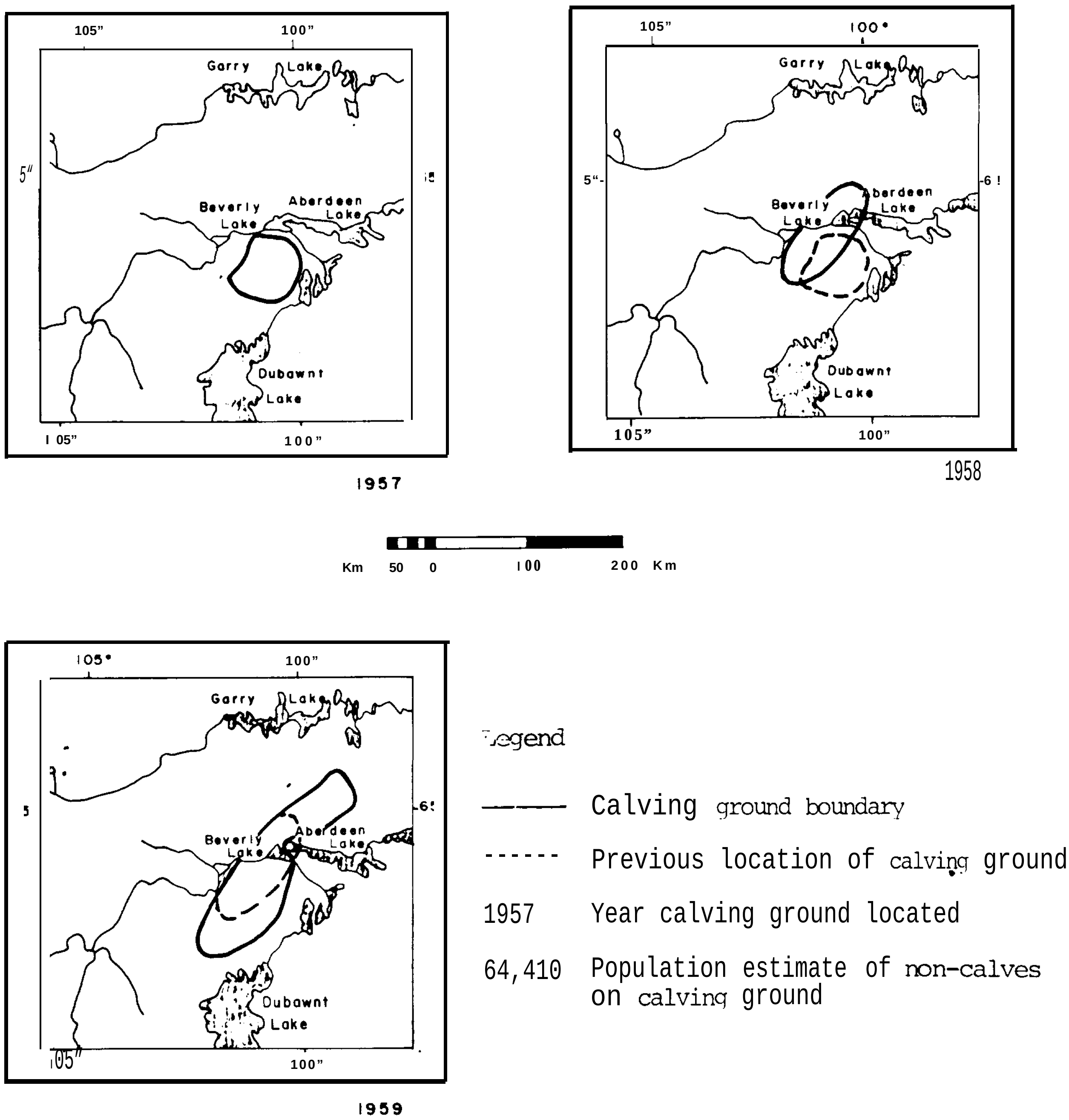
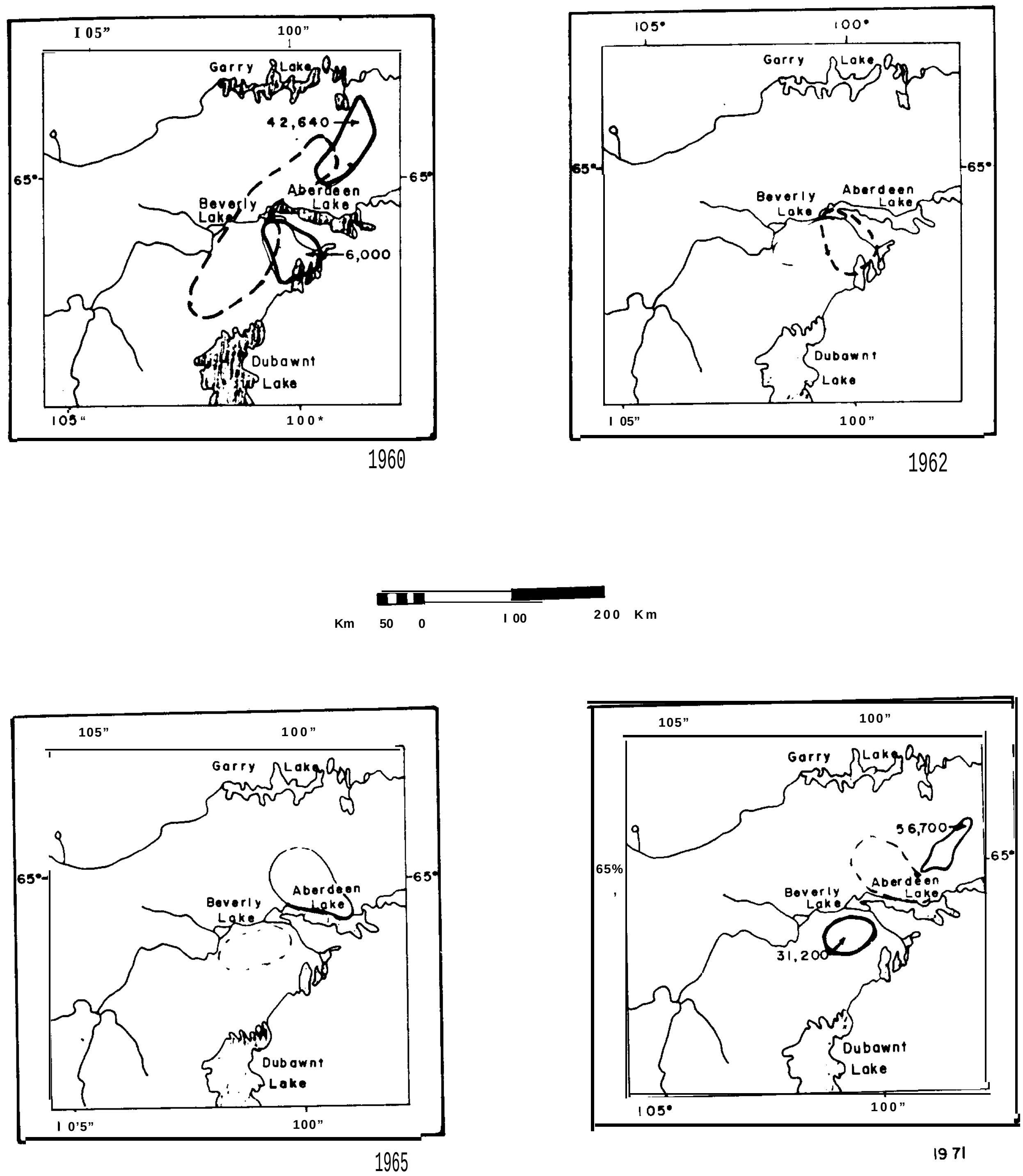


Figure 4. The location of Beverly calving ground in 1957-1960, 1962, 1965, 1971, 1974, 1978-1980.

Figure 4 continued



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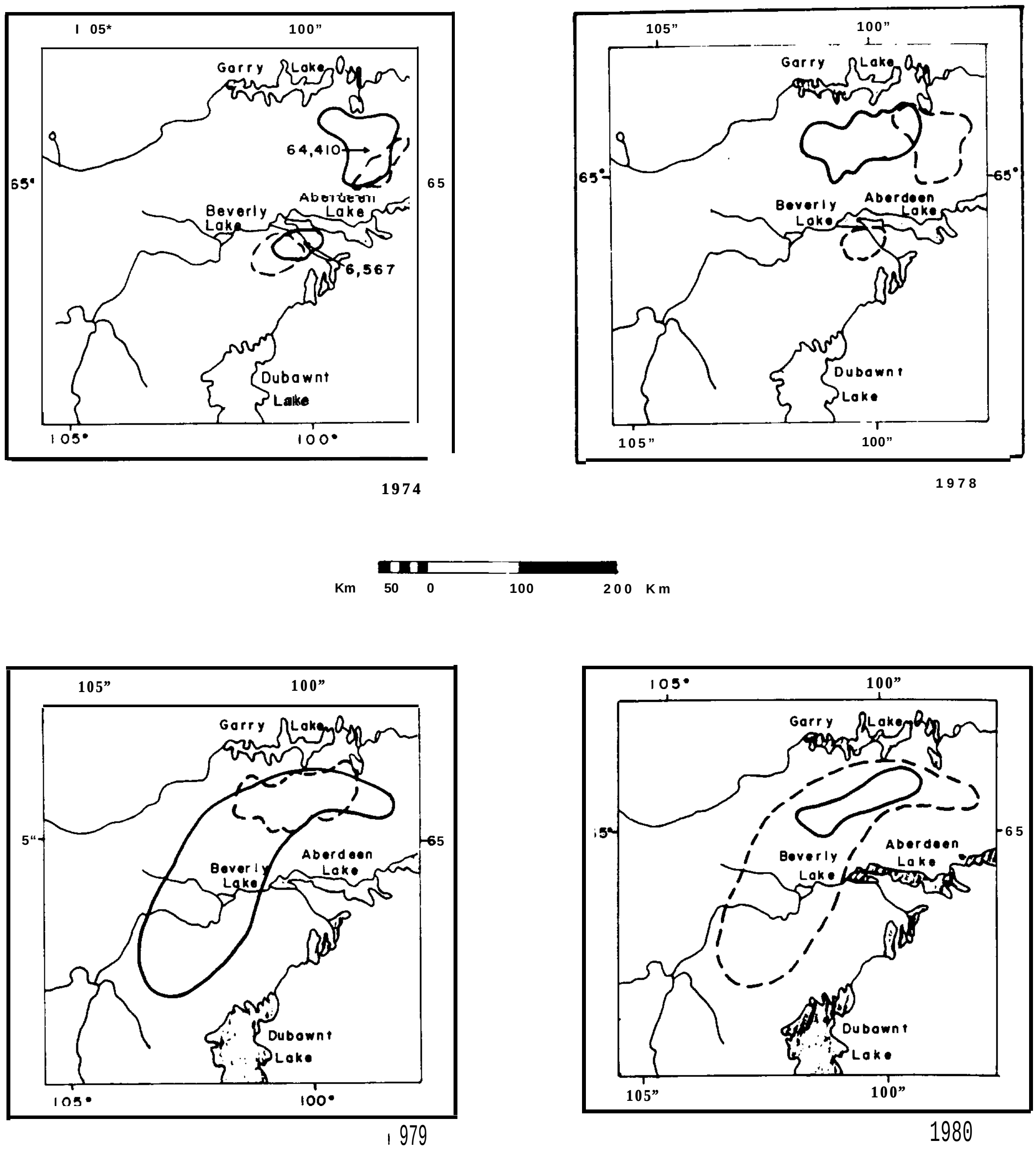


on the calving ground has been censused in only 5 years (Table 2) . Most of the calving occurred south of Beverly Lake in 1957, 1%2 and 1979 (Kelsall and Loughrey 1958, McEwan 1962, Darby 1979). In 1957 and 1962, the peak of calving was late: 14 - 17 June. During both years, t racks across the Thelon River west of Beverly Lake indicated that some cows did calve north of Beverly Lake. Kelsal 1 (1958) did not fly north of Beverly Lake during calving in 1957. After calving, most cows that calved to the south continued to move north across the Thelon River, Beverly Lake and Aberdeen Lake. In 1958, 1%0, 1%5, 1971 and 1974, most of the calving occurred north of Beverly Lake with the yearlings, bulls and varying numbers of pregnant cows remaining south of Beverly Lake (McEwen 1959 and 1%0; Look 1965, Rippin 1971, Moshenko 1974) . In 1978 and 1980, all calving occurred north of Beverly Lake (Heard and Decker 1980; Gunn and Decker 1981) .

The data suggest that most calving occurs north of Beverly Lake except when spring migration is delayed by snow. The extent of the Beverly calving grounds (Fig. 3) was determined by superimposing the 11 calving grounds delineated during those aerial surveys between 1957 and 1980. The Thelon River bisects the Beverly calving grounds into the northern Beverly calving grounds and the southern Beverly calving grounds. In 1958 sane calving occurred outside this zone. McEwen (1959) reported calves among a few thousand animals east of Artillery Lake. Kelsall (1958) suspected that there was a second smaller calving area south and west of the Thelon River towards Aylme r Lake in 1957. He observed tracks of several thousand animals which had split f ran the main movement and moved north along the west side of the Thelon River in early June. He does not comment on the composition of that group; he lost contact with them before they left the main herd.

Table 2. Estimated number of 1+ year old caribou Canal size of Beverly calving ground, 1%0-1980.

Year	1+ year old caribou on calving ground *		Size of calving ground (km^2)	Reference
	North	South		
1%0	42,640	6,000	5,979	McEwen 1960
1971	56,700	31,200	3,363	Rippin 1971
1974	64,410	6,567	4,209	Moshenko 1974
1978	51,000	**	6,000	Heard and Decker 1980
1979	***	***	16,000	Darby 1979
1980	43,000	**	4,849	Gunn and Decker 1981

* Population estimates revised by Heard and Decker 1980.

** No caribou seen on southern calving ground during reconnaissance.

*** No census.

This route to the Aylmer Lake area is followed frequently by migrating bulls during May (Darby 1978, Darby 1979).

Since 1971, the population of 1+ year old caribou on the calving grounds has declined (Table 2). The varying methodology among surveys cautions against evaluation for a trend in size of calving ground.

By mid-June, cows with calves form nursery bands which later coalesce into postcalving aggregations. There are few anecdotal observations describing postcalving movements of the Beverly herd. In late July of 1900 and 1901, both Tyrel 1 and Hanbury saw large numbers of cows and calves moving south across the Thelon and Hanbury Rivers (Preble 1908). In August of 1929, large numbers of cows and calves were moving west-northwest of Baker Lake. Those movements correspond to postcalving movements made by Beverly cows and calves today. In mid-July 1957, cows and calves crossed the Dubawnt River and headed towards Baker Lake. They remained north and west of Baker Lake throughout July (Kelsall 1% 0) . In 1978 and 1980, the postcalving aggregations moved west and southwest. They had left the calving ground by 27 June in 1978 and by 7 July in 1980 (Darby 1978, Cooper 1981) . In 1979, the calving ground arched from south of the Thelon River to north of Beverly Lake. After calving, cows south of the Thelon River moved north towards the Back River, while cows on the northern portion of the calving ground moved west. At the end of June, many cows remained on the eastern portion of the calving ground. In 1979, cows had left the calving ground and were south of the Thelon River by the end of July (Darby 1979) .

Kaminuriak Calving Grounds

The Kaminuriak herd migrates in spring to the calving grounds east of Kaminuriak Lake (Fig. 5) . Spring migration routes vary in length from 150 km to over 600 km. In most years, the migration moves north or northeast; however, in sane years when segments of the herd winter near Chesterfield Inlet, their sping migration movements are to the south.

Prior to 1947, there are no records of the location of the calving grounds of the Kaminuriak herd. The first suggestion came in 1947 when Turner reported many dead newborn calves around Kaminur iak Lake (Banfield 1951) . Lawrie (1948) inferred from conversations with local people that there was a major calving area in the region between Kaminuriak and Maguse Lakes. Pregnant cows were seen north of Carr Lake in late May 1960 (McEwen 1960) . Those reports are all consistent with the current location.

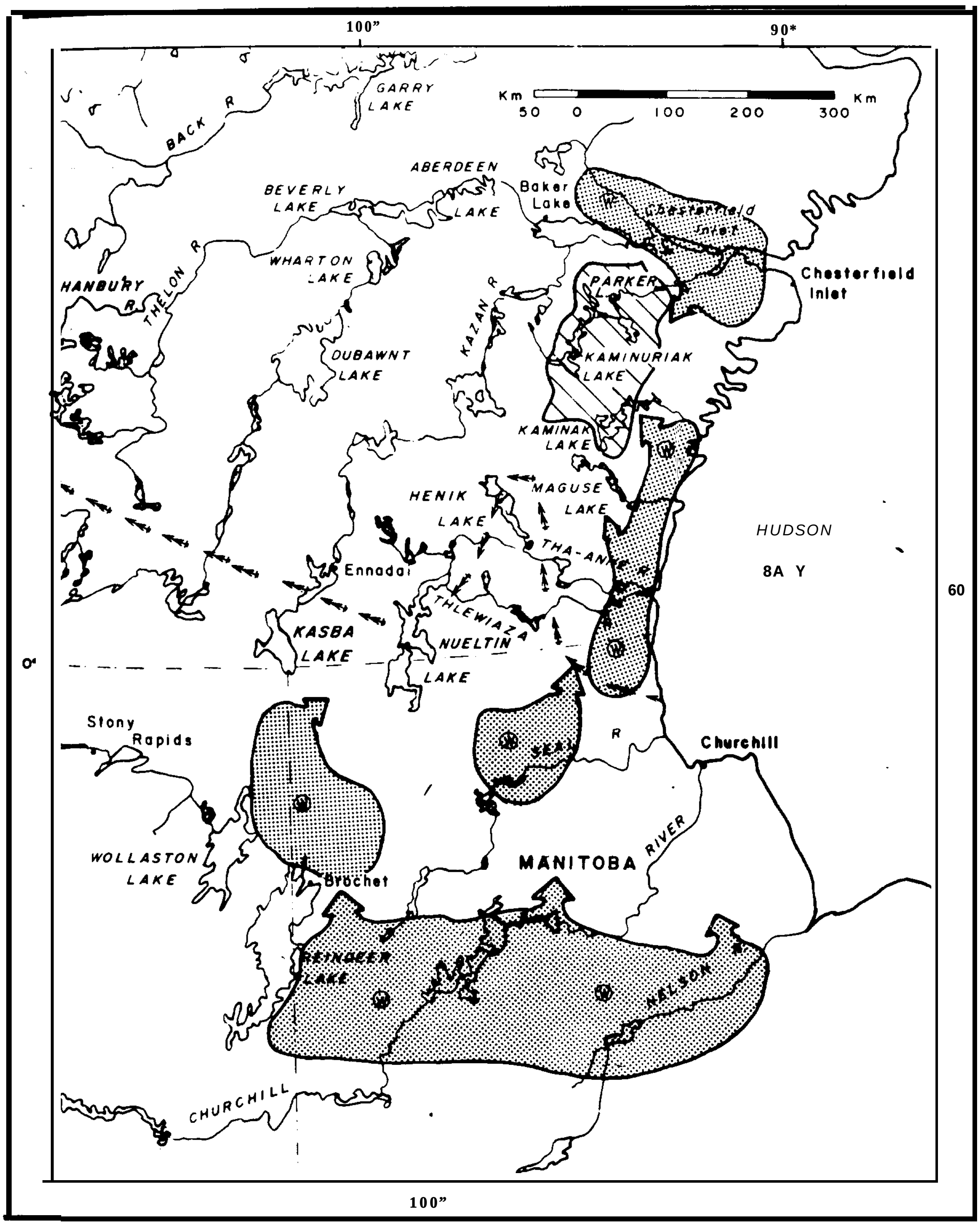
Malfair (1963) conducted the first survey which defined a Kaminuriak calving ground. Since then, the calving grounds of the Kaminuriak herd (Fig. 6) have been located during 13 aerial calving ground surveys between 1966 and 1980 (Land and Bowden 1971, Bowden and Timmerman 1972, Parker 1972b, Land and Hawkins 1973, Hawkins and Howard 1974, Miller and Broughton 1974, Hawkins and Calef 1977, Darby 1978 and 1979, Heard 1980b and 1981) . Each year, the calving ground has been within 60 km north, south or east of Kaminuriak Lake. The extent of the Kaminuriak calving grounds (Fig. 5) was determined by superimposing the 14 calving grounds delineated between 1963 and 1980. Although censuses in 1971, 1972 and 1973 were conducted, problems in the methodology of each survey preclude an estimate of the population of those calving grounds (Cook and Jacobsen 1976) . The high proportion of yearlings and subadults on the calving ground in 1980 produce an artificial implication that the size of the Kaminuriak herd has increased since 1977 (Heard 1980b). In reality, the population on the Kaminuriak calving grounds has declined steadily since 1968 (Heard 19 80d) . The variation in size of each calving ground is partially a reflection of inconsistent methods used to define the boundary of a calving ground (Table 3) .

Postcalving aggregations are normally f ormed by the end of June. In 1%6, 1%7, 1%8, 1970 and 1976, postcalving aggregations moved north or northwest towards Baker Lake and the Lower Kazan River and had left the calving ground by the end of June (Parker 1972b, Miller and Broughton 1974, Fischer et al. 1977) . In 1978, half the cows remained on the calving ground until early August; however, one large group moved southeast and reached Eskimo Point by mid-July (Darby 1978) . In 1980, the general movement was toward the southeast, and cows and calves had left the calving ground after the end of June (Cooper 1981). In 1979, cows and calves remained scattered throughout . the calving ground and summer range and did not form postcalving aggregations (Darby 1979).

Figure 5. Known winter ranges and direction of spring migration used by Kaminuriak barren-ground caribou herd, 1950-1979.

Legend

- Calving ground
- Winter range used 2 or more years
- Direction of spring migration
- Treeline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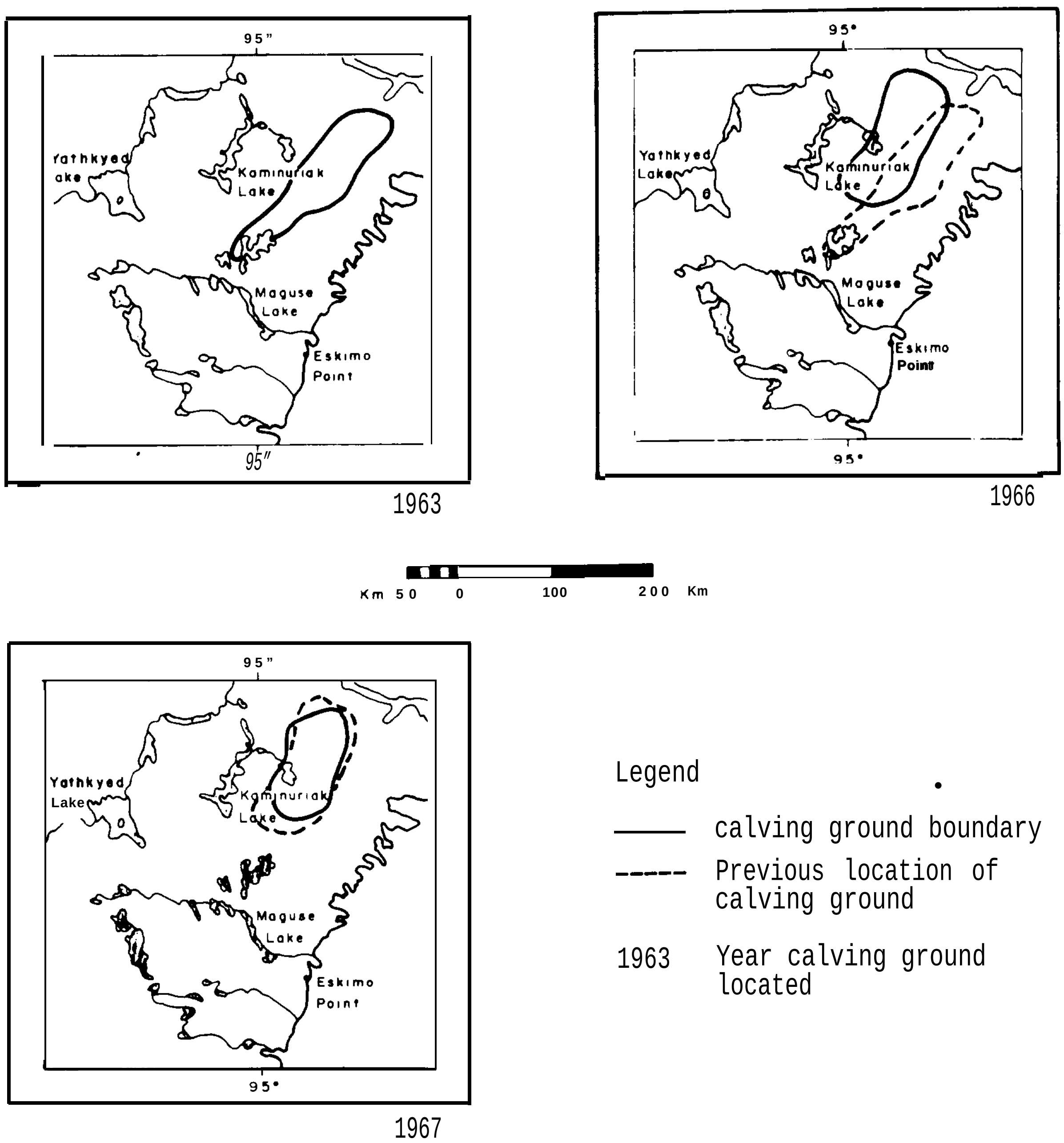
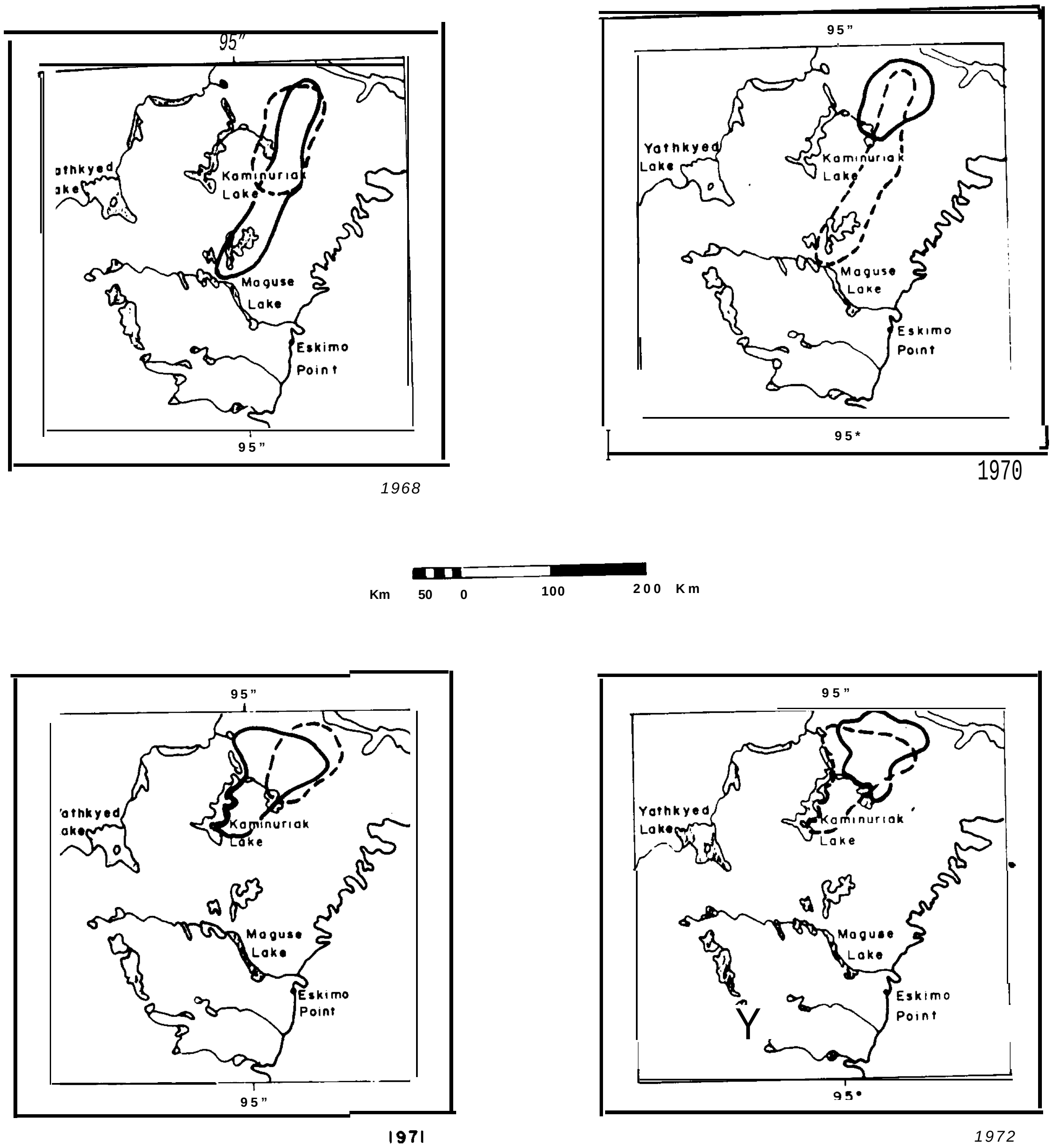


Figure 6. The location of Kaminuraik calving ground in 1963, 1966-1968, 1970-1974, 1976-1980.

Figure 6 continued



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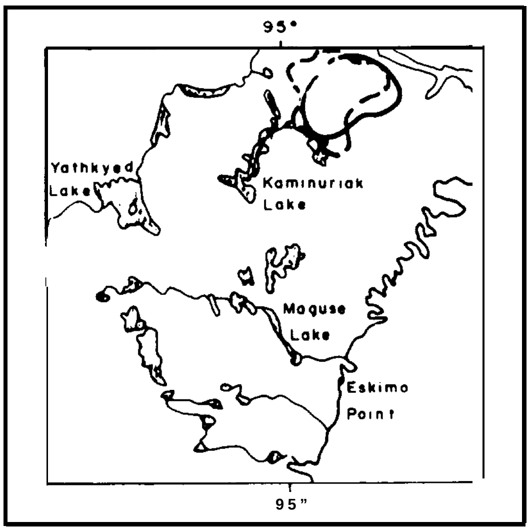
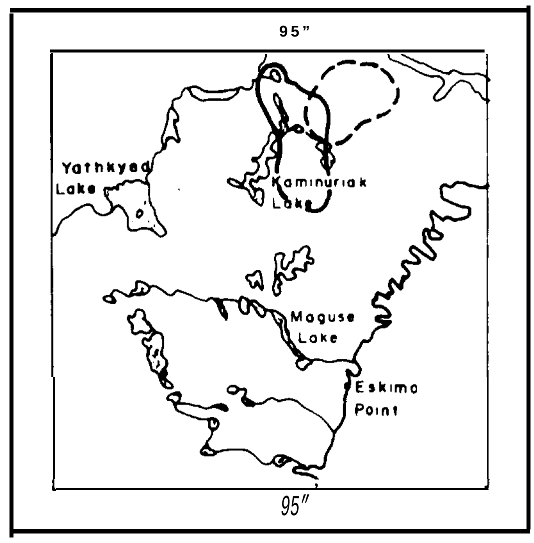


1973



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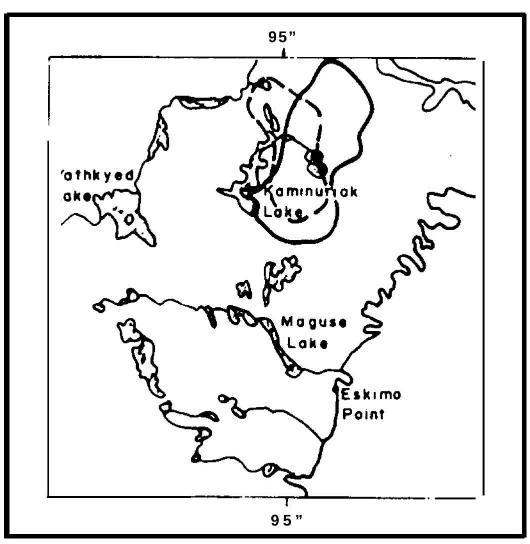
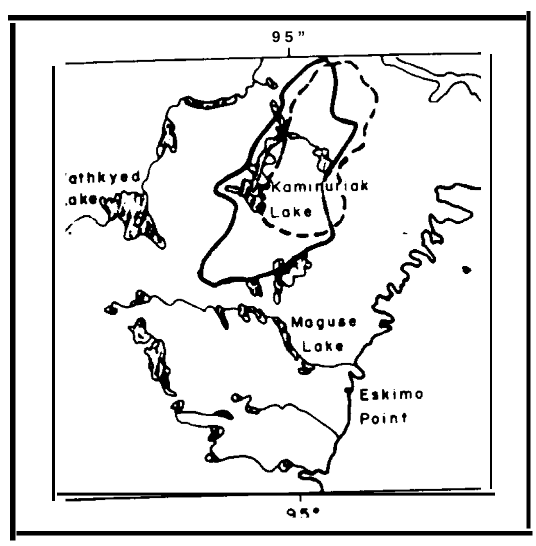
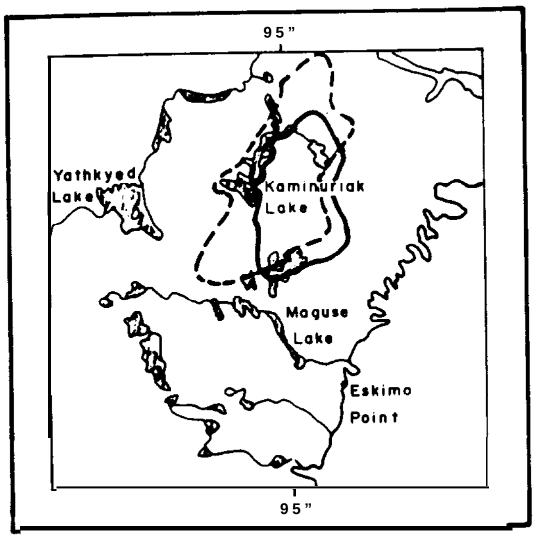


1976

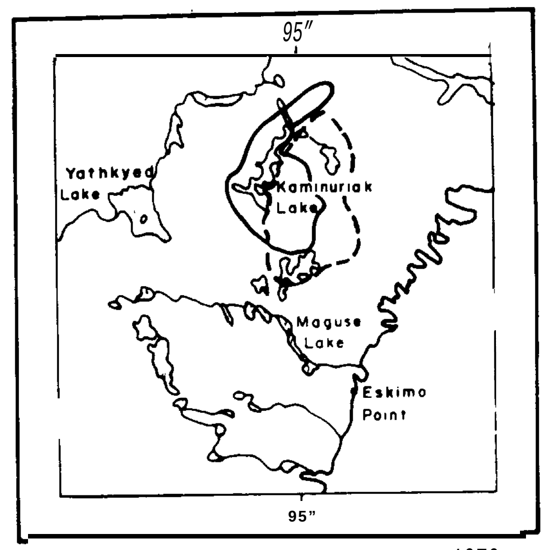


1977

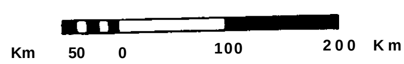
Figure 6. continued

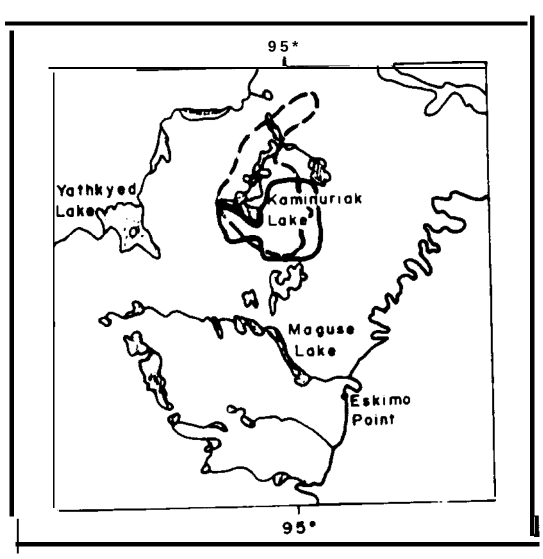


1978



1979





1980

Table 3. Estimated number of 1+ year old caribou and size of the Kaminuriak calving ground, 1966-1980.

Year	1+ year old caribou on calving ground *	Size of calving ground (km^2)	Reference
1%6	**	6,400	Parker 1972b
1%7	**	6,400	Parker 1972b
1968	27,178	5,972	Parker 1972b
1970	**	5,200	Miller and Broughton 1974
1971	*	4,710	Land and Bowden 1971
1972	*	5,000	Bowden and Timmerman 1972
1973	*	2,939	Land and Hawkins 1973
1974	24,500	6,021	Hawkins and Howard 1974
1976	18,888	9,700	Hawkins and Calef 1977
1977	16,503	18,500	Heard 1981
1978	**	8,200	Darby 1978 .
1979	**	6,500	Darby 1979
1980	20,551	1,525	Heard 1980b

* Population estimates revised by Heard 1980d.

** No census.

ANNUAL RANGE OF THE THREE HERDS

The western portion, south of Great Bear Lake, of the present range of the Bathurst herd is within one physiographical region -- the Interior Plains (Bostock 1970) . The remainder of the Bathurst range, as well as the present ranges of the Beverly and Kaminuriak herds (Fig. 7) , are within one other physiographical region -- The Canadian Shield (Bostock 1970) . The Shield is a vast plate of Precambrian rock thinly covered by glacial rubble.

The total change in elevation is less than 600 m from the centre of the Shield to the Arctic ocean border. The gradual change in elevation and the lack of structural control by the underlying bedrock result in poorly developed drainage patterns. Lakes are numerous and cover an estimated 40% of the land surface (Kelsall 1%8) . Most large lakes are remnants of glacial lakes formed during the recession of the last ice sheet.

The caribou ranges lie within the boreal forest (taiga) and tundra biomes (Pruitt 1978) . The taiga is an open woodland of black spruce (Picea mariana) interspersed with white spruce (Picea glauca) on alluvial. sites, and tamarack (Larix laricina) and jack pine (Pinus banksiana) on drier ridges. The deciduous species, paper birch (Betula papyrifera) , balsam poplar (Populus balsamifera) and trembling aspen (Populus tremuloides) , occur throughout the taiga. Lichens, shrubs and heath species are dominant understory species. All three calving grounds are on the tundra which is characterized by an absence of trees (Bradley et al. 1981) .

The soils of the taiga and the tundra are thin mixtures of glacial tills, eroded bedrocks and organic matter. The calving

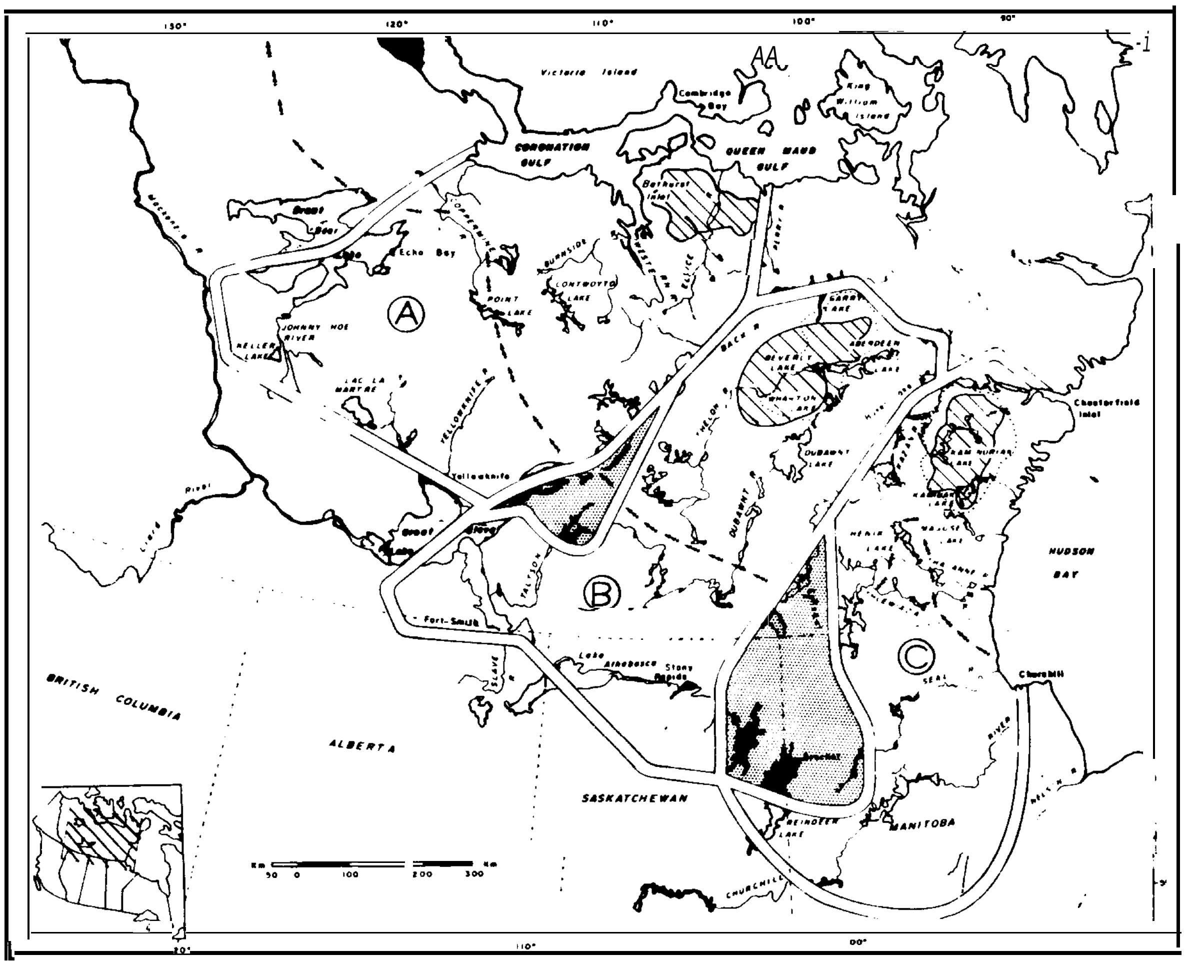


Figure 7. Annual range and calving grounds of Bathurst, Beverly and Kaminuriak barren-ground caribou herds.

Legend

calving g-rounds

Caribou Protection Zone - Primary Calving Areas

Overlap between ranges

Treeline

grounds are within the zone of continous permafrost. The active layer during summer is rarely deeper than 1 m. The continous freezing, thawing and refreezing has resulted in large areas of patterned ground throughout the tundra. Peat deposits are common in wetlands which are dominated by Sphagnum mosses and sedges; the growing season is short; and the nutrient supply is limited. Thus, the annual productivity of the taiga and tundra is relatively low compared to more southern regions.

On the winter ranges of the three herds, below treel ine, the mean daily temperatures rise above freezing during May. Lakes begin to thaw and become ice free during early June. On the tundra calving grounds, the mean daily temperatures do not rise above 0°C until late May. Mean daily temperatures during calving are less than 5°C (Kelsall and Loughrey 1958, Pruitt 1958, McEwen 1%0). Snow storms or freezing rain are common during the calving period. The small lakes on the calving ground are normally free of ice by the end of June but the larger lakes such as MacAlpine, Beverly, Aberdeen, Baker and Kaminuriak frequently contain large ice pans until the end of July.

Average annual precipitation in the taiga and tundra is less than 25 cm. The majority of the average annual snowfall of 100 cm drops on the taiga and tundra during late fall and early winter. The strong prevailing northwesterly winds during the winter cause the snow to become windpacked across the tundra and on the lakes within the taiga.

TOPOGRAPHY

Introduction

Topography is defined as the "physical features of a district or region taken collectively" (American Geological Institute 1974) . In our description of topography of the calving grounds, we have also considered the topography of the surrounding areas. Bedrock gives the landscape its basic expression. Glaciation and marine inundation are among the major processes that modified the landscape.

The granites, gneisses, sedimentary and volcanic rocks of the Canadian Shield evolved during the Precambrian age. Over a period of 200 million years, erosion flattened the surface, and the major coastal bays and inlets were formed (Bostock 1970). Glaciers formed elongated bedrock ridges (roches moutonnees), crag-and-tail hills, and drumlins. The retreat of the glaciers left a discontinuous blanket of till enclosing erratic boulders and shaped into various landforms -- minor moraine ridges (transverse ridges or ribbed moraines oriented transversely to the direction of ice flow), end moraines and ground moraine or till blanket (Ice 1959). Deposition from meltwater of the glacial retreat formed sand and gravel landforms -- eskers (sand worms), kames (isolated gravel mounds) and outwash plains (formed at the ice margin during a pause in the retreat of the glacier). Large glacial lakes formed when the retreating ice blocked drainages. As ice retreat continued, drainages opened and the water level in lakes fell, leaving behind elevated beaches or strand lines. Lakes were formed in the Thelon, Lockhart and Back River systems as well as in the Contwoyto Lake and Dubawnt Lake basins (Craig 1964). The glacial ice continued to retreat until it occupied a small portion of the

District of Keewatin known as the Keewatin ice divide. The Keewatin ice divide was the centre of the Laurentide ice sheet which covered most of the Northwest Territories during the last ice age. It is both the origin and the last stand of the Laurentide ice sheet (Shilts 1980). The location of the Keewatin ice divide aligns with the border between the summer ranges of the Kaminuriak and Beverly herds. There are few glacial landforms in that area because there was no active ice f low. Instead, the final remnants of the Laurentide ice sheet melted 6,000 years ago (Shilts 1980) .

The weight of the glaciers depressed the land. As the ice melt ed, seas flooded much of the northern and caste rn edges of mainland Northwest Territories. Slowly the land rebounded and the retreat of seas left marine strand lines and layers of marine silts, and formed terraces along glacial landforms.

Since the retreat of the seas 7000 years ago, topography has changed relatively little. Sane river canyons have been cut and debris has been removed by river or crept down slopes. Shattered rock (felsenmeer) and various types of patterned rock have been formed by frost action (James 1972) .

At least two research hypotheses in the literature propose that topography has influenced the selection of calving ground sites by cows . One considers the use of various topographical features by cows and calves during inclement weather while the other considers the indirect ef feet of topography on vegetation.

Parker (1972b) discussed the provision of relatively dry or sheltered sites by varied topographical features as shelter for newborn calves from wet snow, rain storms and strong winds. The Combination of precipitation, strong winds and low temperatures is most lethal to newborn calves (Miller and Broughton 1974) as hypothermia and respiratory ailments, including pneumonia, can result. Banfield (1951) and Kelsall (1953, 1%0, 1%8) described increased mortality after storms on calving grounds.

There are no published observations of calves seeking shelter behind rocks or ridges during storms. Our observations and those of F.L. Miller (pers. comm.) indicate that calves seek shelter by bedding down on the leeward side of the bedded cow. Cottle (1959) attributed the survival of four 4-day-old calves during a storm to their ability to seek shelter compared to four 4-day-old calves that were tethered, unable to seek shelter and died. The small sample size and possible stress of being tethered restrict interpretation of his results. There are no published observations of cows seeking shelter on the calving grounds. Kelsall (1953) and Skoog (1968) suggested that cows are more restless during a storm but DeVos (1%0) stated that cows bed during strong winds.

A second hypothesis proposes that the import ante of the topography is indirect. The effect of varied topography on creating vegetative variation that gives caribou a choice of vegetation in progressive phonological changes and under various snow conditions has been described in studies of calving grounds and caribou behaviour in Alaska (Kuropat and Bryant 1980) and in the Yukon Territory (A. Martell pers. comm.) .

Methods

Information on the geology, glacial landforms and marine inundation of the calving grounds was taken from 1:1,000,000 or

1:500,000 geology and surficial geology maps and supplemented by information fran the literature. On the tundra, variations in topography are primarily a result of the presence of glacial landforms and bedrock outcrop. We evaluated this variation by using surficial geology maps to outline areas with recurring types of glacial landforms (landform units). Nine different landform units have been identified. The type of bedrock influences the physical characteristics of an outcrop, which influences the character of the topography. Thus the nine landform units are subdivided on the basis of absence of bedrock outcrop or the presence of granite/gneissic, sandstone, volcanic, conglomerate or quartzite outcrop. For example, the landform unit, drumlin fields-sandstone, indicates an area covered primarily by drumlin fields with varying amounts of sandstone outcrop. (Two glacial landforms, roches moutonnees and crag-and-tail hills, are bedrock modified by glacial action; therefore, they are considered as bedrock outcrop.)

Landform units are mapped for the Beverly and Kaminuriak calving grounds, but not for the Bathurst calving grounds as detailed maps of surficial features did not cover those areas. The data on elevation" were taken from 1:1,000,000 topographical maps.

Results

Bathurst Calving Grounds

In the central and eastern portions of the calving grounds, the bedrock is usually exposed as long, low, narrow ridges of frost-heaved rock slabs and boulders. The amount of exposed bedrock increases to 100% towards Bathurst Inlet (Bird and Bird 1%1). Glacial landforms are more abundant on the southwest and southeast portions of the calving grounds. North, towards the Queen Maud Gulf, there are extensive marine silt plains. Average elevation is 150 m asl.

The Bathurst calving grounds are underlain by gneissic granitic rocks enclosing narrow volcanic belts. The land west of Bathurst Inlet and the Western River is underlain by tilted layers of quartzites and sedimentary rocks (Fraser 1%4) which increased local relief and elevation. Bathurst Inlet and the Western River trench are the expression of a major fault zone separating the sedimentary rocks to the west fran the granitic gneisses and schists underlying the calving grounds (Fig. 8) .

Glacial landforms found on the Bathurst calving grounds include drumlin fields, eskers, outwash plains, end moraines and till plains (ground moraines) . Drumlins and eskers are oriented northwest-southeast in the direction of the ice flow. The till is composed of boulders in a sandy matrix. The end moraines around MacAlpine Lake parallelled the edge of the retreating ice sheet and trend northeast-southwest. In areas of thin till cover, removal of the sand matrix has created extensive boulder fields (Bird and Bird 1%1) .

A study of the literature indicates that six landform units are unevenly distributed on the Bathurst calving grounds (Table 4) . Three other areas on the tundra range of the Bathurst herd have an abundance of glacial landforms similar to that of the Bathurst calving grounds (Prest et al. 1970) . One area extends from MacAlpine Lake to the Bullen River. The other two zones are near the treeline; one is Central on Point Lake and the other extends north of Coppe rmine Rive r and Takijuq Lake to the Coronation Gulf. None of those areas were flooded by marine waters after the retreat of the ice sheets.

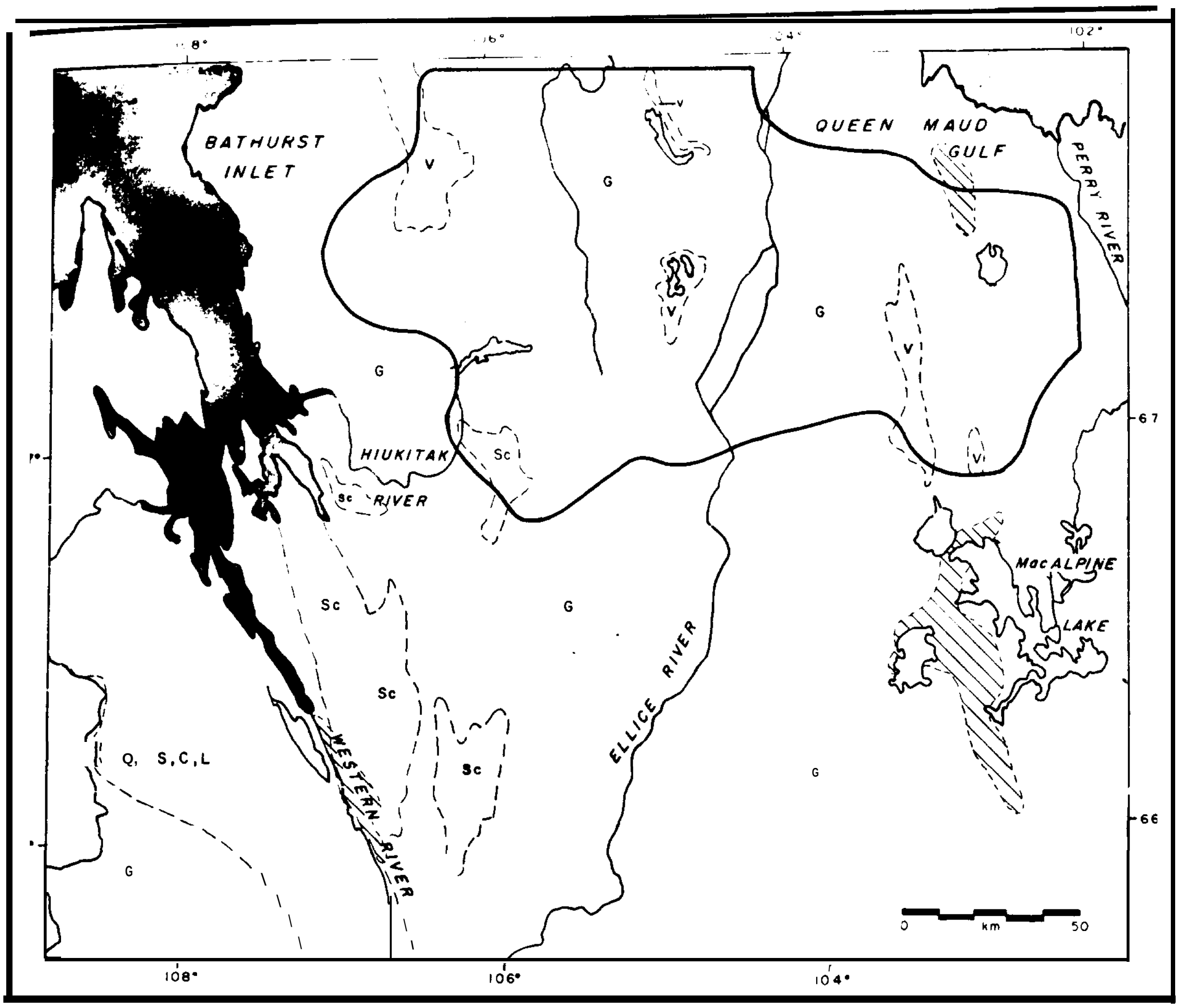


Figure 8. Geology of Bathurst calving grounds.

Legend

——	Calving ground boundary	Q	quartzite
▧	No outcrop	S	sandstone
G	granite/gneiss	C	conglomerate
V	volcanic	L	limestone
Sc	schist		

Table 4. Landform units* on Bathurst calving grounds.

Dominant glacial landf orm(s)	Outcrop geology		
	no outcrop	granitic/ gneissic	volcanic
Drumlin fields		X	
Eske rs		X	
Outwash sand deposits		X	
Till plain		X	X
End moraine	X	X	

* Landform units are subdivided depending upon the daninant geological outcrop occur ring in the subdivision.

Marine waters inundated all the the Bathurst calving grounds following deglaciation (Fig. 9). Zones of marine silts and muddy lakes are common. Wave action has slightly modif ied the outline of glacial landf orms. Marine strand lines occur on rocky slopes near Bathurst Inlet and Queen Maud Gulf (Blake 1%3) . Extensive deposits of marine silt and sand fill the depressions between glacial landf orms and bedrock outcrops from Queen Maud Gulf south to MacAlpine Lake and on the west shores of Bathurst Inlet (Bird and Bird 1%1). Unlike the country east of the calving grounds, areas south of the calving grounds and west of Bathurst Inlet were not flooded by marine waters; however, portions along the major rivers were flooded by glacial lakes.

The aspect of the calving grounds is northeast. The distance between south and north borders is 110 km; the range in elevation, however, is only 200 m (50-250 m asl) , and local relief changes are less than 60 m (Fraser 1%4). Elevations and local relief increase to 300+ m south and west of the calving grounds (Fig. 10) (Fraser 1964) .

Beverlv Calvina Grounds

Little bedrock outcrops on the Beverly calving grounds. Glacial landf orms are abundant throughout the calving grounds. No marine deposits occur on the calving grounds; however, lacustrine deposits occur throughout the central portion of the calving grounds. Average elevation is 200 m asl.

Gneissic granitic rocks outcrop in the northeast corner of the calving grounds. Volcanics, gneissic granites and conglomerate outcrop in the southeast corner of the calving grounds (Wright 1955,

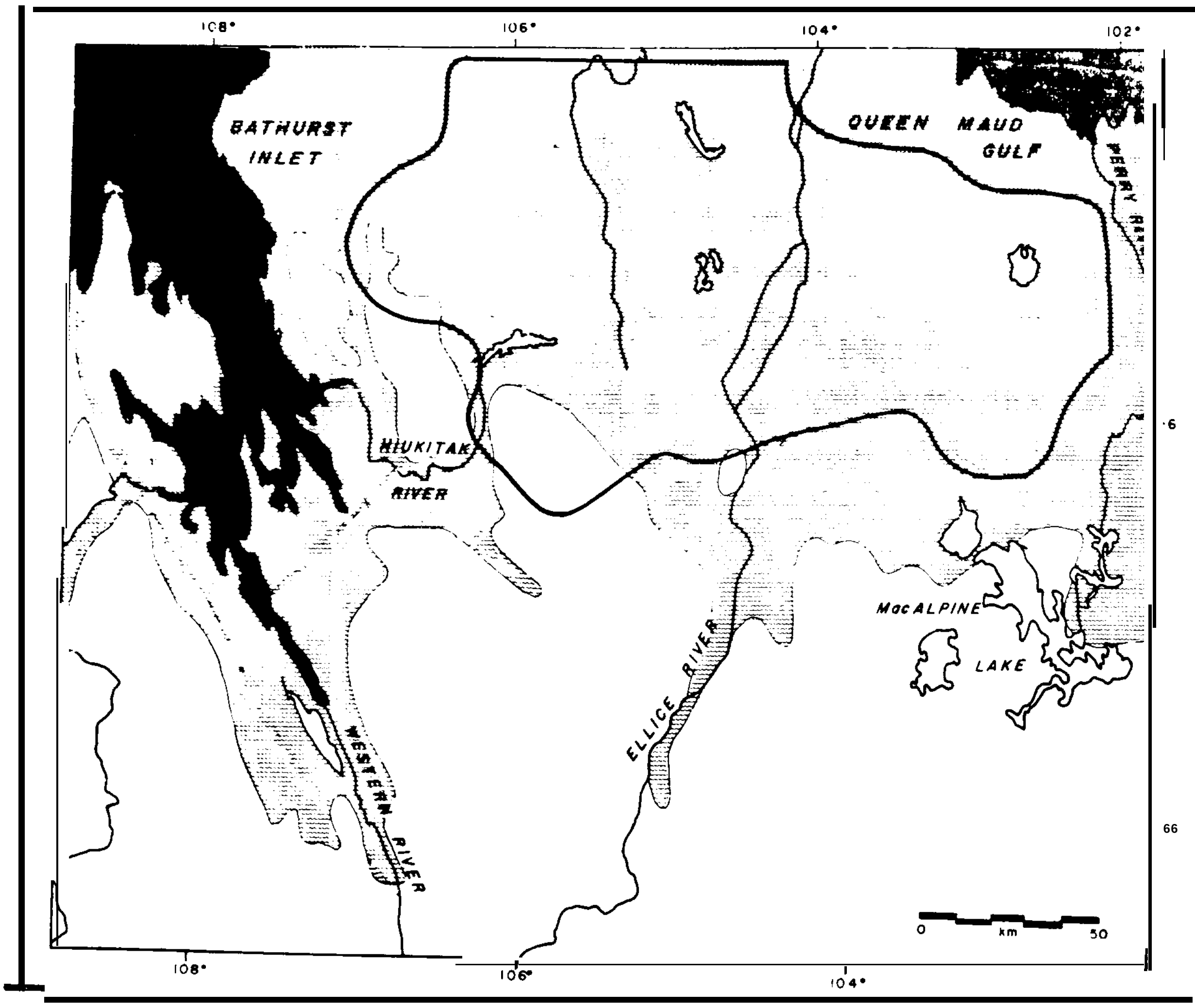


Figure 9. Marine inundation of Bathurst calving grounds.

Legend

calving ground boundary

Marine inundation

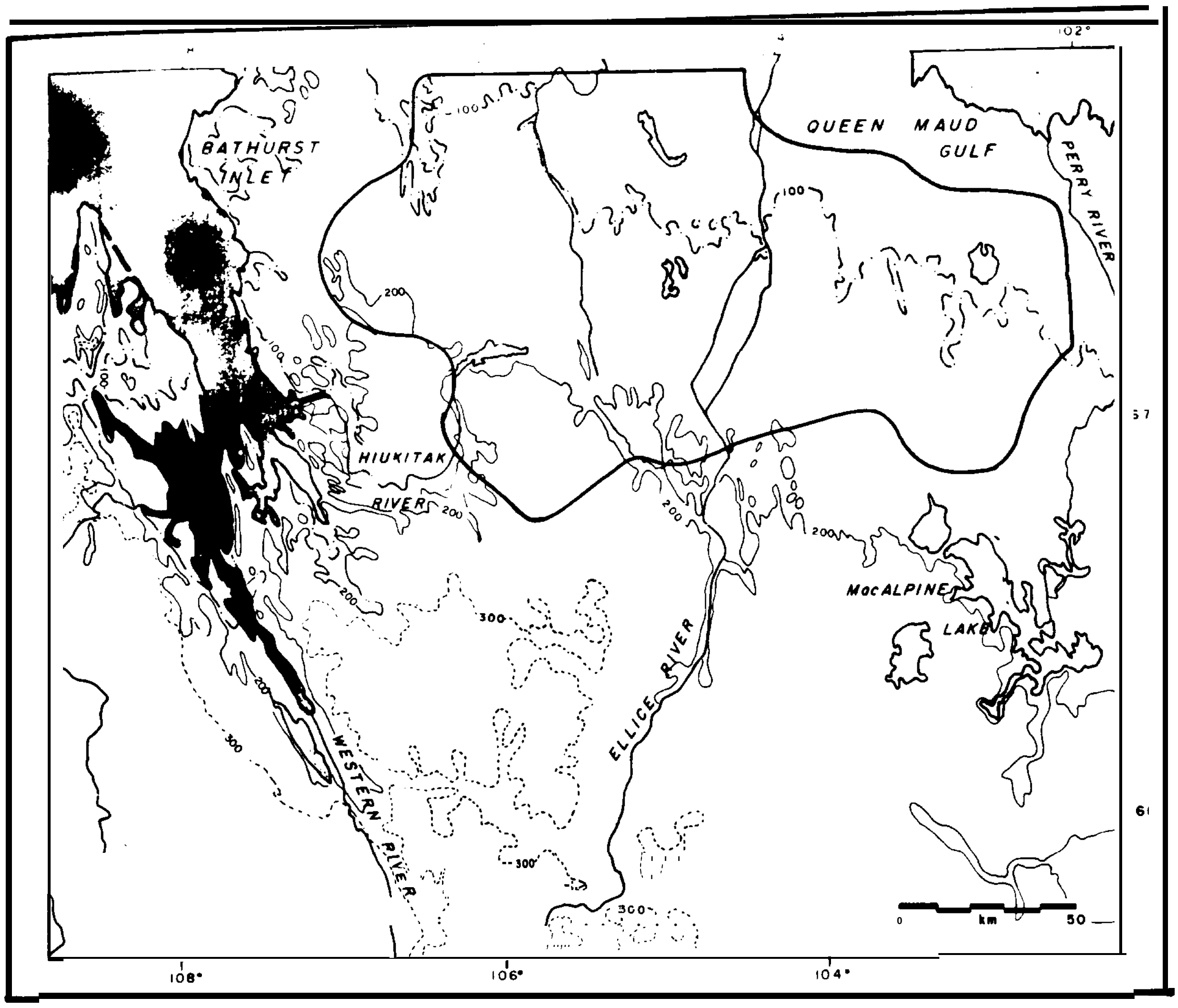


Figure 10. Elevation on Bathurst calving grounds.

Legend

—— Calving ground boundary

—·—·— 100 m

—— 200 m

- - 300 m

1957). Flat-lying sandstone underlies most of the Beverly calving grounds. The sandstone is poorly exposed; the scattered outcrops are only a few inters higher than the extensive layer of glacial drift (Wright 1%7). This terrain extends southwest of the calving grounds throughout most of the Thelon Game Sanctuary. Gneissic granitic rocks outcrop north, east and south of the calving grounds (Wright 1955, 1957). Outcrop in those areas is more extensive and the bedrock exerts tetter structural control over drainage and the shape of lakes.

Glacial landforms on the Beverly calving grounds include drumlins (usually aggregated into fields), eskers, outwash plains, ribbed minor moraines and till plains. Drumlins and eskers are oriented northwest-southeast while ribbed minor moraines trend northeast-southwest. Most of the til 1 is inundated with boulders (Craig 1%4).

Eight landf orm units are distributed throughout the Beverly calving grounds (Table 5, Fig. 11). Such a variety of landf orm units in one area does not occur on the remaining tundra range of the Beverly herd. West and south of the calving grounds, landf orm units tend to be more extensive and composed of only one recurring glacial" landf orm. Southeast of the calving grounds, the extensive till blanket produces a uniform topography. The lack of relief is a consequence of the Keewatin ice divide (Lee 1959). An area similar to the Beverly calving grounds exists south of the treel ine between Kasba, Ennadai and Nueltin Lakes; however, the orientation of the glacial landf orms is northwest-southeast and bedrock is pr imaril y volcanics with some granitic rocks (Wright 1%7).

Only the southern shores of Beverly Lake on the calving grounds were covered by sea inter after the ice receded. Strand lines seen

Table 5. Landform units* on Beverly calving grounds.

Dominant glacial landform(s)	Outcrop geology: no outcrop	sand-stone	conglom-crate	granitic/gneissic	volcanic
Drumlin fields.	X	X	X	X	X
Eskers	X	X	X	X	X
Ribbed minor moraines	X	X			
Till plain	X	X	X	X	
Outwash sand deposit	X	X	X	X	X
Drumlins and eskers	X	X		X	
Drumlins and ribbed minor moraines	X	X	X	X	X
Drumlins, eskers and ribbed minor moraines		X			X

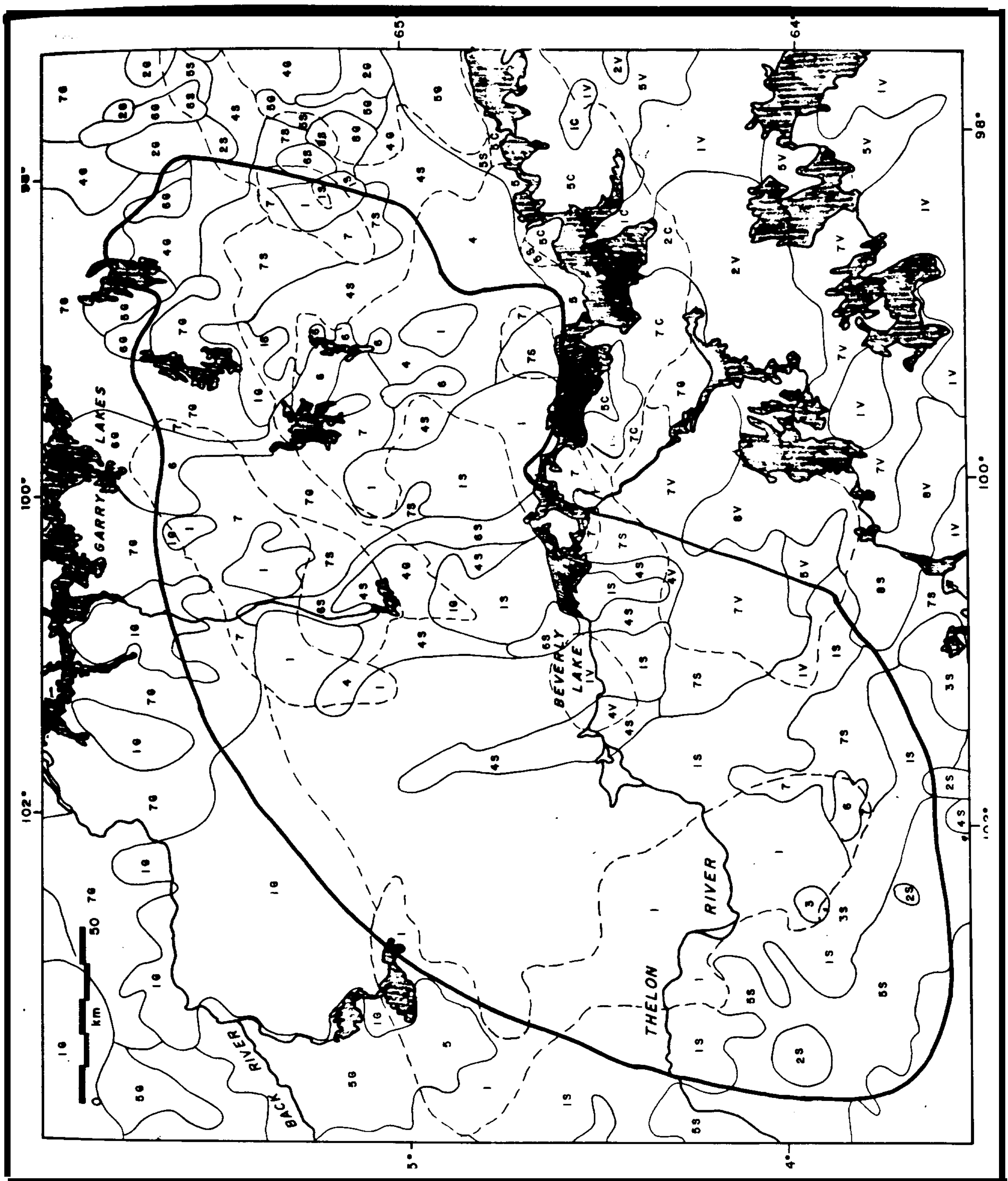
* Landform units are subdivided depending upon the dominant geological outcrop occurring in the subdivisions.

Figure 11. Landform units and geology of Beverly calving grounds.

Legend

——— Calving ground boundary

	Dominant glacial landform in landform unit:		Rock outcrop wi5 landform unit:
1	drumlin fields	S	sandstone
2	ribbed minor moraines	C	conglomerates
3	drumlin fields	G	granitic/gneissic
4	eskers	V	volcanic
5	till plain		
6	outwash sand deposits		
7	drumlin fields and eskers		
8	drumlin fields, eskers and ribbed minor moraines		


GARRY LAKES
BEVERLY LAKE
THELON RIVER
BACK RIVER
km
50
0
100°
102°
98°
65°
64°

elsewhere are from post-glacial lakes formed in the Thelon valley (Wright 1%7) . Marine silt is uncommon on the calving grounds (Fig. 12) .

The surf ace of the northern Beverl y calving grounds is slightly lenticular. The change in elevation from the centre, which is north of Sand Lake (259 m asl) , is stout 100 m to the north border (148 m asl) , and about 150 m to the south border (100 m asl) . The radius is 75 km. Local relief is less than 60 m. On the sout hem Beverly calving grounds, elevations decrease toward the Thelon River, Beverly Lake and Dubawnt River. The magnitude of change is similar to the northern calving grounds. Elevations increase west and south of the Beverly calving grounds and decrease to the north and east. Local relief remains similar (Fig. 13) .

Kaminuriak Calving Grounds

Outcrop is plentiful throughout the Kaminur iak calving grounds and there are no extensive glacial deposits. Pockets of marine silts are scat t ered throughout the calving grounds. Average elevation is . 100 m asl.

'l'he northern and southern sections of the Kaminuriak calving grounds are underlain by volcanic rocks. These "greens tones" outcrop as low, rounded hills (bosses) such as east of Parker Lake (Wright 1%7). The far northwest corner of the calving grounds is underlain by flat-lying sandstone and relief is low. Granitic gneiss underlies the central portion of the Kaminuriak calving grounds (Wright 1955) . This rock type extends east and west of the calving grounds and north across Chesterfield Inlet. Outcrops are common, of varying size and

Shape, and of moderate relief. North of Kaminak Lake, quartzite outcrops with the green stone belt as long, white ridges oriented east-west.

Glacial landforms found on the Kaminuriak calving grounds include drumlin fields, eskers, ribbed minor moraines and till plain. The orientation of the drumlins and eskers is northwest-southeast while ribbed minor moraines trend northeast-southwest.

Five landform units occur on the Kaminuriak calving grounds (Fig. 14, Table 6). Those landform units occur throughout the calving grounds. Such a variety of landform units does not occur on the remaining tundra range of the Kaminuriak herd. South and west of the calving grounds, fields of drumlins predominate. The variation in landform units also decreases towards Hudson Bay and north of the calving grounds. An area similar to the Kaminur iak calving grounds exists south of treeline between Kasba, Ennadai and Nueltin lakes; however, the orientation of the glacial landforms is northeast-southwest.

All of the calving grounds were inundated by the Tyrell Sea (Prest et al. 1970). Wave action modified the glacial landforms and' sane drumlins and eskers are terraced. Strand lines may occur on west-f acing slopes and deposits of marine silt and gravels may overlie bedrock or till (Lee 1959) (Fig. 15). No marine flooding occurred north of Chesterfield Inlet, or west and southwest of the calving grounds.

The aspect of the calving grounds is generally east with three prominent tosses (northeast of Parker Lakes, east of Kaminuriak Lake and west of Savage Lake). The change in elevation is less than 150 m (53-183 m asl) over a distance of 130 km with local relief less than

Figure 12. Marine inundation of Beve calving grounds.

Legend

—— Calving grounds

..... Caribou Protection Zone – Primary Calving Area

▤ Marine inundation

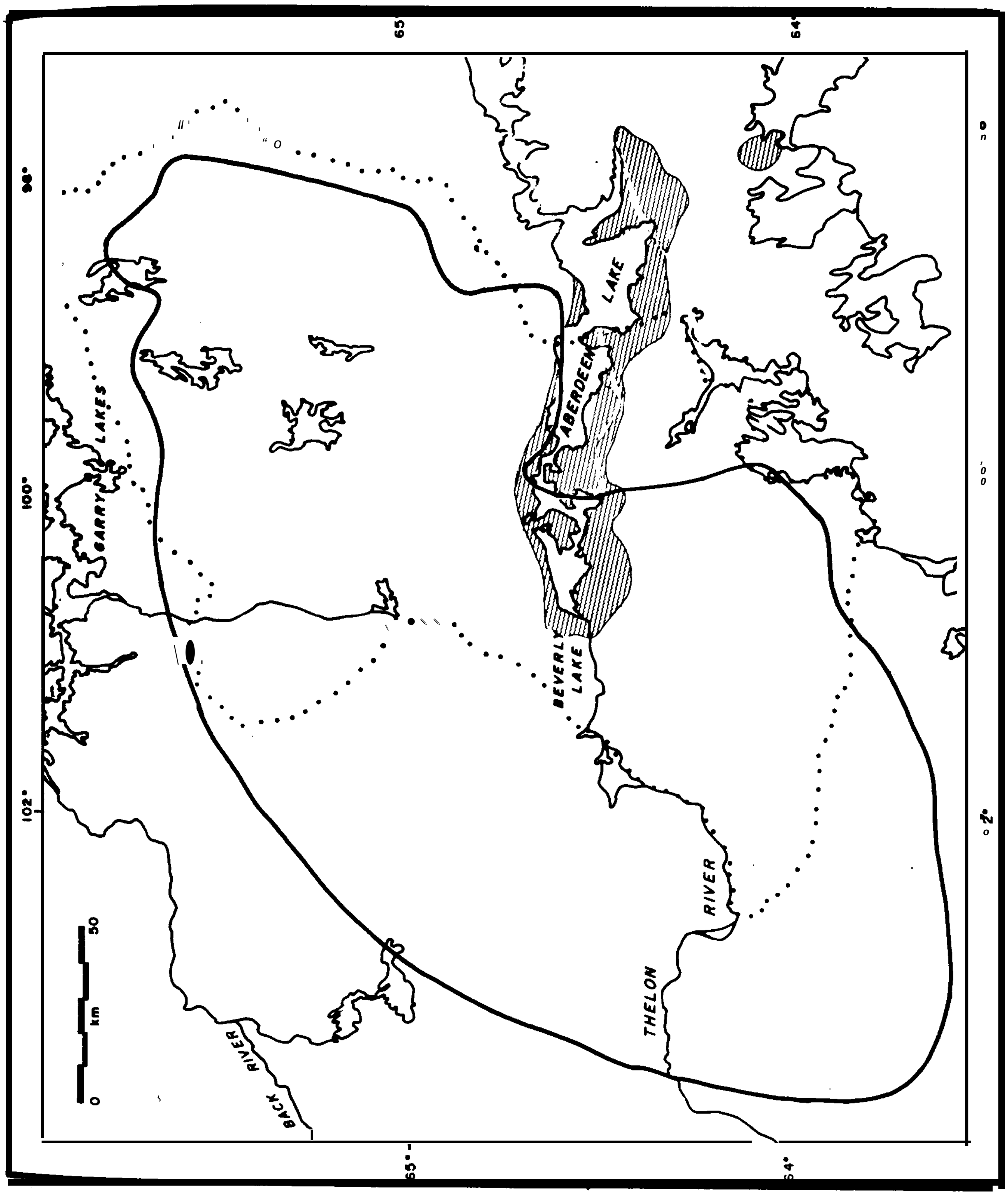

ABERDEEN
LAKE
BEVERLY
LAKE
GARRY
LAKES
THELON
RIVER
BACK
RIVER
km
0
50
65°
64°
98°
100°
102°

Figure 13. Elevation on Beverly calving grounds.

Legend

——— Calving ground boundary

..."" .Caribou Protection Zone - Primary Calving Area

-·-·- 100 m

— 200 m

----- 300+ m

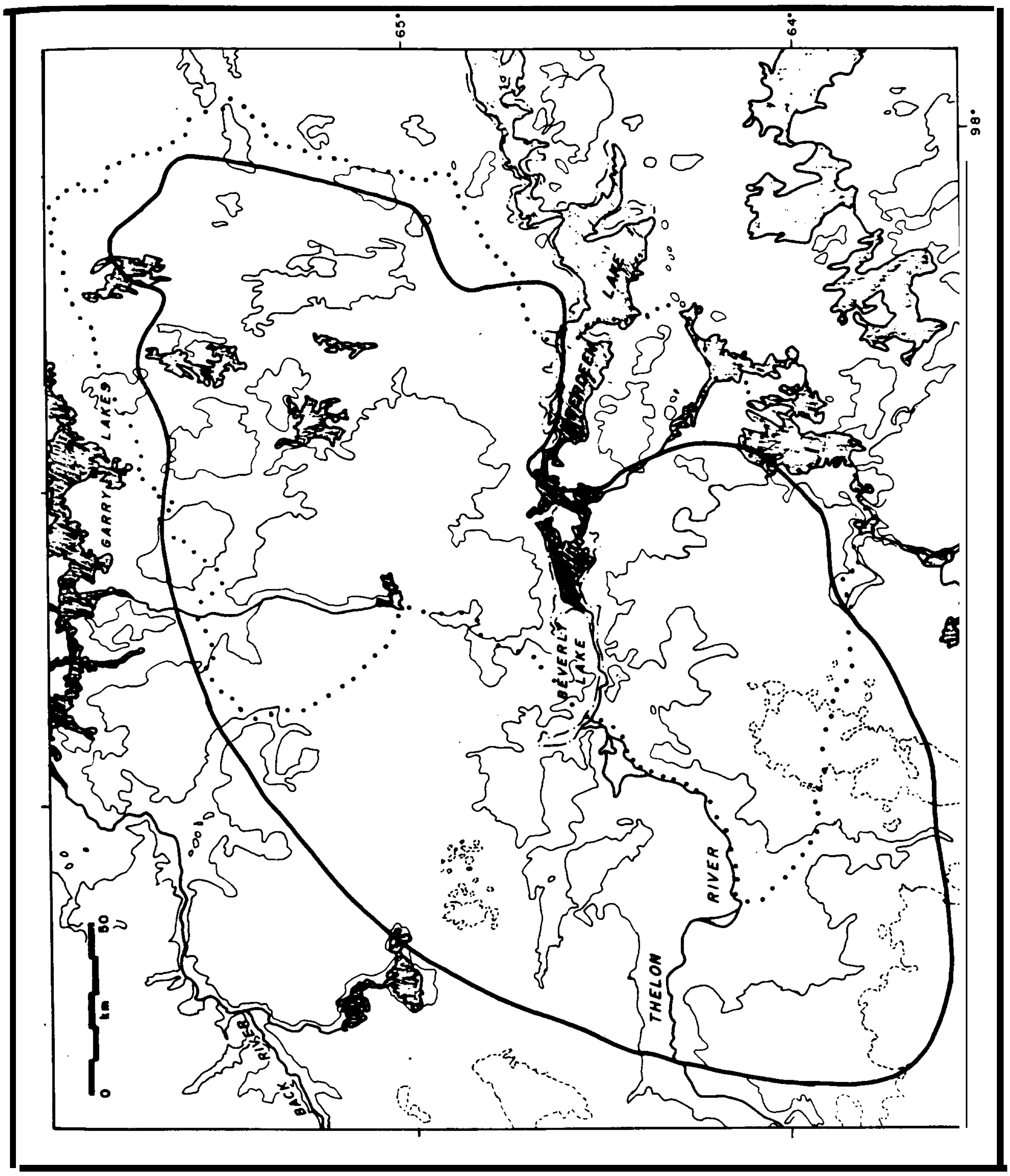

65°
64°
98°
GARRY LAKES
ABERDEEN LAKE
BEVERLY LAKE
THELON RIVER
BACK RIVER
0 km 50

Figure 14. Landform units and geology of Kaminuriak calving ground .

Legend

—— Calving ground boundary

Dominant glacial landform in landform unit:

1 drumlin fields

2 ribbed minor moraines

3 drumlin fields and ribbed minor moraines

4 eskers

5 till plain

Rock outcrop associated with landform minor moraines:

s sandstone

Q quartzite

G granitic/gneissic

v volcanic

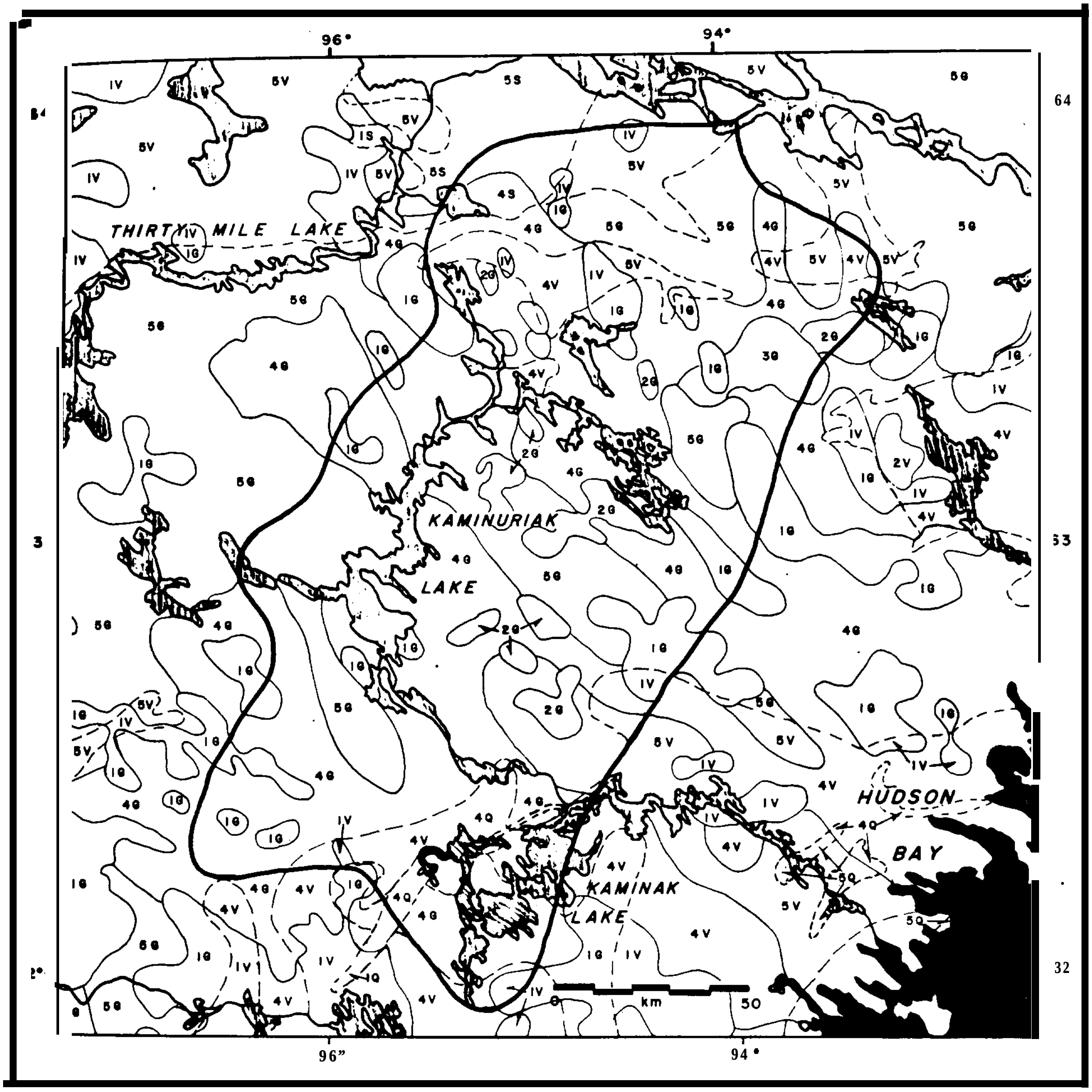

96°
94°
64
THIRTY MILE LAKE
KAMINURIAK
LAKE
KAMINAK
LAKE
HUDSON
BAY
km
50
96°
94°

Table 6. Landform units* on Kaminuriak calving grounds.

Dominant glacial landform(s)	outcrop geology			
	sandstone	quartzite	granitic/ gneissic	volcanic
Drumlin fields	X	X	X	X
Eskers			X	
Ribbed minor moraines			X	
Till plain	X	X	X	X
Drumlin and ribbed minor moraines	X	X	X	X

* Landform units are subdivided depending upon the dominant geological outcrop occurring in the subdivision.

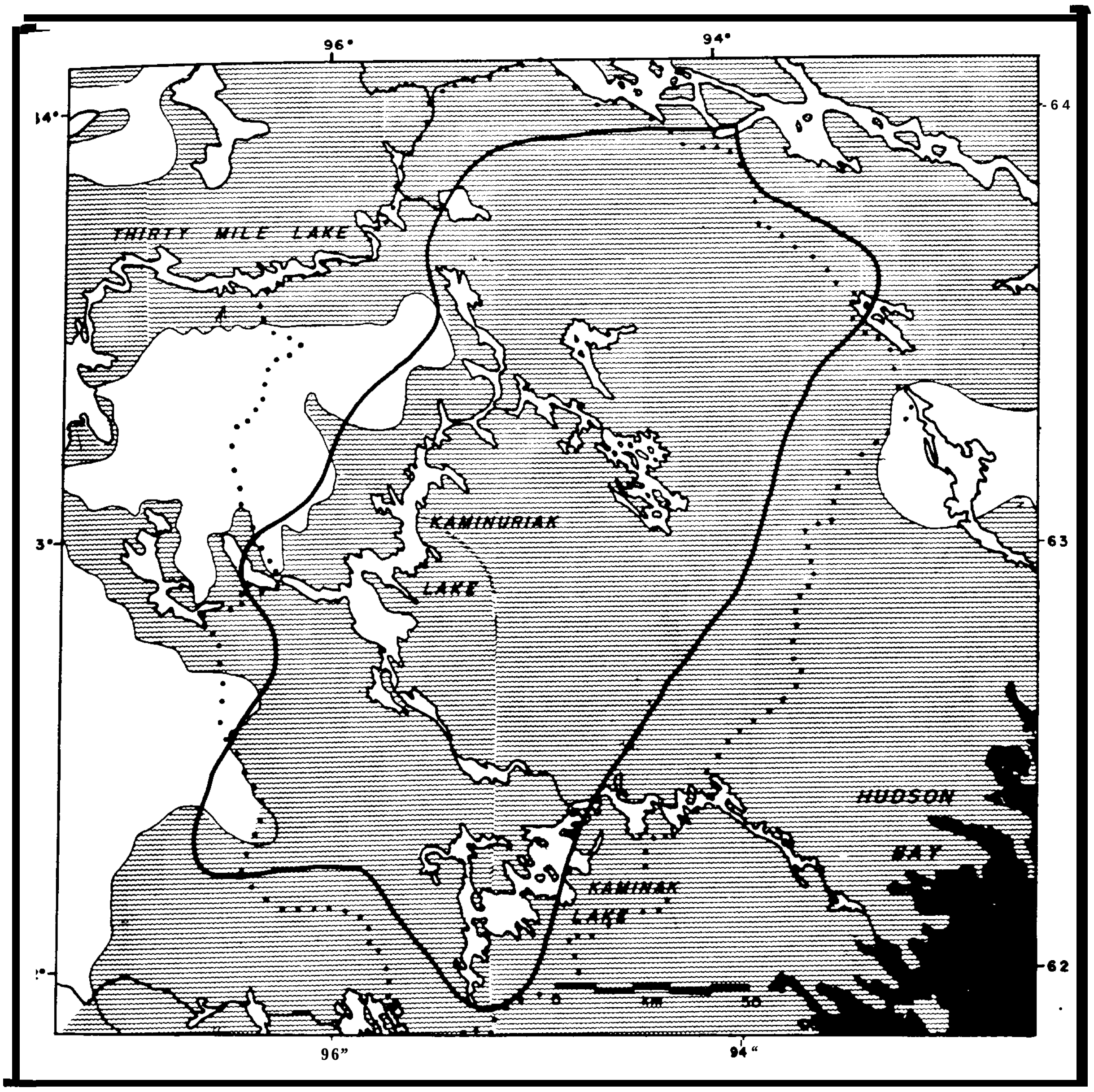


Figure 15. Marine inundation of Kaminuriak calving grounds.

Legend

——— Calving ground boundary

..... Caribou Protection Zone - Primary calving Area

❑ Marine inundation

70 m. Elevation continues to decrease east of the calving grounds, remains similar south of the calving grounds and increases north, west and southwest of the calving grounds (Fig. 16) .

Discussion

Varied topography is characteristic of all three calving grounds. Flat-lying sandstones character ize the Beverly calving grounds and form a smooth surface overlain by various glacial landforms. Outcrops as well as mar ine lacustrine deposits are uncommon on the Beverly calving grounds. The surface of granitic and gneissic bedrock characterizing the Bathurst and Kaminuriak calving grounds is more uneven. Glacial landforms are superimposed on the undulating landscape; bedrock is often exposed as low, rugged outcrops or ridges. We suggest that the outcrop is most abundant on the Bathurst calving grounds. Outcrop is also abundant on the Kaminuriak calving grounds but it is much more variable in extent and shape. Strand lines on those two calving grounds are striking to the casual observer but they and other marine deposits have little effect on topography. The marine influence is not found elsewhere on the range of the Bathurst caribou herd; however, the presence of ma rine silts is not confined to the calving grounds on the Kaminuriak range. The presence of marine silts may increase the productivity of tundra vegetation (Zoltai et al. 1980) .

In contrast, surrounding areas have more uniform topography due to the decrease in variety of glacial landforms. Underlying bedrock is often similar to the calving grounds. Marine silts are uncommon anywhere on the tundra ranges of the three herds except the coastal zones of the Kaminuriak range.

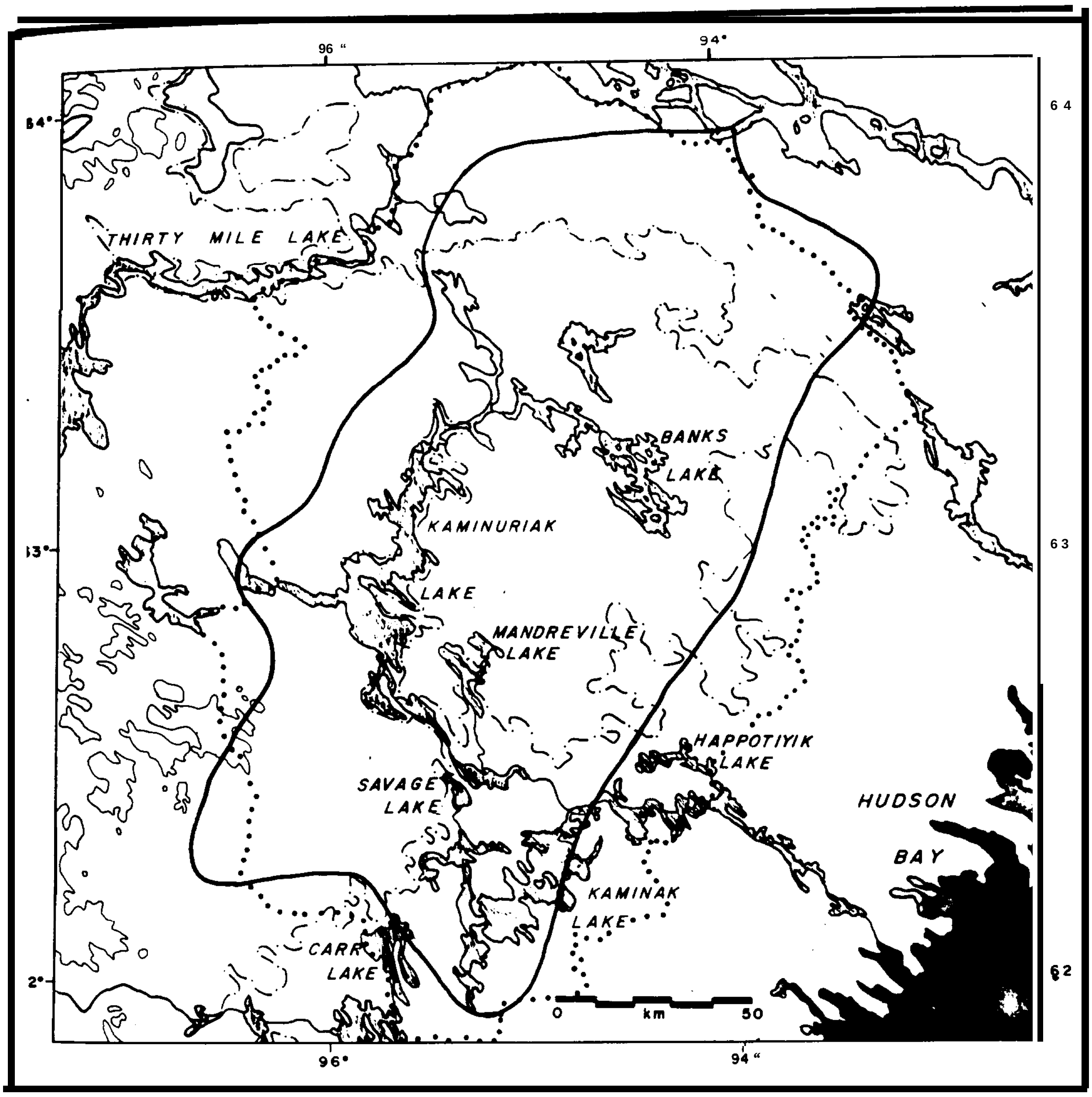


Figure 16. Elevation on Kaminuriak calving grounds.

Legend

——— Calving ground boundary

..... Caribou Protection Zone - Primary calving Area

-·-·- 100 m

——— 200 m

In relation to winter range and spring migration routes, the caribou of the three herds, except those of the Kaminuriak herd wintering along the Hudson Bay coast, move to areas of lower elevation for parturition. Kelsall (1968) , after observations on the Bathurst and Beverly range, and Parker (1972b) , after observations on the Kaminuriak range, suggest that calving occurs on elevated terrain. They likely refer to elevation of sites within the calving grounds. The summits of bedrock outcrops and glacial landforms offer slightly elevated terrain on the calving grounds. We do not knew whether cows concentrate on those areas during calving.

The lack of field observations prevents us from evaluating the importance of topographical features as shelter to calves; however, if the calves do use topographical features for such a purpose, those features are available on all three calving grounds and off the calving grounds. The granitic, gneissic and volcanic outcrops that could offer shelter to calves on the Bathurst and Kaminuriak calving grounds are uncommon on the Beverly calving grounds and southwest of the Beverly calving grounds. South of the Beverly calving grounds, those outcrops are more common. The abundance of boulders in the till ensures that some shelter from wind could be available to calves on the Beverly calving grounds. Although the relief of glacial landf orms is usually less than 50 m, such features could act as a windbreak for young calves .

Topographical features are not, however, essential for the provision of shelter on the calving grounds. Klein (pers. cam.) has pointed out the shelter offered by *Eriophorum* tussocks on the Western Arctic and Porcupine caribou calving grounds. On well-drained hillsides and sloping ground, calves can lie between tussocks. Klein (pers. comm.) noted that large boulders would tend to disperse the caribou and reduce long range detection of predators, thus favouring predation.

Studies of caribou and vegetation on other calving grounds suggest that the availability of a variety of phenological stages can be important to caribou (Kuropat and Bryant 1980). Such observations imply that, indirectly, topography can be an important characteristic of sites selected as calving grounds. We need observations of caribou feeding habits on the calving grounds to evaluate the importance of topography as a characteristic of the calving grounds. Certainly, the variety and orientation of the glacial landforms within the three N.W.T. calving grounds maximizes the combinations of slope, aspect, moisture and substrate available for plant growth. The implication of the varied topography on the calving grounds is that vegetation communities form a mosaic which offers choices of microhabitat sites to the caribou. It is expected that the more uniform topography off the calving ground reduces this variation in vegetation. On the windswept barrens, the summits of outcrops and glacial landforms may be snowfree and immediately available as feeding sites upon arrival of" caribou on the calving grounds. However, although they are sparsely vegetated (Thompson et al. 1978, Zoltai et al. 1980), they are only temporary feeding sites.

SNOWMELT PATTERNS

Introduction

Lent (1980) used LANDSAT imagery to document the pattern of snowmelt for 3 years in northwestern Alaska. He observed that portions of the eastern and western ends of the North Slope of Alaska had earlier snowmelt (mid-May) than surrounding areas. Those snowf ree "islands" cor responded to the gene ral locations of the calving grounds of the western Arctic and Porcupine herds and Lent (1980) suggested that the locations were largely in response to snowmelt patterns.

Availability of newly greening vegetation is dependent upon timing of snowmelt. The pattern of snowmelt also affects the nutrient cont ent of the vegetation. Pregnant and lactating cows on the calving grounds have high demands for nitrogen and phosphorus and require high quality forage to meet those demands.

Cows can respond to the effects of snowmelt at two levels. First, at a regional level, the overall pattern of snowmelt on the calving grounds when compared to surrounding areas may influence" the general location of the calving grounds. Seared, at a local level, the pattern of snowmelt is influenced by local relief and, in turn, may influence habitat use by cows on the calving ground. We adopted Lent IS (1980) approach and used satellite imagery to determine the pattern of snowmelt on the three calving grounds.

Methods

Data on snowcover and snowmelt patterns were obtained from three sources: (1) Snowcover observations in earl y June during reconmissance flying on calving ground surveys were collated. (2) Snowcover on each calving ground between mid-May and mid-June, 1974-1977, was determined from Northwatch snowcover charts (prepared by Gregory Geoscience Ltd. , Ottawa, Ontario) . They determined snowcover through visual interpretation of images produced by NOAA4, NOAA5, LANDSAT 1 and LANDSAT 2 satellites. Snowcover was initially determined from NOAA-VHRR (very high resolution radiometer) imagery and verified with LANDSAT-MSS (multispectral scanner) imagery. Cycling time was 24 hours for NOAA satellites and 18 days for LANDSAT satellites. (3) We also examined LANDSAT-MSS imagery on a microfiche scanner to determine the position of snowline and the regional trends of ice break-up on lakes. Imagery was available every 9 days for 1974 and 1 976, and every 18 days for 1977-1980.

Results and Discussion

Clouds frequently obscured the three calving grounds during late May and early June, which limited the usefulness of the LANDSAT image ry. However, the existing data for 1974, 1976 and 1977 agree with the Northwatch results (Table 7 and 8) . The few comparisons of snowcover observed during calving ground surveys with snowcover estimates from the satellite imagery (Tables 7, 8 and 9) generally agree. An exception was during 29 May 1979 when 90% snowcover was observed during reconnaissance flights on the Kaminuriak calving grounds and interpretaion of the LANDSAT imagery suggested the area was snowf ree. This discrepancy would not have occur red if the NOAA imagery which is received daily had been available for inter pretat ion.

Table 7. Snowcover between mid-May and mid-June on Bathurst, Beverly and Kaminuriak calving grounds as documented from NorthWatch snowcover maps, 1974-1977.

Date	Bathurst calving ground	Beverly calving ground	Kaminuriak calving ground
1974			
May 13	75%+	75%+	75%+
June 1	75%+	25-75%	0-25%
June 18	0-25%	north--rest lakes frozen; south--most lakes open	most lakes open
1975			
May 13	75%	75%+	75%+
May 20	75%+ Bathurst Inlet--25-50%	75%+	0-75%+
May 27	75% Bathurst Inlet--0	north--25-75% south--0-2%	0-25%
June 3	0-25%	0-25%	0-25%
June 10	most lakes frozen	most lakes open	most lakes open
May 17	75%+	75%+	75%+
May 25	25-75%	75%+	25-75%
May 31	25-75%	75%	0-25%
June 8	west of Ellice R.--0-25% east of Ellice R.--25-75%	north--75% south--25-75%	0-25%
June 14	0-25%	north--25-75% south--0-25%	0-25%
June 18	0-25%	north--25-75% south--0-25%	most lakes open
1977			
May 16	75%+ Bathurst Inlet--25-75%	75%	25-75%
May 23	75%+	75%+	25-75%
May 29	west of Ellice R.--25-75% east of Ellice R.--75%+	north--75%+ south--25-75%	25-75%
June 6	25-75% Bathurst Inlet--0-2%	north--25-75% south--0-25%	0-25%
June 14	most lakes frozen	north--most lakes frozen south--most lakes open	most lakes open

Table 8. SnowCover during June on Bathurst, Beverly and Kaminuriak calving grounds as documented from LANDSAT imagery 1974, 1976, 1977-1980.

Date	Bathurst calving ground	Beverly calving ground	Kaminuriak calving ground
1974 June 1	*	*	most lakes frozen and snowfree
June 8	west of Ellice R.–0% east of Ellice R.--0-2%	*	*
June 17	*	north--rest lakes frozen and snowfree south--*	most lakes open
1976 June 6	*	*	snowfree and most lakes frozen
June 15	west of Ellice R.--0% east of Ellice R.--0-50%	*	
June 24	northeast of Hiutak R---most lakes frozen	*	most lakes open
1977 May 25	*	*	snowfree and most lakes frozen
June 16	east of Hiutak R---most lakes frozen and snowfree west of Ellice R.--most lakes open	*	most lakes open
1978 June 23	snowfree and most lakes frozen	snowfree and most lakes frozen	snowfree and small lakes open
1979 May 31	*	north--100% south--snowfree most lakes frozen	snowfree and most lakes frozen
June 12	100% Bathurst Inlet--snowfree and most lakes frozen	*	*

Table 8. (cent'd)

Date	Bathurst calving ground	Beverly calving ground	Kaminuriak calving ground
1980			
June 7	0-50% Bathurst Inlet--snowfree	*	*
June 13	*	*	0-50%
June 18	snowf ree and most lakes open west of Ellice R.	north--most lakes frozen South--rest lakes open	*

* cloudy or no data available.

Table 9. Snowcover during reconnaissance flights 1-3 June of Bathurst, Beverly and Kaminuriak calving ground surveys 1957-1980.

	Bathurst calving ground		Beverly calving ground		Kaminuriak calving ground	
Year	Snow cover (%)	Reference	Snow cover (%)	Reference	Snow cover (%)	Reference
1957	-		90	Kelsall and Loughrey 1956	-	
1958	-		90	Pruitt 1958		
1959	-		0*	McEwen 1960		
1962	-			McEwen 1962		
1963	-				*	Malfair 1963
1965					*	Look 1965
1966	*	Williams 1966			low	Parker 1972b
1967					*	Parker 1972b
1968	-				*	Parker 1972b
1970	*	Boxer 1970			low	Miller and Broughton 1974
1971	90	Boxer 1971	*	Rippin 1971	5*	Rippin 1971
1972	-					Bowden and Timmerman 1972
1973	-				90	Land and Hawkins 1974
1974	70	Boxer 1974	100 north 50 south	Moshenko 1974	50-75	Hawkins and Howard 1974
1976	-				*	Hawkins and Calef 1977
1977	*	Calef and Boxer 1977			0-30	Heard 1981
1978	95	NWT Wildlife Service files	80-100	Darby 1978	5-10	Darby 1978
1979	80	NWT Wildlife Service files	80-100	Darby 1979	90	Darby 1979
1980	65-70	Heard 1980a	50-80 <10 south	Gunn and Decker 1981	10-20	Heard 1980b

* no data on snowcover in report.

Only 7 years' data are available from satel lite image ry and few records have keen kept of snowcover during early June on calving ground surveys but we were able to infer three points (Tables 7, 8 and 9). First, the Kaminuriak calving grounds, and possibly the southern Beverly calving grounds were consistently snowfree earlier than the Bathurst and northern Beve rly calving grounds. The end of snowmelt coincides frequently with the onset of calving (l-7 June) on the Kaminuriak and southern Beverly calving grounds, but snowcover is often more than 75% on the Bathurst and northern Beverly calving grounds.

Second, the snowmelt pattern of the three calving grounds are dissimilar to those observed in North#eStern Alaska (Lent 1980). The Bathurst, Beverly and Kaminur iak calving grounds and the immediate surrounding areas appear to be the last portions of each herd's range to become snowfree (Appendix A and B) . Snowmelt is earlier around Bathurst Inlet than on the calving grounds east of the Inlet, and earl ier on the southern Beverly calving grounds than on the northern calving grounds (north of the Thelon River) . The northward progression of snowmelt across the Northwest Territories follows "a northwest-southeast gradient. Thus the border of snowfree areas parallels the northern boundary of treeline.

Third, the end of snowmelt occurs later on the Bathurst and the northern Beve rl y calving grounds than on those of the Western Arctic and Porcupine herds observed by Lent (1980) . The timing of snowmelt on those N.W. T. calving grounds appears to be more similar to Central Arctic herd (Whitten and Cameron 1980) . The timing of snowmelt on the southern Beverly and the Kaminur iak calving grounds appears to be similar to that observed on the Western Arctic and Porcupine calving grounds (Lent 1980, A. Marten pers. comm.) .

VEGETATION

Introduction

When caribou cows are on the calving grounds, the burdens of late pregnancy and lactation impose an increased need for high quality forage. The highest quality and most digestible forage is unfurling leaves and flower buds (Chapin et al. 1980) typical of newly greening vegetation at the beginning of the annual growth season. Lactating reindeer and caribou continue to lose weight until 35-55 days postpartum (Luick et al. 1980). Reimers (1980) suggests that animals feeding on newly greening vegetation during calving undergo a less pronounced weight loss. Klein (1970) and Lent (1%6) suggested that summer forage governs body size and reproductive success, implying that earlier or longer access to high quality vegetation would produce larger calves by fall as well as allowing cows an earlier recovery from winter and lactational weight losses. Dauphiné (1976) also stressed the importance of summer forage to the reproduction and growth of caribou.

The progression of newly greening vegetation f 01 lows a pattern dependent on the plant community and on physical factors such as aspect and temper ature. A description of those plant communities is necessary to begin to understand the role of vegetation in determining how and perhaps why caribou use calving grounds.

The vegetation of all three calving grounds and the surrounding tundra is classified as Low Arctic Zone, meaning that trees are absent and vegetative cover is virtually "complete" (Pruitt 1978) . Within the tundra range of the three caribou herds, two phytogeographic subdivisions are described by Gubbe (1976). The subdivisions are characterized by the presence or absence of shrubs taller than 30 cm (phanerophytes) and probably reflect temperature gradients. Wielgolaski (1980) suggested that mean summer air temperature is an important determinant for the structure of floral communities (physiognomy) in the Arctic. Zoltai et al. (1980) described Bathurst Inlet as a "climatic oasis" in the central Arctic. Phanerophytes are common here in comparison to surrounding areas. Gubbe (1976) notes the disappearance of dwarf birch north of Pitz and Baker lakes and the increasing prominence of arctic plant species. Wielgolaski (1980) has observed the decreasing height of willow species with an increasing distance north of the treeline. Wielgolaski (1980) also comments that soil moisture influences life forms present. Again, this is a local phenomenon with lichens becoming much more prominent than vascular species on the driest sites as noted by Thompson (1980).

Other factors also influence the vegetation of an area. Larsen (1971), Parker (1975), Gubbe (1976), Fischer et al. (1977), Thompson et al. (1978) and Zoltai et al. (1980) demonstrated that moisture and substrate strongly influence percentage cover of the same floristic composition on different sites. Within each calving ground, the range of moisture conditions influences the amount of area a vegetative association will occupy. Locally, as taller shrubs rely on winter snow cover to insulate root and leaf buds, they become more prominent on sites where snow accumulates (Larsen 1971).

For practical purposes, identification of physiognomic vegetative types is the simplest system to apply in the field (Thompson 1980). The physiognomic systems reflect climate, the primary influence on vegetation (Fosberg 1%7). Substrate, moisture regime and winter snow depths influence the species association and percentage cover composition on local sites. Gubbe (1976), Fischer et al. (1977) and Thompson et al. (1978) have produced the most comprehensive classification schemes for the District of Keewatin. Zoltai and Johnson (1979) studied the soils of different landforms in the District of Keewatin and briefly discussed vegetation associated with the soils. Their vegetative descriptions agree with those outlined by Gubbe (1976).

Gubbe (1976) sampled vegetation along the Keewatin section of the proposed Polar Gas pipeline route. This route extends northeast from the Manitoba border at 60°00′ N, 97°15′ W, passes west of Baker Lake and continues north through the isthmus of Boothia. Fischer et al. (1977) were concerned with vegetation north of Baker Lake while Thompson et al. (1978) sampled vegetation along the Polar Gas pipeline route south of Baker Lake and throughout the tundra range of the Kaminuriak caribou herd.

The exact methodology of Gubbe (1976) is different from that of Fischer et al. (1977) and Thompson et al. (1978), but the approach is similar. Each selected initial sampling sites from various landforms recognized on aerial photographs. On the ground, the decision to sample vegetation was based on physiognomy. Gubbe (1976) then compared vegetative communities within one physiognomic type to determine the predominant vegetative associations. Fischer et al. (1977) and Thompson et al. (1978) combined their species information into 14 species groups (willows, evergreen shrubs, lichens, etc.) for each community and then compared all their communities using several Clustering analyses. Thus, they delineated recurring vegetative groups. The use of species groups by Fischer et al. (1977) and Thompson et al. (1978) precludes identification of vegetative associations as described by Gubbe (1976).

There have been no surveys of the vegetation on the Bathurst calving grounds. However, investigations at Bathurst Inlet by Zoltai et al. (1980) and our subjective observationsof the vegetation during calving ground surveys suggest that physiognomic vegetative types present can be compared with those described by Gubbe (1976). Since the discussion of vegetation on the Bathurst and Kaminuriak calving grounds is based primarily on descriptions from the literature, only our vegetative sampling of the Beverly calving grounds is presented as results.

Methods

We sampled the vegetation of three sites (1,2 ,3) on the northern Beverly calving grounds during late June and July 1980. At two sites (4 ,S) east of the southern Beverly calving grounds, we concentrated on sampling vegetation not present on the northern Beverl y calving grounds during July 1980.

The choice of a vegetative site to sample was based on three requirements, which were evaluated sequentially, First, the physiognomy of the vegetation had to be relatively homogeneous. Second, the minimum overall size of areas to be sampled was 150 x 50 m. The minimum size was determined by the length of the transect line used to sample the vegetation (125 m). Third, the vegetative community had to be recognizable from a distance on the ground of 1 km. The term vegetative community applies to a site which satisfies these three requirements.

In each community, we made a plant collection, compiled a species list and established two phenology plots (10 x 10 m). We recorded the phenological stage of the vascular plant species when the plots were established. Only communities at Site 1 were revisited to record phenological changes. The following phenological categories were used :

NFL - no new leaves forming on evergreen species
LG - leaves of evergreen species turning green
U - leaves of deciduous plants unfolding or elongating
L - leaves unfolded
BF - flower buds swelling
EF - early flowering (some in flower)
FF - full flowering (most in flower)
LF - late flowering (most past flowering)
S - seeds present
GB - green berries
RB - ripe berries

In each community at a site, we photographed a minimum of 25 Daubenmire plots (25 x 25 cm) fran a vertical distance of 1 m using 3S mm Kodachrome colour slide film (ASA 25 or 64) . The plots were. located at 5 m intervals along a 125 m transect that crossed the middle of the community. Transects were oriented in north-south and east-west directions and placed between the two phenology plots. Elevation, slope, aspect and approximate depth of active layer were recorded and we described total vegetative cover (ocular estimate), substrate (gravel, sand, organic) , moisture regime (xeric, mesic, hydric, hygric), microtopography, shrub vigour (creeping, erect), animal sign and microsite preferences of individual plant species.

Lichens were identified by P.T. Wong, National Museum, Ottawa, while G. Brassard, Memorial University, Newfoundland, identified the mosses. Nomenclature for vascular plants followed Porsild (1973) and Hulten (1974). The identification of sedges and grasses were verified by B. Cody, Agriculture Canada, Ottawa; while G. Argus, National Museum, Ottawa, verified the identification of the willows.

Edmonds Ecological Services (Edmonton, Alberta) determined percentage cover and frequency of occurrence of plant species from the 35 mm slides. Each slide was projected onto a screen (38 x 25 cm) marked with a grid of 25 inter sections. Plants under intersections were recorded for estimates of percentage cove r. They were identified to species excepting willows, sedges (including Eriophorum spp.) , mosses and crustose lichens. Frequency of occurrence was determined by recording all species within each Daubenmi re plot.

Mean percentage cover (P. C.), standard deviation of cover and frequency of occurrence (F. G.) , as well as prominence value (P. V.), which is an index of relative importance (Douglas 1974) , were calculated for each species or group in each transect (25 quadrats) .

$$P.V. = \bar{x}P.C. \times \sqrt{F.O.}$$

Those calculations were repeated when two transects from one community had teen sampled.

Two transects were analyzed for each community. If a vegetative community with apparently similar floral composition had been sampled at two sites, the second transect was taken from the replicate site. If two transects were from different sites, they were tested for similarity by calculating their similarity coefficient (S. C.) using prominence values (Bray and Curtis 1957) . A similarity coefficient larger than 0.90 indicated that communities from different sites were the same.

S.C. = $\frac{2W}{a+b}$

W = sum of the lowest prominence values of species common to both transects

a = total prominence value for all species in transect A

b = total prominence value for all species in transect B

We adopted the approach of Gubbe (1976) to classification and grouped vegetative communities with similar structural strata. The strata recognized were low shrub (30+cm), dwarf shrub (<30 cm), forbs, tussocks, short sedges (mesic to zeric species), tall sedges (hydric to hygric species), moss, lichens and rock. The term, physiognomic type, refers to a vegetative community or group of vegetative communities with similar percentage cover of structural forms. Within each physiognomic type, we present the moisture regime and substrate that appear to produce a specific vegetative association. The term, vegetative association, refers to a vegetative community with similar floral composition and percentage cover.

In the nomenclature of the physiognomic types, capital letters indicate dominant structural form(s) (≥ 30% cover), small letters indicate subdominant form(s) (10 - 30% cover), a slash indicates an order of decreasing percentage cover while a dash indicates equal percentage cover values. There are six physiognomic types (I - VI). Within each physiognomic type there may be one or more Vegetative associations which relate to moisture and substrate. The nomenclature of the vegetative associations represents floristic composition. The order represents decreasing percentage cover. All species with more than 10% cover are incorporated into the nomenclature. There are eleven vegetative associations (A - K).

Results

The phonological data is on file at the Northwest Territories Wildlife Service, Yellowknife, N.W. T. It was gathered as reference material for comparison with sequential observations in subsequent years. Vegetation on eskers was not sampled because the three requirements outlined in the methodology were not met. Time constrictions prevented the sampling of outcrops. Percentage cover and frequency of occurrence obtained from analysis of Daubenmire plots were used to characterize the physiognomic types and vegetative associations (Appendix C.) . Information for the range of vegetation associations within physiognom ic types on the Beverl y cal ving grounds is incomplete. Appendix D lists the common names of the vascular plants collected on and off the Beverly calving grounds. The sampling scheme was designed to develop a preliminary vegetative scheme to assist planning of subsequent field work. We recognize 11 vegetative associations within six physiognomic types at the five sites on and off the Beverly calving grounds (Table 10, Fig. 17) . They are:

I. LICHEN/dwarf shrub

A. Cornicularia divergens/Alectoria ochroleuca: Vegetative cover was 92% to which lichens contributed 88% and dwarf sh rubs 11% . The dominant lichens were Cornicularia divergens and Alectoria ochroleuca. Together, they formed a thick black and green carpet throughout which were scattered other lichen species and tufts of Hierochloe alpina (a characteristic xerophylic graminoid). Evidence of frost

Table 10. Locations of vegetative sampling sites on and off Beverly calving grounds, 1980.

Site number*	Location Latitude	Longitude	Date 1980	Vegetative association sampled
1	65°25′	100°11′	June 20	A - *Cornicularia*/*Alectoria*
			June 21	K - *Carex*/moss
			July 31	**K - *Carex*/moss
			June 21	I - *Eriophorum*/*Carex*/*Vaccinium*
			July 31	**I - *Eriophorum*/*Carex*/*Vaccinium*
2	65° 29′	99° 06′	July 3	C - Boulders/crustose lichens
			July 4	J - *Eriophorum*/*Carex*/moss
			July 4	B - *Alectoria*/*Cornicularia*
3	65° 14′	100° 46′	July 13	E - *Vaccinium*/moss
			July 14	D - *Cetraria*/*Ledum*/*Vaccinium*
			July 14	**A - *Cornicularia*/*Alectoria*
			July 14	**J - *Eriophorum*/*Carex*/moss
4	64°24′	97° 41′	July 18	G - *Carex*/*Dryas*/moss
			July 19	H - *Betula*/moss/*Carex*
5	64° 17′	99° 04′	July 21	F - *Dryas*/moss
			July 22	G - *Carex*/*Dryas*/moss
			July 22	K - *Carex*/moss

* Sites 1, 2 and 3 were located on the northern calving grounds while Sites 4 and 5 were 5 and 60 km respectively east of the southern Beverly calving grounds. Vegetative associations are described in text.

** 25 Daubenmire quadrats photographed; all other associations were sampled with 50 quadrats.

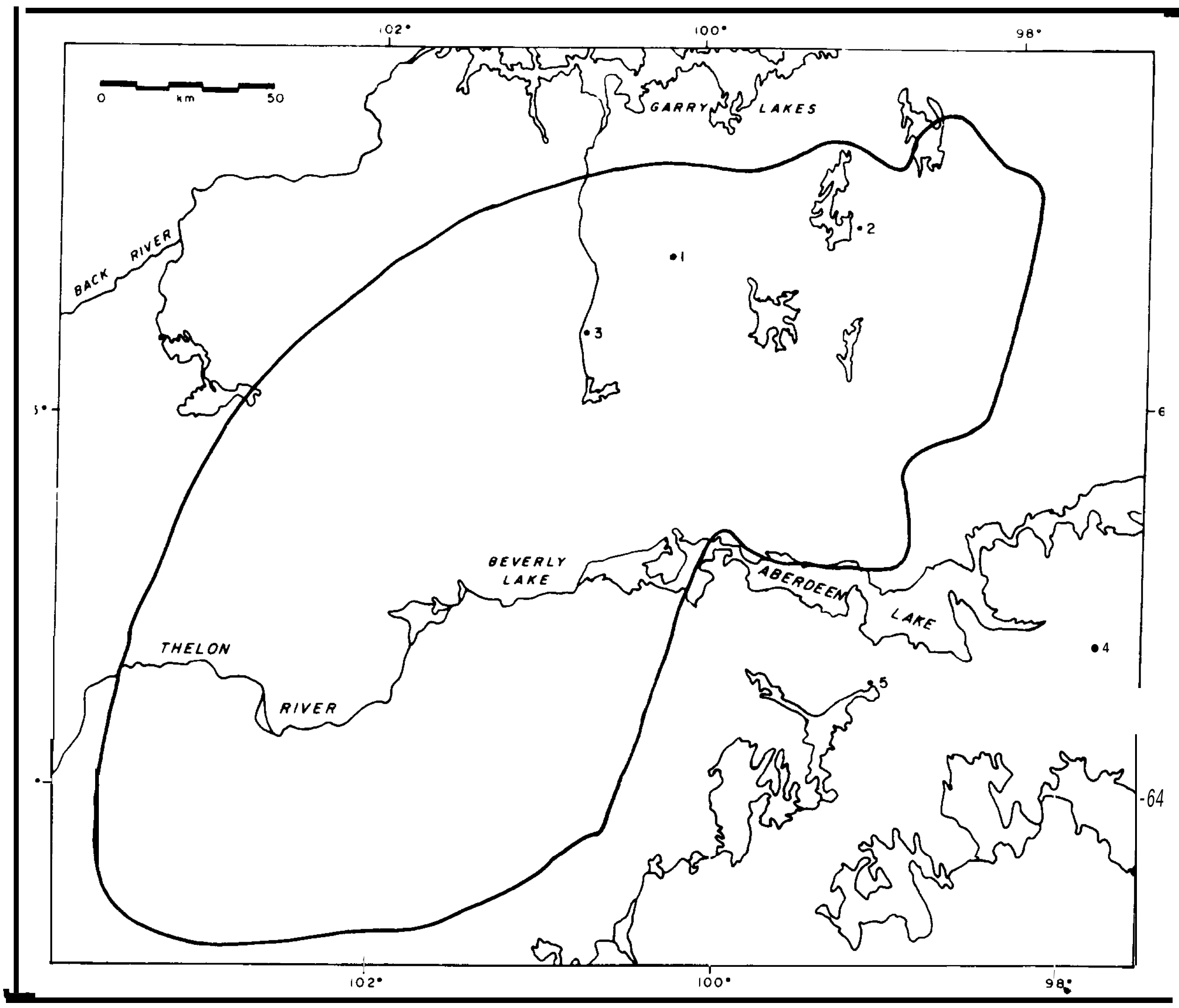


Figure 17. Vegetative sampling sites on Beverly calving grounds, 1980.

action, shattered sedimentary rocks and weak polygonal nets, was common. In the moister polygonal troughs, dwarf shrubs (*Ledum decumbens* and *Vaccinum vitis-idaea*) and *Cetraria* lichens were dominant over the *Cornicularia* and *Alectoria* lichens. This vegetative association was sampled at two sites (no. 1 and 3). Substrate was very well drained gravel-sand till with occasional boulders. The active layer was deeper than 50 cm. This community was confined to xeric ridge tops of glacial landforms.

B. *Alectoria ochroleuca/Cornicularia divergens*: Vegetative cover was 97% to which lichens contributed 73%, dwarf shrubs 12% and mosses 10%. In the more mesic environment, *Alectoria* was dominant over *Cornicularia*. The thick, predominantly green carpet is interrupted by a sunken polygonal network containing large boulders (0.5 - 1.5 m diameter) as well as increased cover of dwarf shrubs (*L. decumbens*, *V. vitis-idaea*, *Cassiope tetragona*) and other lichen species (*Cetraria* and *Cladina* spp.). It was sampled at site no. 2. Substrate was gravel-sand till with boulders and was well drained. The active layer was deeper than 50 cm. Frost-shattered rocks were common. This community occurred on the lenticular surface of shallow drumlins and undulating, well drained ground moraines.

C. Boulders/crustose lichens: Vegetative cover was 78% to which lichens (primarily crustose) attributed 61% and dwarf shrubs 14%. The coarse till with many boulders and intense frost action (many raised rock circles) restricted plant substrate formation. Crustose lichens occurred primarily on rocks and accounted for 34% cover. Vascular vegetation was very sparse and the visual appearance of the community was daninated by boulders. The dwarf shrubs (L. decumbens, V. vitis-idaea, Empetrum nigrum) were confined to the depressed areas between the rock mounds which collected finer grained materials and retained moisture (Gubbe 1976). Various fruticose lichen species were associated with the dwarf shrubs. It was sampled at one site (no. 2). The active layer was deeper than 50 cm. This community occurred on mid to upper slopes and tops of bouldery till landforms.

D. Cetraria nivalis/Ledum decumbens/Vaccinium vitis-idaea: Vegetative cover was 89% to which lichens contributed 60% and dwarf shrubs 29%. The thin yellow carpet formed by C. nivalis contained scattered clumps of L. decumbens and E. nigrum. Vaccinium vitis-idaea was evenly distributed. Graminoids were uncommon. This association was sampled at one site (no. 3). The substrate was well drained and primarily gravel-sand till. Boulders were uncommon. The active layer was deeper than 50 cm. Evidence of frost action was limited to some split rocks. This community occurred on gentle slopes of medium to fine grained till landforms.

II. DWARF SHRUBS/moss/lichens/short sedge

E. Vaccinium vitis-idaea/moss: Vegetative cover was 94% to which dwarf shrubs contributed 28%, lichens 30%, mosses 40%

and graminoids 9%. Frost boils or non-sorted circles were the most obvious visual feature. The frost boils were poorly vegetated with Dryas integrifolia, V. vitis-idaea, Calamagrostis purpurascens and Cetraria spp. concentrated around the edges. Between the frost boils were mesic, well vegetated areas with a high cover of mosses and dwarf shrubs such as V. vitis-idaea, L. decumbens, C. tetragona, E. nigrum and the occasional Vaccinium uliginosum. The 13 forb species present were uncommon. This association was sampled at one site (no.3). The substrate was well drained, silty sand and gravel. The active layer was deeper than 50 cm. The community occurred on flat till plateaus.

F. Dryas integrifolia/moss: Vegetative cover was 85% to which dwarf shrubs contributed 36%, mosses 29% and lichens 25%. Frost boils were the most obvious visual feature and were bright pink in colour. The increased praninence of D. integrifolia probably reflects a higher concentration of calcium in the substrate (Gubbe 1976). Frost boils were usually poorly vegetated and surrounded by well vegetated areas dominated by dwarf shrubs and sedges. Fourteen forb species were present but their total ground cover was sparse (<1%) . This association was sampled at one site (no. 4). Substrate was well drained sand and gravel till. This community cccurred on higher elevation flat, till plateaus.

G. Carex spp./Dryas integrifolia/moss: Vegetative cover was 99% to which sedges contributed 36%, mosses 80%, and dwarf shrubs

29% . Visually, the sedges and dwarf shrubs formed a smooth yellow and dark green pattern. Dryas integrifolia was the dominant shrub; however, Salix spp., Betula glandulosa, V. uliginosum, C. tetragona and Rhododendron lapponicum were also present. Ledum decumbens was absent. Fifteen species of forbs occurred which included Oxytropis Maydelliana and Astragalus alpinus in flower. Lichens were not common (<5%). Small frost boils were present. This association was sampled at two sites (no. 4 and 5). Substrate was sand-gravel till, and boulders were uncommon. The active layer was deeper than 50 cm. This community occurred over large areas of shallow, undulating, finer grained till. The presence of D. integrifolia suggests a higher concentration of calcium in the substrate (Gubbe 1976).

111. LOW SHRUB/moss/short sedge/dwarf shrub

H. Betula glandulosa/moss/Carex spp.: Vegetative cover was 99% to which low shrubs contributed 30%, dwarf shrubs 13%, sedge 29% and mosses 79%. This community was dominated by a canopy of B. glandulosa, Salix planifolia and S. glauca. Between clumps of these orthophyllic shrubs, short sedges daninated the plant cover. Dwarf shrub species occurred on earth mounds characteristic of this association. Earth mounds were formed by frost action (Gubbe 1976). A variety of forb and lichen species were present but occupied less than 5% cover. This type was sampled at site no. 4. Substrate was a thin organic layer composed of leaf litter over gravel-sand till.

Moisture conditions were mesic and the active layer was about 50 cm deep. This community occurs on gentle slopes, especially along lower edges of vegetative association G.

IV. Tussock-short sedge-moss-dwarf shrubs-lichen

I. Eriophorum spp.-Carex spp.-moss-Vaccinium vitis-idaea: Vegetative cover was 99% to which sedges and cottongrass species contributed 43%, dwarf shrubs 19%, mosses 34% and lichens 24%. This association is a mix of vegetative associations J, E and A. The visual impression is of a dry sedge plain. From the air, weak polygonal nets and turf rows are apparent. Moisture conditions vary. Patches of xeric, gravel till are dominated by C. divergens, A. ochroleuca with xerophyllic sedge and grass species and dwarf shrubs. Hydr ic organic patches are dominated by Eriophorum vaginatum tussocks while hygric organic patches are dominated by E. angustifolium. These patches combine to form a heterogeneous community. Depth to permafrost varied with depth of the organic layer over till. This community appeared to occupy the sites between lichen dominated ridgetops and hydric tussock or wet sedge meadows. This association was sampled at one site (no. 1).

V. TUSSOCK/moss

J. Eriphorum vaginatum/Carex spp./moss: Vegetative cover was 98% to which cottongrass and other sedge species contributed 80% and mosses 52%. Eriphorum tussocks dominated the visual aspect. Between the tussocks were various Carex species and forbs (Pedicularis sudetica, P. labradorica, Saxifraga hirculus, Potentilla palustris and Polygonum viviparum). Dwarf shrubs occurred on the drier tussocks. Lichen cover was less than 1%. The substrate was an organic layer of variable thickness and imperfectly drained. This association was sampled at two sites (no. 2 and 3). It was also observed at site no. 4. The association was prevalent at the foot of gentle slopes or on imperfectly drained depressions.

VI. TALL SEDGE/moss

K. Carex spp/moss: vegetative cover was complete and dominated by Carex species (80%) and mosses (69%). Lichens were uncommon as were forbs and dwarf shrubs (<4%). Eriophorum tussocks cccurred at the outer edges of this community. It was sampled at two sites (no. 1 and 5). The substrate was a thick layer of peat formed from Sphagnum spp. and sedges. Standing water occur red in places and the active layer was less than 50 cm. This association cccurred at lake edges and in depressions where the water table was close to or above the surf ace.

Aerial observations during July 1980 suggested that the vegetation sampled on the southern Beverly calving ground is similar to the sites sampled immediately east of the calving grounds. Phanerophytes dominate on the physiognomic types (II 1. LOW SHRUB/moss/ short sedge/dwarf shrub) sampled on the southern Beverly calving grounds. This type was absent from the northern Beverly calving grounds and cursorial aerial observations confirm this conclusion. Instead, there were more 1 ichen dominated vegetative associations on the northern Beverly calving grounds (Tables 11 and 12). Subjective aerial observations during July 1980 suggest that the vegetation to the west of the northern calving grounds is similar. Those observations also suggest that the vegetative associations on the Beverly calving grounds have a more patchy distribution than those off the calving grounds. The more varied topography on the calving grounds would influence the distribution of vegetative associations.

Discussion

The absence of phanerophytes on the northern Beverly calving grounds suggests that the Thelon River is the continuation of the border between the two phytogeographic subdivisions recognized by Gubbe (1976) in the eastern Keewatin. A comparison of the physiognomic types and vegetative associations recognized by OUr preliminary study on the northern Beverly calving grounds general ly agrees with those described by Gubbe (1976) and Fischer et a]. (1977) for the region north of Chesterfield Inlet to Wager Bay (Table 13). A similar compar ison of the vegetation of the southern calving grounds agrees with descriptions of vegetation for the region south Of Chesterfield Inlet by Gubbe (1976) and Thompson et al. (1978) (Table 14).

A review of Zoltai et al. (1980) and our ground observations suggests that the following physiognomic vegetative types might be present on the Bathurst calving grounds:

Table 11. Physiognomic types and vegetative associations sampled on northern Beverly calving grounds in relation to moisture and substrate, 1980.

Physiognomic type	Moisture regime	Substrate	Vegetative association
1. LICHEN/dwarf shrub	xeric	gravel-sand till	A - *Cornicularia divergens*/ *Alectoria ochroleuca*
	xeric-mesic	gravel-sand till	B - *Alectoria ochroleuca*/ *Cornicularia divergens*
	xeric-mesic	bouldery till	C - Boulders/crustose lichen
	mesic	gravel-sand till	D - *Cetraria nivalis*/*Ledum decumbens**Vaccinium vitis-idaea*
II. DWARF SHRUB/moss/ lichen/short sedge	xeric-mesic	sand-gravel till	E - *Vaccinium vitis-idaea*/ moss
IV. Tussock-short sedge-dwarf shrub- lichen-moss	mixed with	mixed organic with till	I - *Eriophorum* spp./*Carex* spp./mosses/*Vacc inium vitis-idaea*
V. TUSSOCK/moss	hydric	organic over till	J - *Eriophorum vaginatum*/ *Carex* spp./moss
VI. TALL SEDGE / ITOSS	hydric-hygric	organic over till	K - *Carex* spp.- moss .

Table 12. Physiognomic types and vegetative associations on southern Beverly calving grounds in relation to moisture and substrate, 1980.*

Physiognomic type	Moisture regime	Substrate	Vegetative association
II. DWARF SHRUB/moss/ lichen/short sedge	xeric-mesic	sand-gravel till	F - Dryas integrifolia/moss
	mesic	sand-gravel	G - Carex spp./Dryas integrifolia/moss
III. LOW SHRUB/moss/ short sedge/dwarf shrub	mesic	thin organic over till	11 - Betula glandulosa/moss/ Carex spp.
V. TUSSOCK/moss	not sampled but present		
VI. TALL SEDGE/moss	hydric-hygric	organic over till	K - Carex spp./moss

* This scheme is inferred from sites sampled to the east of the southern calving grounds.

Table 13. Comparison of vegetative classification scheme for northern Beverly calving grounds with classification of vegetation on Wager Plateau physiographic region (Gubbe 1976) and classification in the central north Keewatin (Fischer et al. 1977).*

Northern Beverly calving grounds	Wager Plateau physiographic region (Gubbe 1976)	Central Northern Keewatin (Fischer et al. 1977)
**	**	Barrens
I. LICHEN/dwarf shrub A. Cornicularia divergens/ Alectoria ochroleuca B. Alectoria ochroleuca/ Cornicularia divergens C. Boulders/crustose lichen D. Cetraria nivalis/ Ledum decumbens/Vaccinium vitis-idaea	I. Lichen steppe A. Hierochloe alpina/ Cornicularia divergens/ Alectoria ochroleuca	Lichen Uplands
	II. Lichen heath B. Rhacomitrium lanuginosum/Cornicularia divergens/Cassiope tetragona	Lichen Heath Plateaus
**	III. Graminoid cryptogam C. Hierochloe alpina/ Rhacomitrium lanuginosum/ Cornicularia divergens/ Alectoria ochroleuca D. Carex bigelowii- Arctagrostis latifolia/ Cladina/Rhacomitrium lanuginosum	
II. DWARF SHRUB/moss/ lichen/short sedge E. Vaccinium vitis-idaea/ moss	IV Lichen-moss-sedge-heath E. Cladina/ Rhacomitrium lanuginosum/Carex/Cassiope tetragona	
	V. Dwarf shrub-sedge-heath F. Salix fuscescens/Carex/ Vaccinium uliginosum G. Dryas integrifolia/Luzula nivalis/Cassiope tetragona	

Table 13. (cent'd)

Northern Beverly Calving grounds	Wager Plateau physiographic region (Gubbe 1976)	Central Northern Keewatin (Fischer et al. 1977)
**	**	Orthophyll Shrub
**	VI. Dryas herbmat H. Saxifraqa oppositifolia/ Carex scirpoidea/Dryas intearif olia	
IV. Tussock-short sedge-moss-dwarf shrub-lichen 1. Eriophorum spp. -Carex spp.-mosses-Vaccinium vit is-idaea	**	**
V. TUSSOCK/moss J. Eriophorum vaainatum /Carex spp./moss	VII. TUSSOCK tundra 1. Aulacomnium/Salix/ Eriophorum vaainat um var. spissom	Willow sedge meadow
VI. TALL SEDGE/moss K. Carex spp.-moss	VI 1. Wet sedge meadow	Sedge meadows

* Descriptions of vegetation from these reports were used to compare physiognomic types and vegetation associations of Gubbe (1976) with habitat types of Fischer et al. (1977) .

** No equivalent vegetative associations or habitat types described.

Table 14. Comparison of vegetative classification scheme for southern Beverly calving ground with classification of vegetation on Kazan Upland physiographic region (Gubbe 1976) and classification of vegetation in the central south Keewatin (Thompson et al. 1978). *

Southern Beverly calving grounds	Kazan Upland physiographic region (Gubbe 1976)	Central South Keewatin (Thompson et al. 1978)
**	**	Rock barrens
	1. Lichen steppe A. Poa glauca/Cornicularia divergens/Alectoria ochroleuca	Lichen steppe
**	11. Lichen heath E. Cetraria nivalis/ Vaccinium uliginosum/ Empetrum nigrum C. Cetraria islandica/ Luzula nivalis/Cassiope tetragona	Lichen heath
III. LOW SHRUB/moss/ short sedge/dwarf shrub H. Betula glandulosa moss/ Carex spp.	111. Dwarf shrub tundra D. Aulocomnium/Salix-Betula glandulosa	Dwarf shrub lichen
II. DWARF SHRUB/moss/ lichen/short sedge F. Dryas integrifolia/ moss G. Carex spp/Dryas integrifolia/moss	IV. Dwarf &rub-sedge-heath E. Salix (fuscescens)/Carex/ Vaccinium uliginosum Fe Salix-Dryas integrifolia -Carex-mixed heath	Dwarf shrub sedge
V. TUSSOCK/moss	V. TUSSOCK tundra	TUSSOCK tundra
VI. TALL SEDGE/moss K. Carex spp/moss	VI. Wet sedge meadow	Sedge meadows

* Descriptions of vegetation from these reports were used to compare physiognomic types and vegetation associations of Gubbe (1976) with habitat types of Thompson et al. (1978).

** No equivalent vegetative associationsor habitat types described.

I. Rock barrens: occur ring on bare bedrock outcrops, boulder fields and sandy deposits (eskers, strand lines) . Vascular plants are scarce and confined to cracks where soil has accumulated. Crustose lichens and mosses are most prevalent. 'I'he type of reck substrate available as well as moisture conditions influence the species composition (i.e. vegetative association) .

II. Lichen - dwarf shrub: occurring on well to excessively drained till upland. C. divergens and A. ochroleuca are not common. Instead, Cetraria and Cladina species are prominent along with dwarf shrubs (<30 cm) , L. decumbens, V. vitis-idaea, V. uliginosum, E. nigrum, C. tetragona, Arctostaphylos rubra and D. integrifolia. Again substrate influences the vegetative association. On the calving grounds the dominance of granitic till dictated the prevalence of ericaceous shrubs (Zoltai et al. 1980) . On less acidic, high nutrient tills derived from either volcanic or sedimentary rocks D. integrifolia is the prevalent species. This substrate preference explains the dominance of Dryas on the Beverly calving ground.

III. Low shrub - dwarf shrub: occurring on well to imperfectly drained till slopes. The shrubs are less than 30 cm tall and include B. glandulosa and Salix spp., as well as the dwarf shrubs described in physiognomic type II. Grasses, sedges, lichens and sane forbs are present in varying amounts. The vegetative association depends upon available moisture and substrate. Betula and Salix spp. increase on protected or more mesic sites. Patterned grounds in the form of mud boils with a turfy ring are common.

IV. Tussock: these are well developed on imperfectly drained marine clays. E. vaainatum, E. callitrix and Carex spp. dominate. On the tussocks or on slightly better drained areas Salix and Betula spp. are common as well as Andromeda and other dwarf shrubs. Cetraria and Cladina lichens occur. In the central and eastern port ions of the calving ground this physiognomic vegetative type is very common.

V. Tall sedge: occurs on poorly drained depressions. Zoltai et al. (1980) note that there are two vegetative associations. Carex - moss is prevalent on nutrient rich sites where the pH is almost neutral. Carex - Sphagnum is prominent where waters are acidic (usually associated with granitic tills) . Low center polygons are often associated with Carex - Sphagnum. These polygons are common on the Bathurst calving grounds.

These five physiognomic types also occur off the Bathurst calving grounds (Zoltai et al. 1980). However, the lack of marine deposits south and west of Bathurst Inlet suggests that tussock tundra is uncommon. At Bathurst Inlet, the low shrub physiognomic type is present. Salix spp. , B. glandulosa and Alnus crispa form prominent shrub thickets (2 m tall) along lower slopes, sides of streams and imperfectly drained, f luvial sands. We did not document whether this type occurred south and west of Bathurst Inlet.

The physiognomic types of the Bathurst calving grounds are similar to the northern Beverly calving ground; however, the dominance of nutrient poor, acidic till and outcrop on the Bathurst calving grounds implies that vegetation associations will be different.

Tussock tundra may be more prevalent on the Bathurst calving ground because marine clay deposits are uncommon on the Beverly calving ground.

Thompson et al. (197 8) and Beckel (1958) mapped complexes of the vegetation associations of the Kaminuriak calving grounds. Both state that on the tundra range of the Kaminuriak herd, lichen dominated communities on well-drained uplands were more prevalent towards the north and east, while communities on poorly drained lowlands, daninated by low shrubs and sedge species, increased towards the south and west. Neither suggests that the vegetation communities or their distribution on the Kaminuriak calving grounds are unique. However, Thompson et al. (1978) show that the area between Banks, Mandreville and Happotiyak Lakes on the Kaminuriak calving grounds has more lichen heath vegetation and bedrock outcrop than the remainder of the Kaminuriak tundra range. Those studies imply that vegetation of the Kaminuriak calving grounds will be similar to the southern Beverly calving grounds and the summer range of the Kaminuriak herd.

Thus the most obvious vegetative characteristic separating the Calving grounds and surrounding tundra north of Beverly Lake from the cal ving grounds and surrounding tundra south of Beverly Lake is the absence of phanerophytes. If climate is the primary factor affecting the northern limit of phanerophytes then the similar physiognomic forms found on the Bathurst and northern Beverly calving grounds indicate a cooler or shorter growingseason in comparison with the Southern Beverly and Kaminuriak calving grounds. Observations of percentage snow cover during surveys of calving grounds and f rom sat ellite imagery support the suggestion that the growing season begins later north of Beverly Lake. Although the vegetation on each of the calving grounds occurs elsewhere on each herd's tundra range, the calving grounds are located in the coolest sector of each range. The calving grounds should be the last portion of each herd's range to develop newly greening vegetation. It is expected that the phonological characteristics of calving grounds will differ from surrounding areas to the south and west.

The onset of new plant growth within a local region varies with elevation and aspect. In the absence of marked elevational changes, West Greenland caribou maintain intake of high quality food, which is associated with vegetation at an early phonological stage, by shifting from south aspect feeding sites in April and May to north aspect sites during July and August (Thing 1980). If a phenological gradient does exist it is likely a function of topography as elevational changes are small on the three calving grounds.

Immediately after snowmelt, nitrogen and phosphorus content of Eriophorum inflorescences and culms peaks (Chapin et al. 1980). Maximum nitrogen content of new leaves of deciduous shrubs and Eriophorum spp. is reached 3-4 weeks after snowmelt. However, snowmelt does not occur simultaneously over any area, and the duration varies among years. Thus it is important to quantify the amount and phonological stages of greening vegetation available during calving to determine when cows switch from winter to summer diets. There is a need to compare the difference in timing and phonological stages of greening vegetation available among various calving grounds.

Calving grounds of caribou and reindeer grade into two groups characterized by the presence or absence of greening vegetation during cdl ving. The Western Arctic herd (Alaska) and the Porcupine herd (Yukon-Alaska) have calving grounds where some emergent shoots and buds are usually available at the onset of or shortly after calving (Kuropat and Bryant 1980, Lent 1980, A. Marten pers. comm.). On the Kaminuriak calving grounds, greening vegetation may or may not be available during calving. Miller and Broughton (1974) observed greening vegetation at the peak of calving on the Kaminuriak herd in 1970. Their observations support our description of an earlier snowmelt on the Kaminuriak calving grounds. Cows of the Central Arctic herd (Alaska), reindeer herd (Tuktoyaktuk), Bathurst herd and Beverly herd calve 1-2 weeks before new vegetation is available (Kelsall 1968, Whitten and Cameron 1980). The data for Bathurst and Beverly herds are based on scanty evidence from snowmelt conditions. Additional evidence comes from observations of feeding on the Beverly calving ground. Pruitt (1958) and Loughrey (in Kelsall 1968) observed that cows on the Beverly calving grounds in 1957 and 1958 primarily fed on snowfree lichen dominated ridges during calving. Inflorescences of Eriophorum spp. , usually the first plant to develop after snowmelt (A. Martell pers. comm.) , had not greened up until late June.

The vegetation on the Bathurst, Beverly and Kaminuriak calving grounds is not unique and the presence of greening vegetation during the peak of calving is not characteristic of, at least, the Bathurst and Beverly calving grounds. However, within 2-3 weeks after calving when lactational stress is high, newly emergent vegetation becomes available to cows. It remains to be determined: (a) whether the pattern of vegetation is unique to the calving grounds, (c) how long cows are on the calving grounds, (c) what the use is of vegetation types by cows in different years, and (d) whether the phenology on the calving grounds after calving is different from surrounding areas.

PREDATORS

Introduction

Throughout most of their respective life cycles, caribou and their principle predator, the wolf (Canis lupus), are in continual contact with each other. Only during denning is the range of most wolves reduced. At this time, caribou are calving and are the most vulnerable to predation. The location of the calving grounds beyond the effective hunting range of most denning wolves would be a strategy to reduce predation on newborn calves (T. Bergerud pers. cam.). Kelsall (1968) suggested that the choice of a calving ground was associated with an absence of predators. Parker (1972b) recognized that absence of predators would be an advantage but doubted this could influence the location of calving grounds. In the Northwest Territories, the barren-ground grizzly (Ursus arctos) is the other most important predator of barren-ground caribou during calving.

Methods

We obtained data through a literature search of published and unpublished material and from field notes of N.W. T. Wildlife Service personnel. We searched for information on the distribution of wolves and bears during calving, location of wolf den sites and summer food habits of wolves and bears.

Results and Discussion

There are difficulties in interpreting the numbers of wolves on the Bathurst, Beverly and Kaminuriak calving grounds. Observations of wolves were made during aerial censuses of the calving grounds over varied terrain under a variety of snow conditions. Nevertheless, the data suggest that the numbers of wolves are low on the calving grounds (Table 15) where prey densities can be similar to or higher than those found in areas of late winter caribou concentrations. High numbers of wolves have been described in association with caribou concentrations on winter ranges (Table 16). Surveys designed specifically to determine wolf densities have not keen flown on the three calving grounds or areas adjacent to the Bathurst and Kaminuriak calving grounds.

Breeding wolves and associated non-breeders do not f ol low the spring migration of caribou to the calving ground unless den sites are on or near the calving ground. In 1979, the N.W.T. Wildlife Service began to study the movements and territoriality of wolves on the range of the Bathurst caribou herd. In March-April 1979, 35 of the 130 wolves observed were fitted with radio transmitters.

In early June 1979, only 2 of the 19 radio collars still transmitting were located near the calving grounds. Both wolves were males, one mature and the other immature. Of the remainder, one was not located, eight were at known den sites and the rest were located south of Contwoyto Lake (Fig. 18) . BOth Kuyt (1969) and Miller and Broughton (1974) believed that wolves on the calving grounds are primarily non-breeders. The results from observations of the radio-collared wolves support this belief. None of the den sites of the radio-collared wolves in 1979 were within 30() km of the Bathurst calving grounds. Zoltai et al. (1980) reported the location Of four wolf dens at Bathurst Inlet; Kelsall (1955) also reported one wolf den there, but those dens are not on the Bathurst calving grounds. The

Table 15. Wolves and grizzly bears observed during Bathurst, Beverly and Kaminuriak calving grounds surveys, 1951-1980.

Year	Bathurst calving grounds Sightings wolf	Bathurst Sightings grizzly	Bathurst Reference	Beverly calving grounds Sightings wolf	Beverly Sightings grizzly	Beverly Reference	Kaminuriak calving grounds Sightings wolf	Kaminuriak Reference
1951	1	1	Kelsall 1953	-				
1958				6	2	Pruitt 1958		
1959				0	2	McEwen 1960		
1%2				1	1	McEwen 1962		
1%3							0	Malfair 1963
1%5				1	3	Look 1%5		
1%6	3	0	Williams 1%6	-				
1970	1	0	Boxer 1970	-			19	Miller and Broughton 1974
1971	0	0	Boxer 1971	north 0 south 16	0 -	Rippin 1971	3	Rippin 1971
1972							*	Bowden and Timmerman 1972
1973							*	Land and Hawkins 1973
1974	12	2	Boxer 1974		50	R. Decker pers. comm.	6	Hawkins and Howard 1974

Table 15 continued

Year	Bathurst calving grounds			Beverly calving grounds			Kaminuriak calving grounds	
	Sightings		Reference	Sightings		Reference	Siahtinas	Reference
	wolf	grizzly		wolf	grizzly		wolf	
1977	*	*	Calef and E?oxer 1977	-			1	Heara 1981
1978	5	0	N.W.T. Wildlife Service files	49	6	Heard and Decker 1980	*	Darby 1978
1979	-	-	-	*	*	Darby 1979	*	Darby 1979
1980	9	1	Heard 1980a	13	4	Gunn and Decker 1981	4	Heard 1980b

* No data on predators observed during calving ground survey.

Table 16. Number of wolves associated with wintering groups of caribou.

Date	Location	Area km^2	Wolves counted	Caribou counted	Reference
1%7 March	McTavish Arm, Great Eear Lake, N.W.T.	300	90	75,000	Thomas 1969
1%8 January	Hara and Charcoal Lakes, Saskatchewan	8300	258	51,000	Miller 1975
1%8 April	Hara Lake Saskatchewan	1800	211	51,000	Miller 1975
1978 April	Desmarais Lake, N,W.T.	1.700	70	60,000	R. Decker pers. comm.
1979	Carp Lakes, N.W.T.	1600	130	no estimate	D. Heard pers. comm

first recorded den on the Bathurst calving grounds was found in 1980 (Heard 1980a). The den was a shallow pit dug into an esker and had five pups with five adults and the renains of two newborn calves.

Kuyt (1969) conducted aerial and ground searches between 1960 and 1965 for dens in the vicinity of the Thelon River and Beverly calving grounds. Three of ten active dens and 12 of 19 inactive dens were located on the southern Beverly calving grounds (Fig. 19) . No dens were located on the northern Beverly calving grounds. The higher number of wolves on the Beverl y cal ving grounds in compa r ison to the other calving grounds may reflect the closer proximity of a denning area to the Beverly calving grounds. No active dens have been located on the Kaminuriak calving grounds; however, Miller and Broughton (1974) found two inactive den sites in 311 hours of flying during June and July 1970.

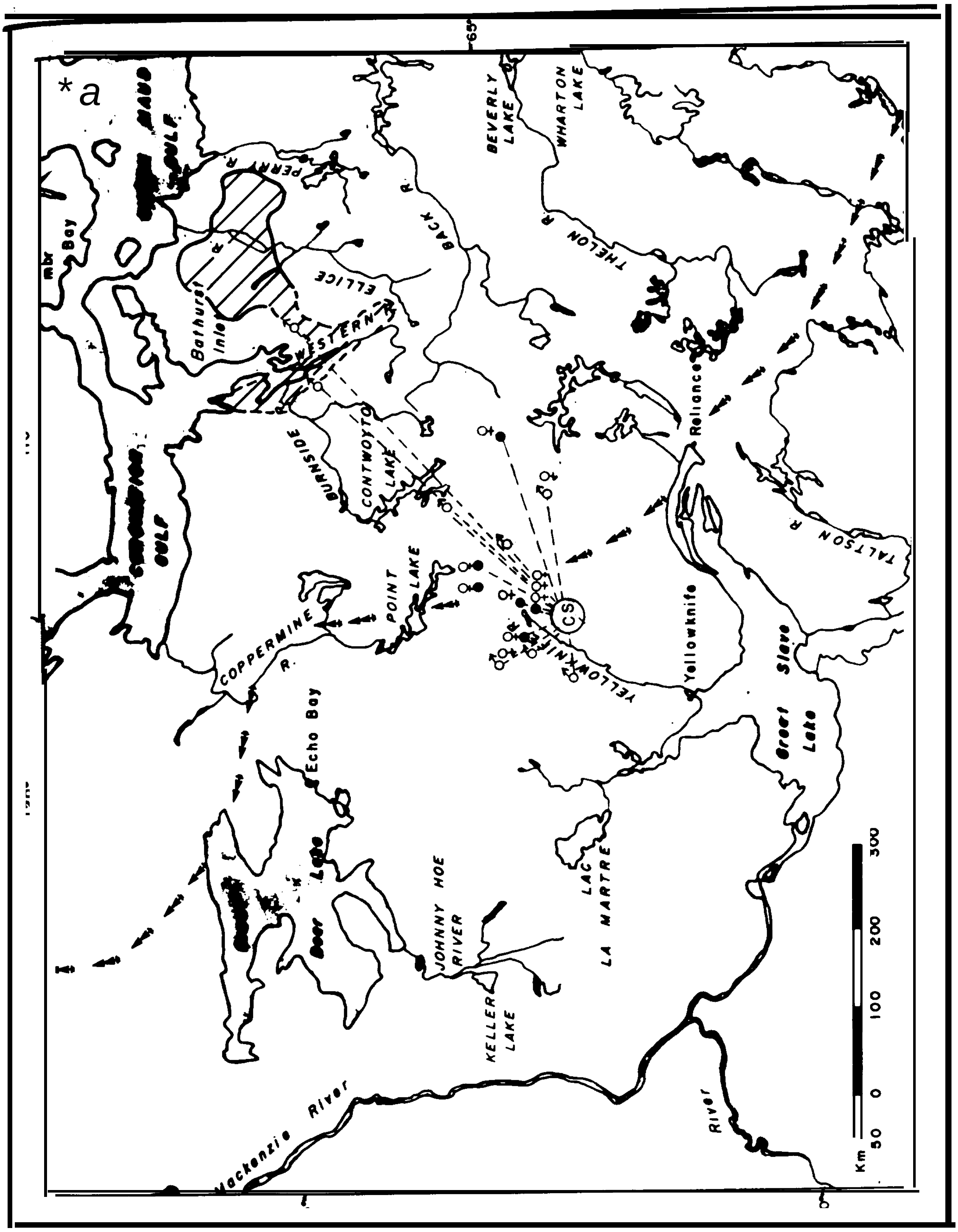
Most dens on the barren-grounds have been located in sandy areas at or near treeline; sites with shrubs or small clumps of trees on eskers are f avoured (Jacobson 1979) . Stephenson and Johnson (197 2) note a similar trend on the North Slope of Alaska and comment that fox dens are often enlarged and used by wolves. The presence of mntinuous permafrost restricts suitable den sites to gravel or sand deposits on all three calving grounds. It appears that the locations of barren-round caribou calving grounds are different from the locations of preferred wolf denning areas.

The same den my be used several times over a period of Years (Makridin 1960, Kuyt 1969, Stephenson and Johnson 1972). At the three dens visited along Greenstockings Lake (64° N, 113° W) in 1979, our own observations revealed numerous scats older than 1 year and many well used trails leading to the den sites.

Figure 18. Locations and den sites of 18 radio-collared wolves on the Bathurst caribou range in early June, 1980.

Legend

CS	Capture site March and April 1979
●	Den site active in 1979
♂	Male wolf
♀	Female wolf
↑	Treeline
——	Calving ground boundary


*a
Bathurst Inlet
PERRY R.
ELLICE R.
BACK R.
BEVERLY LAKE
WHARTON LAKE
THELON R.
WESTERN R.
BURNSIDE
CONTWOYTO LAKE
Reliance
TALTSON R.
CS
YELLOWKNIFE R.
Yellowknife
POINT LAKE
COPPERMINE R.
Echo Bay
Great Slave Lake
LAC LA MARTRE
JOHNNY HOE RIVER
KELLER LAKE
Bear Lake
Mackenzie River
River
Km 50 0 100 200 300
65°

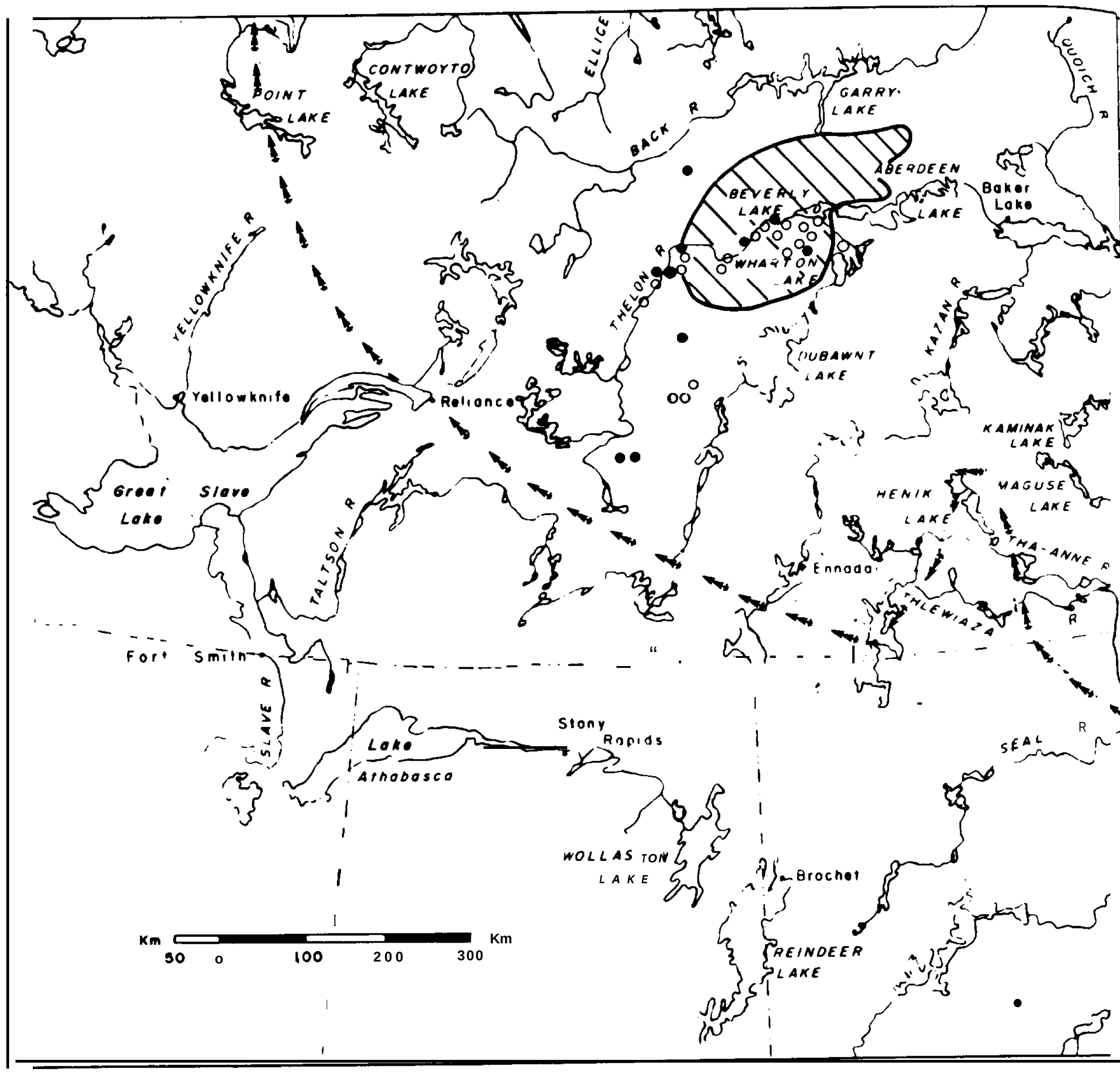


Figure 19. Den sites of wolves on Beverly caribou range, 1960-1965.

Legend

——— calving ground boundary

● Den site active between 1960 and 1965

0 Inactive den site

Whelping coincides with the early calving period of caribou (Makridin 1%0, Kuyt 1972, Stephenson and Johnson 1972). The pups are unable to travel long distances with the adults until late August. This implies that the older wolves associated with a den remain relatively sedentary. Kel sal 1 (1953) suggests that wolves remain within 30 km of their den site.

Analyses of scats collected from den sites record a summer diet of caribou supplemented by small prey and fish (Banfield 1954, Clark 1970, Kuyt 1972) . Stephenson (197 9) and Stephenson and Johnson 1972) studied northwest Alaskan wolves which also rely on caribou as their prey source and reported analogous results for summer food habits. Banfield (1954) and Stephenson and Johnson (1972) reported that wolves will return to feed on old kills close to dens during the summer and they suggested that wolves cache caribou during spring migration.

Al 1 those observations support the strategy Parker (1972b) outlines concerning the preferred locations of wolf den sites. He proposes that wolves who den near treel ine will minimize their time without caribou. Although female caribou have left the area by mid-May, the bulls are still on their way north and some caribou linger near treeline all summer (Banfield 1954, Parker 1972b, Miller and Broughton 1974, Darby 1978 and 1979) . When female caribou return towards treel ine, the pups are old enough to follow the adult wolves as they hunt for caribou (Kuyt 1972) . A den on a calving ground ensures a food supply of caribou for less than a month and involves a long trek for the pups to keep up with the caribou in late August.

Kelsall (1%0) and Kuyt (1972) observed that the wolves during smr killed calves more frequently than adults. Those wolves were associated with the Beverly caribou herd. Miller and Broughton (1974) reported that 3 0% of 57 dead calves found on and near the 1970 Kaminuriak calving ground had been killed by wolves. They postulated that 25 wolves on the calving ground could kill 20 - 30% of the Kaminuriak calf crop in 2 ninths. Heard and Decker (1980) saw over 218 dead calves on the Beverly calving ground during June, 1978. They noted that 50% of the 28 calves examined had crushed skulls and subcutaneous hemorrhaging indicating predation as the cause of death.

Bears have keen rarely observed on the Bathurst and Kaminuriak cal ving grounds and are not numerous on the Beverly calving grounds during the calving period (Table 15) . However, there are frequent observations of grizzly bears along Bathurst Inlet (Zoltai et al. 1980) and along the Thelon River west of Beverly Lake (Kelsall 1%0, Cooper 1981) .

In Alaska, grizzly bears are common along the North Slope where several caribou (R. t. granti) calving grounds are located. Grizzly bears whose home ranges do not overlap the calving grounds did not leave their home range to reach aggregations of calving car ibou (Reynolds 1980) .

The density of bears on the western Brooks Range was estimated at 1 bear/44 km^2 (Reynolds 1980). That density is higher than the estimated densities (1 bear/140 - 260 km^2) on the eastern North Slope. Reynolds (1980) suggested that the availability of carrion and prey from the calving grounds of the Western Arctic caribou herd may be the explanation for the higher densities of bears on the western Brooks Range; however, bears on the eastern North Slope have access to car r ion and prey of the Central Arctic and Porcupine caribou herds. The only density data available for the barren-ground grizzly in the N.W.T. are from the Tuktoyaktuk area where a density of 1 bear/100 km^2

was estimated in 1975-1977 (R. Russell pers. comm.) .

Bears are opportunistic omnivores and the search for prey and carrion is superimposed on the vegetation-influenced use of habitat types (Reynolds 1980) . Bergerud (1979) observed in British Columbia that grizzlies and wolves searched barren mountain ridges during calving of mountain caribou (R_ t. caribou) , where vegetative food would be generally unavailable. Barren-ground grizzlies on the Brooks Range tend to switch from roots and overwintered berries to early phonological stages of sedges, grasses and forbs in early June (Reynolds 1980) . A similar pattern would be expected on the barren-grounds of the N.W. T. The earlier availability of greening vegetation, due to earlier snowmelt patterns , along southern Bathurst Inlet and the Thelon River may attract more bears in comparison to surrounding areas. The timing of movements of N.W. T. barren-ground grizzlies in relation to vegetative phenology and the caribou calving grounds remains speculative.

SUMMARY DISCUSSION

The most obvious characteristic of the calving grounds is that cows traditionally return there to calve. At the generalized levels that we discussed, topography, snowmelt patterns, vegetation and predators, we could not clearly separate the calving grounds from their immediate surroundings. There is some evidence that topography is more varied on the calving grounds than on the surrounding areas. Snowmelt occurs on and near the calving grounds later than on other portions of the range of each herd. The ef feet of topography and snowmelt on the vegetation on and near the calving grounds suggests that the distribution and phenology of vegetative associations will be more varied than on other portions of the tundra range of each herd. Wolves , wolf dens and bears appear to be uncommon on and near the calving grounds.

If the location of the calving grounds has been stable during the last 6000 years, then the original factor (s) influencing the location of the calving grounds may no longer exist. If we consider the location of calving grounds on evolutionary terms, then their location should remain stable as long as the ef feet of the factor (s) which originally influenced and presently are influencing the location of the calving grounds remains neutral or is beneficial to the pregnant cows. In addition, we must realize that calving grounds are probably a product of several interacting factors which may be different for each area considered (D. Klein pers. comm. , D. Thomas pers. comm.).

The observations of biologists on calving grounds in the District of Keewatin lead to suggestions that shelter for calves by topographical features (Parker 1972b) or avoidance of predators (Bergerud 1974, F. Miller pers.comm.) were likely reasons for the locations of calving grounds. Roby (1978) suggested that avoidance of predators had influenced the location of the calving grounds of the Central Arctic herd in Alaska. In contrast, investigators have suggested that an early loss of snowcover and an availability of forage in early phonological stages have influenced the location of the calving grounds for the Western Arctic herd in Alaska (Kuropat and Bryant 1980, Lent 1980) and the Porcupine herd in the Yukon (Lent 1980, A. Marten pers. comm.). Those conclusions emphasize the statement that calving grounds are probably a product of several interacting factors which may differ for each area considered.

'l'he relationship between caribou canal their chief predator, the wolf, has likely been a driving force in caribou evolution. One of the advantages of calving north of the treeline in open habitat can be summed up by the old adage of safety in numbers. Bergerud (1974) and Estes (1974, 1976) have suggested that the more individuals a predator is confronted with, the harder it becomes for the predator to select and kill an individual. The advantage of calving in large groups is increased if the timing of births is synchronized. The short, highly synchronized calving period of caribou suggests that vulnerable, newborn calves are only available to predators for a few weeks. In domesticated reindeer on whom selection pressure by predators is reduced, births occur over a longer time span, are of longer duration and the cow does not usually consume the afterbirth (Thomson 1980). During whelping, the movements of wolves associated with dens are restricted to areas around their dens. Caribou calves born distant from whelping areas should have a higher rate of survival than calves born near whelping areas. Thus, if the location of the calving areas is a reflection of factors which favour a higher calf survivorship, then one factor limiting the possible choice for the location of a calving ground would be the proximity of an area to the denning areas of wolves.

The research hypotheses proposed by different investigators were useful in focusing on factors that may affect the location of the calving grounds. In each section of this report we examined those hypotheses incorporating the relevant environmental factor. It is apparent that the data are inadequate to accept or reject the hypotheses. Observations of cow-calf pairs during storms in different topographic types are necessary to support or refute the research hypothesis that varied topography is used by calves as shelter from rain and snowstorms. Acceptance or rejection of the research hypothesis that varied topography causes a variety of plant communities which allow alternative strategies for obtaining high quality forage under different snow condit ions during the calving period requires considerable data. Those data include descriptions of vegetation in relation to topographic types, the use of vegetation by cows and calves under different snow conditions, and the progression of phenology in different years. The distribution of breeding and non-breeding wolves in relation to the calving grounds would have to be established to support or refute the research hypothesis that calving grounds are located to minimize predation by wolves. It appears that a rigorous examination of the research hypotheses is impractical if not unfeasible.

Our tentative comparisons from the literature and our impressions do not suggest the calving grounds have any distinct and obvious characteristics of topography, snowmelt patterns, vegetation and predators separating them from other portions of the tundra used by each herd. The choice of traditional locations may lie in the advantage of traditional behaviour; that is, there are benefits in following the same pattern of behaviour as long as it is successful or not detrimental to the population. During spring migration, caribou tend to follow similar traditional routes to an area of traditional importance -- the calving grounds. However, the precise location of the calving grounds on an annual basis may reflect factors such as the severity of spring travel ling condit ions.

Possibly sane understanding of the role cf traditional behaviour in the location of calving grounds could be deduced from obse rving the establ ishment of a new calving ground. Such an opportunity is possible with reintroduced populations of barren-ground caribou as on Southampton Island, N.W.T.

The likelihood that traditional behaviour is a key factor in maintaining the locat ion of calving grounds emphasizes the need for a conservative approach to the management of human activities on the calving grounds. This approach is currently manifested in DIAND's. Caribou Protection Measures.

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APPENDIX A. Retreat of snow line between mid-May and mid-June 1974-1977 from Northwatch snow cover maps.

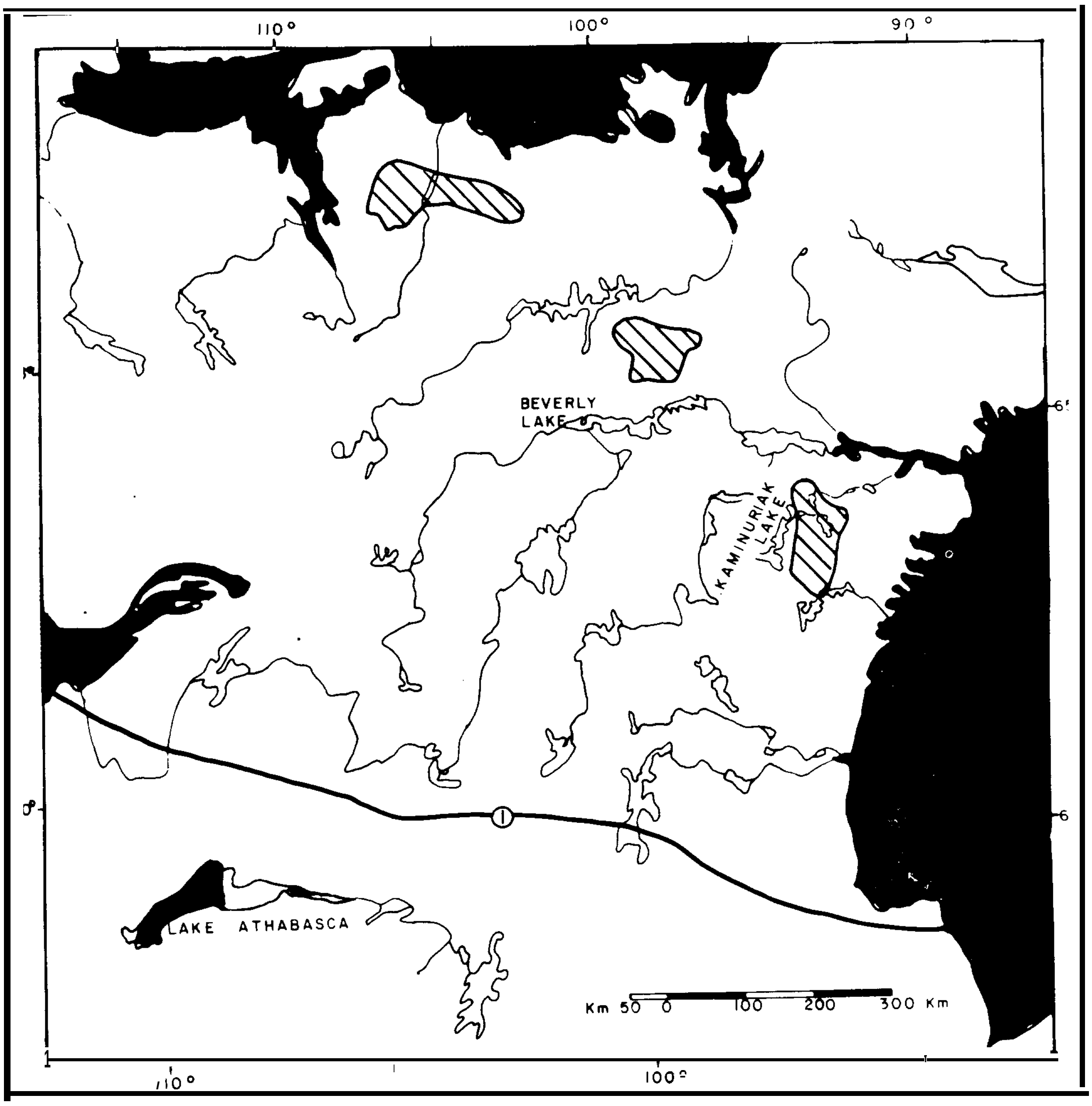
Legend

—①— 75+% snow cover

—②— 25-75% snowcover

--③-- snowfree and most lakes open

--④-- most lakes open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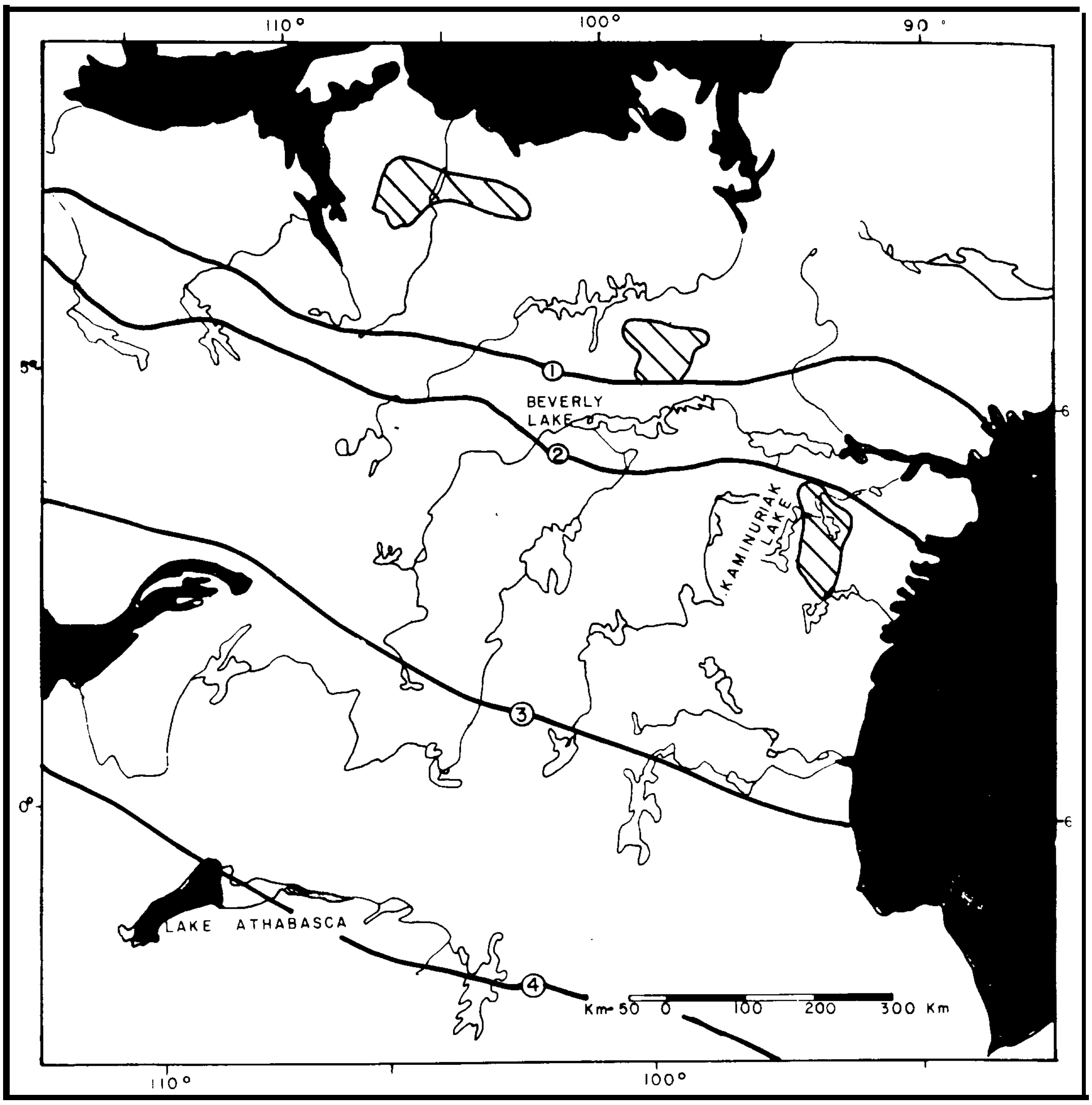
May 13,1974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1
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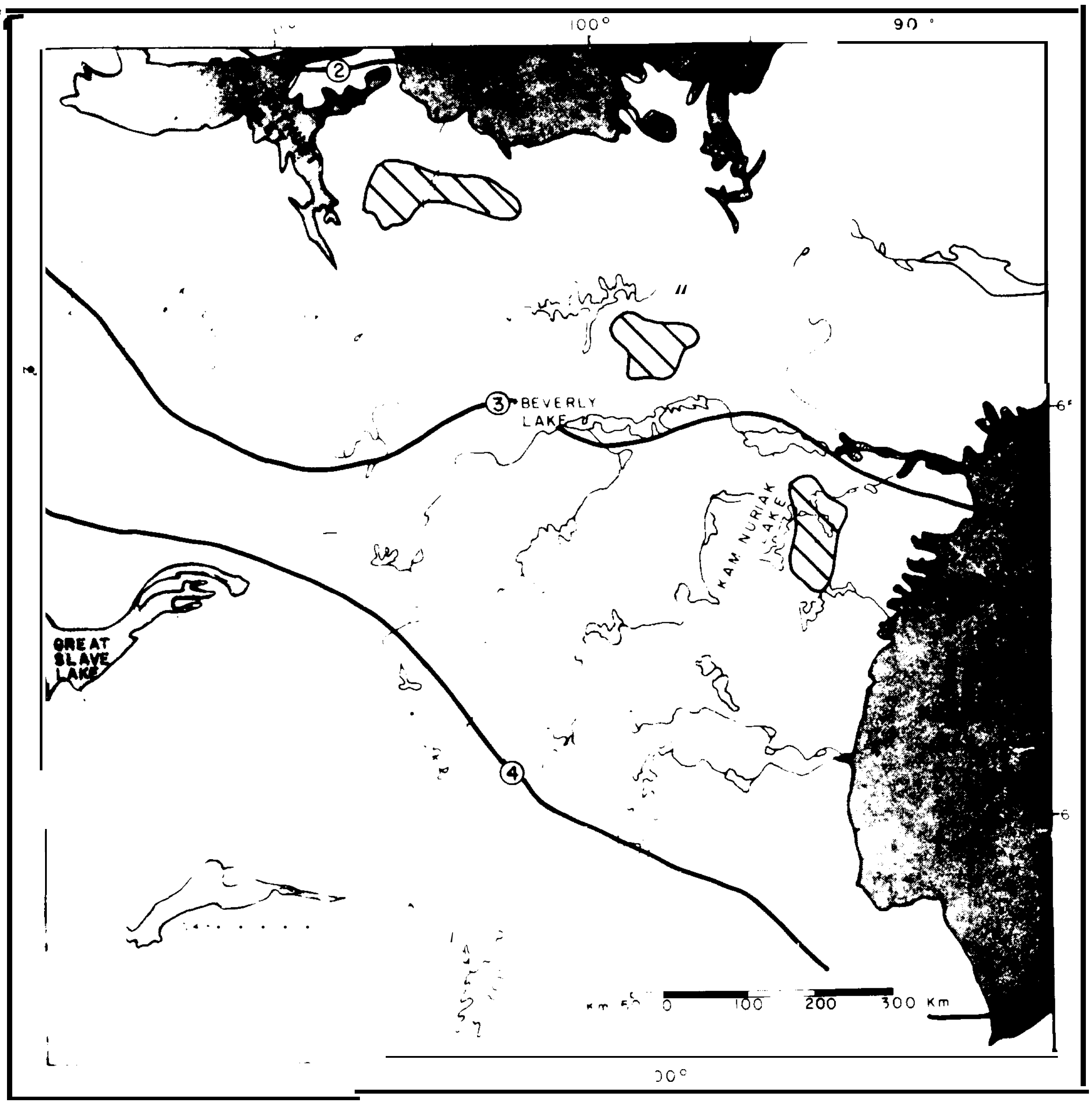
June 1, 1974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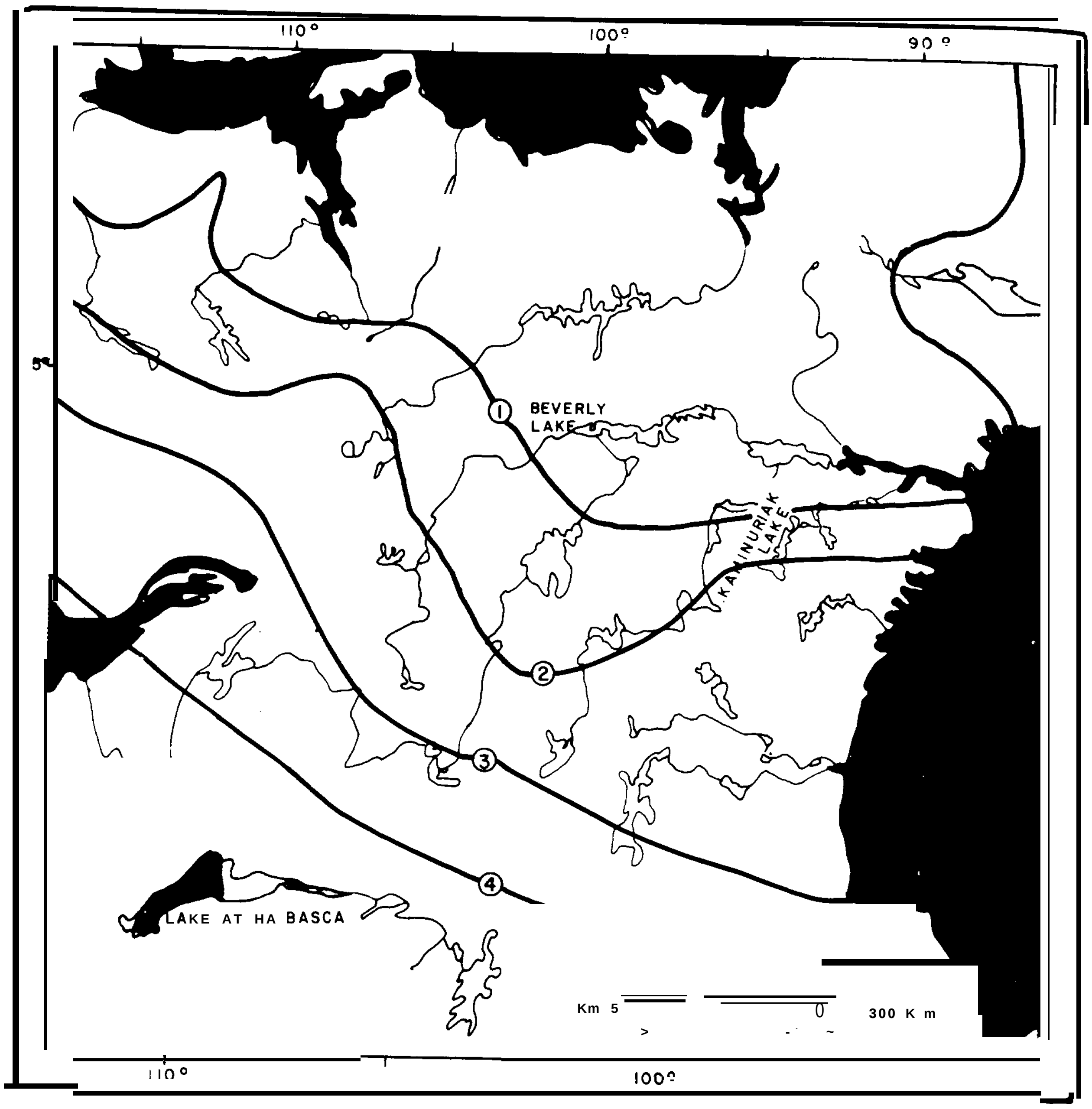
June 18, 1974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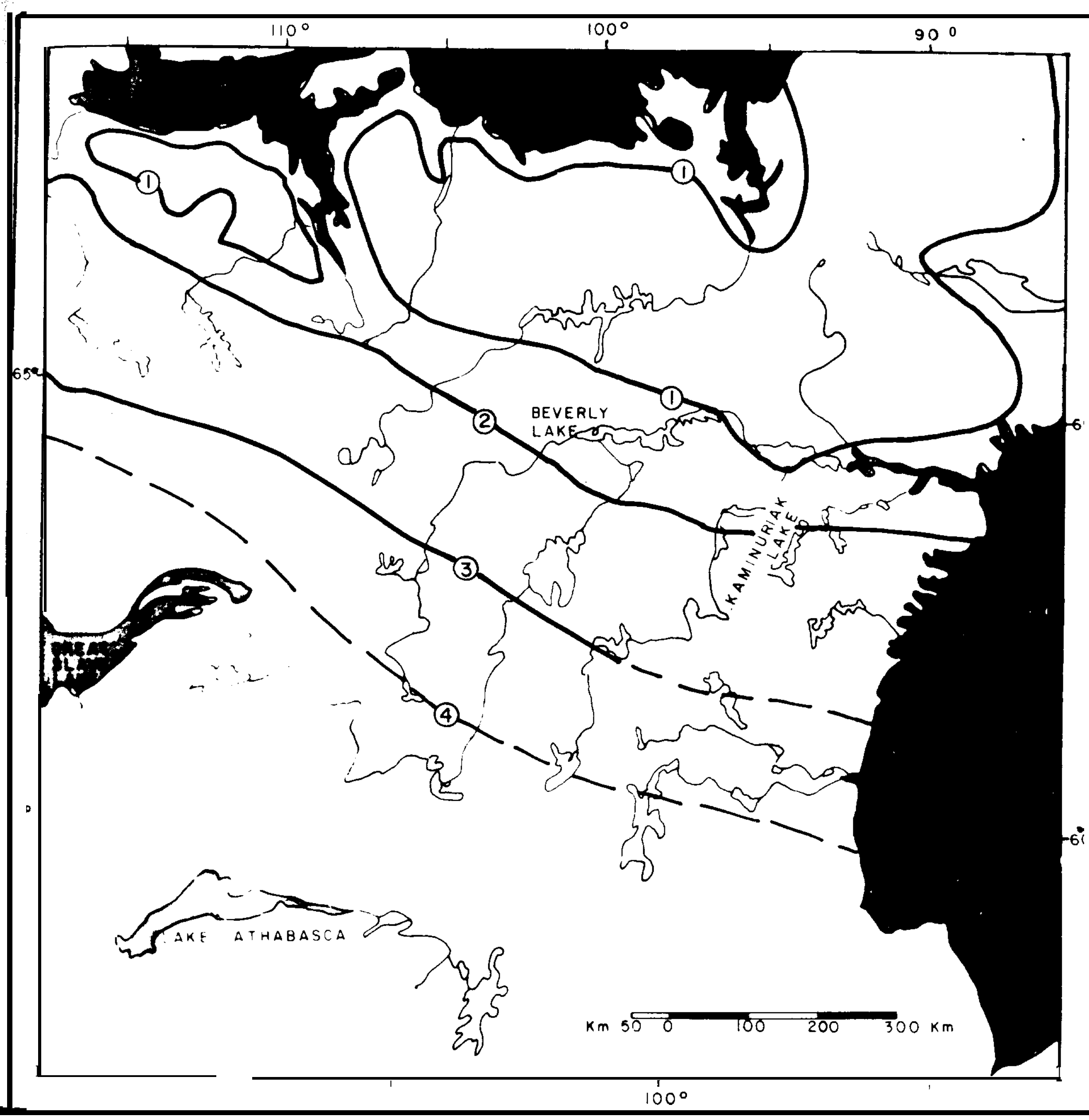
Ma y 20, 1975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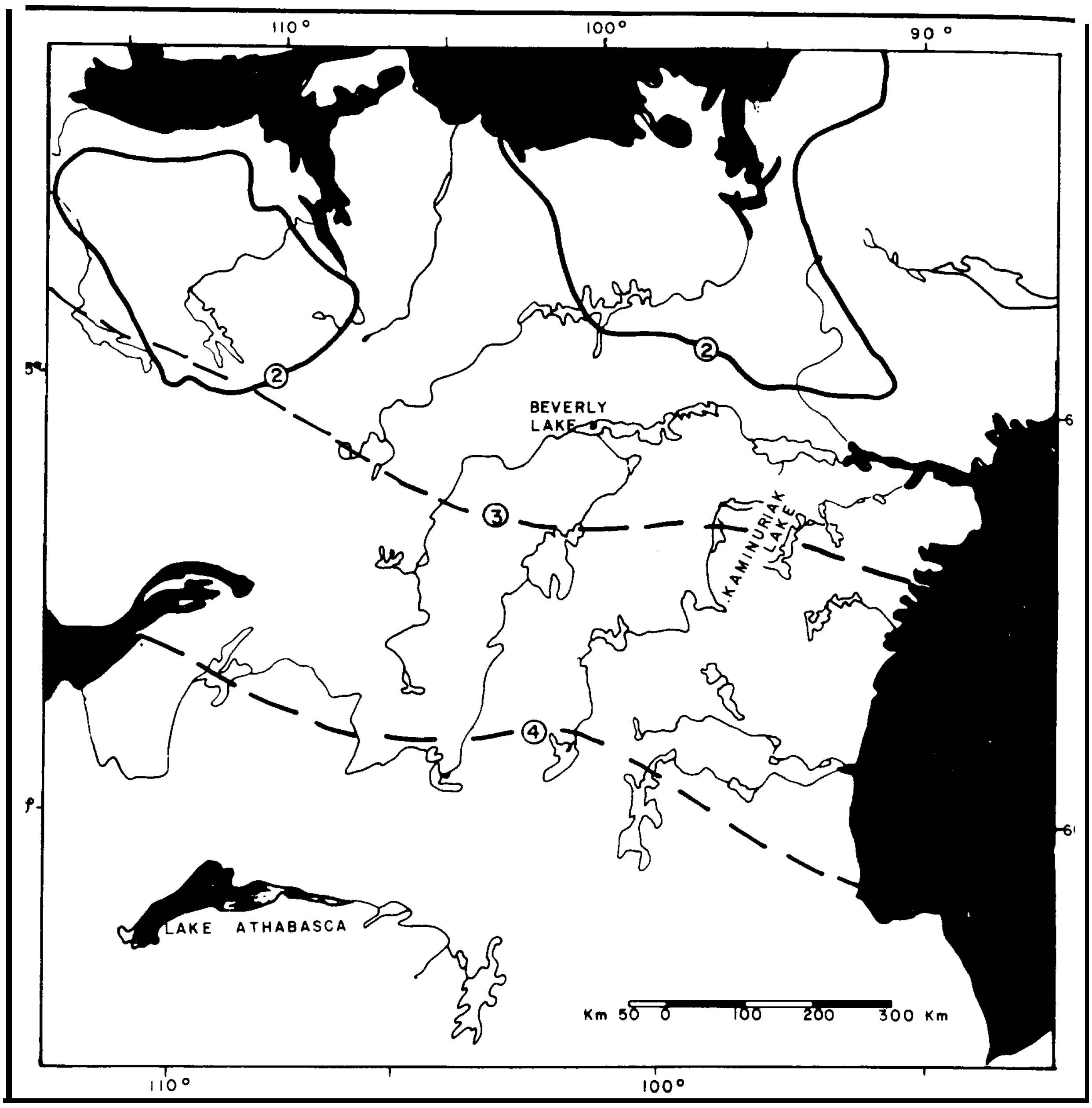
May 27,1975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100°
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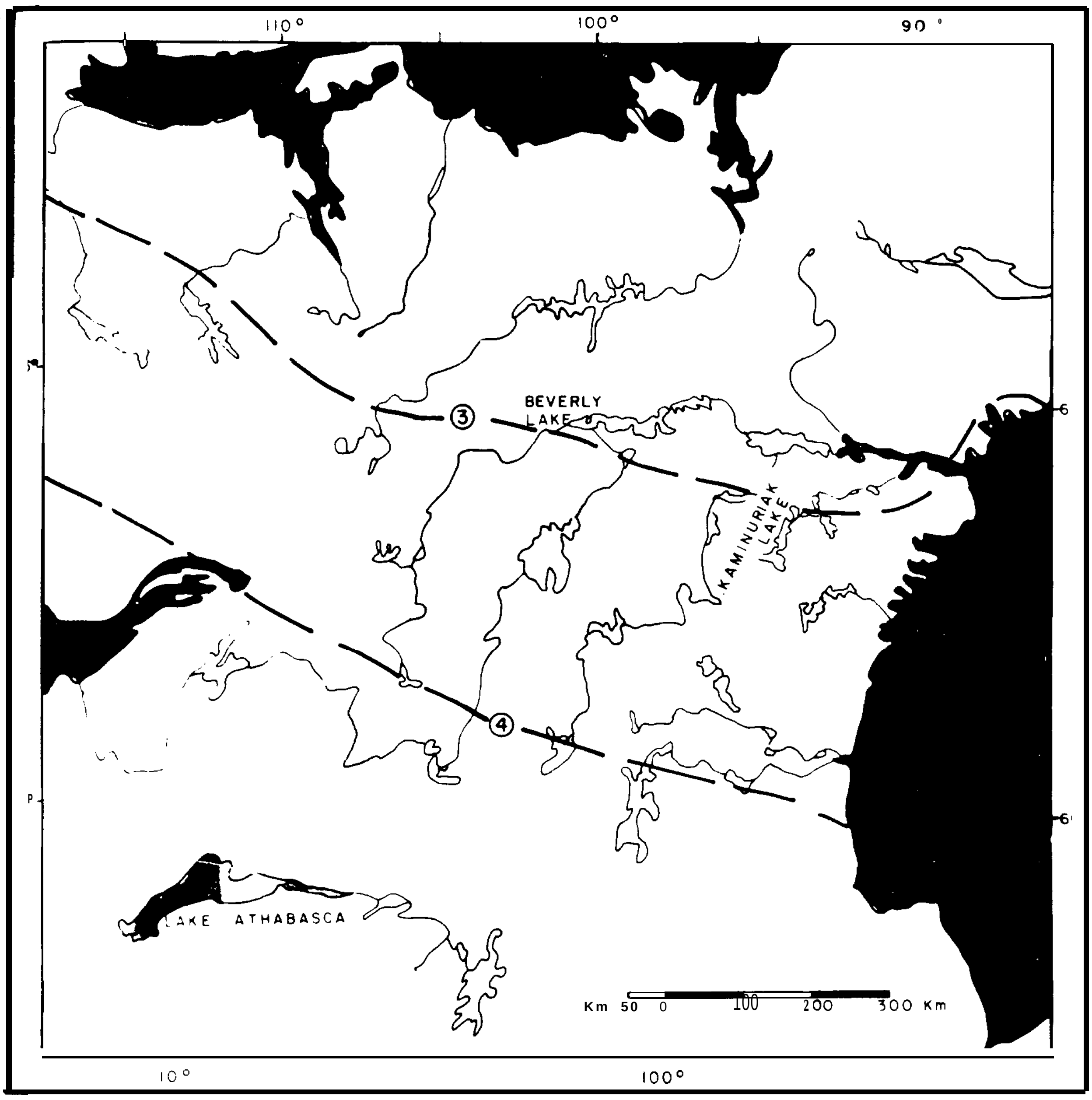
3
4

June 3, 1975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LAKE
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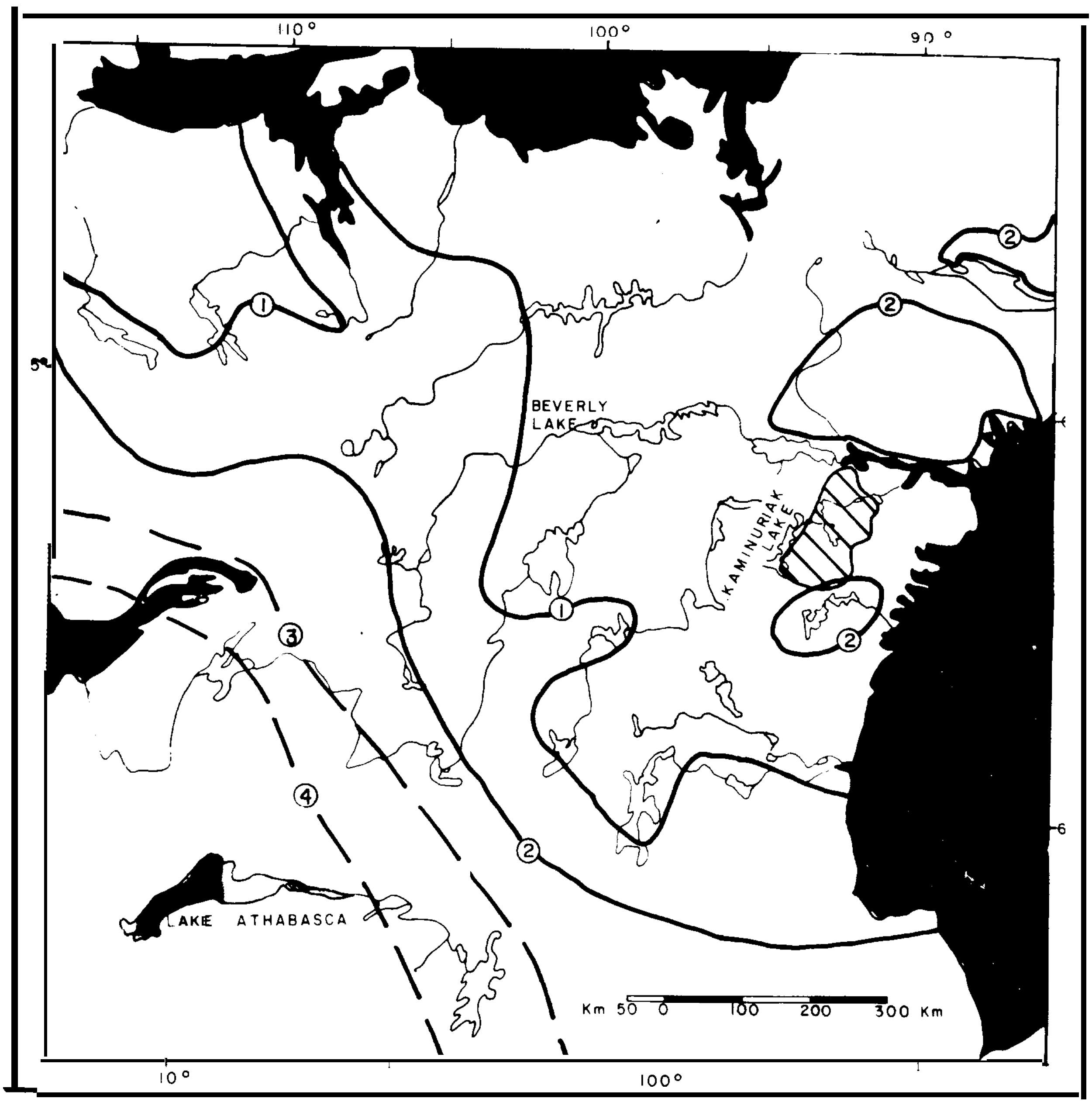
100°

June 10, 1975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LAKE
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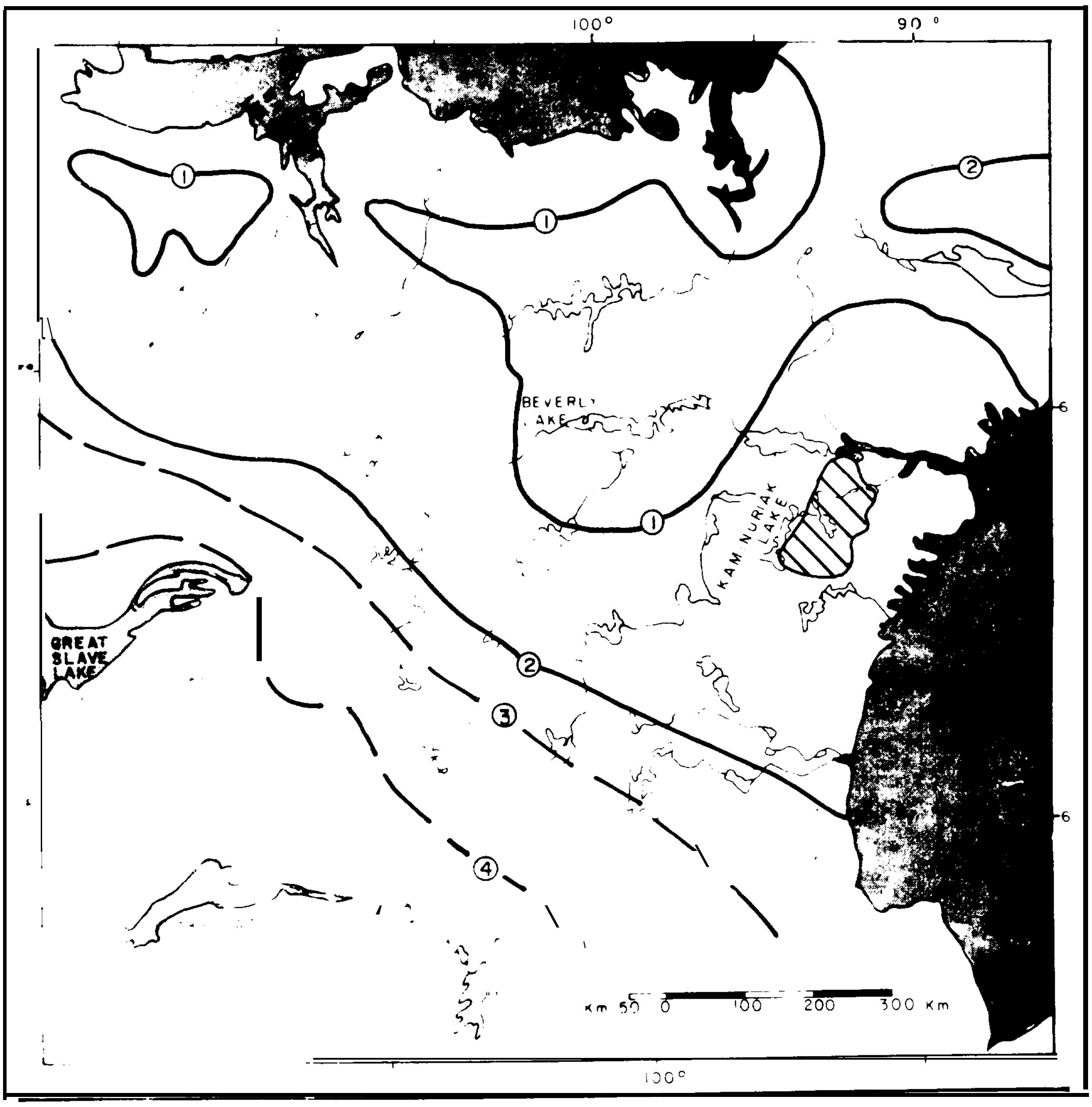
100°

May 17,1976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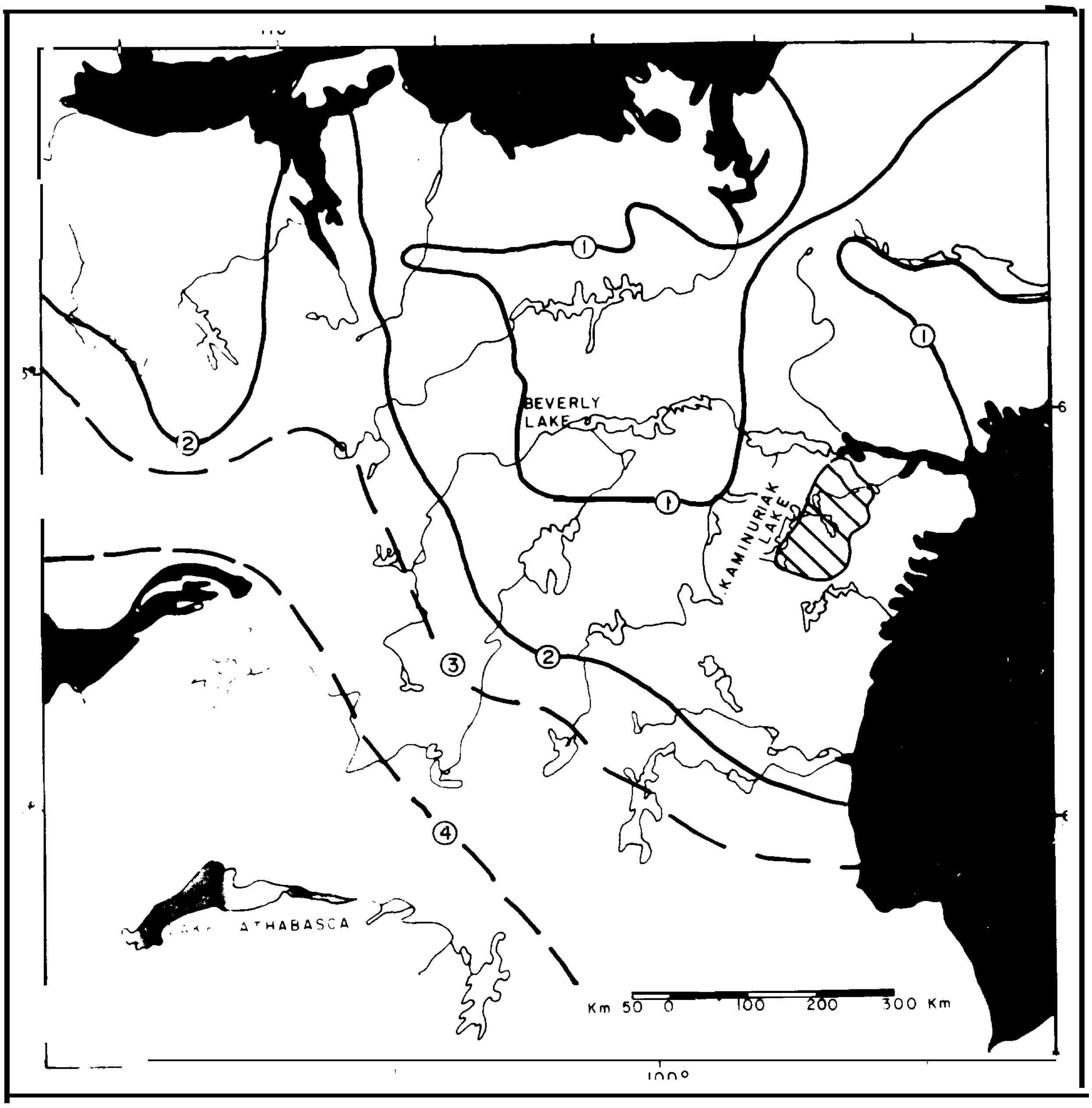
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ATHABASCA
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May 31,1976


110°
100°
90°
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LAKE
2
3
KAMINURIAK
LAKE
4
LAKE ATHABASCA
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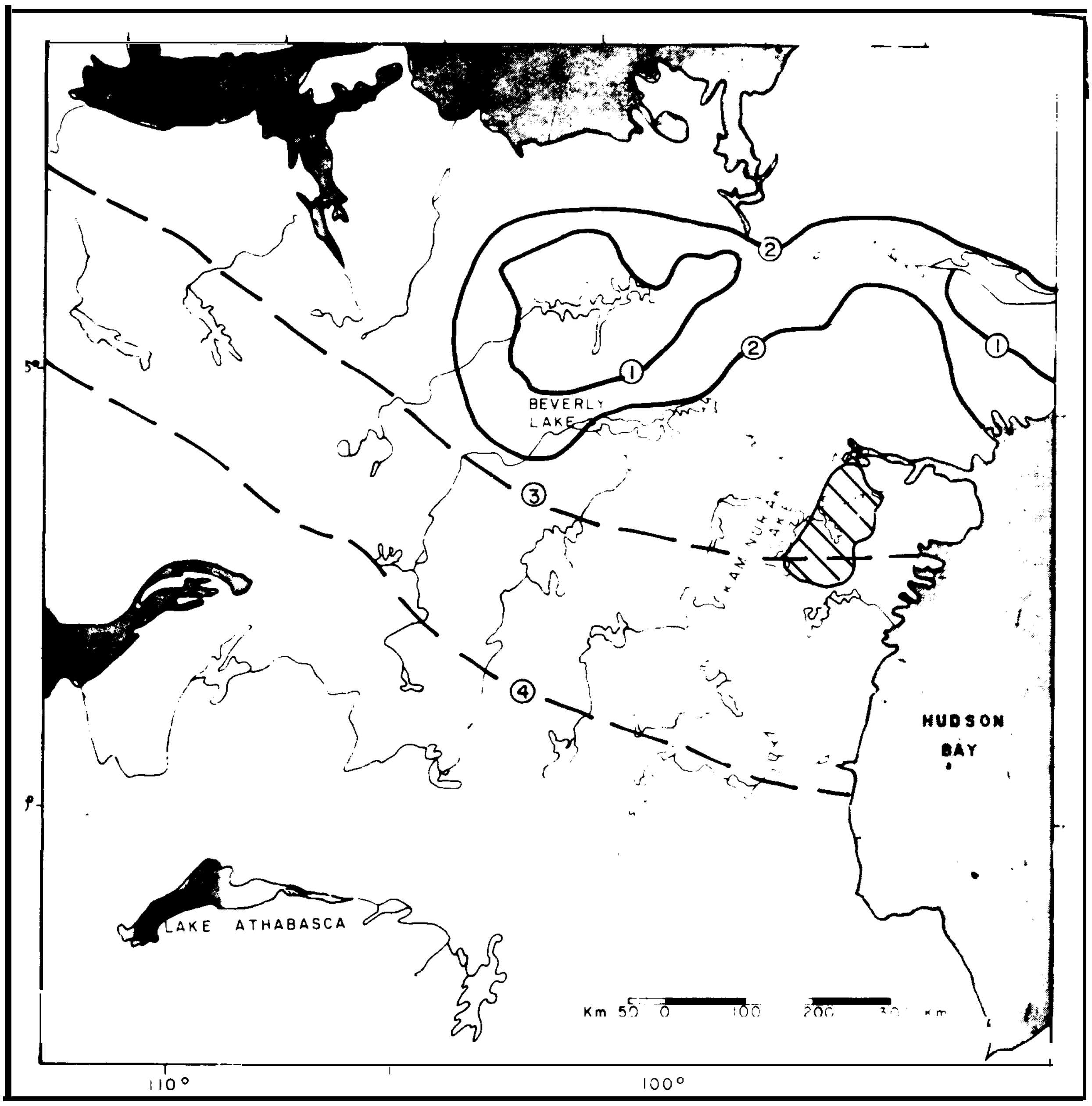
100°

June 8, 1976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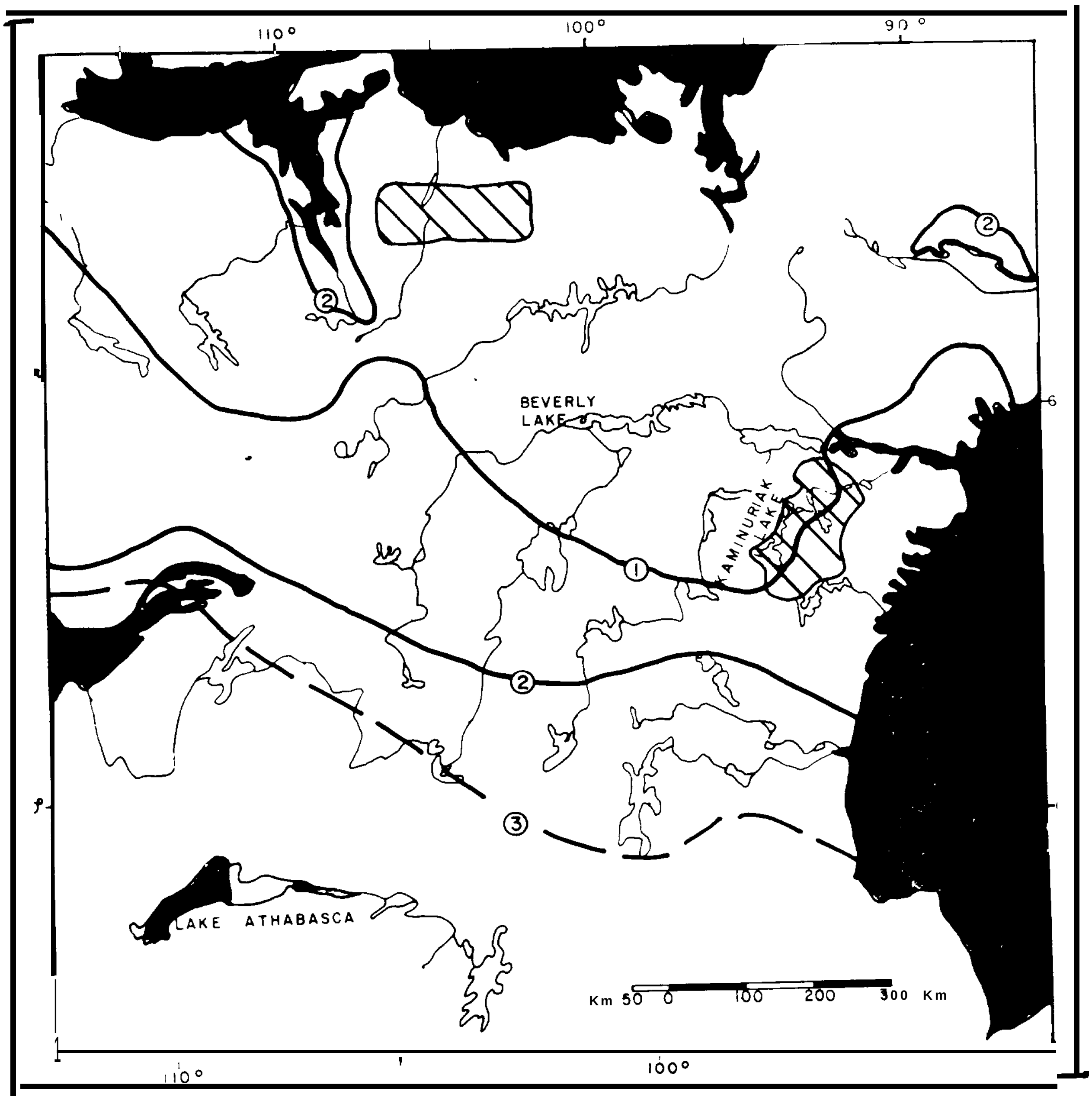
June 14,1976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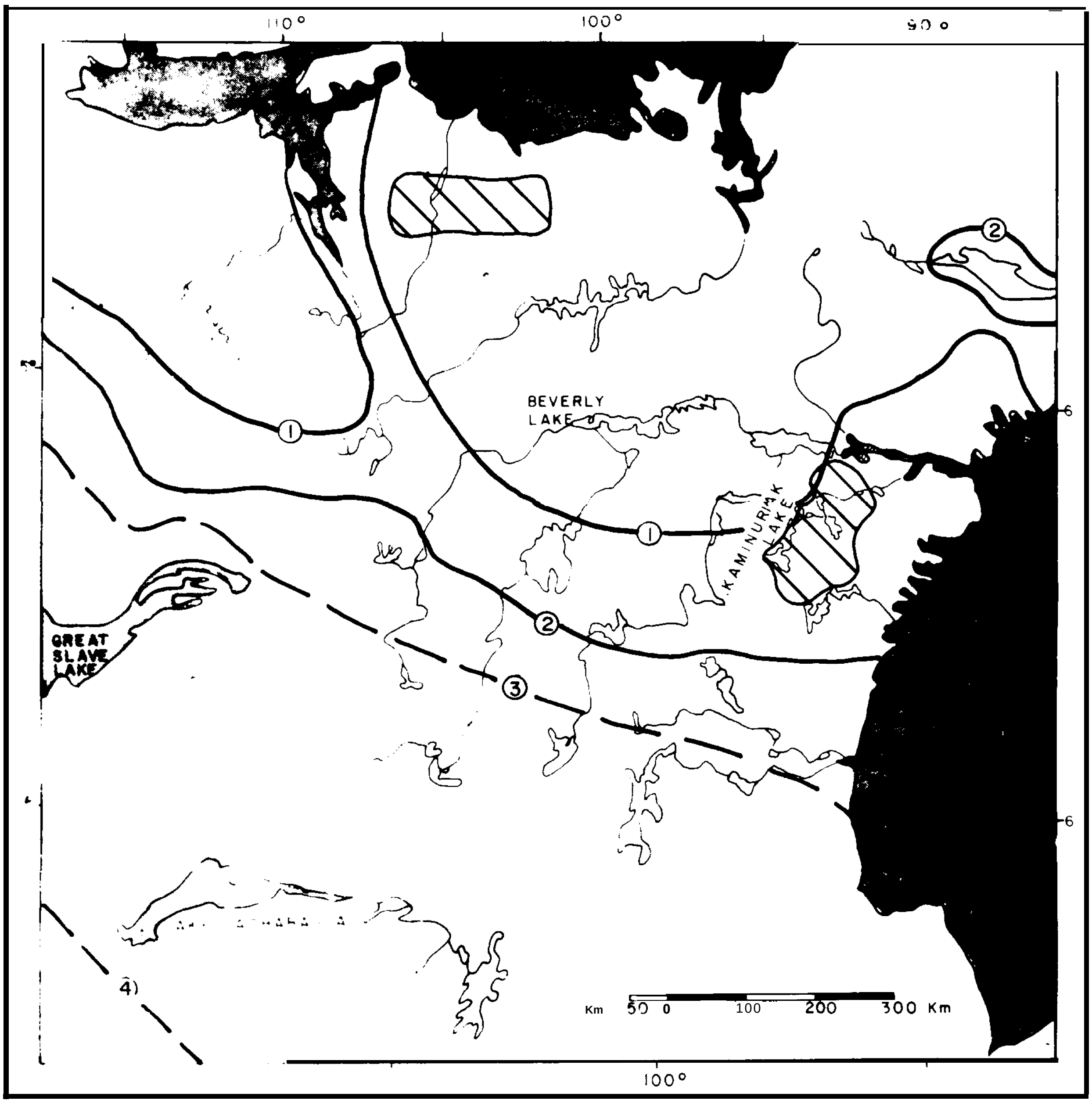
May 16, 1977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BEVERLY
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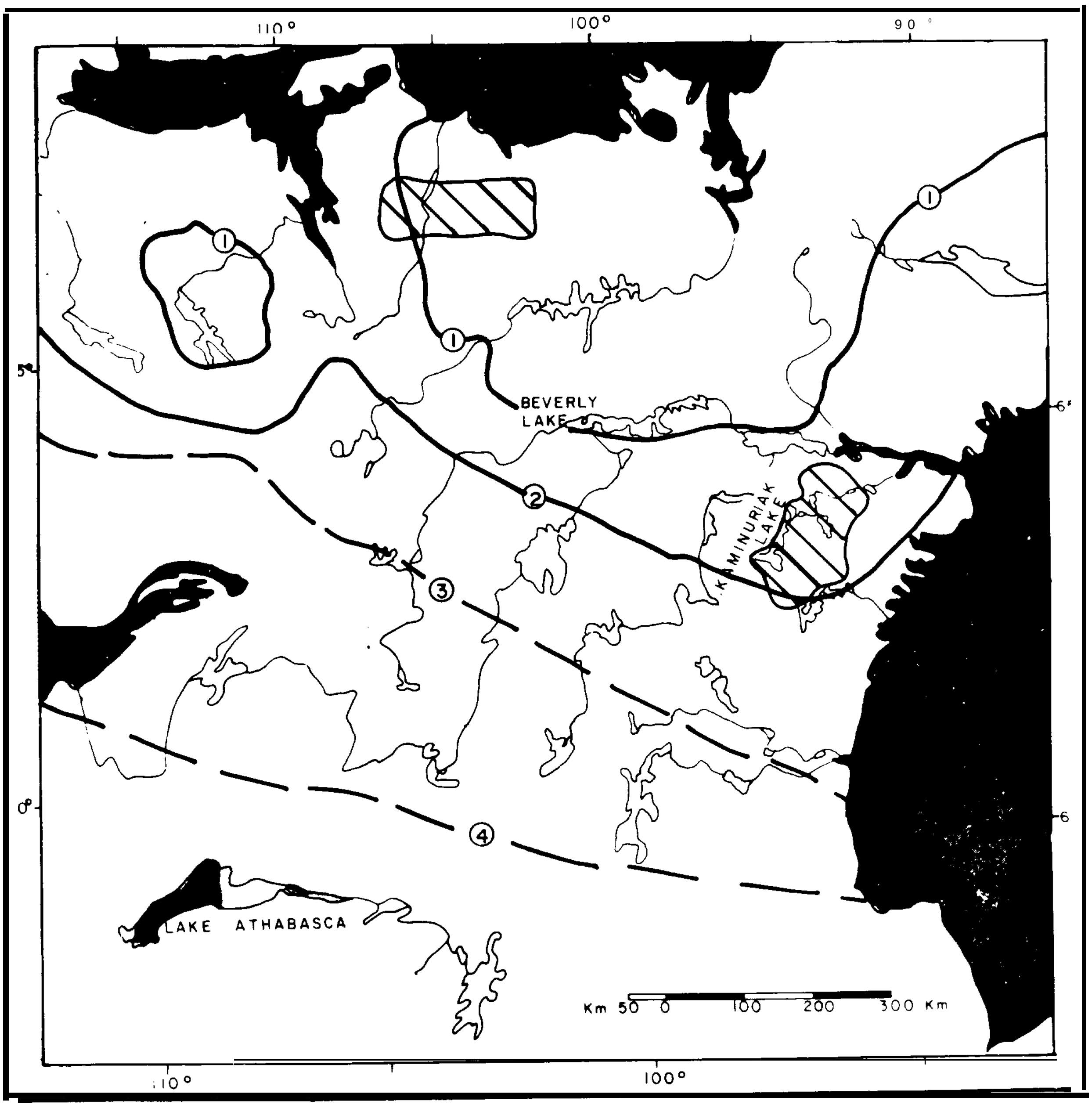
May 23,1977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LAKE ATHABASCA
Km 50 0 100 200 300 Km
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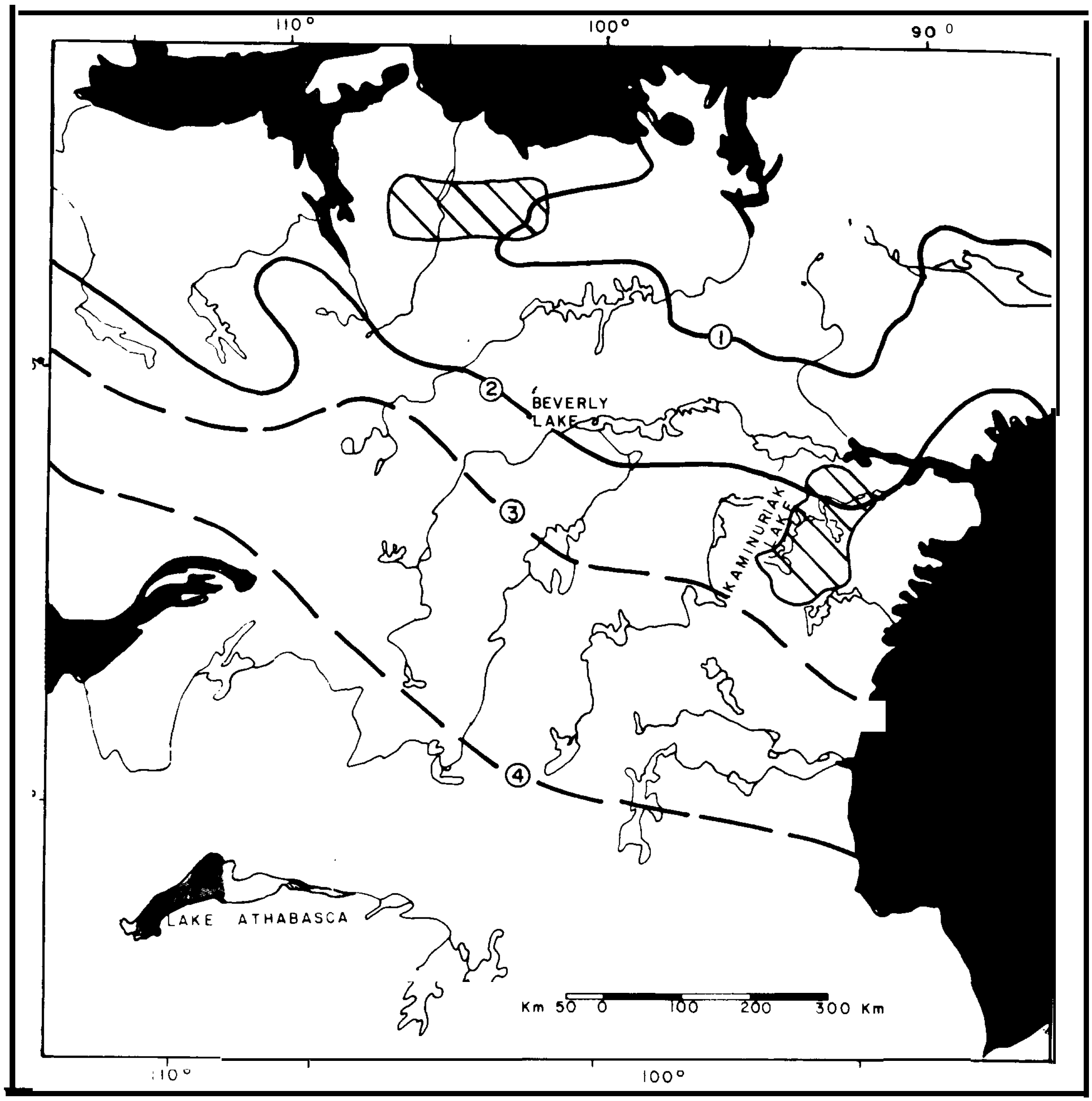
May 29, 1977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KAMINURIAK
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LAKE ATHABASCA
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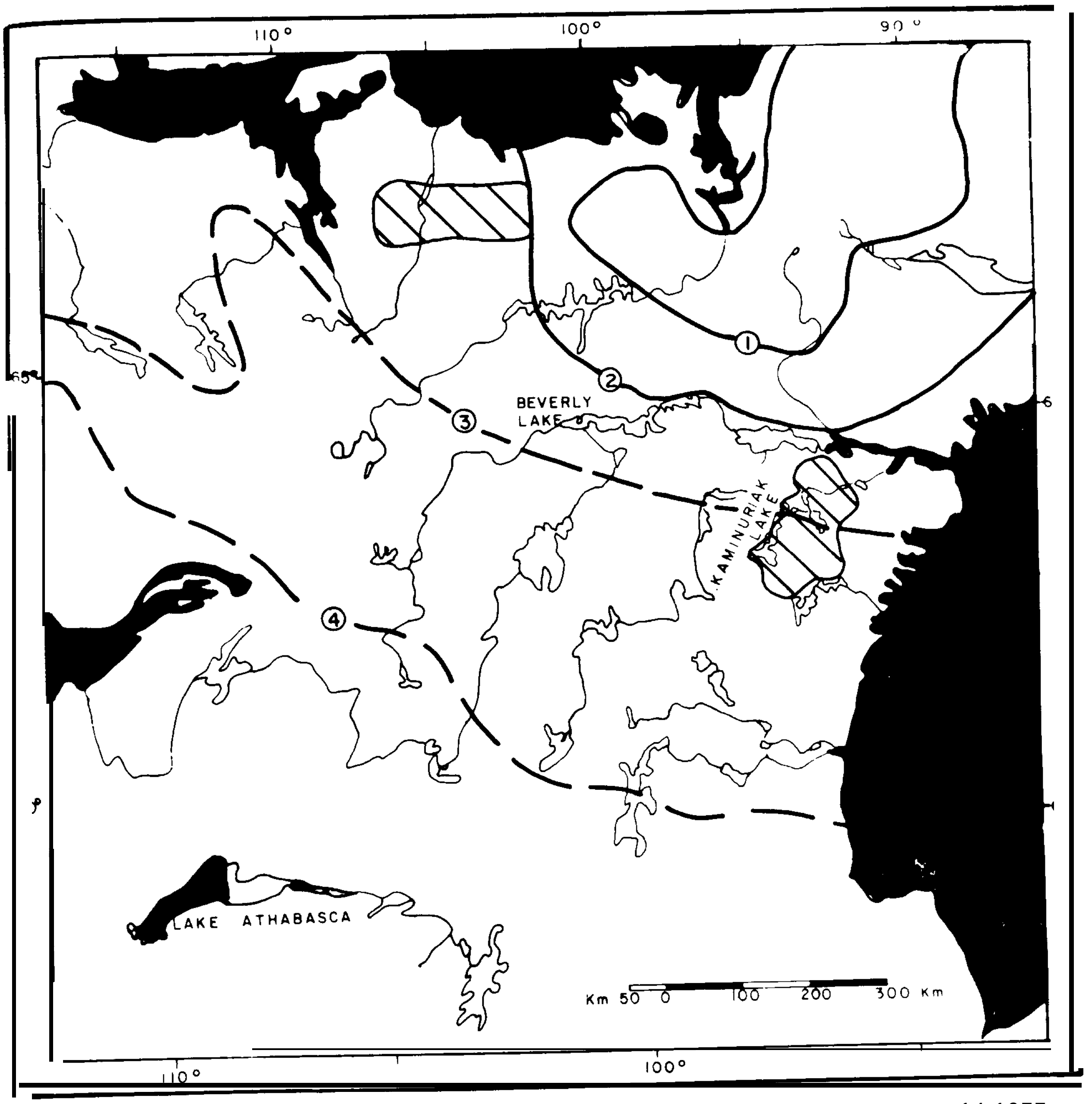
100°

June 6,1977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June 14,1977

APPENDIX B. Snow cover during June 1974, and 1978-1980 from LANDSAT-MSS imagery.

Legend

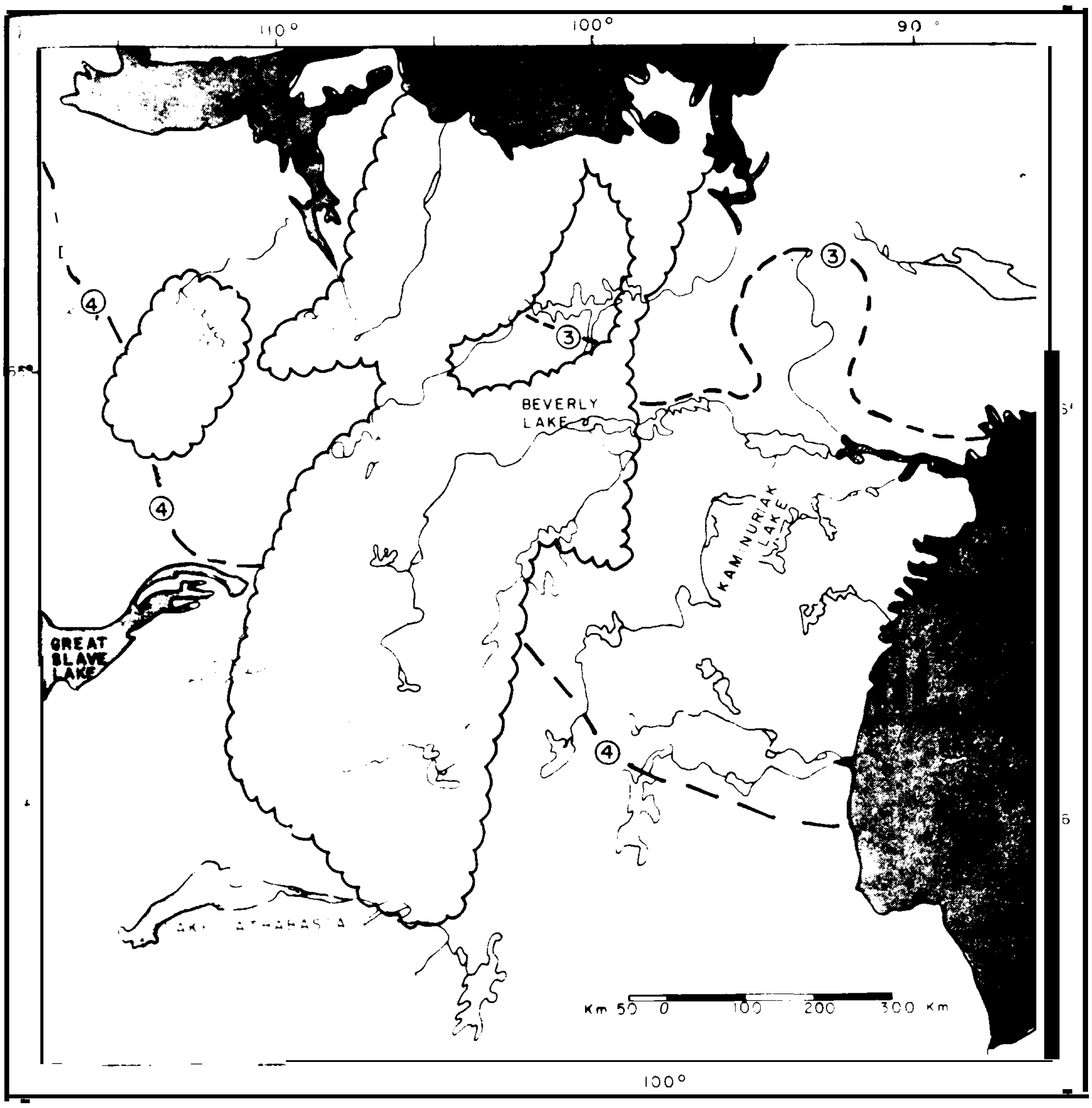
—①— 75+% snow cover

—②— 25-75% snow cover

—③-- snow cover and most lakes frozen

—④-- most lakes open

 persistent cloud cover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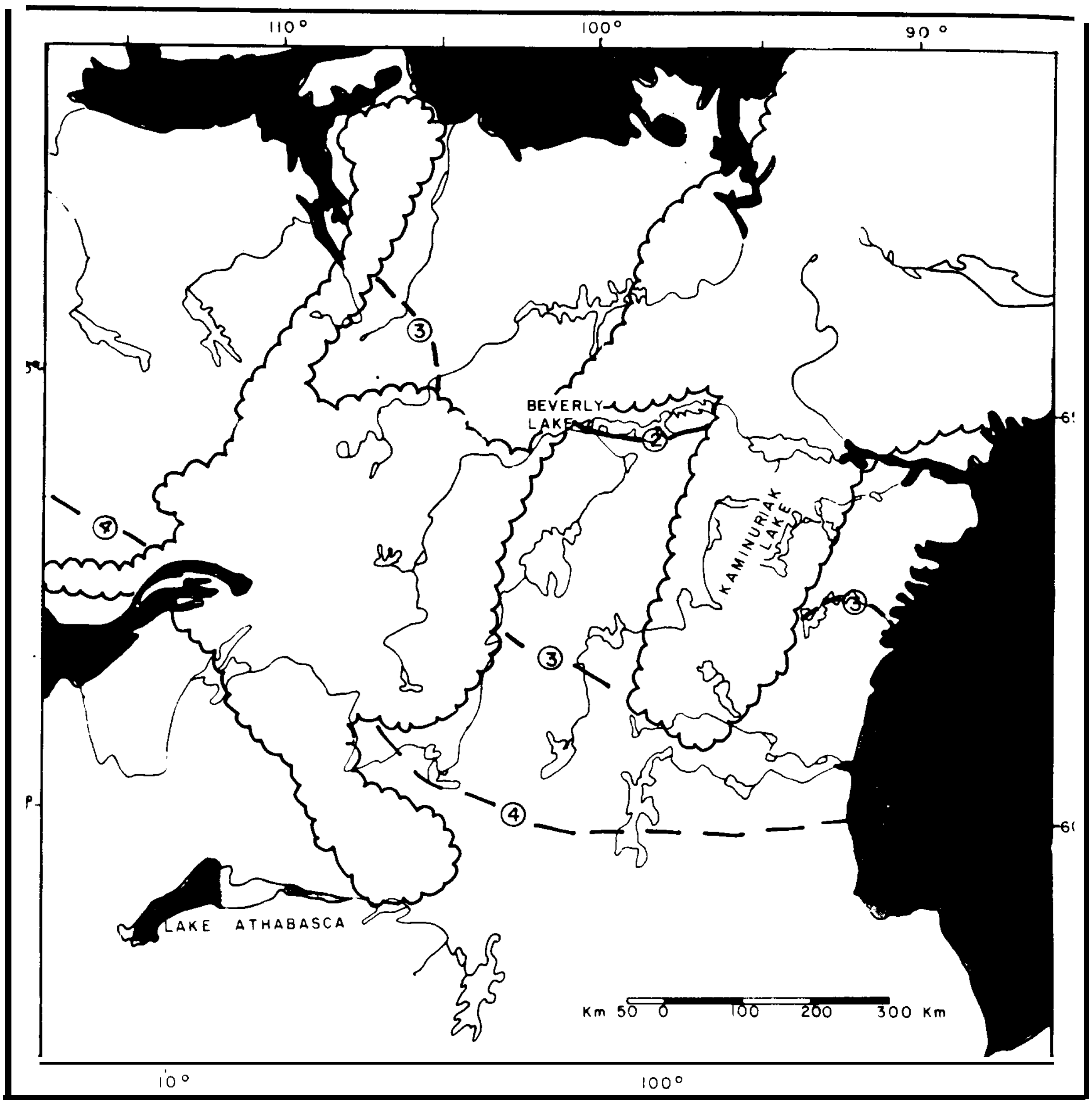
June 17, 1974



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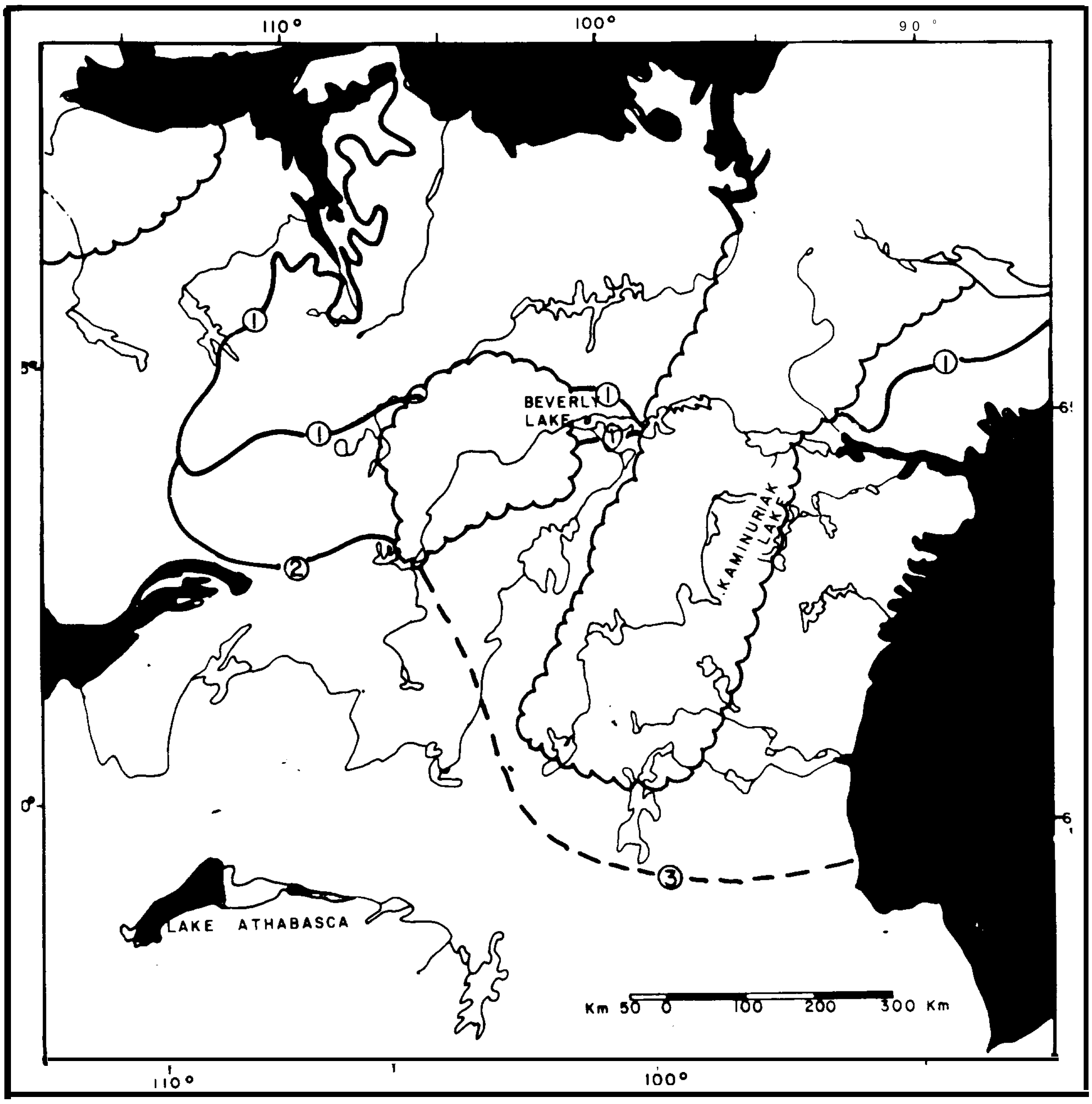
June 23,1978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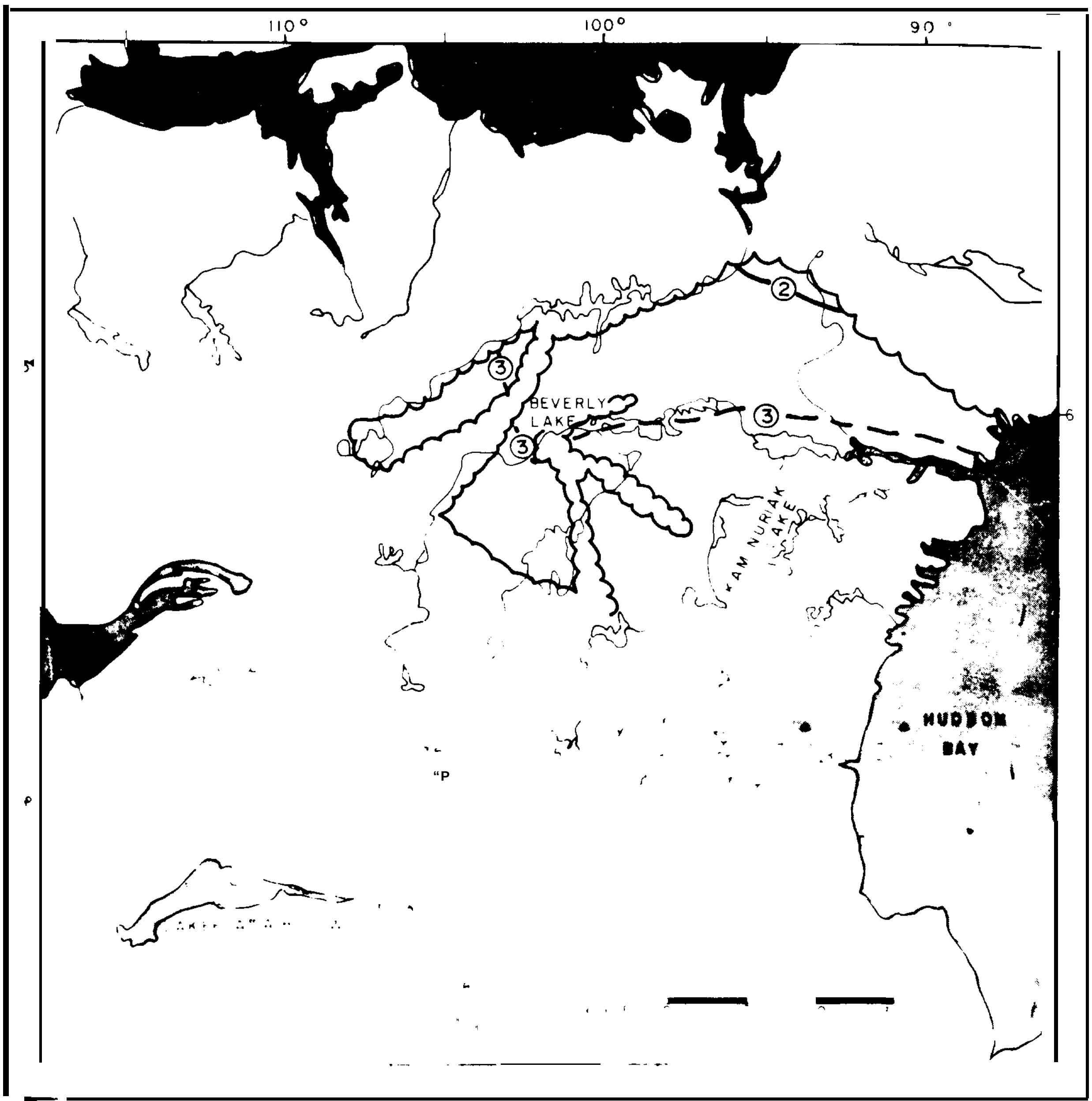
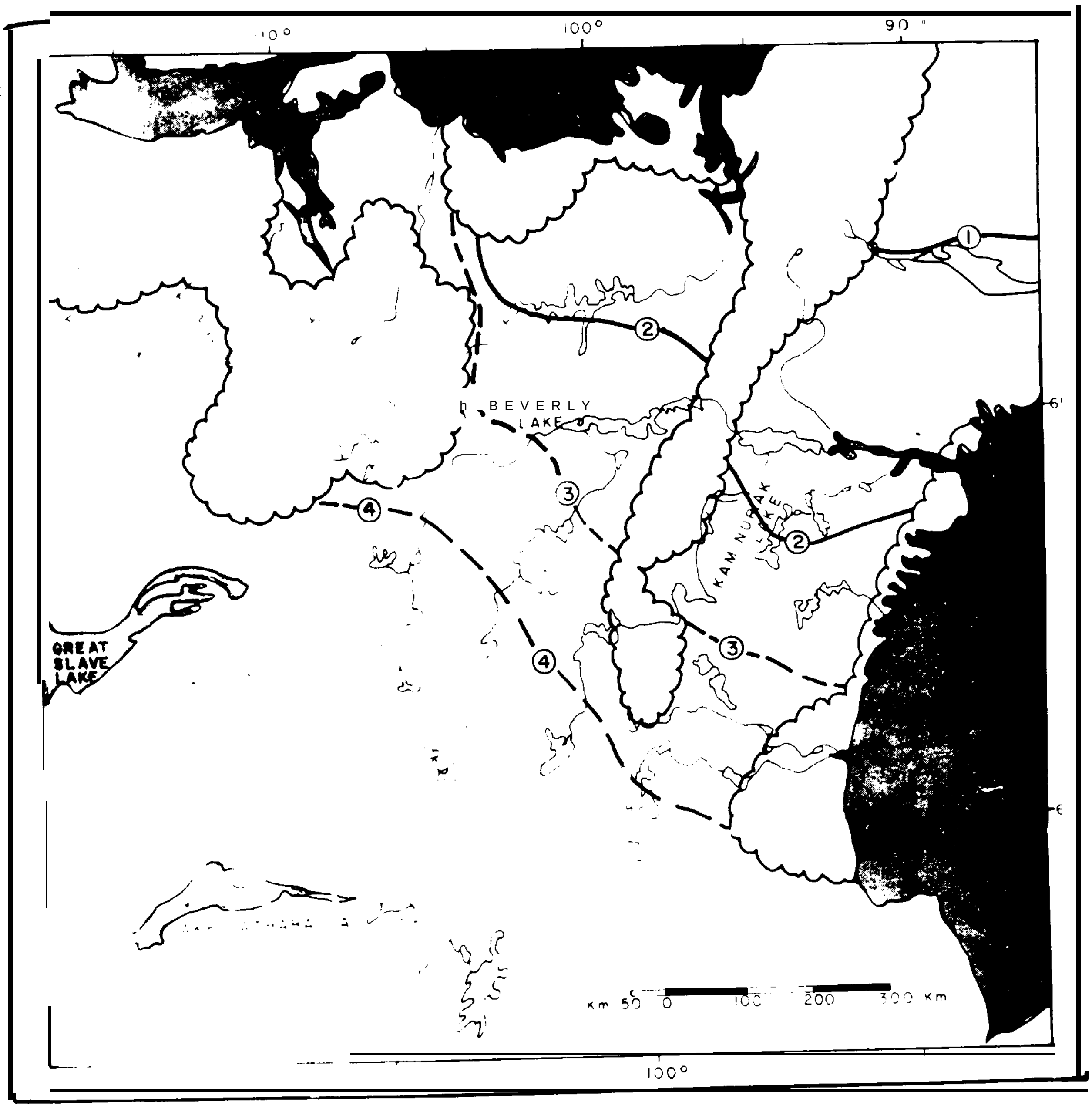
KAMINURIAK LAKE
LAKE ATHABASCA
Km 50 0 100 200 300 Km
110°
100°

June 1, 1979



June 19,1979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BEVERLY LAKE
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Km 50 0 100 200 300 Km
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June 13, 1980

APPENDIX C. Percentage cover, frequency of occurrence and plant species lists of vegetative associations (A-K).

I LICHEN/dwarf shrub

Vegetative Association A
Cornicularia divergens/Alectoria ochroleuca

Site 1: June 21, 1980
Site 3: July 14, 1980

N = 75

Species	Mean % Cover ± S.D.	% Freq. of Occ.	P.V.
Cornicularia divergens	45.6 ± 26.3	96	4'77
Alectoria ochroleuca	21.2 ± 26.3	93	205
Crustose lichens	14.9 ± 14.1	95	145
Ledum decumbens	6.4 ± 9.1	92	61
Vaccinium vitis-idaea	4.5 ± 11.1	59	35
Cetraria nivalis	3.0	65	24
Cetraria cucullata	1.6	63	13
Hierochloe alpina	1.2	52	9
Mosses	1.1	59	8
Luzula confusa	0.1	12	1
Thamnolia vermicularis	0.1	4	1
Stellaria longipes	0.1	1	1
Cladonia spp.	0.1	19	1
Sphaerophorus globosis	0.2	9	1
Empetrum nigrum	0.2	1	1
Cassiope tetragona	0	1	0
Saxifraga tricuspidata	0	1	0
Total vegetation cover	100.3		
Nonvegetated surface	8.1 ± 10.1	88	76

Other species noted in vegetative association:
Alectoria nitidula
Cetraria andreievii
Cetraria delisei
Parmelia separata
Umbilicaria hyperborea
Cladonia pleurota
Cladonia bellidiflora
Pertusaria panyrga
Cladonia gracialis

I LICHEN/dwarf shrub

Vegetative Association B
Alectoria ochroleuca/ Cornicularia divergens

Site 2: July 4, 1980

N = 50

Species	Mean % Cover ± S.D.	% Freq. of Occ.	P.V.
Alectoria ochroleuca	27.8 ± 19.8	90	264
Crustose lichens	19.3 ± 19.5	94	187
Cornicularia divergens	15.8 ± 16.3	72	134
Cetraria spp.	9.4 ± 9.0	92	90
Ledum decumbens	9.4 ± 10.7	80	84
Mosses	10.3	54	76
Cladina stellaris	5.8 ± 9.0	78	51
Cladina mitis	2.8	24	14
Cassipoe tetragona	1.3	28	7
Cladina rangiferina	1.3	18	6
Vaccinium vitis-idaea	1.0	40	6
Hierochloe alpina	1.0	40	6
Dactylina arctica	0.1	6	1
Luzula confusa	0.1	6	1
Thamnolia vermicularis	0.1	24	1
Vaccinium uliginosum	0.2	2	1
Cladonia spp.	0.1	6	1
Sphaerophorus globosis	0	2	0
Lycopodium selago	0	2	0
Carex spp.	0	2	0
Total vegetation cover	105.8		
Nonvegetated surface	3.1	74	27

Other species noted in vegetative association:
Betula glandulosa
Empetrum nigrum
Alectoria nitidula
Cetraria nivalis
Cetraria andrejevii
Cetraria delisei
Parmelia separata
Cladonia bellidiflora
Cladonia gracialis
Sphaerophorus fragilis
Cladonia pocillum

I LICHEN/dwarf shrub

Vegetative Association C
Boulders/crustose lichens

Site 2: July 3, 1980

N = 50

Species	Mean % Cover ± S.D.	% Freq. of Occ.	P.V.
Crustose lichen	34.1 ± 16.8	98	338
Cornicularia divergens	9.7 ± 17.1	48	67
Cladina mitis	7.3 ± 12.2	58	56
Ledum decumbens	6.5 ± 9.1	58	50
Vaccinium vitis-idaea	5.1 ± 8.0	72	43
Alectoria ochroleuca	4.9	66	40
Cetraria spp.	3.4 ± 5.7	74	29
Mosses	1.8	50	13
Empetrum nigrum	2.4	10	8
Hierochloe alpina	1.2	38	7
Umbilicaria spp.	1.0	36	6
Sphaerophorus globosis	0.6	34	4
Cassiope tetragona	0.4	10	1
Cladina rangiferina	0.4	4	1
Xanthoparmelia centrifuga	0.1	4	1
Thamnolia vermicularis	0.2	26	1
Luzula confusa	0.1	8	1
Carex spp.	0	2	0
Cladonia spp.	0	6	0
Cladina stellaria	0	4	0
Total vegetation cover	77.2		
Nonvegetated surface	21.8 ± 17.1	98	338

Other species noted in vegetative association:
Vaccinium uliginosum
Diapensia lapponica
Alectoria nitidula
Cetraria nivalis
Cetraria cucullata
Dactylina spp.
Cetraria andreievii
Parmelia separata
Parmelia omphalodes
Cladina mitis
Cladonia pleurota
Cladonia belliflora
Cladonia amaurocraea
Thamnolia subuliformis
Cladonia umcialis
Cladonia phyllophora
Cladina mitis
Pertusaria dactylina

I LICHEN/dwarf shrub

Vegetative Association D
Cetraria nivalis/Ledum decumbens/Vaccinium vitis-idaea

Site 3: July 14, 1980 N=50

Species	Mean % Cover ± S.D.	% Freq. of Occ.	P.V.
Crustose lichen	29.9 ± 18.8	100	299
Cetraria nivalis	22.5 ± 10.5	98	223
Vaccinium vitis-idaea	10.9 ± 9.2	92	98
Ledum decumbens	11.8 ± 20.9	60	91
Empetrum nigrum	7.3	28	38
Cladina mitis	3.4	68	28
Cetraria cucullata	1.0	46	7
Alectoria ochroleuca	0.6	22	3
Cornicularia divergens	0.2	12	1
Mosses	0.3	22	1
Cladonia spp.	0.0	8	1
Calamagrostis purpurescens	0.7	4	1
Cetraria islandica	0.2	8	1
Luzula confusa	0.2	8	1
Xanthoparmelia centrifuga	0.3	6	1
Hierochloe alpina	0.2	10	1
Arctagrostis latifolia	0	2	0
Umbilicaria spp.	0	6	0
Sphaerephorus globosis	0	2	0
Total vegetation cover	88.9		
Nonvegetated surface	11.0 ± 12.1	90	104

Other species noted in vegetative association:
Cassiope tetragona
Eutrema spp.
Alectoria nitidula
Cetraria laevigata
Cetraria delisei
Parmelia separata
Umbilicaria hyperborea

11 DWARF SHRUB/moss/lichen/short sedge

Vegetative Association E
Vaccinium vitis-idaea/rross
N = 50

Site 3: July 13, 1980

Species	Mean % Cover ± S.D.	% Freq. of ccc.	P.V.
Mosses	40.9 ± 27.1	98	405
Crustose lichen	22.1 ± 18.3	100	221
Vaccinium vitis-idaea	13.2 ± 12.8	88	124
Cetraria spp.	5.9 ± 6.2	98	58
Ledum decumbens	5.6	3A	33
Calamaqrostis purpurescens	4.7	44	31
Dryas inteqrifolia	4.8 ± 10.2	28	25
Carex spp.	2.3 ± 8.6	18	10
Cassiope tetraqona	2.1	10	7
Hierochloe alpina	1.1	32	6
Empetrum niqrum	1.7	10	5
Cornicularia divergens	0.8	10	3
Sphaerophorus qlobosis	0.6	20	3
Salix spp.	0.6	18	3
Luzula confusa	0.3	24	2
Betula qlandulosa	_0.8	6	2
Alectoria ochroleuca	0.2	18	1
Thamnolia vermicularis	0.1	16	1
Arctaqrostis latifolia	0.2	6	1
Cladonia spp.	0.3	22	1
Bryoria pubescens	0.1	2	1
Rhododendron lapponicum	0.1	2	1
*Tofieldia pusilla	0	2	1
Polyqonum viviparum	0	4	0
Cladina mitis	0	2	0
Luzula nivalis	0	2	0
Saussurea anqustifolium	0	2	0
*Armeria maritima	0	4	0
Stellaria lonqipes	0	2	0
Total vegetation cover	100.5		
Nonvegetated surface	6.3 ± 10.3	66	51

Other species noted in vegetative association:

Salix herbacea	Pedicularis labradorica
Salix pseudopolaris	Eutrema spp.
Andromeda polifolia	Saxifraqa hirculus
Vaccinium uliqinosum	*Carex qlacialis
Arctostaphylos rubra	Alectoria nitidula
Silene acaulis	Cetraria niqricans
Saxifraqa tricuspidata	Cetraria cucullata
Saxifraqa roseate	Ochrolechia friqida
Antennaria monocephala	Cetraria ruqricans
Arnica alpinum	Pertusaria panyrqa

* growing on frost boil

II DWARF SHRUB/moss/lichen/short sedge

Vegetative association F
Dryas integrifolia/moss
N = 49

Site 5: July 20, 1980

Species	Mean % Cover ± S.D.	% Freq. of Occ.	P.V.
Mosses	29.2 ± 34.9	69	243
Crustose lichens	18.6 ± 17.2	82	168
Dryas integrifolia	14.3 ± 16.2	61	112
Carex spp.	8.9 ± 14.1	71	75
Ledum decumbens	6.0	22	28
Vaccinium vitis-idaea	3.6 ± 7.6	43	24
Vaccinium uliginosum	4.8212.2	24	24
Cetraria spp.	3.2 ± 5.1	57	24
Empetrum nigrum	3.5	18	15
Salix spp.	1.6	34	9
Sphaerophorus globosis	1.9	16	8
Cassiope tetragona	1.5	18	6
Hierochloe alpina	1.0	29	5
Cornicularia divergens	0.6	12	2
Arctagrostis latifolia	0.2	4	1
Thamnolia vermicularis	0.2	31	1
Alectoria ochroleuca	0.3	12	1
Silene acaulis	0.2	16	1
Betula glandulosa	0.2	6	1
Potentilla spp.	0.1	6	1
Calamagrostis purpurescens	0.2	4	1
Astragalus alpinus	0	4	0
Saussurea augustifolium	0	12	0
Umbilicaria spp.	0	8	0
Polygonum viviparum	0	8	0
Luzula confusa	0	4	0
Armeria maritima	0	2	0
Cladina mitis	0	2	0
Oxytropis Maydelliana	0	2	0
*Saxifraga oppositifolia	0	2	0
Stellaria longipes	0	2	0
Total vegetation cover	99.8		
Nonvegetated surface	15.1 ± 21.4	69	125

Other species noted in vegetative association:

Salix arctica
Salix reticulate
Rhododendron lapponicum
Andromeda polifolia
*Tofielda pusilla
Tofielda coccinea
*Antennaria monocephala
Cardamine hyperborea
Saxifrac7a cernua
Arctostaphylos rubra
Lycopodium selago
*Carex glacialis
Alectoria nitidula
Alectoria ochroleuca
Cetraria nivalis
Cetraria cucullata
Dactylina spp.

* growing on frost boils

11 DWARF SHRUB/moss/lichen/ short sedge

Vegetative Association G
Carex spp./Dryas integrifolia/moss

Site 4: July 18, 1980
Site 5: July 21, 1980

N = 50

Species	Mean % Cover ± S.D.	% Freq. of Occ.	P.V.
Mosses	"79.8 ± 23.9	100	798
Carex spp.	36.0 ± 23.3	100	360
Dryas integrifolia	17.8 ± 13.7	92	1.71
Salix spp.	5.4 ± 7.8	70	45
Vaccinium uliginosum	2.6	42	17
Cetraria cucullata	1.2	64	10
Rhododendron lapponicum	1.6	28	8
Crustose lichens	1.6	22	8
Cassiope tetragona	1.5	22	7
Cetraria nivalis	0.8	38	5
Oxytropis Maydelliana	0.9 ± 2.4	22	4
Betula glandulosa	2.5	16	3
Thamnolia vermicularis	0.5	42	3
Polygonum viviparum	0.3	26	2
*Astragalus alpinus	0.6	12	2
Vaccinium vitis-idaea	0.2	16	1
Cladina rangiferina	0.3	6	1
Arctagrostis latifolia	0.2	10	1
Saussurea angustifolium	0.2	8	1
Calamagrostis purpurescens	0.1	4	1
Cladina mitis	0	10	0
Dactylina arctica	0.1	12	1
Armeria maritima	0	2	0
Sphaerophorus globosis	0	2	0
Peltigora spp.	0	4	0
Stellaria longipes	0	4	0
Luzula nivalis	0	2	0
Cladonia spp.	0	2	0
*Tofieldia pusilla	0	8	0
*Silene acaulis	0	2	0
Total cover	154.2		
Nonvegetated surface	0.6	8	2

Other species noted in vegetative association:

Salix herbacea	Salix planifolia	Poa Spp.
Salix reticulate	Arctostaphylos rubra	Eriophorum angustifolium
Salix arctica	Pyrola grandiflora	Carex misandra
Andromeda polifolia	Cardamine hyperborea	Carex glacialis
Cruciferae spp.	Pedicularis sudetica	Alectoria nitidula
Castilleja spp.	Pedicularis lapponica	Alectoria ochroleuca
Hierochloe alpina	Pedicularis lanata	Cetraria cucullata
Salix arctophila	*Saxifraga oppositifolia	Cetraria laevigata

* growing on frost boils

III LOW SHRUB/moss/ short sedge/ dwarf shrub

Vegetative Association H
Betula glandulosa/moss/Carex spp.
N = 50

Site 4: July 19, 1980

Species	Mean % Cover ± S.D.	% Freq. of Occ.	P.V.
Mosses	79.7 ± 25.6	100	717
Carex spp.	29.1 ± 29.5	%	285
Betula glandulosa	24.8 ± 28.8	76	215
Salix spp.	6.5 ± 10.1	72	72
Dryas integrifolia	4.5	44	30
Vaccinium uliginosum	2.6 ± 5.8	36	16
Cassiope tetragona	2.6	10	8
Crustose lichens	2.3	32	13
Cetraria cucullata	0.8	38	5
Arctagrostis latifolia	0.7	14	3
Vaccinium vitis-idaea	0.6	22	3
Oxytropis Maydelliana	0.6	10	2
Astragalus alpinus	0.5	14	2
Cetraria nivalis	0.5	32	3
Saussurea angustifolia	0.3	18	1
Silene acaulis	0.2	10	1
Eriophorum angustifolium	0.2	14	1
Thamnolia vermicularis	0.2	8	1
Peltigera spp.	0.2	2	1
Dactylina arctica	0.2	12	1
Polygonum viviparum	0.1	16	1
Cetraria islandica	0.1	8	1
Sphaerophorus globosis	0.1	4	1
Cladinia mitis	0.1	4	1
Cladonia spp.	0	2	0
Lycopodium selago	0	2	0
Total vegetation cover	157.3		
Nonvegetated surface	0.8	10	3

Other species noted in vegetative association:

Salix glauca
Salix herbacea
Salix arctica
Salix reticulate
Salix planifolia
Andromeda polifolia
Ledum decumbens
Artemesia borealis
Armeria maritima
Stellaria longipes
Pedicularis sudetica
Pedicularis lapponica
Hierochloe alpina
Alectoria nitidula
Alectoria ochroleuca

IV. Tussock-short sedge-dwarf shrub-lichen-moss
Vegetative Association I
Eriophorum spp.-Carex spp. -mosses-Vaccinium vitis-idaea

Site 1: June 22, 1980 N=75

Species	Mean % Cover ± S.D.	% Freq. of Occ.	P.V.
Sedges	43.7 ± 34.2	76	381
Mosses	34.5 ± 34.1	85	318
Vaccinium vitis-idaea	12.4 ± 13.8	75	107
Ledum decumbens	7.7 ± 10.8	57	58
Alectoria ochroleuca	6.5 ± 12.7	49	46
Cornicularia divergens	7.4 ± 15.2	33	43
Cetraria spp.	4.8 ± 7.6	75	42
Crustose lichen	3.2	35	19
Cladina rangiferina	2.5	16	10
Calamagrostis purpurescens	1.6	9	5
Hierochloe alpina	0.7	12	2
Cladonia spp.	0.2	24	1
Cladina stellaria	0.2	7	1
Rubus chamaemorus	0.1	5	1
Luzula confusa	0.1	4	1
Sphaerophorus globosis	0.3	4	1
Cladina mitis	0.3	15	1
Pedicularis spp.	0	1	0
Peltigera spp.	0	1	0
Total vegetative cover	125.6		
Nonvegetated surface	0.8	24	4

Other species noted in vegetative association:

Betula glandulosa
Andromeda polifolia
Eriophorum callitrix
Eriophorum vaginatum
Eriophorum angustifolium
Alectoria nitidula
Cetraria nivalis
Cetraria cucullata
Siphula ceratites

V TUSSOCK/moss

Vegetative Association J
Eriophorum vaginatum/Carex spp./moss

Site 2: July 4, 1980
Site 3: July 14, 1980

N = 50

Species	Mean % Cover ± S.D.	% Freq. of Occ.	P*V.
Sedges	80.1 ± 13.9	100	801
Mosses	51.8 ± 32.6	92	497
Salix spp.	1.5 ± 3.1	64	12
Crustose lichens	1.8	12	6
*Dryas integrifolia	1.3	18	6
*Vaccinium vitis-idaea	0.8	4	2
*Betula gladulosa	0.3 ± 1.4	20	1
*Cassiope tetragona	0.7	2	1
*Vaccinium uliginosum	0.2	6	1
*Andromeda polifolia	0.1	2	1
Potentilla palustris	0.2	14	1
Polygonum viviparum	0.1	26	1
Arctagrostis latifolia	0.2	2	1
Empetrum nigrum	0.1	2	1
Cladina mitis	0.1	2	1
*Cetraria nivalis	0.1	2	1
*Ledum decumbens	0	6	0
Pedicularis spp.	0	12	0
Saxifraga hirculus	0	2	0
*Cetraria cucullata	0	6	0
Dactylina arctica	0	2	0
Total vegetative cover	139.4		
Nonvegetated cover	1.4	18	6

Other species noted in vegetative association

*Salix arctica
*Salix herbacea
Pedicularis labrodorica
*Pedicularis lapponica
Pedicularis sudetica
*Eriophorum vaginatum
*Alectoria nitidula
*Alectoria ochroleuca
Cladonia pleurota
Cladonia amaurocraea
*Salix arctophila
*Salix reticulate
*Saxifraga hieracifolia
*Rubus chamaeomorus
*Cardamine hyperborea
*Hierochloe alpina
Eriophorum angustifolium

* growing on tussocks

VI TALL SEDGE/moss

Vegetative association K
Carex spp./moss

Site 1: June 22, 1980
Site 5: July 20, 1980

N=50

Species	Mean % Cover ± SOD.	% Freq. of Occ.	I?. V.
Sedges	79.8 ± 19.4	100	798
Mosses	68.6 ± 36.4	98	619
Salix spp.	3.0 ± 5.2	48	21
Potentilla palustris	0.5	30	3
*Betula glandulosa	0.4	8	1
Polygonum viviparum	0	8	0
Ledum decumbens	0	4	0
*Andromeda polifolia	0	2	0
*Vaccinium vitis-idaea	C	2	0
Luzula spp.	0	2	0

Total vegetation cover 152.3

Nonvegetated surface 0

Other species noted in vegetative association:

Salix herbacea
Salix arctophila
Salix arctica
Empetrum nigrum
Vaccinium uliginosum
Luzula wahlenbergii
*Eriophorum angustifolium
*Cetraria nivalis
*Cetraria cucullata
Dactylina spp.
Cetraria andreievii
Umbilicarea hyperborea
Salix planifolis
*Pinguicula borealis
*Pyrola grandiflorum
Pedicularis sudetica

* growing on tussocks

APPENDIX D. Scientific and common names of vascular plants collected on the Beverly calving grounds.

Scientific Name	Common Name
Andromeda polifolia	bog rosemary
Antennaria monocephala	pussy toes
Arctostaphylos rubra	bearberry
Armeria maritima	thrift
Arnica alpina	—
Artemesia borealis	wormwood
Astragalus alpinus	milkvetch
Betula glandulosa	dwarf birch
Cardamine hyperborea	bittercress
Cassiope tetragona	heath
Castilleja spp.	paintbrush
Diapensia lapponica	--
Dryas integrifolia	dryas
Empetrum nigrum	crowberry
Eutrema edwardsii	—
Ledum decumbens	labrador tea
Lycopodium selago	club moss
Oxytropis Maydel liana	locoweed
Pedicularis labradorica	lousewort
P. lanata	woolly lousewort
P. lapponica	lousewort
P. sudetica	lousewort
Polygonum viviparum	smartweed
Potentilla palustris	marsh cinquefoil
Potentilla spp.	cinquefoil
Pyrola grandiflora	wintergreen
Rhododendron lapponicum	lapland rosebay
Rubus chamaemorus	cloudberry
Salix arctica	willow
S. arctophila	willow
S. glauca	willow
S. herbacea	willow
S. planifolia	willow
S. pseudopolaris	willow
S. reticulate	netted willow
Saussurea angustifolia	--
Saxifraga cernua	bulblet saxifrage
S. hieracifolia	stiff-stemmed saxifrage
S. hirculus	bog saxifrage
S. oppositifolia	purple saxifrage
S. roseate	saxifrage
S. tricuspidata	prickly saxifrage
Silene campion	moss tampion
Stellaria longipes	chickweed
Tofieldia coccinea	false asphodel
T. pusills	false asphodel
Vaccinium uliginosum	blueberry
V. vitis-idaea	bog cranberry