WILDLIFE MANAGEMENT BULLETIN

DEPARTMENT OF NORTHERN AFFAIRS
AND NATIONAL RESOURCES
NATIONAL PARKS BRANCH
CANADIAN WILDLIFE SERVICE
OTTAWA

SERIES I NUMBER 12

FEBRUARY 1957

CANADA
DEPARTMENT OF
NORTHERN AFFAIRS AND NATIONAL RESOURCES
NATIONAL PARKS BRANCH
CANADIAN WILDLIFE SERVICE

CONTINUED BARREN-GROUND CARIBOU STUDIES

by

John P. Kelsall

WILDLIFE MANAGEMENT BULLETIN
SERIES 1 NUMBER 12

Issued under the authority of
The Minister of Northern Affairs and National Resources

OTTAWA

1957

86629—1

CONTENTS

86629—1½

.....

Wildlife Management Bulletins are produced to make available to wildlife administrators the information contained in reports which are submitted by officers of the Canadian Wildlife Service.

The reports do not, in most cases, cover extensive studies and are not written primarily for publication. Recommendations arising from the studies are not included.

INTRODUCTION

The preliminary barren-ground caribou investigation was undertaken during 1948 and 1949 under the leadership of Dr. A.W.F. Banfield. The report on this phase of the study (Banfield, 1950) was published as a Wildlife Management Bulletin in 1954. It brought together all the previously published information on the barren-ground caribou and presented for the first time a unified account of the biology of the subspecies and its utilization as an important northern wildlife resource.

Before the completion of the initial phase it was clearly recognized that the study should continue. Annual data were needed for management purposes, and much research remained to be undertaken. It was decided to reduce the financial allotment and confine future operations to four herds with differing numerical and economic status. Yellowknife was chosen as a base because of its concentration of transportation facilities and its closeness to the winter ranges of the four herds.

The present report presents the data gathered from February, 1950, when the writer undertook field investigations, until March 31, 1953. The report has a two-fold objective: first, to present data on the annual movements of the herds studied intensively since 1950, to establish whether they were as independent as outlined by Banfield; and second, to present additional research data on the biology and utilization of the caribou, gathered to form a basis for a management plan.

ACKNOWLEDGMENTS

Many agencies and persons assisted the caribou investigation during the continuing phase. The game branches of the three Prairie Provinces arranged the collection and forwarding of information about the herds in their respective provinces. Active assistance and advice was received from the Advisory Committee on the Barren-Ground Study. Other organizations whose representatives co-operated were the Canadian Army, the Royal Canadian Air Force, the Royal Canadian Mounted Police, the Defence Research Board, the Department of Citizenship and Immigration, the Department of Transport, and the Hudson's Bay Company. Free transportation

was provided by bush pilots for more than 10,000 air miles of travel during which much valuable information was secured.

Hospitality and assistance, often purely voluntary, was received from Indians, Eskimos, white trappers, missionaries, teachers, traders, and others. These were too numerous to be mentioned by name, but the author is warmly grateful.

ITINERARY

Banfield (1954, Pt. I, p.7) has outlined the writer's activities during February, 1950. On April 15 of that year the writer again left Ottawa, to attempt the observation of caribou calving and to devote the field season to gathering information on caribou and other wildlife in the central Arctic mainland. Between April 19 and May 11 one short flight was made northward of Yellowknife and two extended trips to the Arctic Coast. En route, Indin, Hottah, and Contact Lakes, Port Radium, Read Island Post on Victoria Island, and Coppermine were visited.

E.H. McEwen, summer assistant, arrived on May 9, and on May 11 the two investigators flew to Bathurst Inlet (Map No. 1). Until September 5 the area around the inlet was worked from a base camp a few miles south of the Hudson's Bay Company post at Burnside Harbour. During the summer, aerial surveys were made of the Arctic Sound and Bathurst Inlet areas. After the break-up of the sea ice extensive canoe trips were undertaken between the mouth of Western River in the south and Banks Peninsula in the north.

Shortly after his return to Ottawa on September 11, 1950, the writer was officially placed in charge of the investigation. He reached Yellowknife to take up residence there on December 4, after visits in western provincial capitals, for discussion of matters connected with the investigation.

Seventeen field trips were made between December 9, 1950, and May 30, 1951. Seven of these were one-day flights from Yellowknife. In three flights before December 31, Fort Rae, Hottah Lake, Sawmill Bay, Grizzly Bear lumber camp, Port Radium, Coppermine, Bathurst Inlet, Cambridge Bay, Perry River, and Sherman Inlet were

visited. From January 18 to 27 ground patrols were carried out in the Fish Lake area (lat. 63.8' N., long. 122 W.). For this purpose the party, which included Earl Bulmer, the Yellowknife game warden, and his patrolman, Ben Lafferty, was transported to and from the area by aircraft. During February and March a very wide area in the Central Arctic was covered. A joint caribou-musk-ox survey in which J.S. Tener participated covered mainly the Arctic Sound-Bathurst Inlet area, the country between Great Bear Lake and Darnley Bay, and the Thelon River valley northeast as far as Beverly Lake. Extensive flying was also done over the winter ranges of the Rae and Yellowknife herds and one flight was made over the ranges of the Great Bear and Radium herds. Fort Rae, Port Radium, Fort Wrigley, Fort Norman, Fort Simpson, Fort Reliance, Paulatuk, Coppermine, and Bathurst Inlet were visited or flown over. In April, a courtesy flight to Cambridge Bay was provided by the Royal Canadian Air Force, the return via Bathurst Inlet being made in a Royal Canadian Mounted Police Norseman.

During May, Fort Smith was visited briefly for discussions with W.A. Fuller, and Nolan Perret arrived to act as summer assistant. Late in the month Perret and the writer participated in extensive search for a missing pilot, making useful observations in areas where summer field work was to be done.

Early in June, 1951, six small caches were planted inland from Burnside Harbour by means of aircraft. During a walking trip between caches later in the month, caribou calving was observed (Map No. 2). The two observers flew back to Yellowknife on July 2, and on July 17 were set down at the junction of the Thelon and Hanbury Rivers. A month was spent on a canoe trip down the Thelon to Baker Lake. They were picked up by aircraft on August 19, conducted a survey for caribou and musk-oxen while flying between Baker Lake and Fort Reliance, and reached Yellowknife on August 20.

During the winter of 1951-52 the writer was absent on educational leave. Alan G. Loughrey was appointed to the caribou investigation for this period, and between December 10, 1951, and May 14, 1952, made 13 trips from Yellowknife, covering more than 10,000 miles. He was assisted in some of his work by D.R. Flook and by T.G. Douglas, then warden at Yellowknife. On two flights during December he visited Fort Rae, Hottah Lake, Port Radium, and Norman Wells, and surveyed the north shore

of Great Bear Lake. In January he made a trip by dog team to the islands in the east arm of Great Slave Lake and surveyed the Blackwater Lake and O'Connor Lake areas from the air. Late in the month he flew with an Indian companion and a dog team to the Blackwater Lake area and did ground work there until February 5.

In February he surveyed by air north and east of Fort Reliance and again visited the islands in the east arm, this time by snowmobile. J.S. Tener arrived on March 11, and a second joint caribou-musk-ox survey was carried out, ending on March 19. From March 25 to 31, Loughrey did extensive flying over the Great Bear and Radium herds, visiting Norman Wells, the north shore of Great Bear Lake, Port Radium, Grizzly Bear lumber camp, and the Snare River hydro camp. In April he made flights to Fort Rae, Fort Providence, and Fort Simpson, and in early May a survey flight to the Lac la Martre and Ghost Lake areas.

The writer resumed work at Yellowknife on May 10, 1952. W.I. Campbell, the summer assistant for that year, arrived on May 14. During that month two flights were made over the winter ranges of the Rae and Yellowknife herds to select areas for summer field work (Map No. 3). Stops at Fort Wrigley, Fort Rae, and Gros Cap were made.

On May 5 Campbell and the writer were flown to Keller Lake, which was explored by canoe. Range studies of various forest types in this area occupied about two weeks. Similar studies were carried out on the islands in the east arm of Great Slave Lake, June 22 to July 2.

From July 10 to August 4 the writer was absent attending the annual reindeer round-up, visiting Aklavik, the Reindeer Station, the summer herd camp at Kidluit Bay, and various native herd camps. On his return to Yellowknife, he made a canoe trip to Fort Rae with Warden A. Brown to make arrangements for later field work. On August 20 and 21 he accompanied pilot Ernie Boffa on a flight to pick up J.S. Tener and his assistant at Beverley Lake in the Thelon Game Sanctuary. On September 3, Campbell and the writer surveyed the Winter Lake area from the air and established a camp at Aurora Lake for a week's ground work. The aircraft returned on September 10 and extensive survey work was done south as far as the Snare Hydro development and north to Rawalpindi Lake. A second camp was then established at Roundrock Lake and this area was worked until the return to Yellowknife on September 17. Campbell then terminated his term of

service. During October the writer accompanied D. R. Flook and J. P. Richards on a beaver survey in the Lac la Martre area, and attended a six-day game conference at Fort Smith.

Fourteen field trips, involving 36 days absence from Yellowknife, were made between December 1, 1952, and March 31, 1953. In December, a trip was made to Salamita Mine at Courageous Lake. Coppermine, Port Radium, Hottah Lake, the Keller Lake and Blackwater Lake areas, Fort Rae, Hay River, Fort Resolution, Gros Cap, and the islands in the east arm of Great Slave Lake were reached on one long and three short flights during January.

During February the writer, accompanied by E.H. McEwen, flew out of Norman Wells, covering some 2,500 miles north and south of Great Bear Lake. A herd of more than 90 musk-oxen north of the lake was seen for the first time during this survey. Port Radium and Paulatuk were visited, and a great deal of country in the Colville Lake and Indian River areas, hitherto uninvestigated, was surveyed. Late in the month two more flights were made to investigate caribou wintering in the vicinity of Yellowknife.

More than 6,000 miles were covered by survey flying in March, including 2,500 miles on a musk-ox survey. This survey involved flights to Fort Reliance and to Baker Lake and return via Muskox Lake. En route, an intensive strip survey was flown east of Beverly Lake, between the Back and Thelon Rivers. Warden A. Brown and the pilot, Dave Floyd, were of great assistance in completing the survey in three days, March 9 to 11. Later in the month a gasoline cache was placed on a lake 250 miles northwest of Yellowknife and used during extensive surveying of the winter ranges of the Rae and Radium herds, March 22 to 27. Several days during this period were spent at Fort Simpson, Fort Franklin was visited, and a brief stop was made at Sawmill Bay on Great Bear Lake. Following this, long flights were made March 30 and 31 north as far as Port Radium and east to MacKay Lake, Snowdrift, and O'Connor Lake. This concluded the winter's field work and the period of time covered by this report.

A summary of mileages reported in the monthly diaries of the field men between January 1, 1950, and March 31, 1953, follows. It does not include duplicate mileages where two or more men travelled together, or

mileages involved travelling to a base in the north. Mileages for travel by automotive vehicles and on foot are approximate and probably conservative.

Type of Transportation	Miles
By aircraft	58,141
On foot	1,921
By canoe, boat.....	1,848
By motor car, jeep, truck, snowmobile.....	2,209
By dog team.....	400
	64,519

SECTION I. THE STUDY HERDS

As previously stated, financial limitations forced the continuing investigation to be confined to four herds within easy reach of Yellowknife. In the report of the initial phase (Banfield, 1954, Pt. I, Table 15, p. 59) the names and numbers of these herds were as follows:

Herd	Population
Great Bear	30,000
Radium	5,000
Rae	210,000
Yellowknife	4,000

The movements and identity of the herds during the three years of the continuing investigation showed wide variation from those reported for the preliminary investigation. Some years, herds in excess of 100,000 were found during winter in coastal areas hitherto regarded as summer range only. In some years at least, the Rae herd appeared to overlap the Great Bear and Radium herds, and at some seasons it appeared to be two or three discrete herds. It was impossible to identify the Yellowknife herd; apparently its movements had merged with those of larger herds to the east and west. However, the four herds are considered, for convenience, under the

names originally assigned to them, since at least the geographical areas they inhabit are relatively distinct. An additional section is devoted to the coastal herds.

The Rae Herd

The Rae herd, which is one of the largest, is a major factor in the lives of native peoples on both its summer and winter ranges. Much attention was paid to it during the preliminary investigation and during the first three years of the continuing study its movements were closely scrutinized and can be described with confidence.

Movements and Ranges

Winter Range. - This herd has shown great variation in its choice of winter ranges. In 1950-51 it occupied a comparatively small area (Map No. 6) west of the western limit shown by Banfield. It seldom reaches the Franklin Mountains, but that winter it pastured up to the 4,000-foot level on the higher peaks and used several valleys as passageways to the Mackenzie River. A few caribou actually crossed the river at Fort Norman and may have done so elsewhere. Two small groups, numbering not more than 5,000 in all, wintered east of the main herd; one on the Johnny Hoe River, near Lac Taché, and the other on the great muskeg area southeast of Lac la Martre.

In 1951-52 the herd occupied the huge area outlined in Map No. 7, reaching the Franklin Mountains but apparently not going through them. Northward its range overlapped that of the Radium herd, making it impossible to determine positively which herd some bands belonged to.

In 1952-53, the winter range was, in part, much the same as in the previous year (Map No. 9), but there were many fewer caribou. Large elements of the herd congregated along tree-line in the Drybones Lake area in mid-November, and some of these moved west across the Marion River. During the winter fair numbers were to be found at Slemon Lake, Lac la Martre, and Bulmer Lake, and in the Creasy Lake and Fish Lake areas, with only scattered groups between the larger concentrations. Farther north choice ranges were occupied in a similar pattern in the Snare River valley, at Lake Taché and Keller Lake, and between Blackwater and Fish Lakes. Caribou also remained at Gordon Lake through the winter, and some moved from the mid-November concentration at Drybones Lake southeastward

into ranges along the east arm of Great Slave Lake and northward. Here they mixed with caribou already in the area, some of which were elements of the Rae herd which had remained there since late August, and others probably from the Hanbury herd.

Spring Migration. - The first spearhead of the spring movement in 1950 crossed Faber Lake in mid-April, heading due east, until it passed through the Ghost Lake area. By April 27, caribou were moving east through the whole country between Hottah and Faber Lakes, with fringe groups north and south of those points. They had crossed the line between Yellowknife and Port Radium by May 9, although several thousand were still as far west as Ghost Lake and stragglers were to be found over an immense area. By May 13, movement was spread out over a path at least 200 miles long on a front of 100 miles. It was slowing down and beginning to scatter. The leading elements had now turned northeast towards Contwoyto Lake.

The initial eastward movement took place again in each of the following two years. In 1951, it probably started in late February. By March 24 a large spearhead could be observed heading east through Keller Lake, and another, converging on the first, southeast from a point just south of the Bear River. A minor movement of animals from the south part of the range passed south of Lac la Martre across the north end of Great Slave Lake and the Marion River. Caribou were crossing the line from Yellowknife to Port Radium all the way from Faber Lake to Hottah Lake on April 9, and on May 3 thousands were still moving east near Indin Lake. Between May 24 and 30 the herd was observed spread out over an immense area in the central barrens from MacKay Lake in the south to the north shore of Contwoyto Lake. It was clear from the scattered distribution that the migration had nearly ended.

The 1952 spring movement was not so closely watched. However, wintering groups were drifting eastward early in January, and the eastward movement was pronounced by the last week in March. Stragglers remained as far west as Lac la Martre on May 3, but the main body was then believed to have passed east of Ghost Lake (Map No. 7), about a week earlier than in either 1950 or 1951. From May 11 to 14, caribou trails showed plainly between southeast Contwoyto Lake and southern Bathurst Inlet, but it was not clear from the few observations whether the trails were those of animals from

the Rae herd or from coastal herds, and the direction of movement could not be determined. However, most, if not all the Rae herd remained on the central barrens during the summer.

Midsummer Migration. - The midsummer movements of the Rae herd are not so well known as those of other seasons, since they take place on the barrens where the herd is seldom observed either on the ground or from the air. During the summer of 1950, bands circulated widely on the barrens from Contwoyto Lake to the Arctic coast, and may have mingled with caribou which had remained on the coast. However, by late August the herd had reached timber-line from MacKay Lake to Winter Lake and north to Rawalpindi Lake. The reverse movement was not well marked, although the whole herd withdrew beyond tree-line.

The 1951 midsummer movement was not observed. In 1952 the herd appeared in mid-August at MacKay and Courageous Lakes. From this southern limit, it moved westward on a broad front, reaching well beyond tree-line by the last of the month. In the south, some elements penetrated as far as Ghost Lake, and in the north almost to Hottah Lake (Map No. 8). The largest numbers followed the Snare River watershed past Winter Lake, Roundrock Lake, and Snare Lake, and then went east across and around Indin Lake. Not all the herd penetrated the tree-line, however, and thousands of small groups stayed on the tundra, moving in no clearly defined pattern, as they apparently do every year. The reverse movement was well under way by September 10 and reached a climax at Roundrock Lake on September 17. This movement carried some of the caribou 50 to 60 miles beyond tree-line, although some remained along the edge of the forest.

Population

Banfield observed major concentrations of the Rae herd while conducting an aerial census in April, 1949. During the next three years, no such concentrations developed, and re-estimates were difficult. However, as the herd appeared to be much smaller in number than the first estimate indicated, re-estimates were attempted in 1951 and 1953.

From March 24 to 26, 1951, the herd occupied areas which could be defined with fair accuracy, and strip counts were possible. A summary of the data is as follows:

Estimated area of the range....	4,900 sq. miles
Area of transects.....	552 " "
Caribou counted.....	14,909
Caribou per square mile.....	27
Estimated population.....	132,000

To this was added 3,000 caribou counted in each of two isolated pockets. The total of 138,000 is much smaller than the original estimate of 210,000. Admittedly the result is subject to error, but the occupied range was so small that there could not have been many more animals. As it was, the winter range as a whole must have carried about 15 caribou per square mile, a surprisingly high average.

In 1953 the herd was so widely scattered that flights had to be made over it in January, February, and March, thus making it difficult to estimate the size of the occupied range. The following summary refers to areas known to have been occupied by the Rae herd.

Estimated area of the range....	17,100 sq. miles
Area of transects.....	1,380 " "
Caribou counted.....	2,914
Caribou per square mile.....	2.1
Estimated population.....	35,910
Plus one concentration of 3,000	38,910

In addition to this, caribou from the Rae herd were mixed with those from the Hanbury herd in the Gros Cap-Rae-Reliance triangle (Map No. 9). There the population was calculated separately for a remarkable concentration which existed within the range and for the rest of the range.

Estimate of the Concentration

Area occupied.....	225 sq. miles
Area of transects.....	104 " "
Caribou counted.....	4,918
Caribou per square mile.....	47.3
Estimated population.....	10,642

Estimate of the Remainder

Area occupied.....	3,675 sq. miles
Area of transects.....	238 " "
Caribou counted.....	1,675
Caribou per square mile.....	7.0
Estimated population.....	25,725

The grand total in this area was therefore approximately 36,400 by the estimate. Of these, not more than one-third, about 12,000 had come in from directions indicating that they were members of the Rae herd. Therefore, during the winter of 1952-53 it was possible, in spite of the most thorough coverage up to that time, to account for only a little more than 50,000 from a herd which had certainly numbered more than 120,000 in some years.

Annual Increment

Annual increment was studied principally by making calf counts during the winter months. The data are given in Table I.

As shown in the table, 1950-51 and 1951-52 were very poor years, whereas 1952-53 was phenomenally good. Similar results were obtained in other herds. The lowest percentage obtained in 1952-53 - 19.3 per cent - should actually have been higher since adult males were present in very abnormal proportions at that time, making up more than 30 per cent of animals segregated. The last two counts given in the table were among caribou wintering in the Yellowknife area, no more than about a third of which were from the Rae herd. In this case the counts are believed to be accurate and significant of the area covered. They are very high and may be somewhat misleading, since there were comparatively few young, non-breeding animals present following two poor years. Also, 5,000 caribou were taken in this area during the winter by selective hunting which favoured the calves. Significantly, 28.5 per cent was obtained from a ground count in early February and 29.9 per cent from an aerial count in late March.

The Great Bear Herd

The Great Bear herd was chosen for study because, unlike the others, it is not fully utilized by humans. When the continuing study began, its annual movements were less well known than those of the other herds. Deficiencies in the maps of its range made surveying difficult, but a fair amount of information concerning this herd was gathered from a limited number of survey flights and from reports passed along by bush pilots and the game warden at Fort Norman.

Movements and Ranges

Winter Range. - It is not known where this herd wintered in 1949-50. On a survey flight in late April no sign of caribou was seen along northern Great Bear Lake or between Dease Arm and Coppermine. Very likely the herd wintered not far north of the shore of the lake and moved out on spring migration so early that no tracks were visible at the time of the flight.

In 1950-51 the herd was observed on two flights in February and April. It then occupied a large area from a short distance south of the west end of Smith Arm around the north shore of the lake to where a wedge of true barren land almost intersects the shore between the mouths of the Katseyedie and Haldane Rivers. Northward the occupied area extended up the Haldane at least 100 miles into barren or lightly timbered country.

In 1951-52 Loughrey flew over the herd in December and March and found it in occupation of a range extending along nearly the whole north shore of the lake. No caribou were found in the wedge of barren land which formed the eastern limit of the herd in the previous year, but there was abundant evidence of movements to the east and west.

In 1952-53, a thorough survey was carried out from Norman Wells in February. Caribou were found in an enormous wintering area (Map No. 8) from south of the Bear River to Simpson Lake on the Anderson River, and from a short distance west of the mouth of the Haldane River to within a few miles of Fort Good Hope.

Additional groups estimated at 10,000 in 1950-51 and 11,000 in 1951-52 wintered on Point MacDonnel along the south shore of Dease Arm. This is a frequent wintering area and caribou have been known to calve there.

However, the groups in this area cannot confidently be assigned to either the Great Bear herd or the Radium herd, and may constitute an independent herd. In 1952-53 they were far less plentiful and occupied only the high barren interior, although there were a few at the mouth of the Dease River in January.

Spring and Autumn Migrations. - In 1950-51 the Great Bear herd moved into its winter range from the region of the headwaters of the Haldane and Horton Rivers. From scanty reports, it migrated back in spring on the same routes.

From his surveys in December and March of 1951-52, Loughrey believed that the herd moved into its range from around the eastern end of Dease Arm, small bands splitting off to occupy the country around the Haldane, the remainder continuing on, close along the shore, past the mouth of the Katseyedie, and then spreading out west around Smith Arm and northwest to the Lac des Bois region. He believed that the bands retraced these movements in the spring.

Caribou in the Great Bear River region came in from the south side of Great Bear Lake in both the above winters, but in 1952-53 most of the caribou in this region came in from the north. It is notable that the spring migration appeared to be only to the northward. In other words, elements of the Radium herd apparently accompanied elements of the Great Bear herd on spring migration.

Summer Range. - During July and August, 1951, caribou from the Great Bear herd were seen on the ground by a Geographical Survey party working in the vicinity of Darnley Bay. From the numbers and distribution noted by the geographers, it seems reasonable to conclude that bands of caribou might have been found anywhere from the east end of Dolphin and Union Strait to Baillie Island. At the same time, Eskimo reports indicated caribou inland on the Rae and Richardson Rivers which may have been the ones that wintered on Point MacDonnel. The route across the Dismal Lakes and down the Dease River is one well known since the time of the first white trappers in the early 1900's.

In spring and late summer 1952, caribou appeared again in coastal areas about Darnley Bay. At Paulatuk they appeared first in March and left in early September.

Population

In 1950-51 estimates following a partial coverage indicated that Banfield's figure of 30,000 for this herd was reasonable. More accurate coverage by Loughrey in 1951-52 produced an estimate of between 24,200 and 29,200.

In 1952-53 an effort was made to give thorough coverage to the range outlined in Map No. 8. The results may be summarized as follows:

Area of range.....	17,000 sq. miles
Area surveyed.....	976 " "
Caribou counted.....	1,991
Caribou per square mile.....	2.0
Estimated population.....	34,000

This figure is in line with previous estimates, but it should be noted that the range included that ascribed by Banfield to the Colville Lake herd, which he estimated to have a population of 5,000. During the continuing study no reason for considering a Colville Lake herd as a separate entity was discovered, although the caribou in that region may be isolated to some degree in some winters from those farther south.

Annual Increment

No significantly large calf segregation counts were made among animals of the Great Bear herd prior to the winter of 1951-52. During the winters of 1951-52 and 1952-53 segregation counts yielded the information presented in Table 2.

The Yellowknife Herd

During the first three years of the continuing investigation it was not possible to verify the migration routes and ranges described for this herd in the report of the preliminary investigation. From time to time these routes and ranges were used by groups of caribou, but in every case they were believed to be elements of the Rae or Hanbury herds, even when separated temporarily by as much as 100 miles from the main bodies of these great herds.

In 1949-50 caribou wintered some distance south of the east arm of Great Slave Lake, probably in connection with the Hanbury herd. There were no caribou on the north shore or islands of the east arm in that winter or the next.

In 1950-51 an isolated herd wintered in a rather small area within the triangle formed by Thuburn, Rutledge, and O'Connor Lakes, about 20 miles south of the east arm, where its cohesion was assured because the available range has been limited by forest fires. This herd came in during the autumn around the south shore of the lake and went out in the spring on the same route. The whole Hanbury herd makes the swing around the end of the lake, and the small herd must surely have lost its entity in the larger movement.

Caribou wintered on the north shore and islands of the east arm in 1951-52, but these were ascribed by Loughrey to the Hanbury herd. Other small groups wintering at Gordon Lake were believed to be elements of the Rae herd.

Midsummer movements in 1952 took the herds much farther than usual into the forest. Groups from the Hanbury herd reached Stark Lake on the south shore of the east arm in mid-August. Some of these may not have made the reverse movement, since there were caribou 70 miles northeast of Fort Smith on October 11. Other elements of the Hanbury herd entered the forest west of Artillery Lake and moved along the north shore to within 20 miles of the Gros Cap fishing camp on September 11. At the same time, caribou from the Rae herd came into the Gordon Lake area and these were joined by others in the autumn migration. Thus elements of both the great herds were present in the Gros Cap-Reliance-Rae triangle at the beginning of winter, and in January more than 15,000 came in from the Slave Delta-Rocher River country over the westernmost islands. These spent two and a half months moving up the north arm toward Yellowknife and then headed toward the barrens northeast past Gordon Lake.

Since the evidence indicated that the Yellowknife herd did not exist as a separate entity, no further treatment seems necessary.

86629—2½

The Radium Herd

Movements and Ranges

Winter Range. - This herd concentrated in certain areas along the east and south shore of Great Bear Lake from Port Radium to Fort Franklin in each of the three winters of continuing study. The concentration on Point MacDonnel has been described above in connection with the Great Bear herd.

In 1950-51 the herd occupied a comparatively narrow strip along the lake. The concentrations were on the southeast shore of McVicar Arm and around Fort Franklin, which they reached in early November and began to leave early in March. In the following year the concentrations were at Conjuror Bay, southeast of McVicar Arm, and at Lac Ste. Therese on the Johnny Hoe River. In both winters the Radium herd mingled to some extent with the Rae herd on the southern extremes of its range.

In 1952-53 the Radium herd, like the Rae herd, was much reduced in numbers. That year some of its elements mingled with the Great Bear herd around Fort Franklin and, as previously mentioned, appeared to go northward with that herd in the spring. Caribou were also present in small numbers about Lac Ste. Therese and Hottah Lake, west of the latter, along the shore of Great Bear Lake from Port Radium to Conjuror Bay, and eastward from there.

Summer Range. - Little information on this subject has been gathered, but the herd is now believed to utilize a large strip of tundra from Point and Rawalpindi Lakes north to Kigyik Lake and east to western Contwoyto Lake. In this region there must be some overlapping with the Rae herd.

Migrations. - This herd has followed well-marked migration routes, almost identical from year to year, the dates of movement corresponding closely with those of the Rae herd. Movement to the winter ranges is generally evident in November and early December. The caribou enter timber on a broad front from Rawalpindi Lake north to the big bend in the Coppermine River. In the south they move nearly due west across Hottah Lake to the Johnny Hoe River, near which most of them stop for the winter. Farther north, other groups reach Great Bear Lake from the northeast, farthest north at Port Radium, and continue on around the shore as far as Fort Franklin,

many dropping off along the route in areas of concentration and also in small scattered bands.

Outward movement becomes evident in late February and March, and is back along the same routes. Trails leading east, and, to the north, more and more northeast, from southern Hottah Lake to northeast of Port Radium, have been seen each spring. In the south it is difficult to distinguish between the southern elements of this herd and the northerly scattering of bands from the Rae herd.

Population

During the continuing investigation conditions were never found suitable for strip census flights over this herd, and overlapping often made the boundaries between it and the Rae herd impossible to define. In 1950-51 it was estimated at 4,000 to 5,000. In 1951-52 Loughrey judged from the density of tracks and the 8,000-square mile area of utilization that there were at least 10,000. In 1952-53 caribou were found wintering in thick forest, so thinly scattered that a good estimate was not possible. However, eye-witness accounts of the autumn migration indicated that there were in the order of 10,000.

Annual Increment

Increment figures on the Radium herd were obtained only from the air in 1950-51 and 1951-52. In the first of these years there were nine calves among 118 animals counted, representing a calf percentage of 7.6 per cent. In the latter year a total of 241 caribou included 30 calves, giving a calf percentage of 12.4 per cent.

The Coastal Herds

Observations during the three years of the continuing study indicated that important populations of caribou may remain in coastal areas, especially in the area of Coronation Gulf, throughout the winter, and that discrete herds not mentioned in the report of the preliminary investigation may be involved. In April, 1950, two trips were made to the Arctic Coast, which included visits to Coppermine and Read Island and flight from Coppermine to Arctic Sound and return. Reports of the presence of caribou came in from all posts and major camps east to Perry River, and tracks and a few

animals could still be seen along the coast. Competent observers also stated that it is not unusual to have caribou in these areas all winter, although at that time they are generally in the rugged inland where hunting parties seldom find them.

The observations since that time may be described as follows.

Ranges and Movements

Lower Coppermine Area. - Among the reports received on the flight to Coppermine in April, 1950, was one that a considerable number of caribou had wintered west of the post on the barrens. In February and April 1951, they were present in good numbers in the Coppermine and September Mountains on both sides of the river. They were reported again in December 1952, when they actually appeared at the settlement. Two strips were flown over the herd in January 1953, and they were observed again in February. At that time, caribou were plentiful in the country between the Coppermine and Dease Arm and abundant in the September and Coppermine Mountains, particularly around the Dismal Lakes. An unusual feature was that they were utilizing only high ground; all hills more than 1,000 feet high had isolated groups. The abundance of caribou along the Coppermine in that year may be connected with the low population on Point MacDonnel, mentioned above in connection with the Great Bear herd.

Bathurst Inlet Area. - McEwen and the writer arrived at Burnside Harbour on Bathurst Inlet on May 13, 1950, and worked out from there until September 5. The principal object of the trip was to observe caribou calving, and it was presumed that the Rae herd would be involved.

On the day of arrival a major migration across the inlet was just ending. It came from the northeast and could not have included elements of the Rae herd which was still far to the south in the vicinity of Contwoyto Lake.

On May 25 a second migration, possibly a second wave of the first migration, crossed the inlet, coming from the east and northeast, and passed through the area of the base camp a few miles south of Burnside Harbour. Three days later, when the second migration was still passing, a third one started crossing farther down the inlet from the west. At the time, it was considered

possible that this was a reverse movement of the first migration, but this is now believed unlikely. In crossing the sea ice of the inlet, the movements actually crossed paths and long files could be seen moving in opposite directions at the same time.

In addition to these three movements, there were scanty Eskimo reports of another in the Western River area, confirmed in August by the observation of shed antlers of cows and yearlings.

All these movements involved massed groups, whereas the southern wintering herds seem to spread out on a broad front in great depth when they reach summer ranges. It was therefore concluded that the movements consisted of caribou that had wintered in coastal areas.

By the end of June the sea ice would no longer support moving animals and the migrations were complete. However, caribou were under observation from time to time throughout the summer. During an aerial survey in mid-July, they were scattered throughout the country on both sides of the inlet, especially in the Gordon Bay, Arctic Sound, and Banks Peninsula areas. At this time, they were concentrated in the lush, green lowlands along the coast and were travelling at random in groups of from 4,000 to 10,000.

In late August and early September caribou were seen drifting south in small scattered bands. On the ground it was assumed that this was the start of the annual movement to tree-line, but on the return flight to Yellowknife the heavy trails of the Rae herd were seen from north of Contwoyto Lake to tree-line at MacKay Lake, and the herd had reached tree-line near Winter Lake. Coupled with reports of bush pilots this indicated that the Rae herd had been well south of the coast on inland ranges at the end of August, and that most of it might never have reached the coast during the summer.

From December to May, 1951-52, four flights fairly well covered the Arctic Coast from Darnley Bay to Sherman Inlet. Three of these were courtesy flights not connected with caribou investigation, and the weather was generally unsatisfactory for observation. However, groups of caribou numbering several hundred or more were seen frequently. Besides the concentration on the lower Coppermine, described above, caribou were found plentiful in the Kent Peninsula and the rugged

country south to Gordon Bay, and also between Tree River and Banks Peninsula. As in the previous winter, Eskimo reports indicated good numbers of caribou along the Coronation Gulf coast all winter.

On May 29, 1951, the Bathurst Inlet region was covered in search and rescue aircraft, at half-mile intervals and 500 feet altitude, from well up the Western River north to the Burnside and Hood Rivers on both sides of the inlet. At this time, the trails of two movements from east to west were apparent. Wireless messages previously received had reported these movements from Burnside Harbour, and the actual ice crossings were mostly concluded by the time of the search flights.

The movement through Burnside Harbour had come from Gordon Bay and inland from there, and after crossing the inlet had continued inland in a southwesterly direction. At Burnside the front had been about 10 miles wide, but after the crossing it had widened considerably. At the time of the flight it was losing impetus, and the few caribou still moving were about 50 miles northeast of Contwoyto Lake, with a relatively narrow gap between them and the northeast-moving Rae herd. The second movement had headed due west across the southern end of the inlet. It had originated on the headwaters of the Ellice River, where Eskimo reports suggested there had been a large concentration during the winter. Most of the caribou in this movement probably stopped before they reached the Burnside River, at least for the calving season, as they were widely scattered when the survey flight took place.

There had also been a migration across the inlet from the west and northwest. This movement had been on a broad front from south of the mouth of the Western River to within ten miles of Burnside Harbour, and had crossed paths with the movement going in the opposite direction as observed in the previous year. At the time of the survey flight it had scattered all along the east shore, where bands seemed to be moving in a random manner north to Gordon Bay and south in the Western River Valley. There was a strong movement to the northeast and a marked one to the southeast. Only the latter could have carried the caribou far inland before calving time, and it was already fanning out over a great plain which commences about 30 miles southeast of the Western River.

Caribou were present at Bathurst Inlet during

the summer of 1951, but good reports on them were lacking. During the following winter Loughrey had no opportunity to investigate the coastal herds, and the reports he received indicated a scarcity along the coast of Coronation Gulf, with only a few thousand caribou wintering there. In the spring of 1952 fewer animals were reported in the migrations across Bathurst Inlet. However, this is not conclusive evidence, as the post at Burnside Harbour is screened from the place where the crossing is made by a high ridge about a mile south of the post, and there is little travel in that direction at the time of the migrations.

From information gathered from a number of first-hand sources and confirmed by information gathered independently by Loughrey, many caribou from the 1952 spring migration across Bathurst Inlet spent the calving season east of the inlet and then continued eastward. A few returned in August and crossed the islands in the inlet from Gordon Bay to Banks Peninsula. Caribou already well spread out along the coast to Adelaide Peninsula were joined in November by a movement down the Armak River which split, going west at least to Perry River and east for an unknown distance.

The concentration on the Coppermine during the winter of 1952-53 has been described above. East of Coppermine, caribou were scarce or absent. A few were reported in the Kent Peninsula area and Melbourne Island. Farther east, reliable reports indicated the presence of large numbers from Perry River through Sherman Inlet, Adelaide Peninsula, Chantry Inlet, and at least as far as Murchison River. Hunters at Gjoa Haven, Spence Bay, and other points where caribou had been very scarce or absent for a number of years, were able to get all they needed. There is no doubt that a large part of these herds had moved in from the Coronation Gulf area. They may also have included caribou from the Aberdeen Lake and Garry Lake areas. These are frequently used wintering-grounds but were devoid of caribou that year.

Population

Aerial census and calf segregation counts on the coastal herds were impracticable, but some idea of their numbers was obtained from observation of the spring migrations at Bathurst Inlet in 1950, described above.

From tracks and shed antlers, the evidence of residents of Burnside Harbour, and later experience, it is believed the first migration could not have involved less than 50,000 caribou. In the second migration, starting on May 25, the main herd took three days to pass and from actual counts was estimated at 46,000. Besides this, there were at least 3,000 stragglers. The greater part of the third migration was too far off to count, but on the second day it was sufficiently scattered for 3,000 to be noted. On the third day, it was too closely packed for a short time for individuals to be distinguished. An absolute minimum for this herd was 15,000. From Eskimo reports and the evidence of shed antlers the fourth movement may have included anywhere from 10,000 to 60,000.

These migrations, therefore, in total, consisted of from 126,000 to 176,000 caribou. Considering that there may have been other unobserved movements across Bathurst Inlet and that some caribou may never have crossed it, it seems safe to say that at least 126,000 caribou spent the winter of 1949-50 on the barrens towards the coast.

Observations since 1950 in no way indicate that this estimate is too great. Loughrey did not receive reports of heavy concentrations in coastal areas in 1951-52, but this may have been because they were in inaccessible areas. The reports from the coastal areas in 1952-53 indicated a population of more than 100,000.

Discussion of Herd Data

Ranges and Movements

During the first three years of the continuing study it became increasingly apparent that the ranges and migration routes of the caribou are extremely variable, and by no means limited to those described in the report of the preliminary investigation. On the winter ranges all herds were found overlapping in some degree with adjacent herds, and overlapping is believed to be even greater and more frequent on the summer ranges. The range areas shown on Maps Nos. 4 and 5 show that nearly all the study area was utilized at some time and many areas are shown as unutilized only because no positive reports of utilization were received from them.

An example of route variation is that of the Great Bear herd. In the report of the preliminary investigation this herd is reported to have crossed Dease and Smith Arms and between Point MacDonnel and Etacho Point. No such movements were observed or reported during the continuing study. From research and inquiry it appears that the longer routes over the ice are used only occasionally, but short cuts across the arms of the lake may be used with fair frequency, particularly at the east end of Dease Arm where islands make a partial bridge. Only one certain instance was discovered of the caribou crossing between the two points during the past 40 years. On this crossing there are no islands and the shortest possible distance over the open ice is 35 miles.

Overlapping was observed so frequently that the whole concept of discrete herds was brought into question. There was no clear-cut division between Rae and Radium herds on the winter range or in migration and the Great Bear and Colville Lake herds were similarly inseparable. Actually, the distribution may alter so much from year to year that certain groups may appear to be discrete herds. An example in point is the herd which winters on Point MacDonnel, whose relation to other herds has not been determined.

A more practical concept for study purposes might be that of regional groups in which the caribou are considered as one herd or group of herds. Such a herd group inhabits the winter and summer ranges roughly north of the Bear River, Great Bear Lake, and Port Radium. The winter ranges south from there to the Horn Mountains and Great Slave Lake have geographical continuity, and the caribou inhabiting them might be considered as a second regional group. Overlapping in various places along the boundaries of the regions is comparatively easy to define. A third region might be outlined from Great Slave Lake south and east to Lake Athabasca, and a fourth along the Arctic Coast from Coppermine to the Adelaide Peninsula. Tentatively suggested boundaries for these regions are shown on Map No. 10.

The observations of coastal caribou during the continuing study are of great importance since no discrete herds for this region are described in the report of the preliminary investigation. In that report the spring migration route of the Rae herd is described as follows (Banfield, 1954, Pt. II, p. 22):

"The route (of the Rae herd in spring) extends northeast .... past Yamba and Ajax Lakes to the south end of Contwoyto Lake and continues to the headwaters of the Western River and the head of Bathurst Inlet. After reaching the Arctic coast at Bathurst Inlet the route turns northwest along the western shore of the Inlet and continues across Burnside and Hood Rivers. The greater part of the herds find summer pasturage in the vicinity of Arctic Sound but some movement may continue west as far as Gray Bay and the mouth of the Tree River. From Contwoyto Lake, the herds may reach the coast by a second route leading down to Burnside River."

As observed during the present study, the migrations of this herd appeared to lose impetus and directional trend near Contwoyto Lake. There they scattered during the calving season in bands of mostly less than 100, which grew in size and apparently wandered at random until the southward movement began in August. On this range they may at times meet and mingle with bands drifting southward from the Bathurst Inlet area. In view of this, it becomes questionable whether caribou seen at the Inlet in 1949 were from the Rae herd or from coastal herds. It remains a possibility that there is interchange between the herds, or that in some years all the caribou are drawn south, whereas in other years large numbers remain behind on the coast. This point can only be decided by further investigation, possibly by marking large numbers of caribou in both herd groups.

Occasionally there are reports of scarcity of caribou from coastal regions in winter, which might be taken as evidence that they had migrated to the south. However, there is reason to believe that such reports can be very misleading. In 60,000 square miles of possible winter range in this area, there are only two trading posts with white residents and two native trading posts. Eskimo camps are fairly widely scattered on the coast and inland, but the Eskimo hunts the same area year after year and huge tracts of land may never be crossed by human beings. Hardship and starvation are also more readily and quickly reported than normal conditions. Early travellers in this region found caribou in winter and they were just as likely to find them scarce or absent in summer as in winter. The voluminous accounts of Stefansson indicate that caribou could be found on the mainland coasts all winter, and nowhere suggest a complete southward withdrawal.

It was discovered that even aerial observations from aircraft may also be misleading, even under ideal conditions, with continuous snow cover and no trees to obstruct the view. There are days when caribou and their trails do not show up clearly.

In summary, from 100,000 to 200,000 caribou are now believed to have frequented coastal ranges during the study period, from Coppermine to Chantry Inlet and south to the big lakes on the Back River, Beechy Lake, Contwoyto Lake, and the Coppermine River at about 66 degrees north latitude. These herds seem to be split into western and eastern groups by Bathurst Inlet, across which they all move in spring. The ranges occupied in winter are extremely variable, but the lower Coppermine, Kent Peninsula, Gordon Bay, and the headwaters of the Ellice River are frequently utilized. The herds circulate widely in summer: both sides of Bathurst Inlet and adjacent pastures to the north of the Inlet are favoured.

Animals that cross the inlet in spring migration often return in midsummer either by swimming via the islands north of Burnside Harbour or overland through the Western River valley. Calving is known to take place in the hills on the west side of the inlet, and undoubtedly also takes place on the east side. Routes and ranges are changed so frequently that they cannot be precisely defined. These changes are doubtless necessitated by the relatively poor quality of the range.

Herd Populations

A comparison of the estimated population figures for the study during the initial investigation with those made during the continuing work is given in Table 3. The figures for the continuing study are believed to be the more accurate because they are based on a longer period and more intensive work. Allowances are made in the table for different definitions of herds and groups, and insignificant numbers are ignored. The estimate for the Rae herd is that of 1950-51. The estimate of this herd in 1952-53 was some 60,000 fewer, but there was no evidence that the missing caribou had left the study area, although not on their usual ranges. At the end of the study period it was believed that there were at least 50,000 more caribou in the study area than estimated by Banfield.

SECTION II. HUMAN UTILIZATION

For the purposes of this section the study area is considered in three regions, as in Map No. 10. Only the effect of the human kill on the caribou populations in these regions is discussed. Phases such as techniques of killing and storage, which have been dealt with adequately in previous reports, are avoided. Loss by crippling, a by-product of human utilization, is not reported statistically.

The reports of caribou killed come in nearly all cases from police officers or game wardens. They are very irregular and incomplete even in the most recent years. The number of reporting hunters varies more from year to year than it should, even allowing for field difficulties and movements of the human population. In some cases, the reports do not give a true indication of the number of hunters using an area. In some cases also, they obviously cover hunting done in areas other than the one reported from. The data are valuable but could be much improved by greater completeness and accuracy.

The Coastal Region

Data for areas used by the coastal herds are presented in Tables 4 and 5. There are many gaps in the information given in Table 4. There are no recent reports from Perry River, Sherman Inlet, and other areas of utilization. Hunters from Read Island get caribou only occasionally, and probably get more from the region north of Great Bear Lake than from the coastal region. Natives trading into Cambridge Bay take caribou every year, usually from the mainland between Perry River and Bathurst Inlet. The figures for Bathurst Inlet, 1950, are estimated from information gathered by the writer in that year. The number of hunters reported from Coppermine in 1953 - 155 - is believed to include hunters from other posts, as only about half that number trade regularly at Coppermine.

In Table 5 a theoretical annual kill for each post is obtained by multiplying the average number of caribou killed per hunter per year by the maximum number of hunters reporting in any year. This may give a figure somewhat too high, but some compensation for hunters not reported is necessary, and, in some cases at least, there are more hunters than were

reported in any year during the ten-year period.

The figure arrived at - 10,241.8 - is regarded as reasonable, although the greatest kill reported in any year was 7,404 in 1943. If anything, it may be somewhat conservative. Hunters at Coppermine and Bathurst Inlet probably account for no less than 8,000 caribou per year on the average. Up to 3,000 hides are sold for export annually at these posts, and usually not more than one-third of the hides are exported.

The caribou population in this region has been estimated at a minimum of 126,000. Reproduction, or annual increment, calculated from calf segregation counts made by Banfield and other workers and not using counts obtained during the two obviously poor years of 1950-51 and 1951-52 is believed to be about 20 per cent. Thus the annual increment of the coastal herds may be about 25,000. However, 10 per cent, or 12,500 are lost through factors other than human utilization, leaving the same number available for that purpose. It appears that the desirable maximum of killing is reached in most years, and in some years it may be exceeded.

It may be noted in passing that an independent estimate of the utilization in this region for the year 1951-52 was made by the writer from information gathered by himself and Loughrey. It totalled 11,000 and was believed to be reasonably accurate. This encourages the belief that the permissible kill is being taken annually.

Between Great Bear and Great Slave Lakes

The data for this region are presented in Tables 6 and 7. The information is the best for any region, although there are notable blanks. Fort Rae is well reported, but the figures must be very conservative, as it is known that the Indians from this district take at least half the caribou killed in the region. An insignificant number of woodland caribou may be included in the reports from Forts Providence, Simpson, and Wrigley.

In some years Eskimos may take several thousand caribou from the herds of this region whose summer range extends into their country. There is no record of this kill as such; most of it may be reported through Bathurst Inlet.

The total reported kill varied from 2,508 in 1951 to 9,591 in 1946. The calculated theoretical annual kill is 8,105.6. This may be much more or much less than the actual kill, depending to a large extent on the availability of caribou for the Rae, Simpson, and Wrigley Indians. In 1951 the caribou avoided these posts and there were numerous reports of hardship and starvation. In 1952-53 the herds were reduced in number but exceptionally easy to reach and the kill was very heavy - quite possibly it exceeded 15,000.

The caribou population in this region has been variously estimated at 210,000 in 1949, 132,000 in 1950-51, and about 50,000 in 1952-53. In order to withstand the calculated theoretical annual kill it should be at least 82,000. Further years of study are necessary to determine what population can usually be expected and how great a utilization is desirable.

North of Great Bear Lake

The reported kill in this region is given in Tables 8 and 9. Reports from Tuktoyaktuk, Aklavik, and Arctic Red River were very small and included some stone caribou taken along the east flank of the Mackenzie Mountains, and therefore they are omitted. Fort Norman and Port Radium are near the regional boundary and the hunters there may take caribou from two regions. However, those at Fort Norman are believed to get most of their caribou from north of the lake; and the inclusion of Port Radium in this region is balanced by the inclusion of Fort Franklin, also on the regional boundary, in the interlake region.

Probably the total success of the hunt in this region depends a good deal on whether or not the herds come within reach of Fort Norman. There are few important camps and settlements around the margins, and no central ones except the Indian encampment at Colville Lake. The winter range north of the lake has been uninhabited by humans during the past few years, as far as can be ascertained.

The variation in the reported annual kill in this region was from 150 in 1944 to 1,435 in 1947. The theoretical annual kill is calculated at 1,368.3. Including the herd on Point MacDonnel, the population of caribou may well have been up to 45,000 during the years covered. This population should easily have been able

to stand an annual kill of 4,500. Even if the actual kill was much greater than the theoretical kill, there appears to have been no over-utilization.

It is interesting to note that the present situation appears to be the result of over-utilization in the past. During the early years of the century whaling and trading ships were numerous along the coast, and their crews often wintered there. Both whites and Eskimos were spread out widely. Eskimos were even imported from Alaska to do the hunting. Indians and white trappers regularly hunted the whole north shore of the lake and penetrated to the barrens. It is clear from the records that there was considerable over-utilization and that the depletion of the wildlife was the chief cause of the withdrawal of the human population. The caribou herds are still in process of recovery. Musk-oxen were almost completely decimated and are only beginning to show signs of recovery.

SECTION III. THE CALVING PERIOD

The following observational and descriptive material is based largely on the field notes and progress reports of Lawrie and Peterson at Beverly Lake in 1949, and those of McEwen and the writer in 1950 and Perret and the writer in 1951 at Bathurst Inlet. Only the last of these field parties succeeded in observing the actual calving.

No fixed dates for the calving period can be given. No doubt they vary from year to year, and perhaps from place to place. Dates reported by trappers and others range all the way from the last few days in April to the first few days in July. The present evidence indicates that normally calves are dropped within a period of two or three weeks in June. The following account covers the period from a few weeks before parturition to about a month after it.

Movements During the Calving Period

As observed by Lawrie and confirmed during the continuing study, there is a progressive tendency for cows, particularly pregnant ones, to move to the front and bulls to lag behind on the spring migration. This may begin on the wintering grounds, or not until

the migration is well under way. He gives instances where a definite time interval elapsed between the arrival of the last cows and that of the first bulls at the calving areas. This seems to be general and usual. At Bathurst Inlet in 1950 there were actually a few bulls among the first cows, but most of the bulls were in the rear. In 1951, they were well segregated; during the time spent on the calving area in mid-June, only three adult bulls were seen among more than 5,000 caribou.

This segregation does not seem to affect the younger animals. One- and two-year-olds of both sexes may be found with either cows or bulls. Bulls more than one year of age, and non-breeding cows, tend to remain with adult bulls.

The cows accelerate their movement as calving time approaches. In 1950 the first caribou came across the inlet and moved into the hills to the west at a leisurely pace, stopping frequently to feed and rest. Non-breeding animals and bulls continued crossing at this pace and followed the cows into the hills or remained on the superior ranges near the coast during the calving period. As time went on the cows became more and more hurried; the last ones scarcely paused before moving into the hills. Similar behaviour was noted in 1951. Thus the cows at this time have every appearance of possessing a purpose or instinct to reach a specific area by a specific time.

Some evidence also suggests that the cows which reach the calving grounds first are those most advanced in pregnancy. In 1950 pregnant cows were under observation from late May until June 27, yet no calves were seen. In the following year all pregnant cows except one disappeared into the hills before having their calves, although a few were still passing through the coastal area in late June.

On the calving grounds the caribou at first scatter widely and move slowly, apparently at random. From June 12 to 20, 1951, groups of 20 or less were the rule, and few groups of more than 100 were seen. Later on they began to bunch up again. By July 2 groups may number 1,000 and by July 14, up to 10,000. About this time the cows may mingle with the bulls: in 1950, herds seen in mid-July included animals of all ages and sexes. In 1951, no bulls were present on July 2, and on that date a herd of 1,000 bulls was seen 90 miles southwest

of the nearest cows. The bulls may have stayed all that summer on the east side of the inlet.

The Calving Grounds

Banfield concluded that there are no specific calving grounds and that calves are dropped wherever the cows happen to be at the appropriate season. The continuing study bears this out. However, it does appear that a certain type of calving grounds is favoured year after year in different regions.

On the west side of Bathurst Inlet and in the Kent Peninsula there are gently rising plains and hills extending some miles inland from the sea. These plains are heavily utilized just before and after calving, but calving cows were not found below 1,200 feet during the calving period.

Elsewhere along the inlet the shore rises abruptly. Inland, the country looks comparatively level from the air, but is really rugged. The mean level is probably about 1,800 feet, and some 30 miles southwest of Burnside Harbour a range of hills rises to 2,000 feet above the river valleys. There is much evidence of violent geological action. The exposed rocks include various types of sandstone and conglomerates in place and there are large areas of igneous intrusion and overflow. The results of glacial action are evident on the higher ridges. A clearly defined series of raised beaches between present sea-level and 1,500 feet, reveals that glaciation was followed by rapid emergence from the sea. Because of numerous ridges, the drainage is tortuous and very involved. There are many bodies of water ranging in size from potholes to lakes 20 miles long and several miles wide.

From the account of Hoare (1927) and the records kept by traders and missionaries, it is clear that the spring migrations have crossed the inlet more or less regularly for many years. Except for the one cow referred to above, which apparently calved during the ice crossing, no cows are known to have calved in the coastal areas.

Other large groups of caribou have calving grounds in country remarkably similar to that at Bathurst Inlet. Between Dubawnt Lake and Beverly and Aberdeen Lakes, and north of the two last-named, they appear frequently on the extensive plains near the water before and after calving in rugged inland country. The Radium herd appears to use regularly rugged land west and northwest

of the northern arm of Contwoyto Lake. At Paulatuk in the western Arctic, caribou in good numbers are seen on the coast almost annually before calving time, and in smaller numbers after calving. In each case the land rises to at least 1,000 feet in the area where the calves are dropped.

As yet it is not possible to define a type of country invariably used for calving. The information is too limited, and there appear to be numerous exceptions. However, it seems more than a coincidence that widely separated herds use calving grounds with such important, common characteristics.

Caribou Calves

Excellent physical descriptions of caribou calves are given by Banfield (1954, Pt. II) and Murie (1944). At Bathurst Inlet there did not appear to be quite as wide a variety of coloration as reported by Murie. The reddish-brown phase described by both authors was common, but almost equally so was a light chocolate-brown phase. There seemed to be few cases of intergradation.

Data on measurements of young calves are presented in Table 10. The ages of foetal caribou are calculated from a date of conception fixed arbitrarily at October 22, the mid-point of sexual activity during the rut, as recorded by Lawrie. The ages of post-parturition calves are calculated as if birth took place on June 15, except where the actual date of birth is known. Both dates are subject to revision when better information is available.

Even the youngest new-born calves have fully erupted incisor and incisiform canine teeth, and, in all cases examined, premolars extending one-eighth to one-quarter of an inch above the gum line. The calves are therefore equipped at birth to start eating solid foods.

Behaviour of Cows and Young Calves

Tendency to Become Separated

Parturition among caribou is relatively simple, if the single example observed is typical. This was a cow that lay down for half an hour on a sedge plain on the calving grounds at Bathurst Inlet and dropped her calf while the observers watched closely through binoculars

from a distance of about one-quarter of a mile. No particular evidence of labour was noted and it was not certain that she had calved until she stood up.

The behaviour of this cow and her calf illustrates the great possibility of very young calves being separated from the cows. The cow fled the scene altogether when the observers approached to ear-tag the calf. The calf was so persistent in following the observers that to get away from it it was necessary to roll it on its side behind a boulder and then dash away. The cow returned to the scene twice, the first time for only about two minutes, during which she did no searching. On her second return she came back to the spot where she had last seen the calf, grazed briefly, stood for about ten minutes, moving her head and neck to look about and grunting, and then started to graze again. The calf made no response. When it seemed that the cow had lost interest and was moving off to follow the other caribou, she apparently stumbled upon the calf by accident.

An older calf is likely to aid discovery by standing up, grunting, and walking about. However, it may also follow other moving animals - even a man - and thus remove itself from the cow's scope of search. A cow near Burnside Harbour temporarily abandoned her calf and never found it again, although she searched for some time in the area where it still was located. This calf was found some days later partially eaten by a fox or a wolf. A cow and calf, separated during ear-tagging, went off in opposite directions and were several miles apart when last seen. The calf was grunting lustily, but it seemed unlikely that the cow would find it again.

Precocity

Compared with the young of other ungulates, caribou calves are truly precocious. The calf whose birth was observed, as described above, stood up voluntarily within a few minutes. After 30 minutes, it could walk unsteadily. When reclaimed by the cow it proceeded, upon urging by her, to run, walk, and hop several miles, within an hour and a half after birth. When last seen, it was climbing out of a creek through which it had waded. Up to that time it had been allowed to suckle only twice, both times briefly.

A calf can probably outrun a man when it is considerably less than 24 hours old. Only two calves, both less than four hours old, were captured out of many

hundreds seen. A calf so young that its umbilical cord was still trailing showed great ingenuity in avoiding capture. It would permit approach to within 20 feet, stopping when pursuit stopped and sometimes walking back to make sure that neither observer was its mother.

Even when fleeing, the cow travelling in a herd usually adjusts her speed to that of her calf during its first few weeks. The pace is a slow walk unless danger is imminent. The cow may then trot ahead until the calf is left far behind, wait until it has nearly caught up, and then trot off again. On several occasions, when calves fell behind for various reasons, the cows stood and beckoned with their heads just as a human might when silence and speed are imperative.

If surprised or closely pursued, the cows readily abandon their calves. On two occasions they dashed about the observer before disappearing, as if to distract attention to themselves. At other times they fled at once abandoning the calves entirely.

By the time the calves are a few weeks old, the cows have become much less solicitous for them. When a herd is alarmed, it races off across the tundra and the calves are left scattered behind. Individual cows frequently, but not invariably, come back to wait for their calves if no real danger materializes.

Caribou calves seem to be natural swimmers. When no more than 12 hours old a calf will plunge fearlessly off an ice shelf and swim easily. Within a few days it can keep up with its parent for 150 yards in a moderate current. However, they seem to have difficulty in keeping their heads above water when waves are running. This is mentioned later in this section in the discussion of mortality.

Grazing

Caribou calves are well equipped at birth to start grazing. In 1951 grazing calves were first observed on June 13, when less than half the cows had dropped their calves. Until departure from the area on June 21, grazing was observed oftener than suckling. Among ten calves watched for half an hour at close range, on June 20, in a herd that was quietly feeding and resting, all the calves attempted grazing, but only one was seen suckling - a calf so young that it could hardly stand.

From July 18 to 20, 1950, among several hundred calves mostly not more than a month old, not one was seen suckling. Some groups in the herd were observed at close range for periods as long as two hours.

Reindeer calves about three months old, at reindeer roundups in the Mackenzie Delta in July, 1952, were grazing extensively; but there was still much evidence of suckling. In contrast, among several hundred caribou calves about the same age watched at close range during a two-week period in 1952, no calf was seen suckling,although autopsies of two calves showed that both were still taking milk.

In general, the observations suggest that suckling by calves more than three weeks old is infrequent; that grazing is more frequent than suckling, even on the calving grounds at the time of maximum parturition; and that at least some calves will take milk up to, perhaps after, the age of three months.

Behaviour of Animals Associated with Calving

The segregation of bulls is described above in connection with movements during the calving period. During the 12 days spent on the calving grounds in 1951, the three adult bulls seen were with small groups of younger bulls. All other sex and age classes were well represented. Generally one-third to one-half of a herd were cows and their calves; the rest were one- and two-year-old animals of both sexes. Among these younger animals the sex ratio appeared to be about three females to one male.

When approached by the observers a number of herds on the calving grounds displayed a kind of local segregation. At the first sign of approach, cows with calves, and most of the cows in advanced pregnancy, immediately ran off until they were out of sight. The younger animals, and occasionally one or two pregnant cows, behaved in the fashion typical of caribou at that season, as described below in Section V.

The frequently-expressed belief that caribou cows seek seclusion before calving appears to have no real basis in fact. When a cow is about to give birth, she lies down. After a brief period of labour, cow and calf remain relatively quiet in one spot for at least two or three hours. Meanwhile the herd usually

moves on, sometimes for many miles. It appears reasonably certain that most cows rejoin their herds as soon as the calves can follow. Cows with calves no more than two or three hours old, still trailing the umbilical cord, were seen walking considerable distances to rejoin their herds.

No cows were seen attempting to enforce segregation or displaying evidence of agitation when other animals came between them and their calves. Reindeer cows do this on occasion.

Despite frequent Indian statements to the contrary, there was no evidence that a yearling may run with its mother after a new calf is born. Yearlings appeared to associate for the most part with two-year-olds.

Calf Mortality Factors

Table 11 is a summary of winter calf counts obtained by various observers since the commencement of the caribou investigation. As shown by the table, annual variations in calf percentages, sometimes of great significance, may be shown in a number of herds simultaneously. Thus some years are good ones and some are poor. Reports of a qualitative nature indicated that similar conditions existed each winter right across the caribou range. Whenever exceptions were traced, they were always found to involve herds not representative of the whole population, including as they did unusually large percentages of some age classes. Enough spot counts have been made in summer to indicate that it is usually apparent at an early date whether the year will be good or poor. A count taken on a large herd at Bathurst Inlet in mid-July, 1950, showed that only 9 per cent were calves. Calf counts in the following winter averaged only 7 per cent. In view of this, it seems likely that major, widespread control factors must be operative in causing early mortality.

At present there is little positive evidence to indicate what these factors are. Non-fertilization of a significant number of females, and a pre-parturition disease such as contagious abortion cannot be ruled out, but the possibility that these factors have been operative on a large scale seems remote. All the herds studied had far more bulls than considered desirable for maximum fertilization in reindeer herds. No evidence of pathological conditions that might lead to widespread calf

mortality has come to light. Limited investigation and reports from hunters and trappers show that it is unusual to find a non-pregnant female of breeding age during the winter months. Among large numbers of cows observed during the calving period, few were not lactating.

In 1950 and 1951, two poor years, the heaviest mortality is believed to have occurred on the calving grounds near the time of parturition. Six dead calves were located on the calving grounds at Bathurst Inlet in 1951 during a period in which about 300 living calves were seen at close range. This indicates a mortality of at least 2 per cent, probably far more, since dead calves are very inconspicuous.

The only factors which might influence calf survival at birth or shortly after, over a wide area, appear to be adverse weather and insect infestations.

Weather

It is significant that no apparent reason for death was found in the six calves found dead on the calving grounds in 1951, and that all were found after a period of rough weather. The period June 15 to 19 was one of driving winds, snow, rain, soaking mist, and temperatures close to the freezing point. Caribou seen during this period were drifting rapidly before the wind, crossing any water they came to. In such conditions many tired, young calves must have drowned at water crossings or become separated from their parents. There was similar bad weather again on June 25 and 26, after the investigators had reached camp at sea-level, which must have been nearly as severe as before on the calving grounds.

If weather is a decisive factor, the critical period in the survival of young calves is probably that of heaviest calving. This is considered to be June 10 to 29, inclusive, although the dates may vary. The weather records in the notes of the 1948, 1949, 1950, and 1951 field parties were examined for this period. Temperatures of 32°F. were noted on 16 days in 1950 and 3 days in 1951. Precipitation was noted on 5 days in 1948, 13 days in 1959, and 10 days each in 1950 and 1951. However, records for both years at the Bathurst Inlet include some days spent at the coast, where no rain or snow falls on some days when it is falling on the higher calving grounds.

Lawrie recorded two days with wind force strong (32-28 m.p.h.) in 1948, but for most of the period it was

moderate (13-18 m.p.h.). In 1949 the wind was fresh (19-31 m.p.h.) on two days and gentle to moderate (8-18 m.p.h.) for the rest of the time. The Bathurst Inlet records were not as accurately kept, but they show that high winds were much more prevalent. In 1950 fresh winds were recorded on 17 of the 20 days, and on at least one day the wind was at gale force (39-63 m.p.h. In 1951 it was fresh on eight days and reached gale force on at least three of these. It must also be remembered that wind velocities, as well as precipitation, are greater on the inland calving grounds than at the coast.

Relative humidity figures are available only for 1948, when Lawrie took readings that averaged less than 10 per cent for the period. A few random readings at Bathurst Inlet never exceeded 64 per cent.

More significant than the above is the fact that high winds, temperatures of freezing or lower, and significant precipitation were simultaneous only for very short periods in 1948 and 1949; whereas in 1950 and 1951 they were simultaneous on a number of days, and, in fact, for successsive days.

It seems likely that there is a "chilling point" at which the bodily functions of the caribou calf are greatly impaired. The crucial conditions are probably brought about by various combinations of high winds, low moisture content, low temperatures (not necessarily below freezing), and continuous or frequent precipitation. There is no shelter on the calving grounds except from winds, which seem to make the caribou nervous and keep them on the move for greater distances and longer periods than usual. Many calves not killed outright must be separated from the herd and die later of exposure and hunger. Others must be drowned at water crossings or taken by predators. It is believed that during the calving periods in 1950 and 1951, 50 per cent of the young calves may have perished in this way.

Parasites

Insect infestations cannot cause substantial calf mortality very often, since insects do not usually become dense and troublesome until one to three weeks after the first calves are born. Heavy mortality from this cause could not occur every year and on some of the drier sections of the range it could never occur. Only an unusually calm, wet summer could create conditions severe enough to lead to many deaths.

If death from this cause takes place, it follows fatigue and malnutrition induced by the violence and restlessness to which the caribou are driven. During the investigation no deaths wholly or partially attributed to insects were noted, but caribou were seen so plagued by flies that the possibility of death resulting seemed real. During bad infestations they are on the move night and day, sometimes running at full speed. It seems reasonable to suppose that calves, so young that they are just learning to eat properly, get much less than the desirable amount of nourishment under such circumstances.

During the summer of 1949, Eskimos at Bathurst Inlet reported finding dead caribou, many of them calves, in the coastal marshes. The only signs of injury were swollen, sometimes bloody, eyes and nostrils, broken front or hind limbs, or swollen and infected leg joints. The Eskimos salvaged enough meat from these caribou for their summer's, and part of their next winter's, supply of dog feed. The white residents at Burnside Harbour and the Eskimos believed that insect infestation was the primary cause of death in this case.

Aside from biting insects, the only sign of parasitism likely to prove lethal was found in a three-month-old calf. Its small intestines were so choked with worms that they were white, due to food dilution, in the lower end. This calf probably would not have survived the next winter.

Predation

In 1950 wolves were plentiful on the coast through the last part of May and the first half of June, scarce during the rest of June and July, and plentiful again in August. During the period of scarcity it was presumed that they were confining their activities to the high dry interior. In 1951 they were again plentiful on the coast but on the calving grounds in mid-June only one wolf and the tracks of two others were seen. The adult wolves are confined to their denning areas at this time, but wolves denning along the coast were known to hunt as far as 20 miles from the dens, and the calving grounds should have been well within their radius. No evidence of wolf-killed caribou calves was seen, but one recently killed female was noted. The frequent water areas on the calving grounds would favour caribou pursued by wolves, which can swim when pressed but seem to avoid entering water.

The observations also included one barren-ground grizzly and the tracks of another. The grizzly was resting on a river bank. Alarmed by catching the scent of the observers, it made off in a straight line out of sight. From its speed, there is no doubt that it could catch young caribou if it wished to do so. Droppings found near a fresh set of grizzly tracks contained bones and tendons from young caribou.

No eagles were seen. Owls, hawks, and falcons, which do not directly affect living caribou, were plentiful. On the whole the impression received was that predation on the calving grounds was not heavy.

Straying

Calves found dead on the calving grounds seemed to have been normal and healthy, and the cause of death was not apparent except in one case of incomplete birth. Some of the carcasses had been fed on by small mammals or large birds, but apparently after death. The possibility that many calves may be separated from their mothers at an early age has been discussed previously in this section. This may well be a frequent cause of mortality on the calving grounds.

Contrary to the common impression, caribou cows to not seem to hide their calves deliberately when danger threatens. A cow may often give the impression that her calf is hidden near by, but search for such calves during the present investigation was always fruitless. The cows are therefore unaccustomed to searching for their calves. The result of a sudden dash of a large predator into a herd would be to scatter the herd in all directions, and herds have been seen to scatter and run wildly for no apparent reason. Calves left behind at such times have only a doubtful chance of being found again, and if not found would have little hope of survival.

Drowning

Calf loss from drowning may be larger than indicated in the literature and verbal statements. On August 11, 1951, dead caribou were found scattered along a ten-mile stretch of the north shore of Aberdeen Lake, including the narrows, which is about 4½ miles long. Along one mile of shoreline the following caribou were counted:

Class of Animal	Number	Per Cent of Total
Adult male	3	6.7
Adult female	3	6.7
Two-year-old	2	4.4
Yearling female	3	6.7
Male calf	8	17.8)
Female calf	2	4.4) 75.5
Calf, sex unknown	24	53.3)
TOTAL	45	100.00

Many calves were too badly decomposed for sex identification. It was estimated that drowning had taken place about the first week in July, when the calves were less than a month old. Judging from the mile sampled, there may have been up to 450 carcasses along the ten miles of shoreline. Theoretically this could have meant a 100 per cent calf loss from a herd of 15,000. The narrows is from two to five miles wide, perhaps too great a distance for calves to swim easily. The presence of dead adults which were otherwise uninjured suggested that a high wind was blowing. Fortunately such great losses through drowning are seldom reported.

General Effects of Mortality

Except for what has been stated, little is known about calf mortality among caribou. As with most other game animals, calves are probably more subject to mortality than adults, from such factors as winter kill, disease, and predation. Probably the sex ratio at birth is equal, and since there are generally many more adult females than males in a herd, there is an early differential mortality. Of 15 calves found dead during the continuing study, nine were male and six female; of two live calves examined shortly after birth, one was male, one female. The data are too few to be significant.

SECTION IV. GROWTH

Measurements

Tables 12 and 13 present the weights, measurements in millimetres, and ages as far as known of most of the caribou autopsied during the investigation since 1948. Similarity in a number of measurements is accounted

for by the fact that many of them were converted from inches. Some data presented in Table 10 are repeated for the sake of continuity. As far as known, the weights given were all secured in the field immediately after death of the animals, with fairly accurate scales.

The value of the shoulder measurements is open to question. The variation is so great that much of it is believed to be due to different measuring techniques. The author has measured consistently from the tip of the extended hoof to the dorsal tip of the scapula, with the leg extended, a useful method in dealing with carcasses in all stages of decomposition. Other workers appear to have used the conventional measurement to the top of the back.

Ear and tail measurements are not given, although many were taken. They appear to be relatively constant for animals more than one year old, but there are some surprising individual variations.

The average measurements, except for shoulder height, are slightly smaller than those presented by Banfield. This is because they include a number of animals two to three years of age. In spite of this inclusion, the average weights are somewhat greater. The difference is believed to be due to the inclusion of a number of specimens taken in August and September, when in prime condition. Males No. 33 (338 pounds) and No. 38 (291 pounds) were heavier than any taken during the preliminary investigation. They were the only adult males in a small random sampling at Winter Lake in September, 1952. They appeared unexceptional among many hundreds seen at that time. Specimens nearly 100 pounds heavier might quite possibly have been secured. These caribou were in prime condition, although not generally fat.

Male No. 39 had much greater total and hind foot lengths than any other specimen, as well as a weight relatively great considering that it was in poor condition. When shot it was travelling with two other males which appeared to be still larger. It was the only adult male taken north of Great Bear Lake. This instance lends weight to the belief that caribou may vary in size regionally. Indians and Eskimos in certain areas speak of more than one 'kind' of caribou. The characteristics by which they distinguish the various 'kinds' are difficult to ascertain, but size is usually involved. Possibly factors such as the nutritional quality of the range

vary regionally, resulting in slight differences, in average size.

Although the measurements of adult males and females frequently overlap, their averages differ considerably, particularly the average total lengths. Among animals more than 24 months of age, males averaged 146 mm. longer and 44 mm. taller, and had an average hind foot length 7 mm. greater than females. They also averaged 85 pounds heavier.

Younger animals of both sexes show a relatively constant growth. In some cases involving both sexes, foetal caribou exceeded in size new-born caribou. Variation in size between sexes is not noticeable at the time of birth and does not appear to show clearly until after the first year.

Aging

Accurate aging would add much to the value of these data. The writer has little confidence in assigning ages to caribou more than 15 months old, and apparently the other investigators shared this uncertainty. After two years of age no correlation between age and body size is readily apparent. Male specimens No. 12 and No. 32 were both thought to be two to three years old, although the latter was much the larger. Similarly male specimens No. 15 and No. 35 and female specimens No. 27 and No. 41 differed in size but were believed to be of similar age. Such differences are even more apparent in the field. Calves eight to ten months old are often nearly as large as their mothers, and two-year-old males may be as large as some obviously old males.

Banfield gave an aging technique based on tooth wear in the lower jaw. This has not been used very successfully during the continuing study, partly because of the difficulty of making delicate measurements in the field, partly because of wide variation from the average, and partly because of apparent difference between the sexes. By coincidence, four study skulls on hand are equivalent in age to one of the groups Banfield measured. They consist of a male and female each of caribou and reindeer. As they were all collected in summer, their age was known as closely as possible without rearing from birth. The comparative tooth measurements of the two groups are presented in Table 14. Lower jaw measurements only were used and the technique followed was that given by Severinghaus (1949) and Banfield. Measurements were made from the gum line to the top of the

highest cusp on the lingual side at each tooth.

The sample is too small for great significance, but supports the belief that there is great individual variation in tooth development and wear. Of particular interest is the fact that the female caribou had the greatest molar development but the smallest premolar cusp development of the four specimens. An effort is being made to build up a complete series of study skulls for further research on aging criteria. Tooth development and wear, and the progressive ankylosis of skull sutures, alone or in combination, may eventually provide accurate indices of age.

SECTION V. BEHAVIOUR

As the report of the preliminary investigation deals rather fully with this subject, only a few contributions of a general nature, which may be helpful in understanding the processes of migration, predation, and choice of range, are offered.

Generalizations about caribou behaviour are easily developed, but exceptions are frequent. Thus, the bands can usually be approached to within 100 yards in spring without alarming them, but one band out of ten dashes off in great alarm when the observer is half a mile away. In September, on the other hand, they will usually flee at sight, but occasional bands may be almost as unconcerned as domestic cattle. In August the bands usually stay in areas that are relatively high, dry, and free of insects, but in exceptional cases they may remain for long periods in the most mosquito-infested areas in the country.

Behaviour of Individual Bands

Banfield has pointed out that the caribou bands usually consist of from five to 100 caribou. Except when the caribou are thinly scattered or very abundant, the observer on the ground usually encounters bands of from ten to about 40. The behaviour of groups of this size has necessarily been one of the most frequently observed aspects of study.

Two recognizable types of behaviour have been noted: individual band behaviour - the behaviour of a

single band as a unit; and inter-band behaviour - the behaviour of two or more bands with regard to each other. The latter type is not discussed, as this subject is believed to be one for investigation by a specialist in mass animal behaviour. The following remarks refer only to individual band behaviour.

The main manifestation of this kind of behaviour in relation to humans is no doubt partly an expression of natural curiosity. This is a tendency to move towards the human instead of away from him, at first sight. It was best displayed at Bathurst Inlet during late May and June, 1950, when it was noted again and again that bands as far as one-half mile to the side of the observer's path would come in, sometimes as close as 20 yards, and usually cross it downwind. The general pattern was always the same but no two bands followed exactly the same course at the same speed. Some came in at a walk or trot and stopped, perhaps more than once, downwind, before moving off out of range. Others approached at an increasingly rapid trot, finally passing downwind at full gallop. As caribou seldom change direction sharply in galloping it was possible to run an intercepting course and get close enough even to touch individuals.

Figures 1 to 7 show this behaviour diagrammatically, as displayed by seven different bands. In some cases the band moved first downwind to catch the observers' scent and then upwind to get a close look at them (Figs. 2, 3, and 6). In other cases it made only a single downwind pass (Figs. 4 and 5). Frequently when the observer was moving directly downwind the band moved along in front of him, perhaps stopping and walking back several times to scent and see (Fig. 1). Animals nowwhere near the observers' line of movement, often passed by completely, thus came under close observation.

Large bands had a tendency to come closer than small ones. Single animals and groups of two or three seldom came closer than 100 yards. In some cases the band gave every evidence of confusion and panic, running at a mad gallop, and all the time coming closer and closer. As shown in Figure 3, one band actually circled the two observers at a maximum distance of about 30 yards.

The type of behaviour described above is commonest in late winter and spring, when it is displayed by most caribou bands randomly encountered. A typical behaviour trait of cows during the period of parturition - immediate, rapid withdrawal upon approach of the observer -

was described previously in the section on calving. In summer the bands seem to grow warier. By mid-August their behaviour is hard to predict. During late August and at least the first half of September careful stalking is needed to get within rifle shot of a band on the barrens. Although they still circle downwind, they often do not come closer than one-quarter mile, and as soon as they have caught the scent they proceed directly away.

However, there are exceptions. At Winter Lake on September 16, 1952, more than 1,200 caribou in bands of up to about 75 moving strongly northeast were counted for segregation purposes. Most bands made off at distances of more than one-half mile upon catching the observer's scent, but one group of about 40, mostly adult bulls, were approached without stalking to within 20 yards and moved off in a leisurely manner. On the same day a lone bull was so engrossed in feeding that the writer walked up to it unnoticed and slapped it with a rifle butt

The Senses

Many authors have referred to the caribou's use of its sense of smell, which is generally considered its prime warning sense. The writer is inclined to believe that it is not as acute as generally supposed, although there is no question that it is used frequently. Deer, moose, and bear have all been observed at the moment when they caught a human scent, sometimes at greater distances than for caribou. These animals always reacted positively if man scent meant danger, but caribou frequently seem to doubt the evidence of scent. Even at close range they may, as discussed in the previous subsection, return again and again to the downwind position or even come in closer, as if to confirm by sight what their sense of smell has told them. Large herds pay less attention to unfamiliar odours than small ones do, and herds of several hundred closely-packed animals can often be approached from upwind with only a few paying attention.

The sense of sight of caribou is generally considered inferior to that of most game animals, and there seems little doubt that this is so. However, they are very sensitive to movement, if not to colour and form, particularly in autumn. Caribou bands have shown alarm in that season at a single observer walking against a dark background at measured distances of more than one-half mile. Adult bulls appeared particularly sensitive

and (in August and September only) individual bulls have recognized and fled from an inconspicuously dressed observer at distances up to nearly a mile. Against a background of snow, men or dog teams may alarm caribou on frozen lakes at great distances. However, this sort of behaviour must be considered common only in winter.

In a few instances neither smell nor sight seemed to give warning. All these instances occurred in summer, usually at the height of the fly season, when constant movement had exhausted the animals. On July 19, 1950, the caribou were wary and nervous, perhaps partly because the Eskimos had been hunting them recently, and usually dashed off on the first sign of movement. However, on one occasion six caribou came up the slope of a ridge toward the observers standing on the crest, silhouetted against the skyline, until the leader, a cow, was only 11 paces away. They all halted but did not show much alarm even then until the observers began walking toward them.

During the same day, both observers lay perfectly still for an hour on an exposed hillside among grazing caribou. Individuals fed to within 15 feet, and for a short time one lanky cow seemed to have designs on McEwen's boots. Again none of the caribou seemed to recognize potential danger, by either scent or sight, until the observers moved.

The only comparable behaviour is that of very large herds, which will sometimes come within a few yards of a man. However, this appears to result not from lack of recognition but from indifference.

Behaviour of Caribou and Wolves in Association

Unless wolves show positive signs of aggression, caribou are no more terrified of them than of men. In many instances they showed little fear in the known presence of wolves. On June 2, 1950, a wolf was feeding on freshly-killed caribou near the shore on a small lake some miles from the sea-coast at Bathurst Inlet. Scattered caribou were grazing all along the shore. Some of them raised their heads briefly, from time to time, to watch the wolf, and once two yearlings walked out on the ice to about 40 feet from the wolf to stare at it for some time. As it walked straight away across the lake it met several groups of caribou which raised their heads as it passed, or trotted a few paces to one side.

86629—4½

When the observer walked across the lake immediately afterward the caribou on the ice and on both shores left the area, some of them on the run.

From May 25 to 30, caribou crossing the inlet in great numbers were under observation through binoculars from a commanding position on a high cliff. Wolves were seen among the caribou every day, and could be watched while they travelled distances of five to ten miles. Panic and prolonged flight were not observed. If some caribou met a wolf they sometimes turned back to the land, sometimes trotted off to one side and then resumed their course. If a wolf got among a group unnoticed, there was a flurry of movement which carried the group several hundred yards from the wolf; but the pace quickly slowed to a walk.

Wolves were several times seen running across low islands, mostly less than 100 yards wide, on which many caribou were feeding. The caribou always dashed off the land until the wolf had passed. They then returned to the islands or proceeded along their migration route.

The observations clearly disproved the notion that all wolves are born killers and always attack when prey is convenient. Only once was a wolf seen making a serious effort to kill caribou, and it quickly gave up when the caribou saw it stalking 75 yards away and ran off. Yet there appeared to be no reason why the wolves should not attack if they wished to do so.

Caribou react more strongly and consistently to packs than to single wolves. As far as the observations show, they always try to get out of the way when a pack is clearly sighted. During the second week of September, 1952, a pack of five white wolves was seen a number of times in the Roundrock Lake area. These wolves were visible at great distances because of their colour. The caribou were not observed to react to the occasional howling of the pack, but whenever it came in sight they moved off; and if the pack was within 300 yards when they sighted it, they usually ran more than a quarter of a mile. However, none of the bands was sufficiently alarmed to change its direction of migration.

A pack was once seen cautiously approaching a grove of stunted spruce on a southern hillside, in which about 30 caribou were feeding and resting. When

all the caribou were hidden by the trees, four of the wolves spread out along the southeast margin of the grove while the fifth and largest circled around the northeast side, apparently to drive the caribou back to the others. This wolf was nearly in position when a bull stood up only a few feet in front of one of the waiting wolves, which dashed forward, putting all the caribou to flight. After a chase of about 200 yards the wolves regrouped and moved off to the west. The caribou then slowed to a walk and continued their northeast migration.

In spite of the evidence that caribou are not greatly harassed by wolves, there is no doubt that individuals know when they are in imminent danger and react accordingly. At Bathurst Inlet in the spring of 1950, McEwen saw a wolf pursuing a group of three caribou. Two broke away, circled back, and calmly went about their business. The third fled in evident desperation, and the wolf was still trying strongly to overtake it when they disappeared.

An actual kill has not yet been witnessed, but observation of a number of recent kills showed that the wolves usually took their prey by one of two methods: by a pack running in relay until the caribou was exhausted, or by a single wolf surprising a caribou under circumstances favourable for capture.

Terror may sometimes be a greater factor in causing death than physical injury. A dead calf found on a sand beach in the Thelon Game Sanctuary on August 4, 1951, was examined carefully. The wolf had seized the calf by the throat some distance out in the water and dragged it, already dead, half-way up the beach. It had been lightly fed on by the wolf: the left eye and the throat were slightly chewed, as well as the left flank and abdominal wall. The injuries, including those made by eating, were not believed sufficient to have caused death immediately. Heart failure or something like it must have been the major factor. Numerous other instances of the same nature have been observed or reported.

Very large herds often attract large numbers of wolves, particularly in winter, and a form of association almost symbiotic in nature takes place. Generally, not always, the larger the herd, the less attention the caribou seem to pay to the wolves. On March 26, 1951, a herd of some 16,000 caribou was located by aircraft, feeding and resting on a lake and muskeg area south of

the Bear River. Among them were counted 19 wolves, 12 in one pack and the rest scattered. No dead caribou were noted and no pursuits were in progress. For the most part the wolves were resting. As the aircraft approached they all sprang up and ran. The indifference of the caribou to the wolves is shown by their allowing these predators to mingle with the herd without bunching up and moving on. As the wolves ran through the herd some caribou were alarmed enough to stand up, but that was all.

During the winter of 1950-51, 60 wolves were seen with the wintering herds. This is a surprisingly large number, considering that all those seen attempted to hide in thick forest and that many must have succeeded in doing so before being spotted.

Chewing of Antlers and Miscellaneous Objects

Nothing noticed in the literature indicates the great extent of the chewing by caribou of antlers and other objects. The spike antlers of young animals, which still have velvet on them when shed, are not usually chewed, but unchewed antlers, other than these, are rarely found. Antlers more than two feet long, with several branches, may be reduced to stubby butts, and antlers of fully adult bulls to a foot or less of the lower main beam and butt and a small part of the brow tine. Usually, when the antler is large and heavy, there is evidence that chewing continued even after it caused bleeding about the mouth. Antlers frozen into snow and ice may be chewed down as far as possible.

This was first noted in 1950 at the base camp at Bathurst Inlet, where many cows and young animals shed their antlers, and was attributed to microtine animals. Close examination, however, revealed the distinctive zig-zag shape left by caribou, chewing with a sidewise grinding movement of the jaws.

The limited observational evidence indicates that caribou may chew their own shed antlers, and that most of them will chew any antlers they find. Other bones are chewed, but not so often. Skulls, leg bones, and vertebrae of caribou, usually well weathered, have been found chewed. Bones of other mammals, including wolves and long-dead Eskimos, have been found partly consumed.

Caribou rarely browse in the proper sense of the word, but shrubs and trees on the winter range often show the results of much chewing. Occasionally a number of trees or shrubs in a limited area are affected. Willows - one of the most frequently-chewed shrubs - are often reduced to stubs half an inch or more in diameter. The stubs left by caribou can be distinguished from those browsed off by other ungulates; they are frayed and occasionally bloody instead of neatly bitten off. Spruce, larch, and birch are other species chewed occasionally.

SECTION VI. PREDATION

Minor Predators

The wolverine (*Gulo luscus*), although not common anywhere in the Northwest Territories, is generally more abundant there than in other parts of Canada. It is found throughout the caribou range. Only one was seen on the ground during the continuing study.

Except for a few questionable references, there is no evidence that wolverine kill caribou. In late April, 1953, Dave Floyd, a bush pilot, reported seeing two wolverines, one of them in pursuit of caribou. The pursuit may have been through coincidence rather than intent. However, the size, weight, and well-known strength of wolverines would make it possible for them to kill caribou if they ever get in position to do so.

Barren-ground grizzly bears (*Ursus* sp.) certainly take a few caribou calves and are physically capable of killing adults. The speed displayed by one grizzly in flight left no doubt it could overtake at least calves. Grizzly droppings found on the calving grounds at Bathurst Inlet contained tendons and leg bones from very young calves. Others found at the limit of spruce in the Thelon Game Sanctuary contained caribou remains, but this was in an area where caribou are frequently drowned, and carcasses are plentiful. These bears probably do not obtain fresh caribou meat very often.

Golden eagles (*Aquila chrysaetos*) may take a few calves, but there are too few of them to take many. They are distributed generally but are very scarce on the calving grounds.

The raven (Corvus corax) is known to prey on young reindeer. Kumlien (1879) wrote:

> "Young reindeer fall an easy prey to (ravens). When they attack a young deer, they are generally six or seven in company, and about one-half the number act as relays, so that the deer is given no rest. The eyes are the first parts attacked, and are generally speedily plucked out, when the poor animal will thrash and flounder until it kills itself".

During the calving studies in 1951, 49 ravens, including many single birds and one flock of more than 20, were seen on the calving grounds. It was the nesting season and apparently many were non-breeders. It was considered likely that they had congregated there because dead calves and the afterbirth made excellent scavenging. No evidence that they were preying on the caribou calves was noted, but this is a matter that deserves further study.

The Wolf Population

Clarke (1940) estimated that there were about 36,000 wolves on the caribou range. Banfield reported only 81 wolves seen from aircraft during the preliminary investigation but did not attempt a population re-estimate. During the continuing investigation the aerial observations of wolves were as shown in Table 15.

The 27,324 miles flown over the forested winter range represents about the same flying time - 360 hours - as that in which Banfield recorded 81 wolves. In compiling the table, allowance was made for high altitude flying when wolves were not usually seen, for significant distances over large bodies of water, and for bad-weather flying when little was visible on the ground.

Wolves are much more likely to be missed from aircraft than caribou because they are generally smaller, because in many cases their colour blends with that of the surroundings, and because they always try to hide or make themselves inconspicuous as soon as they see aircraft coming over. Probably no more than half the wolves within one-half mile on either side of survey aircraft may be seen on the tundra. In the forest, probably no more than one-third of those within one-quarter mile on either side of the aircraft are spotted.

Based on these presumptions, an estimate may be calculated from the data in Table 15 as follows:

The summer (tundra and tree-line) ranges of the caribou occupy an area of approximately 360,000 square miles, if the marginal areas are included and no deductions are made for lakes and rivers.

Number of square miles per wolf seen on tundra $\frac{16,300}{25} = 652$

Adjusted to allow twice as many wolves as were seen $\frac{652}{2} = 326$

Number of wolves on the summer ranges $\frac{360,000}{326} = 1,104$

The winter (forested) ranges of the caribou occupy an area of about 390,000 square miles, including marginal areas and lakes and rivers.

Number of square miles surveyed $\frac{27,324}{2} = 13,662$

Number of square miles covered per wolf seen in forests $\frac{13,662}{80} = 170.8$

Adjusted to allow three times as many wolves as were seen $\frac{170.8}{3} = 56.9$

Number of wolves on the winter ranges $\frac{390,000}{56.9} = 6,854$

Total estimated wolf population on caribou ranges - 6,854 + 1,104 = 7,958

At first thought this estimate may seem incredibly low, and indeed it is not presented with very great confidence. However, it is believed to be reasonably close. Certainly there are not as many as six wolves per 100 square miles, as Clarke suggests, except, perhaps, in limited areas along river valleys and seacoasts, and near settlements. Several thousand consecutive miles of survey have been flown more than once without seeing a single wolf. Also, it is questionable whether a wolf family uses only 100 square miles of country. Wolves were seen hunting, regularly in one instance, at least 20 miles from their dens.

Wolves are not common enough anywhere in the Northwest Territories to be seen very regularly. Men have spent several seasons on active field work there without seeing a single wolf. During about 220 days of ground work on the caribou ranges, only 35 different wolves were seen. Much of this time was spent on the barrens, on ranges occupied by caribou, where wolves could be expected to be comparatively active, abundant, and visible.

The estimate of 8,000 does not appear to be incompatible with the known take of wolves. Between 1922 and 1944 the annual take of wolves in the Northwest Territories varied between the extremes of 323 and 1,958. It seems very likely that a population of 8,000 could support a take of 2,000. Breeding females make up only a small part of the population, but the potential rate of reproduction is high. Young and Goldman (1944) indicate a litter average of seven, but four to six appears more likely in the North. Natural mortality among young wolves is unquestionably high but total mortality is not necessarily increased by a high human kill, which often results merely in lowering the natural mortality. To reduce the population substantially, the human kill must greatly exceed the mortality resulting from natural controls.

Is the estimate of 8,000 wolves compatible with the annual caribou loss to wolves? Since there are no accurate figures on this loss or on the populations of wolves and caribou, any answer is speculation. Banfield estimated a caribou population of about 670,000 and the annual loss to wolves at 5 per cent. At this rate, wolves may take 33,500 caribou per year. Based on a wolf population of 8,000 this would give a kill of about four caribou per year. Few would agree that the

wolf kill is so small but the writer believes that this is a fair average. The evidence gleaned on this point during the investigation is presented in the following paragraphs.

Evidence of Wolf Predation

One rarely sees any considerable number of caribou which unquestionably have been killed by wolves. During a 3½-month period at Bathurst Inlet when caribou were usually present and wolves were seen frequently and were known to be denning near by, not more than a dozen caribou carcasses that had been utilized by wolves were seen. Only two were identified as wolf kills, and one of these two might have been a stray, crippled in Eskimo hunting. Except for these, there was no sign of struggle or blood trails, and in some cases there was clear evidence of partial putrefaction before utilization. In such an area there would always be so many carcasses and crippled animals from hunting operations that the wolves would not need to kill uninjured caribou.

Caribou remains are astonishingly plentiful on the barren grounds, especially where there is regular human activity. Up to 48 skulls have been seen in a ten-mile walk, in an area where hunting is only sporadic; where it is regular, they may be much more numerous. However, unless the carcass is whole and fresh, it is impossible to be sure what caused the fatality. Wolves and foxes may have utilized the carcasses, but that does not necessarily imply that they were involved in the killing. Even when the dead caribou are floating in water, apparently drowned, death may have been the result of a bullet or spear wounds not readily apparent on examination.

The situation is further complicated by the fact that skeletal remains found on the barrens are mostly skulls, vertebrae, and leg bones from adult males and large females. The carcasses of small females and calves are almost entirely utilized. The large bones decay slowly and so accumulate in great numbers.

The evidence from wolf scats is even more confusing. In caribou country almost all wolf scats contain at least caribou hair. This does not necessarily indicate that wolves have been killing caribou. Among 12 scats picked up on the winter range in June, 1952, at least two months after all the caribou had left for the

tundra, all contained caribou remains: seven contained bones, ten hair, and five both hair and bones. In nine of the scats caribou remains made up more than 90 per cent of recognizable matter. Most of the scats were fresh or from dens occupied during the previous summer when the caribou were also absent. Similarly on the tundra, when wolf scats are found without caribou remains in them, this can only mean that other food, such as rabbits and lemmings, is so abundant that scavenging is unnecessary. Undoubtedly most of the caribou remains in wolf scats come from carrion, sometimes so old that nothing is left but bones and hair. When they are hungry enough, wolves will eat anything resembling food by taste or smell. Pieces of human clothing were found twice in scats - evidence of scavenging in discarded native campsites.

Promiscuous and apparently wasteful killing of caribou by wolves is occasionally observed and reported. Such slaughters must be very rare. Some reported kills are exaggerated, and some are really the result of native abandonment after killing or crippling. During the winter of 1953, large numbers of caribou remained close to Yellowknife, and local hunters killed up to 5,000 of them. At that time aircraft passengers frequently reported seeing "wolf-killed" caribou on lakes. Undoubtedly most of these were remains left after human hunting and butchering.

Indiscriminate killing by wolves occurs most frequently in May and June. Banfield (1954, Pt. II, p. 51) records finding 113 carcasses in the wake of a large migration in late April, 1949. No such large numbers have been seen during the continuing study, but occasionally four or five carcasses lay within a mile or so of each other on open lake ice. In April, 1950, half a dozen recently killed caribou were found in a close group on Ghost Lake. All these were whole except for the head, neck, and, in some cases, portions of the foreshoulders. A similar group was seen in late May on the sea-ice of Bathurst Inlet, and natives reported finding about half a dozen carcasses which they used for dog feed. At that time of the year the wolves are settling down at their dens and the pups are being born. The grouping and location of the carcasses lent weight to the belief that they were intended to provide a continuing source of food near the den. Young and Goldman (1944) quote similar examples from Alaska, and Murie (1944) reports seeing wolves cache meat on a number

of occasions. To describe these killings as indiscriminate is not to consider that the wolves may return to the carcasses later. Other predatory animals and birds also utilize many of these carcasses.

In time, observations of wolves in an undisturbed state may give valuable knowledge of their habits and their relationships to caribou. Up to the end of the period here reported 13 hours 48 minutes of observation time had accumulated. Since a number of packs numbering up to seven wolves were involved, the "wolf-hour" time was 43 hours 48 minutes. A number of the conclusions described above are supported by the observations made, but an actual kill was never witnessed. In many cases the wolves were close to caribou and in plain sight of them, but both displayed only indifference.

Observations from aerial surveys in winter were expected to give some indication of the number of caribou killed by wolves on the winter range. They are easily spotted when lying in the open and are presumed to be wolf kills if it is known that human hunters are not present. During the winter of 1950-51 not one wolf kill was seen in 12,542 miles of flying, although 60 wolves and many thousands of caribou were observed. One, possibly two, wolf kills were seen on a 2,000-mile flight over the barrens in May, 1952, both within five miles of a known wolf den. During the winter of 1952-53 seven caribou presumably killed by wolves were seen in 13,360 miles of flying. Six of these were in a relatively small area on the last day of March, and were very likely kills made by wolves from a single den. The only other wolf kills seen from the air were in late April and early May during the migrations. From these observations it is assumed that the wolves make most of their winter kills in forests, where they are invisible from aircraft.

Wolf Control

The Northwest Territories contains vast reservoirs of country which cannot be reached by any control method however extensive. On the other hand, wolves concentrate to some extent on the winter ranges occupied by caribou, and this suggests that limited control in that season might have good results. If successful, it would reduce caribou mortality on underpopulated ranges considerably, and cut down the relatively large spring kill by denning wolves.

SECTION VII - RANGES AND RANGE STUDIES

Geology

The geology of the occupied caribou ranges on the North American mainland is complex and, to a large extent, imperfectly mapped. No clear-cut correlation between geological formation and caribou abundance or dispersal is yet apparent. Future study of soil development and vegetation on various important rock formations may be expected to produce valuable results. As discussed below, the initial development and recovery of vegetation after fires and grazing may be strongly influenced by underlying strata.

The greater part of the summer ranges and large parts of the winter ranges lie within the Precambrian Shield, but apparently the movements of caribou are not restricted to the Shield. Archaean rocks predominate over most of the Shield but Proterozoic rocks of various ages and composition are dominant in very large areas. Recent observations have thrown doubt upon Banfield's conclusion that caribou occur less commonly on Proterozoic sedimentary rocks than on Archaean acid rocks. Some of the summer ranges used most frequently and intensively are in areas presumed to be Proterozoic, and some of these ranges have been used frequently the year round. Among these are the Bathurst Inlet and Kent Peninsula ranges, nearly all the Thelon River basin, and a large tract of often-used country that lies between.

Banfield also wrote (1954, Pt. 1, p. 7):

> "Caribou occur infrequently on volcanic metamorphosed rocks, such as are found in the immediate vicinity of Flin Flon, Manitoba, and Yellowknife, Mackenzie District."

However, it may be pointed out that these rocks are of extremely minor importance and sporadic occurrence. In the Yellowknife area at least, caribou avoid them, as they do large surrounding areas of Archaean sedimentary and volcanic rocks, because they have been burned heavily and often. Probably this is also true in the Flin Flon area. Caribou find good pasturage over rocks of similar age and nature along the Snare River and at Indin Lake, where burning has been less intense.

Topography

The caribou ranges are as complex topographically as geologically. The mainland ranges, estimated at about 600,000 square miles, include almost all types of terrain except high mountains. For the most part the altitudes range from sea-level to 2,000 feet. The topography varies from coastal and inland plains sometimes hundreds of square miles in extent to rugged, broken, rocky country, where even a man without a pack can scarcely travel on foot more than five miles a day.

Caribou are known to utilize every type of terrain in their range. However, topography does have considerable influence on the distribution and lines of movement of individual herds. This influence varies with the season, the condition of the vegetation, and the weather.

Topographical influences are particularly noticeable during spring migration. The first positive indication of this migration is a movement from forests and muskegs to valleys and watercourses. A large lake such as Lac la Martre may be the focus for bands moving from various directions. When sufficient impetus has been built up the general movement avoids only the greatest topographical obstructions, but most of the animals still follow major routes of easy movement. Thus the Rae herd may move east across the 116th meridian on a front 100 miles wide; but two-thirds or more of the herd may pass through comparatively narrow valleys in the Snare River watershed.

Once the open barrens are reached, movement in almost any direction is easy, and directional trends are readily recognized from tracks. For nearly 100 miles from tree-line to Contwoyto Lake, the Rae herd moves on fairly straight lines over gently rolling country and frozen lakes.

Before Contwoyto Lake is reached from the west, and after leaving it on the east the terrain is increasingly rugged, and impetus is lost rapidly. By this time the animals have spread out and are much more widely distributed than when they left the forest. Rivers and some lakes are beginning to thaw. For at least a short time topography appears to be the major factor in caribou distribution and movement. Groups start to follow lakes, rivers, and valleys at all angles from their original

direction. Large, widely scattered herds break up into small, compact groups. Every physical obstruction tends to split groups or bring them together again. By the time strong directional movement is completely lost, the herd is scattered over thousands of square miles in groups of mostly less than 100.

Until this time rock ridges, mountains, and hills have been avoided, because the caribou, like man, finds climbing laborious in the soft spring snow. When the snow is gone, even the steepest slopes are utilized, and open lakes and rivers become the major obstacles.

In summer, bodies of water have a very great influence on behaviour and distribution. On the mainland barrens, particularly the great central and eastern plains, lakes have been estimated to make up 40 to 60 per cent of surface area in some localities. Bodies of water range in size from small potholes to lakes among the world's largest. Even the most accurate maps do not show many of the small lakes. Drainage is slow in many places, due to the low relief, and large lakes with two or more outlets are not unusual.

Effect of Forest Fires

It has long been recognized that forest fires have an extremely detrimental effect on lichens and that lichen recovery after a fire is very slow. During the barren-ground caribou study field men have noticed that caribou are apt to avoid burned areas, even very old ones. They do not generally feed in them much although they will sometimes migrate rapidly through them. In some cases it was noticed that bad burns turned or divided major migrations. Field workers have also noted with growing concern that enormous areas in the winter ranges have been burned so recently that the burns still show up plainly during aerial surveys. The winter range of the Yellowknife area has been almost completely burned during the past 60 years, and many other areas have suffered as badly.

No doubt there were fires in the North due to natural causes and the work of Indians, long before the white man came. There is reason to believe, however, that the burning of the past 75 years has greatly exceeded any normal burning that preceded it. It is known, for example, that large areas around Great Slave Lake were burned purposely by prospectors to expose the rock. In

some cases Indians may have burned out white trappers from enmity. Indian carelessness has had more widespread effects since outboard motors increased their range of summer operations; and everywhere white men have increased their summer activity by the use of aircraft. Also, foresters believe there has recently been a high point in a cycle of forest fire hazard. Apparently there have been many more fires than could occur naturally and the wintering situation for many caribou herds grows more and more unfavourable.

Range Requirements

Few realize how large an area is necessary to winter a large herd of caribou year after year. Exact figures are not available but some reasonable estimates may be made, based largely on experience gained in centuries of reindeer herding in northern Europe and Asia, and on recent work in Canada. It seems unlikely that more than six caribou per square mile can be wintered on a long-term basis over much of the normal winter range.

At that rate, the Rae herd, which has numbered 125,000, needs at least 21,000 square miles of winter range. The range it occupied during the winters of the continuing investigation covers about 22,000 square miles. Only about 10,000 square miles more is available to this herd unless it changes its migration routes drastically. In the winter of 1950-51 it occupied only the best portions of the range at a density approaching 15 caribou per square mile. The best parts of the range will stand this density, but not continuously. Superior quality range is strictly limited in extent - the caribou covered all of it during those winters - and there are large tracts that will not support any caribou. Thus the Rae herd, at its present numbers, is believed to be utilizing all its available range and may well be over-utilizing parts of it.

This area is subject to frequent fires; in late August, 1951, local pilots reported 24 unchecked fires burning in the eastern parts of it. A few really bad fires in the better parts of its range would be disastrous to the Rae herd.

The above calculations, although rough, are included to illustrate the range requirements of a large herd of caribou.

86629—5

Caribou Winter Range Study

During late May, June, and July, 1952, an investigation of selected areas on the winter ranges of the Rae and Yellowknife herds was carried out. The prime objective was to assess the influence of forest fires. Secondary objectives were (1) to enumerate the plant species, particularly lichens, and determine their relative densities and proportions; and (2) to determine the forest types and their proportionate utilization by caribou. The study was conceived as a long-term project and the work done in 1952 is regarded as preliminary.

Methods

Every effort was made to use in the field work only those methods which could be used by workers continuing the study in later years. The line-point transect technique was decided upon for sampling the range vegetation. This is possibly the simplest of the range survey techniques, and it also appears to be the fastest in operation. The only articles of equipment needed - and used during the present investigation - are a compass, a 100-foot tape, and a notebook and pencil. The point-sample technique appears to be fully as useful, and was discarded only because it depends to a considerable extent on equipment. The use of the Raunkier's circle and random plot techniques were discarded because they depend too heavily on the judgment of the investigator.

In establishing line transects only the point of commencement of the line was marked. Cairns or large blazed trees were used as permanent markers for this purpose. From the point of commencement each line followed a compass bearing. One hundred vegetative readings were taken along the line at intervals of 300 feet. Thus if the first 100 feet of a line was used for vegetative readings, 300 feet was measured off beyond the end point and then the next 100 feet was used for readings. The first 100 feet of a line were not always used since, for convenience in marking, some of the points of commencement were situated on rocky shorelines and other spots not typical of the area being studied.

Some of the lines were continuous, in which case they were more than 3,700 feet long. In other cases the topographical interference or the smallness of the sample area necessitated running the line in two parts. In some cases this was done by starting two lines at

different compass bearings from the point of commencement, each extending more than 1,800 feet. In other cases one line was run north and a second line south, commencing at some readily recognizable point near the termination of the first, but never crossing or closely paralleling it. In every case, but one, 1,000 readings were made per line. This number was decided upon because it was thought to provide sufficient samples for significance and also gave at a glance the percentage composition of the range by species. It was found that all important species of plants on a given range were present in 1,000 points and, as nearly as could be ascertained, the majority of the less important ones were also present.

In laying the line from which vegetative readings were made, care was taken to use the same procedure in every case. One man held the distal end of the line and walked forward along the proper bearing, letting the line drop on the ground from a height of two and one-half feet. Vegetation above this height did not need to be sampled, since caribou do little browsing. The second man stayed at the point of commencement and held the line until 100 feet was run out. Where bushes or trees were encountered, no deviations were made except to go around tree trunks, and the line was run through the trees or bushes as nearly as possible from the standard height.

In reading the line, the footmarks on a 100-foot tape were used from 1 to 100, inclusive. Any species that appeared directly beneath a footmark on the left-hand side of the tape, was recorded. The left-hand side of the tape was used consistently since sometimes, particularly in lichen areas, different species appeared on different sides of the tape at a footmark. This did not mean that the species nearest to the tape was always recorded; for example, if the tape was running through a dwarf birch a foot or more off the ground, with birch twigs or foliage within an inch or so of a footmark, the vegetation beneath the footmark, even if farther away, might be some grass or lichen on the ground and that was recorded.

Difficulty was experienced in identifying some species of plants found on the transects. All important species were collected and recorded for field purposes on the spot, by a number for which the correct name could be substituted later. It was not possible to collect specimens of all plant species: on some transects minute lichens and mosses of many different species were found. These unidentified species were lumped together

in general categories, i.e., moss, small; lichen, small; annual plant. It is believed that the great majority of them have no significance as caribou food.

Four categories not vegetative in nature were used. These were bare sand, bare rock, bare earth, and water. Bare earth may be defined as bare soil with some obvious mixture of organic material, humus or organic litter. Some of the organic litter classed as bare earth included large and intact leaves and branches. Bare rock included exposed rock in place, crumbled or broken rock, talus, and, occasionally, relatively large pieces of drift.

All the transects were in areas known to have been utilized by caribou during the preceding winter and presumed to have equal chances of utilization. Some quantitative idea of the relative amount of use given the various types of unburned forest and the burns of different ages was wanted. It was decided to use faecal pellet counts. The technique used in most of the summer's work may be called a line-plot sampling method. Every time vegetative determinations were made along a line, pellets within three feet on either side of the line were counted. Thus on each transect 6,000 square feet was inspected for pellet groups.

A faecal pellet group may be defined as any group in which six or more pellets can be clearly distinguished. Six may seem very few but caribou often drop their pellets on the move, leaving a point of concentration and the rest of the pellets scattered widely. Pellets of all ages were counted, as the aging of individual groups was frequently impossible, particularly in damp areas. In any case it seemed doubtful that many of the groups were more than one year old, except possibly in some of the drier habitat.

The ages of burned areas were determined by counting the annual growth rings on trees and shrubs. Where possible, aspen, poplar,and poplar birch were the species used since they generally commence new growth during the summer following burning. Sometimes it was possible to find trees carrying scars which showed that they had survived a fire.

The Keller Lake Study Area

Keller Lake was chosen as a study area after preliminary aerial surveys in the spring. Caribou from the Rae herd had wintered there in some numbers during the previous two winters. The study area included a good variety of forest types and burns of different ages. It would have been desirable to include an area burned recently, and from the air some burns looked recent, but on the ground it was found that the last fire had been 22 years before. This is one of the few areas suitable for study that are easily accessible by canoe.

Keller Lake is situated between highlands on the west and what may be called the Lac Taché lowlands on the east. From the north end of the Cartridge Mountains, west of Lac la Martre, the country slopes rapidly down towards Lac Taché and levels off at about 800 feet above sea-level, maintaining this altitude west to Keller Lake. Water from this district drains northward in the Johnny Hoe River and tributary creeks into MacVicar Arm of Great Bear Lake.

As shown on Map No. 11, Keller Lake is triangular in shape. From the low-lying northeast shore a series of parallel ridges, broken in places by muskegs, sedge swamps, and meadows, and with many small lakes lying between the ridges, extends several miles inland. From the other two shores the land rises, gradually on the northeast, more rapidly on the south. Both these shorelines are more or less sandy. Low sandy beach ridges extend several hundred yards inland from the south shore; beyond that is a narrow stretch of wet spruce forest or muskeg before the rise commences.

The transect data for this study area is given in Table 16.

Transect No. 1. - The first transect at Keller Lake was established in a burn approximately 24 years of age. The area had then been an advanced spruce-*Sphagnum*-lichen association - a common type on damp winter ranges. Characteristically, the spruce in such places is very open-growing and the ground cover, at least initially, is mostly *Sphagnum* and allied plants such as *Ledum groenlandicum* and *Kalmia polifolia*. As a result of a drop in the water table, or an upgrowth of *Sphagnum*, dry areas are established and colonized by lichens suitable for caribou fodder. Caribou frequently make heavy use of such areas in winter.

Fires in such areas are seldom, if ever, completely destructive, because of the dampness of the underlying strata. Even when the spruce is almost completely destroyed there are many refugia for mosses and lichens, on relatively dry "islands" in particularly damp areas.

Unvegetated areas are usually small, as an almost solid moss layer underlies the vegetative strata. In this case 15.3 per cent of the sample points fell on unvegetated areas. Of this, 6.5 per cent was open, standing water and 8.8 per cent was classed as bare earth although it might be more exact to call it organic litter. Lichens made up 32.7 per cent of the ground cover and 11.9 per cent was made up of lichens large enough for use by caribou. Many of the small, insignificant lichens were obviously being replaced by larger types - mostly Cladonia of six different species. By far the most common significant lichen was Cladonia mitis which made up 6.3 per cent of total ground cover, with the next commonest, C. coccifera and Cetraria nivalis each making up 1.5 per cent.

Mosses made up 12.3 per cent of measured ground cover and 9.9 per cent was made up by Sphagnum of two species. Actually, this gives a poor idea of the prevalence of Sphagnum which underlay nearly all other vegetation.

There would have been few species of trees and shrubs but for a small, sandy ridge within the transect area. On it Ribes sp., Betula papyrifera and B. glandulosa were picked up in small quantities. Ledum groenlandicum was by far the dominant single species, making up a surprising 21.6 per cent of total ground cover. Spruce made up 4.0 per cent of ground cover but 3.1 per cent was spruce killed by the fire.

Other plants made up 12.8 per cent of ground cover. The most important were Kalmia polifolia (5.1 per cent), Vaccinium Vitis-Idaea (4.4 per cent), and Carex sp. (1.1 per cent).

Transect No. 2. - The second transect was in unburned spruce-Sphagnum-lichen forest directly comparable with that of Transect No. 1. Unfortunately the unburned stand was limited in extent by adjacent burning. As a result, fewer sample points were taken, and some species may have been missed. Because it is comparable, however, and because even limited sampling reveals the major species, the results are given.

Unvegetated areas included only 4.3 per cent of sample points, the least on any transect. Lichens made up 36.1 per cent of measured cover, only a little more than on Transect No. 1, but the percentage of significant lichens was much greater (31.4 per cent instead of 11.9 per cent). The transect area constituted very good caribou winter range. By far the most important of the lichens were Cladonia mitis (15.4 per cent), and Cetraria nivalis (11.4 per cent). Of four other significant species only Cladonia coccifera (1.3 per cent), and C. multiformis (2.3 per cent) constituted more than 1 per cent of ground cover.

Mosses included four species identified on the burned area in much the same percentages, plus a 1.0 per cent coverage of small, unidentified mosses, altogether making up 14.0 per cent of total ground cover.

Trees and shrubs made up an important percentage (30.0 per cent) of ground cover, but included only three species. Dead and living spruce composed 8.0 per cent and Ledum groenlandicum 20.0 per cent. Chamaedaphne calyculata, present as a trace only in the burned area, formed 2.0 per cent of total ground cover in the unburned forest.

Only three other plants each made up 1.0 per cent or more of ground cover and of these by far the most important was Kalmia polifolia (10.0 per cent). The other two were Vaccinium Vitis-Idaea (4.3 per cent) and V. uliginosum (1.0 per cent).

Transect No. 3. - The third transect was in an area that appeared to have been burned heavily some 39 years before. The fire had almost completely destroyed the spruce. The regeneration was young spruce, ranging from small seedlings to trees up to 12 feet in height. The area was a wilderness of dead spruce, standing and fallen, in heavy thickets of new growth and would be difficult for large animals to travel through in winter (Figs. 8, 9).

The area had no standing water, but it was damp. Only 7.2 per cent of sample points fell on bare earth, leaving an unusually high percentage of vegetative cover. Mosses were abundant, making up 17.0 per cent of ground cover, but without exception they were small and insignificant as food for ungulates. Of a total of 10.8 per cent lichen ground cover, only 2.3 per cent was lichens of significant size. Five different species, none showing

more than trace amounts, were involved. They were Cladonia pyxidata (0.8 per cent), C. mitis (0.7 per cent), C. gracilis (0.3 per cent), Peltigera canina (0.3 per cent), and P. apthosa (0.2 per cent). Obviously the area could have little or no value for feeding caribou.

Trees and shrubs made 52.8 per cent of total ground cover. Living spruce accounted for 18.6 per cent of this and dead spruce 10.1 per cent. Betula glandulosa was far more abundant than on other transects, making up 11.8 per cent of ground cover. It was abundant enough to provide a good source of food for moose, which was being lightly utilized. Only three other species were significant: Salix sp. (6.2 per cent), Potentilla fruticosa (2.5 per cent), and Ledum groenlandicum (1.8 per cent).

This transect was similar to Transect No. 6 as regards the moisture content of the soil and other factors, and the vegetative cover was closely comparable although much less advanced. These transects were the only ones in the Keller Lake area on which Larix laricina and Potentilla fruticosa were found.

Probably because spruce, living and dead, occupied so much ground, plants other than those already mentioned composed only 12.2 per cent of ground cover. Of these the most important were Carex sp. (7.3 per cent) and Equisetum sp. (1.4 per cent).

Transect No. 4. - The fourth transect was placed on an extensive beach ridge parallel to the south shore of the lake. The basic habitat was exactly the same as in Transect No. 5, but whereas the latter had been lightly burned 75 years or more ago, the former had been burned rather thoroughly, only 40 years ago. Superficially, the main difference between them was that No. 5 had an open high canopy of spruce with occasional jack pine, but in many places No. 4 had a rather close canopy of jack pine with occasional spruce (Figs. 10 and 12). Differences such as this did not affect the point sample data, since only ground vegetation was measured.

Bare earth and sand together made up 22.7 per cent of measured ground cover - the greatest unvegetated percentage on any Keller Lake transect. This was due in large part to the thick patches of jack pine, which seemed to create unfavourable habitat for plants growing beneath them, and in part to incomplete vegetative recovery following the fire.

Lichen growth was heavy and diverse (Figs. 10, 11). A total of 21.5 per cent of sample points fell on significant-sized lichens and 17.4 per cent on insignificant and small lichens. By far the most important lichen was Cladonia alpestris which alone made up 13.2 per cent of ground cover. It was followed in importance by Cladonia gracilis (3.2 per cent), Peltigera canina (2.6 per cent), and Cetraria nivalis (1.9 per cent). Other species were represented by traces only.

Only two mosses were of significant size: Hylocomium splendens (3.1 per cent) and Ptilidium ciliare (0.4 per cent). Total moss coverage, including small and unidentified mosses was only 4.9 per cent - the poorest moss growth found on any transect.

Tree and shrub growth found in the point samples was limited to living and dead spruce, (5.1 per cent of ground cover), Betula glandulosa (1.6 per cent), and traces only of Ledum groenlandcum, Rosa sp., Populus tremuloides, and Pinus Banksiana. The remaining vegetative cover was composed largely of Vaccinium Vitis-Idaea (10.5 per cent), Arctostaphylos Uva-ursi (6.1 per cent), Empetrum nigrum (4.6 per cent), and Vaccinium uliginosum (2.2 per cent). A number of other species appeared in the samples as traces only, including 1.0 per cent miscellaneous, unidentified annual plants and 0.6 per cent unidentified grasses.

Transect No. 5. - The fifth transect had the highest percentage of lichen cover found on any transect and must be considered exceptional in that regard. Lichens made up 52.1 per cent of the ground cover and lichens of significant size no less than 43.1 per cent. Inspection from the air had showed that this area had the heaviest lichen cover available for study and it was chosen for that reason. It differs from most areas well within the tree-line in being located along a raised beach near the lake shore. It was therefore consistently sandy and relatively dry, and the trees were very open-growing.

Vegetatively, it may be classed as a spruce-lichen association, although jack pine (Pinus Banksiana) was fairly abundant (Fig. 12). By far the most abundant lichen was Cladonia alpestris which provided 32.8 per cent of total ground cover (Fig. 13). Only three other species each provided more than 1.0 per cent of ground cover. These were Cetraria nivalis (5.1 per cent), Peltigera canina (2.6 per cent), and Cladonia rangiferina

(1.7 per cent). The presence of many mature trees indicated that the burning 75 years before had been light and had not severely damaged the ground cover.

Incidentally, it was established in this area that there may be great variation in the damage caused to lichens by burning. In early morning or near sunset, even on very hot days, lichens burn poorly; whereas at mid-day they flare up with almost incredible heat and flame. Humidity changes in the microclimate at ground level, and possibly dehydration of the lichens, appear to be the most likely factors involved. Under poor fire conditions 50 per cent or more of the lichens may survive if, as on this area, there is not much organic litter to retain the fire.

Bare earth made up 13.5 per cent of the sample points. There was only a trace of bare sand, although the whole area was underlain by sand with an exceedingly thin organic layer on top. Mosses were of only incidental occurrence, making up 5.2 per cent of ground cover, of which 4.0 per cent was made up by a single species, Ptilidium ciliare. Profiles through nearly all heavy lichen areas showed at least a scattering, sometimes a heavy layer, of mosses, about the base of the lichens. These mosses do not, of course, show up in the point sample data. Most of these were much too small to figure significantly in caribou diet.

The canopy was almost continuous in some places, but nearly all the trees were so old that they had little or no living branch growth near their bases. Dead and living spruce together made up only 2.7 per cent of total samples. Among the considerable number of plant species which made up the remaining quarter of ground cover, by far the most important were Empetrum nigrum (11.7 per cent), Vaccinium Vitis-Idaea (8.4 per cent), and Arctostaphylos Uva-ursi (2.9 per cent).

This association far more closely resembled superior lichen areas near the edge of tree-line than winter ranges so far within the forest. Possibly, however, this is because such sandy-based areas are not found frequently within tree-line in the areas covered by the study herds, whereas they are found in many places along the tree-line. Such associations always seem to have a high percentage of lichens in association with Picea sp., Arctostaphylos Uva-ursi, Vaccinium Vitis-Idaea, and Empetrum nigrum.

Transect No. 6. - The sixth transect was in an area which had not been burned for at least 135 years, possibly longer. It was wet, with standing water in a few places, but apparently it did not provide a suitable habitat for *Sphagnum*. It was, rather, an area of stunted spruce, often very close-growing, with fairly frequent openings of sedge and glandular birch and occasional pools of water (Fig. 14.) This is a rather common forest type in many parts of the Mackenzie District and, superficially at least, it appears to provide only poor to fair habitat for important mammals except possibly rabbits (Fig. 15).

Unvegetated areas on this transect made up 12.2 per cent of points sampled, with 1.9 per cent of this standing water and the rest bare earth. Much of the bare earth was in pockets, where standing water must have been present so much of the time that vegetation was drowned out. Mosses were abundant, making up 16.4 per cent of ground cover, and including a wider variety of large, identified species than noted elsewhere. The most important of these were *Hylocomium splendens* (4.1 per cent), *Aulocomnium turgidum* (3.1 per cent), *Camptothecium nitens* (2.5 per cent), and *Dicranum rugosum* (1.0 per cent). Total lichens made up only 18.6 per cent of ground cover, a low percentage considering the length of time since burning. However, a surprising 11.8 per cent was composed of large, significant lichens. Of these the great majority (10.0 per cent) were *Cladonia alpestris*. *Peltigera canina* (1.3 per cent) was the only other species to make up 1 per cent or more of total ground cover.

The closeness of tree growth is shown by the fact that 8.2 per cent of ground cover was composed of living spruce and 5.1 per cent of dead spruce. This high a percentage of living spruce was found on other transects only where the forest was in a state of recovery and there were many seedling spruce. A wide variety of other trees and shrubs were also present and five of them each made up 2.0 per cent or more of ground cover. These were *Ledum groenlandicum* (5.2 per cent), *Betula glandulosa* (3.8 per cent), *Potentilla fruticosa* (3.3 per cent), *Salix* sp. (2.5 per cent), and *Myrica Gale* (2.0 per cent). This was the only transect on which *Myrica Gale* was found.

Other plants made up 21.3 per cent of ground cover. By far the most important of these was *Carex* sp. (10.6 per cent). This was the highest percentage of sedges found on any transect, which could be attributed

to the dampness of the habitat. Only two other species, Vaccinium Vitis-Idaea (4.9 per cent) and V. uliginosum (2.7 per cent) made up significant percentages of ground cover.

The Great Slave Lake Study Area

The islands in the east arm of Great Slave Lake were chosen as winter range study areas because caribou often use them in winter, because they have many large burned areas of different ages, and because they are easily accessible from Yellowknife by freighter canoe or boat. They were used extensively by caribou during the winter of 1951-52 and to a less extent during the previous winter.

No rock outcrops were seen at Keller Lake, which is west of the Precrambrian area, but the islands are of Precambrian formation, with many rocks in place on the surface and rock never far beneath it. The soil is probably very acid for the most part, since there is little chance of leaching. In many places it is very thin and held in place on the rock only by the vegetation.

The transect data for this study area are given in Table 17, and the location of the transects is shown on Map No. 12.

Transect No. 1. - The first transect was on the Caribou Islands - one of the few island groups in the east arm which show from the air little or no sign of recent forest fire. Superficially, the forest on these islands appeared to be mature and undisturbed, but close examination of the transect area showed that fire had been through it at least 122 years before. The area could be classed as excellent caribou winter range, but probably it is not subject to as frequent or intensive usage as some of the other islands, since this island group is one of the most isolated (Fig. 16).

Vegetation on this area was more nearly complete than on any other transect. Only 9.6 per cent of the sample points fell on bare earth, rock, or water, despite the fact that the islands are rocky and the soil is thin. Even rocky hilltops and boulder-strewn areas had nearly 100 per cent ground cover (Fig. 17). In small rock clefts and depressions, well advanced, thick, Sphagnum swamps could be found. On the whole, however, the vegetative cover could be called an open-growing, spruce-lichen association.

The lichen growth was the best found on the transect areas of the east arm, and composed 50 per cent of measured ground cover. Of this 23.1 per cent was made up of small lichens of many insignificant species. Lichens more than one-half inch in height and considered potential caribou food made up 26.9 per cent. These included eight species, of which the most important was Cladonia mitis, supplying 16.2 per cent of the total ground cover. Only three other species provided more than one per cent of ground cover; Cetraria nivalis (3.5 per cent), Umbilicaria hyperborea (2.7 per cent), and Cladonia multiformis (2.3 per cent).

Liverworts were not represented in the point readings. A single fern Dryopteris fragrans was found in trace quantities only (0.2 per cent); and mosses provided only 7.4 per cent of total ground cover. Of the last-named, 4.2 per cent was small and unidentified mosses and the rest was large mosses of six different species.

Trees and woody perennial shrubs made up 22 per cent of measured ground cover. Living spruce showed up strongly (5.7 per cent), as it did in all unburned transect areas, even though it was mostly above the height of the measuring line. Spruce and Betula papyrifera were the only true trees tallied. Betula glandulosa, in shrubby form, made up 2.2 per cent of ground cover. This was the only transect on the islands where it was found. Juniperus communis was present in fair quantity (3.5 per cent), as in all unburned transect areas. This species is generally absent in burns, even relatively old ones, and is found usually in open, dry, mature forest and in small refugia in burned areas. This is one of the few tall plants which appear to provide incidental browse for caribou. They appear to browse fairly often on this plant, particularly in areas of poor lichen growth.

Dead spruce, in the form of broken branches or windfallen, over-mature trees, made up 2.1 per cent of ground cover - an unusually small amount, indicative of a healthy, growing, sub-climax association.

Six other species of bushes and shrubs were recognized, but only two made up significant amounts of ground cover. These were Ledum groenlandicum (5.5 per cent), a common species in almost all northern forests, and Alnus sp. (1.4 per cent), which is also almost universal in distribution in these forests but nowhere very abundant.

The rest of the ground vegetation was made up of ten other plant species and a number of unidentified grasses, sedges, and herbs. Some of these may have value as indicators of specific forest types, either by percentage, or merely by their presence. Thus Vaccinium Vitis-Idaea (1.5 per cent) is usually noted only in forest which is either near recovery following fire or unburned. Vaccinium uliginosum (0.2 per cent) is found only in the areas with the best lichens and poorest moss. Other species present in significant quantities included Arctostaphylos Uva-ursi (2.7 per cent), Empetrum nigrum (1.2 per cent), and Saxifraga tricuspidata (1.0 per cent). Grasses and sedges were present in trace quantities only.

Transect No. 2. - The second transect was located on Wilson Island in an area topographically and geologically comparable to Transect No. 1. It had been subjected to heavy burning 12 years previously. It could be considered almost useless as caribou range. The small lichen growth that remained was almost all found in small damp refugia or growing in small, sessile forms on rocks. Vegetation was reasonably heavy - only 21.7 per cent of sample points fell on unvegetated areas - but there was little preferred caribou food.

Mosses made up 13.4 per cent of measured ground cover, and included four large species and a number of small, unidentified ones. No ferns or liverworts were recognized.

Lichens made up 16.5 per cent of the ground cover but 14.7 per cent of this consisted of small, insignificant species of no present value to caribou. In the remaining significant 1.8 per cent only three species were involved; Umbilicaria hyperborea (1.4 per cent) was by far the most abundant of these. Figure 19 shows typical ground cover in rocky areas with fairly plentiful but insignificant lichens. Figure 18 is a wide view of the burn and shows refugia, marked by green spruce, where most of the significant lichens and mosses were found. Another form of refugia is found on the tops of the most barren rocks where U. hyperborea frequently survives even the heaviest fires.

Picea sp. (15.3 per cent), Populus tremuloides (0.6 per cent), and Betula papyrifera (0.2 per cent) were the only trees represented. In local areas poplar growth was heavy. Of the spruce, only 1.1 per cent involved living trees. The remainder was made up of fire-killed

windfalls and branches (Fig. 18). Eleven shrubs were recognized - far more than generally found anywhere but on fairly recent burns. Included were Salix sp. (3.2 per cent), which is uncommon on the islands except in burns and along water margins; Rosa acicularis (1.9 per cent), which is almost invariably uncommon in unburned areas; the ever-present Ledum groenlandicum (2.7 per cent); and Rubus idaeus (0.2 per cent), which is almost exclusively confined to burned areas.

Transect No. 3. - The third transect was established in an area heavily burned about 150 years previously. The area was rugged and many of the hills still had little or no vegetation. Unvegetated areas accounted for 21.9 per cent of points sampled. Of this 19.7 per cent was classified as bare earth but was largely organic litter thinly covering bare rock, rather than a real soil layer.

Mosses made up 18.3 per cent of ground cover. It was interesting to note that both Sphagnum and mosses usually found in fairly dry habitats were present. Sphagnum made up 4.1 per cent of ground cover and was plentiful in wet "pockets" scattered throughout the area. The only other species found in considerable quantity was Hylocomium splendens (9.6 per cent). Small, insignificant-sized, unidentified mosses accounted for only 3.9 per cent of total ground cover.

A wide variety of lichens was present and made up a total of 20.8 per cent of total ground cover. However, only 8.2 per cent consisted of lichens of significant size. Of seven large identified species only two made up 1.0 per cent or more of total ground cover. These were Cladonia mitis (5.3 per cent) and Umbilicaria hyperborea (1.0 per cent). The latter species reached heavy growth in some places and nearly excluded other species on the highest and most open rocky hilltops.

Living and dead spruce were present in nearly equal quantities, together making up 8.9 per cent of total ground cover. Juniperus communis (3.9 per cent) was in greater quantity than on any other transect. Among a good variety of other trees and shrubs only two, Sheperdia canadensis (2.8 per cent) and Ledum groenlandicum (2.8 per cent), each made up more than 1.0 per cent of ground cover.

Other plants accounted for 18.0 per cent of total ground cover. Noteworthy among these were Equisetum sp. (2.7 per cent) and unidentified grasses (5.2 per cent),

again because there were both damp and dry habitats. Equisetum was found mostly in damp spruce forest in association with mosses in heavy shade. Most of the grass was in dry, open, mixed forest. The lichens were found mostly in even drier habitat than that of the grasses, and associated with them were Vaccinium Vitis-Idaea (4.6 per cent), Empetrum nigrum (1.6 per cent), and Arctostaphylos Uva-ursi (1.1 per cent).

The diversity of habitat and vegetative growth on this small area is typical of a great deal of caribou winter range on the Precambrian Shield, where rock is on or very near the surface. Unevenness of the vegetation is caused by the great irregularity of the rock. Walking in a straight line for as short a distance as a quarter mile, it is possible to cross a dry open spruce belt, a stunted spruce-Sphagnum swamp, a grassy well-forested glade of mixed growth, and a bare, unforested rocky hill-top. It is nearly impossible to assign such country to a specific forest type. It is truly a mixed forest, composed of many kinds of forest, each one of which could be clearly recognized as a distinct type if it covered a large area. Since there is no constant composition in the vegetative cover in such an area there is little purpose in comparing it with other areas.

Transect No. 4. - The fourth transect was established on the south-central shore of Simpson Island in an area that had been burned frequently. The oldest identifiable burn occurred about 110 years ago and the most recent 10 years ago. The latter burn had been relatively complete but fires between the two had been patchy. The dominant new growth was thick aspen poplar with a mixture of willow, alder, and spruce (Fig. 20).

Unvegetated areas comprised 35.7 per cent of points sampled, a high percentage. Spruce made up 10.4 per cent but more than nine-tenths of this was dead fire-falls and windfalls. Deciduous trees and shrubs were more important than on any other transect and included among the more significant forms Salix sp. (5.3 per cent), Populus tremuloides (4.1 per cent), Rosa acicularis (2.9 per cent), Alnus sp. (2.7 per cent), Sheperdia canadensis (2.1 per cent), and Viburnum sp. (1.2 per cent). The good deciduous growth on this area could be credited to the fact that the fire had left much less bare rock than on most comparable areas on the islands.

Mosses were fairly abundant, making up 16.1 per cent of total ground cover. Small unidentified

species made up 15.8 per cent. Lichens were very scarce; species of significant size were only three in number and comprised only 1.6 per cent of ground cover. Total lichen coverage was only 7.7 per cent.

Plants of a number of other species totalled 10.8 per cent of ground cover. The most important were Arctostaphylos Uva-ursi (3.1 per cent), unidentified grasses (2.0 per cent), Carex sp. (1.8 per cent), Epilobium angustifolium (1.7 per cent), and Linnaea borealis (1.6 per cent).

Figure 21 illustrates the miscellaneous ground cover on this transect area.

Transect No. 5. - The fifth transect was established on Simpson Island in an area burned during the previous summer. Burning had been heavy and refugia were very few (Fig. 22). Only the rockiest and most barren hilltops had escaped burning. The spruce had been almost completely destroyed and the humus had been so thoroughly destroyed that soil had been washed down from the hills, exposing bare rock and leaving six inches or more of carbon debris in the depressions. Unvegetated areas made up 71.3 per cent of the sample points. Of this 17.2 per cent was classed as bare rock and 54.1 per cent as bare earth, although the latter included a great deal of thick carbon or charcoal debris. Lichens made up 11.6 per cent of measured ground cover and three species totalling .09 per cent had sufficient growth to be considered as food for caribou. Almost all lichens were in small, isolated, rocky refugia, and most of them would probably be unavailable to caribou during the winter.

Re-colonization of the burned areas by plants had commenced in favourable locations. Three types of colonization were evident. The most noticeable was the development of heavy mats of a liverwort, Marchantia polymorpha, with a few non-flowering examples of Epilobium angustifolium mixed in, in damp areas (Fig. 23). The second type was by a moss, Ceratodon purpureus, also growing in heavy mats. Neither the moss nor the liverwort were found in any other transect area and both were growing, in places, on an almost solid charcoal base. A third type of colonization was by several unidentified grass species, among which were occasional flowering plants growing randomly in presumably suitable spots. Lichen recovery, if there was any, was too slight to be noticeable. Trees and shrubs made up 7.2 per cent of

ground cover but 6.1 per cent was dead spruce - firefalls and subsequent windfalls. There were a few living alders, willows, birches, and roses but they occurred only as occupants of small refugia.

In general, the area of this transect could only be described as a scene of utter desolation. After even short periods of work in it, clothing and exposed parts of the body became black with carbon. The burn is limited in extent and its recolonization from nearby unburned areas should be comparatively rapid. It appears to be an excellent area for continued study.

Transect No. 6. - The sixth transect was placed at the extreme east end of Wilson Island in an area burned 40 years previously. The burning had not been thorough and there were some large surviving spruce (Fig. 24). Bare earth made up 19.7 per cent of ground cover and bare rock 5.4 per cent.

On this transect mosses comprised 6.3 per cent of total ground cover, with five identified species in trace amounts and 4.3 per cent small, unidentified species. Lichens made up 37.8 per cent of points sampled but only 4.3 per cent consisted of large-sized, significant forms. Of the five significant species, the most important were *Cladonia mitis* (1.8 per cent) and *Umbilicaria hyperborea* (1.2 per cent).

A wide variety of trees and shrubs was present. Spruce, mostly living, comprised 11.5 per cent of total ground cover. Four other species were present in amounts greater than 1.0 per cent of ground cover. These were *Ledum groenlandicum* (4.5 per cent), *Juniperus communis* (2.6 per cent), *Salix* sp. (1.0 per cent), and *Viburnum* sp. (1.0 per cent).

Figure 25 illustrates the miscellaneous type of ground cover found generally in this area.

A wide variety of grasses, sedges, and herbs was also present, but again the majority were in percentages of less than 1.0 per cent. The only species which might be considered significant were *Arctostaphylos Uva-ursi* (2.7 per cent) and *Saxifraga tricuspidata* (1.1 per cent).

Transects Nos. 7 and 8. - These two transects are considered together since they are the most directly comparable of the study areas established. Both were on the west coast of Blanchet Island and ran from shore directly inland. The starting points were not more than one-half mile apart and were on the same kind of rock structure at the same altitude. However, Transect No. 7 was in an area burned, for the first and apparently the only time, 12 years previously but Transect No. 8 was in unburned spruce forest. The fire on No. 7 had been heavy, and had destroyed most of the topsoil and humus as well as the vegetation. The burn was undoubtedly quite as thorough as that on Transect No. 4.

Figures 26 to 29 show the contrast between the two areas, which is also well brought out in Table 17. In general, vegetation of all kinds was much the scarcer on Transect No. 7, (42.9 per cent unvegetated as compared with 12.7 per cent). The only comparable vegetation was the mosses, which made up a little more than 18 per cent of ground cover on each transect. However, 17.6 per cent on Transect No. 7 was composed of small, unidentified mosses, whereas only 4.4 per cent of the mosses were in this category on Transect No. 8.

The difference in lichen growth on the two areas was marked. The burned area had only 3.7 per cent lichen cover as opposed to 35.1 per cent on the unburned area. On the burned area only two species, making up 1.2 per cent of ground cover, were considered large enough to provide suitable food for caribou. On the unburned area nine species, making up 15.3 per cent of ground cover, were in this category. This percentage of significant lichens does not indicate superior caribou range; a number of the best range areas studied had percentages up to 40 per cent or even more. It should be noted particularly that *Cladonia mitis*, which was the dominant significant lichen and composed nearly 10 per cent of ground cover in all unburned areas, was still absent entirely from Transect No. 7.

Trees were more abundant on the burned transect than on the unburned one, but only because firefallen and windfallen spruce were everywhere. Both transects showed a good selection of other trees and shrubs, but the greater number of species was on the burned area. *Rubus idaeus*, *Ribes oxyacanthoides*, and *Populus tremuloides* in particular were present in the burned area but absent in the unburned area.

Grasses, sedges, and other ground vegetation made up 11.6 per cent of cover on Transect No. 7 and 16.5 per cent of Transect No. 8. A number of forest-loving species were either absent or relatively scarce on the burned transect. Among these were Vaccinium Vitis-Idaea, Arctostaphylos rubra, A. Uva-ursi, Empetrum nigrum, and Juniperus horizontalis. Grasses were much the commoner in the burned area where they made up 4.4 per cent of total ground cover, as contrasted with 0.2 per cent on the unburned area.

Discussion of Transect Data

Preference for Lichens. - It has been assumed that the preferred caribou food on caribou winter ranges is lichens, chiefly larger fruticose lichens, and hence that lichen growth provides an index of suitability for caribou in winter. These assumptions appear to be valid. Reindeer and caribou are well known to obtain their winter food almost exclusively from lichens in many parts of the world. Ground observations during the caribou study provide further evidence. The preferred feeding areas in winter are those with spruce-lichen associations and, in descending order, those with associations having progressively less lichen growth, such as spruce-Sphagnum-lichen associations and spruce-jackpine-lichen associations. The only commonly-used non-lichen areas are the narrow margins of lakes, ponds, and rivers, where sedge-alder-willow growth and Equisetum are used occasionally by some caribou.

An unusual opportunity to observe the preference for lichens arose during the winter of 1952-53, when many thousands of caribou wintered within easy travelling distance of Yellowknife, on an area long regarded as nearly useless for caribou range. Most of it had been burned as recently as 14 years previously, and much of it had been burned more than once. Lichens of significant size occurred only here and there in small refugia in damp spruce habitat where lichen growth is never heavy, on the numerous bare rocky hilltops where the lichen Umbilicaria hyperborea is the only plant species, and in isolated groups beneath large logs and among rock piles. Examination from the ground and air showed that the caribou had searched out the lichens assiduously wherever they could be found. Patches of fruticose lichens were grazed even when only a few square inches in extent. On the rocky hilltops the caribou forsook their usual method of digging individual feeding craters in the snow, and pushed and pawed their way over areas of many square yards in systematic

search of Umbilicaria. Normally they feed on this plant very little in winter.

Considering the scarcity of lichens in this area, it is noteworthy that only moderate use was made of other plants. Grazing on sedge and Equisetum beds was rare, and there was only the usual amount of incidental browsing on willows and alders. The scarcity of preferred food was shown by the frequent heavy use of Juniperus communis, a plant not usually eaten by caribou. Also, it was clear that more than the usual incidental amounts of such plants as Vaccinium and Arctostaphylos were being taken in the search for larger fruticose lichens.

In some regions the amount of ground-growing lichens does not provide an index of suitability for caribou, since there are also tree-growing lichens. Particularly in some western Canadian mountain areas, caribou are believed to feed on tree-growing lichens at certain seasons. They may also do so on barren-ground caribou winter ranges; but no areas where tree-growing lichens were plentiful were found during the continuing study. Such lichens grow in all areas where there are trees, and in some places it is apparent that the caribou feed on them. Usually, however, they are small or too high to be available, and utilization is light. Evidence that the caribou would utilize more tree lichens if more were available was clearly seen in cases where they stripped heavily-lichened windfalls.

In the Keller Lake area tree-growing lichens were collected. Those of sufficient size to attract caribou, at least occasionally, included Alectoria oregana, Parmelia physodes, P. saxtilis, Usnea plicata, and Ramalina farinacea. Banfield has recorded Evernia prunastri and Alectoria jubata as two of the commoner tree-growing species on the white spruce of the taiga, but these were not identified at Keller Lake.

The question arises whether or not the caribou have marked preferences among lichen species large and dense enough to be important as food. It is quite possible that they do, but there appears to be no quantitative data on this subject. At present it is only possible to consider all lichens of sufficient size as satisfactory caribou food. Certainly all the common and quantitatively important species have been observed to have been used by caribou, and the same species are often the important

ones on reindeer ranges.

It may also be asked what are the relative food values of the chief lichen species. The discovery of important differences would throw new light on the assessment of various range types. Limited investigations of nutritional qualities appear to have been undertaken in Norway and Finland (Hustich, 1951). In this connection it may be mentioned that the caribou which wintered near Yellowknife in the winter of 1952-53 were unusually fat and in good condition in spite of being on a restricted diet.

Effect of Fire on Lichen Growth. - From the study transects so far established the anticipated conclusion developed that significant lichen percentage varies widely even in forests not recently burned. Significant lichen percentages as low as 4.3 per cent and as high as 43.1 per cent were found in forests not burned within the past 75 years. The mean lichen cover in such unburned forest was 19.6 per cent. All the transects were in areas the caribou had used as winter ranges in the previous few years. It is believed that ranges with significant lichen percentages as low as 15 per cent would be reasonably good but that ranges with lower percentages would be progressively poorer. The differences in lichen cover are attributable to many factors and only thorough study by competent forest ecologists can give more than a partial understanding of these factors.

Forest fires greatly complicate the problem. Significant lichen percentages on transect areas burned within the past 40 years ranged from 0.9 per cent to 21.5 per cent. The mean percentage was about 5.9 per cent, much less than adequate for caribou. Even from limited study, it is apparent that many interrelated factors complicate the assessment of burns. Some of the important considerations are:

1. The type of fire. Flash fires may damage little but the coniferous tree canopy. Complete burns may destroy even a large part of the soil and humus. In some cases the forest seems to escape lightly and can revert back closely to climax condition within a short time. In other cases plant growth must start from the beginning and go through long stages of vegetative succession.

2. The type of association present at the time of the fire, its ability to recover after different kinds of

fires, and the rapidity with which it does so.

3. The types of succession found on various areas following different types of burns.

4. The manner in which climax and succession are influenced by the chemical composition of various types of underlying strata.

Clearly, forest fires are very damaging on Precambrian areas, where the rock is near the surface and soils are thin. Only two of the four areas not burned for at least 100 years had more than 15 per cent lichen coverage. None of four recently-burned areas had even 2 per cent significant lichen coverage. Possibly lichen percentages are low in this region, even on the good lichen areas, because of heavy utilization of good areas by caribou.

Forest Types. - Within the study areas a number of distinct forest types can be recognized. Most of them are very like those described for Labrador by Hustich (1951). In fact, the better lichen woodlands in the Keller Lake area particularly are almost identical in plant cover and species of plants with Hustich's pure lichen forests and dwarf shrub lichen forests. The dominant lichen in these woodlands is *Cladonia alpestris*, which is dominant in lichen woodlands in other parts of the world. On the islands this species was not recognized, but its place was taken by *Cladonia mitis*, which is more typical of areas subject to forest fires.

The best forest types for wintering caribou, based on percentage of lichens present, may be called the spruce-lichen forest type. In some cases the spruce is partially or wholly replaced by jack pine. In this category are included Transect Nos. 4 and 5 at Keller Lake and Transect No. 1 on Caribou Islands. The investigated areas do not contain much pure spruce-lichen forest, but what little there is, is heavily utilized. Pure stands become larger, generally speaking, towards the tree-line in the Northern Transition Zone. In some areas shrubs of various species are mixed with the lichen carpet in fairly large percentages. Most frequently noted are species of *Arctostaphylos*, *Empetrum*, *Vaccinium*, and *Ledum groenlandicum*, which is present in greater or lesser amounts in nearly all boreal forests in the Mackenzie District. These forests seldom have less than 20 per cent ground cover of significant-sized lichens and the total

lichen percentage frequently runs much higher. Such forests should have the greatest priority in forest fire protection. Without exception they are normally dry.

A second forest type important in the caribou winter range may be termed the spruce-feather moss forest type. It is illustrated (not very well) by Transect No. 8 on Blanchet Island. A major indicator species appears to be the moss Hylocomium splendens, which usually makes up at least 5 to 10 per cent of total ground cover. In the areas so far studied, total moss percentage approaches 30 per cent of total ground cover, and there are usually associated, significant-sized lichens making up at least 15 per cent of total ground cover. This forest type is used frequently by wintering caribou even though the lichen percentage is not as great as in other areas, possibly because its tree growth provides better shelter from extreme cold and winds than that of pure lichen areas. Forests of this type are normally damp.

The third readily recognizable, basic forest type in the areas so far studied may be called the spruce-muskeg or spruce-Sphagnum moss forest type. This type has open-growing and sporadic stunted black and white spruce, and small amounts of tamarack. Sphagnum moss is decidedly the basic plant even though, in point samples, it does not necessarily constitute more than about 10 per cent of total ground cover. Frequently Sphagnum in beds of great thickness underlies virtually all other vegetation. Such forests are normally wet. However, when the water table drops, or when the Sphagnum grows well above the water level, many plants, particularly lichens, colonize the higher ground. Thus spruce-muskeg areas frequently have lichen growth second only to that of dry spruce-lichen areas. Transect No. 2 at Keller Lake had 31.4 per cent significant lichens, an amazingly large percentage; and the first transect in the same area, even though it had been burned only 24 years previously, had more than 11 per cent significant lichens. Caribou have been noted feeding in such areas in winter frequently, particularly during early and late winter migrations, when the animals were on the move, and the temperature was not extremely low. During the coldest winter months they seem to prefer more heavily wooded forest types.

Recovery of Lichens after Fire. - The present study has showed fairly well that almost all successional changes after a fire up to the climax stage are poor in lichens,

and thus make poor range for wintering caribou. Transect Nos. 3 and 6 at Keller Lake and Transect Nos. 2, 4, 5, 6, and 7 on the islands illustrate such successional types. On a number of these the regenerating growth could best be called mixed forest. Spruce, paper birch, aspen poplar, and a large number of shrubby plants were prominent. In some areas deciduous species, poplar in particular, made up the dominant new tree growth. Poplar in the areas of study probably dies out rapidly when more than 35 years old, and is replaced, except in optimum habitat, by spruce. In damp areas, glandular birch frequently achieved heavy growth and was often mixed with thick young spruce in an almost impenetrable tangle.

It cannot be said that lichen growth takes any definite number of years to recover after a fire. A number of estimated lengths of time for recovery may be found in the literature, most of them indicating less than 100 years. In no case, however, is much detail presented on the form of recovery or other factors which may be important. The following summary gives the condition of significant-sized lichen growth on the burned areas so far investigated. Some of these could support a better lichen growth than others, but it appears safe to assume that all of them could support more than 15 per cent ground cover of lichens, and would have been reasonably good winter caribou range if they had not been burned.

Age of Burn (Years)	Probable Original Forest Type	Significant-Sized Lichens (Per Cent of Ground Cover)	Present Value to Caribou
1	spruce-lichen	0.9	nil
10	spruce-jack pine-lichen	1.6	"
12	spruce-lichen	1.8	"
12	spruce-feather moss	1.2	"
24	spruce-muskeg	11.9	could support light use
39	spruce-feather moss	2.3	nil

Age of Burn (Years)	Probable Original Forest Type	Significant-Sized Lichens (Per Cent of Ground Cover)	Present Value to Caribou
	(continued)		
40	spruce-lichen	4.3	could support incidental use only
75	" "	43.1	excellent winter range
122	" "	26.9	excellent winter range
135	spruce-feather moss	11.8	could support light use
150	mixed	8.2	could support incidental use only

It can be seen that of 11 burned areas only two had enough lichen growth for good winter forage for caribou. In both instances there was considerable doubt whether the burning was very serious. This is also true of the 24-year-old burn in spruce-muskeg forest which had 11.9 per cent ground cover of significant lichens. Nearly that large a percentage may have survived the fire, which had obviously been spotty.

As yet there is no proof that even more than 100 years is sufficient for lichen recovery in significant amounts, following severe burning on forested caribou winter range in the Precambrian area.

Influence of Weather on Choice of Range. - The amount of lichen cover is used as an index of suitability of forests for winter utilization by caribou but there are strong indications that they do not always winter in areas where lichen growth is best. Sometimes they are found in poor lichen areas even when good areas are close by. In most such cases their choice seems to be influenced by such factors as temperature, wind, and thickness of forest cover. In moderate, calm weather they may remain in open areas, but when temperatures are colder than -35°F, particularly when winds are frequent, they are likely to stay close to heavy forest, even when it does not provide as suitable grazing as more open adjacent areas. Thus,

Transect No. 5 at Keller Lake had the highest percentage of significant lichen cover found in any study area but it did not appear to have been subjected to heavy utilization. Very possibly this was because it was open and lay along a northward-facing lake shore. The heavy forest found on Transect No. 8 in the islands provided excellent shelter close to routes of travel on the lake ice, and was subjected to heavy utilization in spite of having relatively light lichen cover.

Exclosure Plots

As a possible aid toward obtaining factual information on the recovery rate of lichens, exclosure plots were established in the best lichen area at Keller Lake. The plots have not been revisited since establishment and it is consequently too early to present data from them.

Four plots were established, two under tree canopy and two on open areas. All were chosen because they had continuous and homogeneous carpets of lichen growth. The plots measured 12 feet by 12 feet and each was sub-divided into 16 squares of 9 square feet each. Squares were chosen at random within each plot to be subjected to various types of treatment as follows:

1. Four squares were left undisturbed to serve as checks.

2. Four squares were burned as completely as possible to simulate the effect of forest fire.

3. Four squares were trampled completely flat at a time when the lichens were dry and brittle, to simulate the effect of severe trampling by a herd of moving caribou.

4. Four squares were stripped of lichen growth to simulate the effect of severe overgrazing.

One plot in each location was enclosed by a stout, high pole fence to keep large animals off and allow recovery to proceed without interruption. The adjacent plot in each location was left unfenced, so that recovery might proceed normally.

It is planned to revisit these plots over a period of years to secure comparative data by measuring

lichen recovery.

Faecal Pellet Counts

The results of faecal pellet counts in conjunction with the vegetative sample transects are presented in Table 18.

The data are inconclusive. A marked tendency of caribou to make greater use of good lichen areas than of poor ones seems to be indicated, but there are notable exceptions. It appears that a number of other considerations besides the number of pellet groups and the lichen percentages must be taken into account.

Forest Fire Protection

The situation may well develop where the maintenance of adequate stocks of barren-ground caribou depends on protecting the forested winter range.

Only a pessimistic view can be taken of the possibilities of preserving from fire most of the winter ranges in the Northwest Territories. Those within practical fire-fighting distance of settlements either are not suitable for caribou range or have been badly burned already. The best-preserved ranges are distant from settlements and from lines of air travel. No system for detecting fires in distant areas is maintained, and fires detected by chance are often too large to be fought successfully.

It is clear that expense is the main difficulty. A recent directive to game wardens in the Northwest Territories (Wilson, 1953) defines the areas in which fires are and are not to be fought, and accents the limitations of the funds available. The only areas to be protected regularly are those within a radius of 100 miles from Fort Smith, Yellowknife, and Fort Rae, and those in the country readily accessible from the Hay and Mackenzie Rivers systems. At least around Yellowknife the forest within the area to be protected has been burned already, some parts of it several times. There is very little left worth protecting and there will be very little for many years, unless management succeeds in restoring good numbers of beaver and moose. Certainly the timber values in that area are nil.

Except along the great waterways, men and equipment for fire-fighting in the Northwest Territories have to be put on the ground by aircraft. Over much of the forest, spotting by regularly-flown aircraft appears to be the only practical method of detecting fires at early stages. To be effective, flights would have to be made frequently during periods of high hazard. In some areas it might be desirable to install radio-equipped lookout towers.

It appears to the author that the problem is largely one of economics. Possibly the dilemma of whether to save the forests or save the money is not insoluble. If only unburned areas and areas adjacent to settlements were marked for protection, there would remain an enormous amount of country where expensive patrolling would be unnecessary. Some parts of it have a low fire-hazard because of many lakes and rivers, and other parts have low existing and potential values in timber and wildlife. When these are eliminated, the remaining valuable country might not be too large for a reasonably adequate protection system, including a few lookout towers strategically located, and aircraft patrols during periods of high hazard.

Certainly the day will come when larger human populations and greatly reduced forests make intensive fire protection necessary. It would be well to keep both planning and field operations in a state of advancement as continuous as financing and personnel will allow.

LITERATURE CITED

Banfield, A.W.F. 1950 The barren-ground caribou. Can. Dept. Res. and Dev., Can. Wildlife Serv. Mimeographed.

1954 Preliminary investigation of the barren-ground caribou. Part I. Former and present distribution, migrations, and status. Part II. Life history, ecology, and utilization. Can. Dept. Nor. Affairs and Natl. Res., Can. Wildlife Serv., Wildlife Mgnt. Bull. Ser. I, Nos. 10A and 10B (2 vols.).

Clarke, C.H.D. 1940 A biological investigation of the Thelon Game Sanctuary. Natl. Mus. Can., Bull. No. 96, Biol. Ser. No. 25.

Halliday, W.E.D. 1937 A forest classification for Canada. Can. Dept. Res. and Dev., For. Br., For. Res. Bull. No. 89.

Hoare, W.H.B. 1927 Report of investigations affecting Eskimo and wildlife, District of Mackenzie, 1924-1925-1926. Can. Dept. Interior, N.W.T. and Yukon Br.

Hustich, Ilmari 1951 The lichen woodlands in Labrador and their importance as winter pastures for domesticated reindeer. Helsinki, Acta Geographica 12, No. 1.

Kumlein, Ludwig 1879 Contributions to the natural history of Arctic America. U.S. Natl. Mus. Bull. 15.

Lawrie, Andrew 1948 Caribou report. (MS in files of Can. Wildlife Serv., Dept. Nor. Affairs and Natl. Res.)

Murie, Adolph	1944	The wolves of Mount McKinley. U.S. Dept. Interior, Natl. Parks Serv., Fauna Natl. Parks U.S., Fauna Ser. No. 5.
Severinghaus, C.W.	1949	Tooth development and wear as criteria of age in white-tailed deer. J. Wildlife Mgnt. 13(2): 195-216.
Wilson, G.M.	1953	Proposals for forest fire protection, Northwest Territories and Wood Buffalo Park. (Mimeographed instruction to N.W.T. wardens.)
Young, S.P. E.A. Goldman	1949	The wolves of North America. Washington, D.C., Am. Wildlife Inst.

Table 1. Caribou Calf Segregation Counts in the Rae Herd, 1950 to 1953.

Date	Method of Survey	Total Animals	Total Calves	Per Cent Calves
Winter, 1950-51	Ground	567	50	8.8
Winter, 1950-51	Aerial	545	36	6.6
Winter, 1951-52	Ground	105	7	6.7
Winter, 1951-52	Aerial	105	10	9.5
Autumn, 1952-53	Ground	3,181	614	19.3
Winter, 1952-53	Aerial	593	130	20.9
Winter, 1952-53	Ground	2,162	671	28.5
Winter, 1952-53	Aerial	2,421	725	29.9

Table 2. Caribou Calf Segregation Counts in the Great Bear Herd, 1951 to 1953.

Date	Method of Survey	Total Animals	Total Calves	Per Cent Calves
Winter, 1951-52	Ground	232	35	15.1
Winter, 1951-52	Aerial	825	101	12.2
Winter, 1952-53	Aerial	806	166	20.6

Table 3. Estimates of Herd Populations from the Initial Caribou Study and from the Continuing Study.

Herd or Area	Initial Estimate	Recent Estimate
Colville Lake	5,000	-
Great Bear	30,000	34,000
Point MacDonnel	-	11,000
Radium	5,000	10,000
Rae	210,000	138,000
Yellowknife	4,000	-
Adelaide and Sherman Gulfs	500	-
Coastal caribou	-	126,000
TOTAL	254,500	319,000

Table 4. Number of Caribou Reported Killed and Number of Hunters Reporting from Areas Inhabited by the Coastal Caribou During a Ten-Year Period.

Year	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
Cambridge Bay										
Caribou	519	1,069	-	709	204	324	-	-	-	-
Hunters	74	62	-	84	42	80	-	-	-	-
Bathurst Inlet										
Caribou	-	-	-	-	-	-	-	5,000	20	-
Hunters	-	-	-	-	-	-	-	45	1	-
Coppermine										
Caribou	6,885	2,667	1,691	241	563	1,448	-	-	145	57
Hunters	155	87	66	36	57	47	-	-	10	3
Read Island										
Caribou	-	-	-	-	-	-	-	-	40	-
Hunters	-	-	-	-	-	-	-	-	1	-
Total Caribou	7,404	3,736	1,691	950	767	1,772	-	5,000	205	57
Total Hunters	229	149	66	120	99	127	-	45	12	3

Table 5. Reported Kill and Theoretical Annual Kill for the Coastal Region.

Place	Total Caribou Killed	Total Hunter Reports	Average Caribou Per Hunter Per Year	Maximum Hunters	Theoretical Annual Kill
Cambridge Bay	2,825	342	8.2	84	688.8
Bathurst Inlet	5,020	46	109.1	45	4,909.5
Coppermine	13,697	461	29.7	155	4,603.5
Read Is.	40	1	40.0	1	40.0
Total for the region					10,241.8

86629—7½

Table 6. Number of Caribou Reported Killed and Number of Hunters Reporting from the Region Between Great Bear and Great Slave Lakes During a Ten-Year Period.

Year	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
Yellowknife										
Caribou	-	-	-	-	-	-	-	-	171	587
Hunters	-	-	-	-	-	-	-	-	11	22
Fort Rae										
Caribou	5,958	5,251	6,455	9,168	9,238	4,552	3,395	4,815	1,634	3,129
Hunters	174	155	125	161	142	176	121	150	110	147
Fort Franklin										
Caribou	-	-	-	254	177	-	-	-	218	99
Hunters	-	-	-	8	9	-	-	-	20	17
Fort Wrigley										
Caribou	-	-	-	8	-	-	-	545	-	5
Hunters	-	-	-	3	-	-	-	29	-	3
Fort Simpson										
Caribou	80	35	215	127	56	206	-	192	447	65
Hunters	74	77	121	53	55	103	-	26	58	22
Fort Providence										
Caribou	75	76	97	34	28	32	26	67	38	20
Hunters	81	70	87	37	22	30	7	15	15	8
Total Caribou	6,113	5,362	6,767	9,591	9,499	4,790	3,421	5,619	2,508	3,905
Total Hunters	329	302	333	262	228	309	128	220	214	219

Table 7. Reported Kill and Theoretical Annual Kill for the Region between Great Bear and Great Slave Lakes.

Place	Total Caribou Killed	Total Hunter Reports	Average Caribou Per Hunter Per Year	Maximum Hunters	Theoretical Annual Kill
Yellowknife	758	33	22.9	22	503.8
Fort Rae	53,595	1,461	36.7	176	6,459.2
Fort Franklin	748	54	13.9	20	278.0
Fort Wrigley	558	35	15.9	29	461.1
Fort Simpson	1,423	589	2.4	121	290.4
Fort Providence	493	372	1.3	87	113.1
Total for the region					8,105.6

Table 8. Number of Caribou Reported Killed and Number of Hunters Reporting from the Region North of Great Bear Lake, During a Ten-Year Period.

Year	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
Paulatuk										
Caribou	-	-	-	-	-	-	-	-	97	68
Hunters	-	-	-	-	-	-	-	-	9	8
Fort Norman										
Caribou	-	-	322	482	965	23	434	116	875	63
Hunters	-	-	32	29	42	38	31	22	59	4
Fort Good Hope										
Caribou	253	150	309	155	470	209	194	192	172	150
Hunters	67	97	56	35	68	72	34	32	36	12
Port Radium										
Caribou	-	-	-	-	-	-	26	103	55	-
Hunters	-	-	-	-	-	-	3	15	10	-
Total Caribou	253	150	631	637	1,435	232	654	411	1,199	281
Total Hunters	67	97	88	64	110	110	68	69	114	24

Table 9. Reported Kill and Theoretical Annual Kill for the Region North of Great Bear Lake.

Place	Total Caribou Killed	Total Hunter Reports	Average Caribou Per Hunter Per Year	Maximum Hunters	Theoretical Annual Kill
Paulatuk	165	17	9.7	9	87.3
Norman	3,280	257	12.8	59	755.2
Fort Good Hope	2,254	509	4.4	97	426.8
Port Radium	184	28	6.6	15	99.0
Total for the region					1,1368.3

Table 10. Measurements, Weights, and Ages of Calf Caribou up to the Age of Ten Months.

Spec. No.	Observer	Date of Death	Total Length	Hind Foot Length (mm.)	Shoulder Height (mm.)	Weight (lbs.)	Age
Males							
1	Kelsall	21-1-51	184	45	79	-	92 days *
2	"	26-1-53	197	48	79	-	97 " *
3	Banfield	30-4-48	520	240	-	-	191 " *
4	Kelsall	25-5-51	680	289	502	12	214 " *
5	"	18-6-51	610	279	483	-	1 day
6	Banfield	14-8-48	1,070	390	750	-	60 days
7	Kelsall	4-9-52	1,270	432	794	85	81 "
8	Banfield	24-4-49	1,390	480	930	-	10 months

Females

1	Kelsall	18-1-51	179	41	77	-	89 days	*
2	"	4-2-53	205	56	91	-	106 "	*
3	"	22-2-51	324	87	147	-	124 "	*
4	Banfield	30-4-48	530	240	-	-	191 "	*
5	"	30-4-48	510	250	-	-	191 "	*
6	"	1-5-48	530	260	-	-	192 "	*
7	"	1-5-48	490	240	-	-	192 "	*
8	Kelsall	17-5-51	660	292	368	-	208 "	*
9	"	21-5-50	660	292	-	12¾	212 "	*
10	"	25-5-51	616	292	514	12	216 "	*
11	"	18-6-51	597	305	533	-	1 day	
12	"	18-6-51	635	305	508	-	1-3 days	
13	"	21-6-51	737	330	559	-	4-7 "	
14	Banfield	6-8-48	1,000	335	660	43	52 "	
15	"	10-8-48	1,000	395	650	40	56 "	
16	Lawrie	29-8-48	1,187	403	805	74	75 "	
17	Kelsall	6-9-52	1,257	419	762	72	83 "	
18	Banfield	24-8-49	1,390	460	890	-	10 months	

* Foetal Caribou

Table 11. Winter Calf Percentages Obtained During Four Different Years.

Caribou Herd	No. Segregated	Calves Segregated	Calf Percentage
1948-49			
Rae	3,163	668	21.1
Nueltin	541	135	24.8
Subtotal	3,704	803	21.7
1950-51			
Rae	1,112	86	7.7
Radium	118	9	7.5
Hanbury	273	13	4.8
Subtotal	1,503	108	7.2
1951-52			
Rae	210	17	8.1
Radium	241	30	12.4
Hanbury	369	52	14.1
Great Bear	1,057	136	12.7
Subtotal	1,877	235	12.5
1952-53			
Rae and Hanbury	5,176	1,526	29.5
Great Bear	806	166	20.6
Subtotal	5,982	1,692	28.3
Grand Total	13,066	2,838	-
Weighted Average (on the basis of 1,000)	-	-	17.4

Table 12. Measurements, Weights, and Ages of Male Caribou Taken During the Caribou Study.

Spec. No.	Observer	Date of Death	Total Length (mm.)	Hind Foot Length (mm.)	Shoulder Height (mm.)	Weight (lbs.)	Age
1	Kelsall	21-1-51	184	45	79	-	92 days *
2	"	26-1-53	197	48	79	-	97 " *
3	Banfield	30-4-48	520	240	-	-	191 " *
4	Kelsall	25-5-51	680	289	502	12	214 " *
5	"	18-6-51	610	279	483	-	1 day
6	Banfield	14-8-48	1,070	390	750	-	60 days
7	Kelsall	4-9-52	1,270	432	794	85	81 "
8	Banfield	24-4-49	1,390	480	930	-	10 months
9	Kelsall	5-8-53	1,486	485	930	140	14 "
10	Lawrie	8-8-48	1,485	460	943	118	14 "
11	"	5-9-48	1,418	477	972	105	15 "
12	Banfield	28-7-48	1,640	499	-	-	Unknown

* Foetal Caribou - same age calculations as in Table 10.

Table 12. Measurements, Weights, and Ages of Male Caribou Taken During the Caribou Study.

(continued)

Spec. No.	Observer	Date of Death	Total Length (mm.)	Hind Foot Length (mm.)	Shoulder Height (mm.)	Weight (lbs.)	Age
13	Banfield	27-7-48	1,667	497	-	-	Unknown
14	"	24-4-49	1,670	540	1,100	-	"
15	"	28-1-49	1,680	520	1,015	-	"
16	Lawrie	22-6-49	1,690	289	1,180	-	"
17	Kelsall	5-9-52	1,702	533	965	178	"
18	Banfield	13-8-48	1,725	515	1,035	-	"
19	Lawrie	30-5-48	1,740	450	1,050	-	"
20	"	3-7-49	1,743	524	1,184	190	"
21	Banfield	14-7-49	1,750	530	1,090	-	"
22	"	29-1-49	1,750	525	1,195	-	"
23	Lawrie	26-10-48	1,777	530	1,175	240	"
24	Banfield	27-1-49	1,780	525	-	-	"
25	"	4-8-48	1,780	530	1,170	-	"
26	Mowat	21-9-48	1,780	540	1,170	270	"
27	"	20-9-48	1,780	540	1,145	-	"

28	Banfield	29-11-48	1,800	-	1,050	-	Unknown
29	Lawrie	9-9-48	1,808	530	1,105	224½	"
30	"	5-6-48	1,810	457	955	-	"
31	Banfield	27-1-49	1,820	530	-	-	"
32	Lawrie	9-4-49	1,829	542	1,080	178½	"
33	Kelsall	12-9-52	1,829	508	1,061	338	"
34	Banfield	16-8-48	1,830	540	1,130	274	"
35	Lawrie	5-6-48	1,843	478	872	-	"
36	Banfield	23-7-49	1,890	520	1,170	-	"
37	Lawrie	4-8-48	1,902	534	1,124	214	"
38	Kelsall	13-9-52	1,905	502	1,041	291	"
39	"	22-8-53	2,083	553	1,054	286	"
High	(more than 24 mos. of age)		2,083	553	1,195	338	
Average	" " " "		1,789	516	1,088	243.6	
Low	" " " "		1,640	450	872	178	

Table 13. Measurements, Weights, and Ages of Female Caribou Taken During the Caribou Study.

Spec. No.	Observer	Date of Death	Total Length (mm.)	Hind Foot Length (mm.)	Shoulder Height (mm.)	Weight (lbs.)	Age
1	Kelsall	18-1-51	179	41	77	-	89 days *
2	"	4-2-53	205	56	91	-	106 " *
3	"	22-2-51	324	87	147	-	124 " *
4	Banfield	30-4-48	530	240	-	-	191 " *
5	"	30-4-48	510	250	-	-	191 " *
6	"	1-5-48	530	260	-	-	192 " *
7	"	1-5-48	490	240	-	-	192 " *
8	Kelsall	17-5-51	660	292	368	-	208 " *
9	"	21-5-50	660	292	-	12¾	212 " *
10	"	25-5-51	616	292	514	12	216 " *
11	"	18-6-51	597	305	533	-	1 day
12	"	18-6-51	635	305	508	-	1-3 days
13	"	21-6-51	737	330	559	-	4-7 "
14	Banfield	6-8-48	1,000	335	660	43	52 "
15	"	10-8-48	1,000	395	650	40	56 "

16	Lawrie	29-8-48	1,187	403	805	74	75 "
17	Kelsall	6-9-52	1,257	419	762	72	83 "
18	Banfield	24-4-49	1,390	460	890	-	10 months
19	Lawrie	29-8-48	1,465	474	1,010	105	14 "
20	Banfield	6-8-48	1,500	484	990	-	14 "
21	Lawrie	3-8-48	1,508	477	929	-	14 "
22	Kelsall	13-6-51	1,549	483	965	-	Unknown
23	"	6-9-52	1,549	483	965	184	"
24	Flook	4-2-52	1,549	521	-	175	"
25	Banfield	28-11-48	1,585	530	1,030	-	"
26	"	27-8-48	1,590	475	1,025	-	"
27	Lawrie	31-7-48	1,595	515	1,055	-	"
28	"	31-7-48	1,600	490	1,138	-	"
29	Banfield	30-4-48	1,600	530	1,040	-	"
30	"	6-8-48	1,630	485	1,025	-	"
31	"	30-4-48	1,630	540	1,060	-	"
32	"	30-11-48	1,635	480	980	-	"
33	"	26-7-49	1,645	492	-	125	"
34	"	1-5-48	1,650	535	1,050	-	"
35	"	30-4-48	1,650	550	1,030	-	"
36	Kelsall	12-8-51	1,651	483	965	-	"

Table 13. Measurements, Weights, and Ages of Female Caribou Taken During the Caribou Study.

(concluded)

Spec. No.	Observer	Date of Death	Total Length (mm.)	Hind Foot Length (mm.)	Shoulder Height (mm.)	Weight (lbs.)	Age
37	Lawrie	14-9-48	1,670	502	1,119	143½	Unknown
38	Banfield	16-8-48	1,690	510	1,055	-	"
39	Lawrie	31-7-48	1,690	510	1,092	-	"
40	Kelsall	11-9-52	1,702	508	959	-	"
41	Lawrie	25-9-48	1,712	502	1,092	-	"
42	Banfield	1-5-48	1,720	535	1,140	-	"
43	Lawrie	4-7-49	1,727	509	1,080	165	"
44	Banfield	1-5-48	1,780	550	1,060	-	"
High	(more than 24 mos. of age)		1,780	550	1,140	184	
Average	" " " "		1,643	509	1,044	158.6	
Low	" " " "		1,549	475	959	125	

Table 14. Measurements in Millimetres, of the Cheek Teeth of Individual Reindeer and Caribou Three Months of Age, Compared with Average Measurements from Four Similarly-Aged Caribou Presented by Banfield.

	Reindeer		Caribou		Banfield's	Range of
	Male	Female	Male	Female	Average	Variation
1st premolar	5.0	5.1	4.8	4.0	4.9	1.1
2nd premolar	6.9	6.3	6.3	5.3	6.4	1.6
3rd premolar	8.2	8.8	8.3	7.2	7.0	1.8
1st molar	0.0	3.1	2.6	7.3	6.2	7.3

Table 15. Number of Wolves seen on Survey Flights, February, 1950, to April, 1953.

Year	Miles Flown		Wolves seen	
	Tundra	Forest	Tundra	Forest
1950	4,452	4,750	11	15
1951	5,680	7,403	9	42
1952	3,452	8,112	0	4
1953	2,716	7,059	5	19
Totals	16,300	27,324	25	80
Total Mileage	43,624		Total Wolves	105

Table 16. Composition of Ground Cover by Percentages on the Keller Lake Transects.

Item	Transect No. and Age of Burn in Years					
	1 (20-24)	2 Nil	3 (39)[x]	4 (40)[x]	5 (75 +)	6 (135 +)
Water	6.5	Nil	Nil	Nil	Nil	1.9
Bare earth	8.8	4.3	7.2	20.2	13.5	10.3
Sand	Nil	Nil	Nil	2.5	0.1	Nil
Total unvegetated	15.3	4.3	7.2	22.7	13.6	12.2
Aulocomnium palustre	Nil	Nil	Nil	Nil	Nil	0.8
Aulocomnium turgidum	"	"	"	"	"	3.1
Camptothecium nitens	"	"	"	"	"	2.5
Dicranum rugosum	0.3	1.0	"	"	"	1.0
Hylocomium splendens	Nil	Nil	"	3.1	0.3	4.1
Polytrichum juniperinum	2.0	1.7	"	Nil	Nil	Nil
Ptilidium ciliare	Nil	Nil	"	0.4	4.0	0.1
Sphagnum spp[1]	9.9	10.3	"	Nil	Nil	Nil
Moss, small[2]	0.1	1.0	17.0	1.4	0.8	4.8

[x]Transect 3, dry habitat; Transect 4, wet habitat.

[1]*Sphagnum rubellum* and *S. fuscum*.

[2]Including, among others, *Calypogeia sphagnicola*, *Cephalozia cennivens*, *Ditrichum Flexicaube*, *Hypnum patentiae*, and *Mylia anomala*.

Table 16. Composition of Ground Cover by Percentages on the Keller Lake Transects.

(continued)

Item	Transect No. and Age of Burn in Years					
	1 (20-24)	2 Nil	3 (39)[x]	4 (40)[x]	5 (75 +)	6 (135 +)
Lycopodium complanatum	Nil	Nil	Nil	Nil	0.1	Nil
Total mosses and club-mosses	12.3	14.0	17.0	4.9	5.2	16.4
Lichens, small[3]	20.8	4.7	8.5	17.4	9.0	6.8
Cetraria islandica	Nil	Nil	Nil	Nil	0.2	Nil
Cetraria nivalis	1.5	11.4	"	1.9	5.1	"
Cladonia alpestris	Nil	Nil	"	13.2	32.8	10.0
Cladonia amaurocraea	0.8	0.7	"	Nil	Nil	Nil
Cladonia coccifera	1.5	1.3	"	"	"	"
Cladonia gracilis	0.1	0.3	0.3	3.2	0.7	"
Cladonia mitis	6.3	15.4	0.7	Nil	Nil	"
Cladonia multiformis	0.5	2.3	Nil	"	"	"
Cladonia pyxidata	Nil	Nil	0.8	"	"	"

[3] Including, among many others Cladonia cornuta, C. crispata, Stereocaulon tomentosum, and Icmadophila ericeterum.

Table 16. Composition of Ground Cover by Percentages on the Keller Lake Transects.

(continued)

Item	Transect No. and Age of Burn in Years					
	1 (20-24)	2 Nil	3 (39)	4 (40)	5 (75 +)	6 (135 +)
Cladonia rangiferina	0.9	Nil	Nil	0.3	1.7	0.2
Cladonia uncialis	Nil	"	"	0.3	Nil	0.3
Peltegera apthosa	0.3	"	0.2	Nil	"	Nil
Peltigera canina	Nil	"	0.3	2.6	2.6	1.3
Total lichens	32.7	36.1	10.8	38.9	52.1	18.6
Significant total lichens[4]	11.9	31.4	2.3	21.5	43.1	11.8
Picea sp. (living)	0.9	3.0	18.6	2.3	1.2	8.2
Picea sp. (dead)[5]	3.1	5.0	10.1	2.8	1.5	5.1
Larix laricina	Nil	Nil	0.1	Nil	Nil	0.8
Pinus Banksiana	"	"	Nil	0.1	"	Nil
Salix sp.	"	"	6.2	Nil	"	2.5
Populus balsamifera	"	"	0.1	"	"	Nil
Populus tremuloides	"	"	Nil	0.1	"	"
Myrica Gale	"	"	"	Nil	"	2.0

[4]Including only those specifically named.

[5]Including firefallen and windfallen trees, standing dead trees, and large broken branches.

Table 16. Composition of Ground Cover by Percentages on the Keller Lake Transects.
(continued)

Item	Transect No. and Age of Burn in Years					
	1 (20-24)	2 Nil	3 (39)	4 (40)	5 (75 +)	6 (135 +)
Betula glandulosa	0.4	Nil	11.8	1.6	0.8	3.8
Betula papyrifera	0.1	"	Nil	Nil	0.5	Nil
Alnus sp.	Nil	"	0.7	"	Nil	"
Ribes sp.	0.1	"	Nil	"	"	"
Potentilla fruticosa	Nil	"	2.5	"	"	3.3
Rosa sp.	"	"	0.5	0.2	0.1	0.5
Shepherdia canadensis	"	"	0.4	Nil	Nil	Nil
Ledum groenlandicum	21.6	20.0	1.8	0.5	"	5.2
Chamaedaphne calyculata	0.7	2.0	Nil	Nil	"	0.1
Total trees and shrubs [6]	26.9	30.0	52.8	7.6	4.1	31.5

[6] Only trees and shrubs more than one foot in height.

Table 16. Composition of Ground Cover by Percentages on the Keller Lake Transects.

(continued)

Item	Transect No. and Age of Burn in Years					
	1 (20-24)	2 Nil	3 (39)	4 (40)	5 (75 +)	6 (135 +)
Equisetum sp.	0.3	Nil	1.4	Nil	Nil	0.3
Juniperus horizontalis	Nil	"	Nil	0.1	0.5	Nil
Miscellaneous grasses	"	"	"	0.6	0.6	0.7
Carex sp.	1.1	"	7.3	0.1	Nil	10.6
Rubus Chamaemorus	0.1	0.3	Nil	Nil	"	Nil
Empetrum nigrum	0.5	Nil	0.1	4.6	11.7	0.8
Cornus canadensis	Nil	"	Nil	0.7	0.1	0.2
Kalmia polifolia	5.1	10.0	"	Nil	Nil	Nil
Arctostaphylos Uva-ursi	Nil	Nil	0.4	6.1	2.9	"
Arctostaphylos rubra	0.1	"	0.7	Nil	Nil	0.5
Vaccinium uliginosum	0.8	1.0	0.7	2.2	"	2.7
Vaccinium Vitis-Idaea	4.4	4.3	0.5	10.5	8.4	4.9

Table 16. Composition of Ground Cover by Percentages on the Keller Lake Transects.
(concluded)

Item	Transect No. and Age of Burn in Years					
	1 (20-24)	2 Nil	3 (39)	4 (40)	5 (75 +)	6 (135 +)
Vaccinium oxycoccus	0.4	Nil	Nil	Nil	Nil	Nil
Linnaea borealis	Nil	"	"	"	0.4	"
Annual plants	"	"	1.1	1.0	0.4	0.6
Total ground vegetation[7]	12.8	15.6	12.2	25.9	25.0	21.3
Total percentage	100.0	100.0	100.0	100.0	100.0	100.0

[7]Less than one foot in height.

Table 17. Composition of Ground Cover by Percentages on Transects on Islands in the East Arm of Great Slave Lake.

Item	Transect No. and Age of Burn in Years							
	1 (122)	2 (12)	3 (150)	4 (10)	5 (1)	6 (40)	7 (12)	8 (nil)
Water	0.3	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Bare rock	3.6	14.4	2.2	8.8	17.2	5.4	27.8	3.3
Bare earth	5.7	7.3	19.7	26.9	54.1[1]	19.7	15.1	9.4
Total unvegetated	9.6	21.7	21.9	35.7	71.3	25.1	42.9	12.7

[1]Included a great deal of thick carbon or charcoal.

Table 17. Composition of Ground Cover by Percentages on Transects on Islands in the East Arm of Great Slave Lake.

(continued)

Item	Transect No. and Age of Burn in Years							
	1 (122)	2 (12)	3 (150)	4 (10)	5 (1)	6 (40)	7 (12)	8 (nil)
Marchantia polymorpha	Nil	Nil	Nil	Nil	1.8	Nil	Nil	Nil
Mosses, small[2]	4.2	9.7	3.9	15.8	5.9[3]	4.3	17.6	4.4
Mosses, large[4]	0.7	Nil	Nil	Nil	Nil	Nil	Nil	5.8
Aulacomnium palustre	0.4	1.8	"	"	"	0.7	"	Nil
Camptothecium nitens	0.8	0.3	"	"	0.2	0.2	"	"
Hylocomium splendens	0.6	0.5	9.6	"	Nil	0.5	"	8.1
Polytrichum sp.	Nil	1.1	0.1	0.3	"	Nil	"	Nil

[2]Less than one-half inch in height. Included some of those itemized, as well as Amphidium meugeotii, Bryum turbinatum, Ceratodon purpureus, Dieranum elongatum, Drepanocladus uncinatus, and many others.

[3]Almost all Ceratodon purpureus in sterile form.

[4]Sample inadvertently confused. Included Aulacomnium palustre, Camptothecium nitens, Drepanocladus aduncus, Hylocomium splendens, Pogonatum alpinum, and Polytrichum juniperinum.

Table 17. Composition of Ground Cover by Percentages on Transects on Islands in the East Arm of Great Slave Lake.

(continued)

Item	Transect No. and Age of Burn in Years							
	1 (122)	2 (12)	3 (150)	4 (10)	5 (1)	6 (40)	7 (12)	8 (nil)
Polytrichum commune	Nil	Nil	Nil	Nil	Nil	Nil	0.6	Nil
Ptilidium ciliare	0.5	"	0.6	"	"	0.3	Nil	"
Sphagnum spp.[5]	Nil	"	4.1	"	"	0.3	"	"
Dryopteris fragrans	0.2	"	0.1	"	"	Nil	"	"
Total liveworts, mosses, ferns	7.4	13.4	18.4	16.1	7.9	6.3	18.2	18.3
Lichen, small[6]	23.1	14.7	12.6	6.1	10.7	33.5	2.5	19.8
Cetraria islandica	0.5	Nil	Nil	Nil	Nil	Nil	Nil	1.5
Cetraria cucullata	Nil	"	"	"	"	"	"	0.7

[5]Mostly Sphagnum rubellum and S. fuscum.

[6]Included most of the species itemized, as well as Cetraria pinastri, Cladonia detormis, C. gracilis, C., verticillata, Cornicularia tennuissima, and Parmelia caperata.

Table 17. Composition of Ground Cover by Percentages on Transects on Islands in the East Arm of Great Slave Lake.

(continued)

Item	Transect No. and Age of Burn in Years							
	1 (122)	2 (12)	3 (150)	4 (10)	5 (1)	6 (40)	7 (12)	8 (nil)
Cetraria nivalis	3.5	Nil	0.1	Nil	Nil	0.9	Nil	1.2
Cladonia mitis	16.2	0.2	5.3	0.7	0.2	1.8	"	9.6
Cladonia multiformis	2.3	Nil	0.4	Nil	Nil	0.1	0.1	0.3
Cladonia rangiferina	0.5	"	0.5	"	"	Nil	Nil	1.0
Peltigera apthosa	0.6	"	0.5	"	"	"	"	0.2
Peltigera canina	Nil	0.2	0.4	0.7	0.2	0.3	1.1	0.4
Stereocaulon tomentosum	0.6	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Unbilicaria hyperborea	2.7	1.4	1.0	0.2	0.5	1.2	"	0.4
Total lichens	50.0	16.5	20.8	7.7	11.6	37.8	3.7	35.1
Significant total lichens	26.9	1.8	8.2	1.6	0.9	4.3	1.2	15.3

Table 17. Composition of Ground Cover by Percentages on Transects on Islands in the East Arm of Great Slave Lake.

(continued)

Item	Transect No. and Age of Burn in Years							
	1 (122)	2 (12)	3 (150)	4 (10)	5 (1)	6 (40)	7 (12)	8 (nil)
Picea sp. (living)	5.7	1.1	4.8	0.7	Nil	7.1	0.3	5.8
Picea sp. (dead)	2.1	14.2	4.1	9.7	6.1	4.4	11.1	4.0
Pinus Banksiana	Nil	Nil	Nil	0.2	Nil	Nil	Nil	Nil
Juniperus communis	3.5	"	3.9	Nil	"	2.6	0.1	0.8
Salix sp.	0.5	3.2	0.9	5.3	0.1	1.0	3.2	0.3
Poplus balsamifera	Nil	Nil	0.1	Nil	Nil	Nil	Nil	Nil
Poplus tremuloides	"	0.6	Nil	4.1	"	0.1	1.1	"
Myrica Gale	0.5	Nil	0.4	Nil	"	Nil	Nil	"
Betula glandulosa	2.2	"	Nil	"	"	"	"	"
Betula papyrifera	0.2	0.2	"	0.4	0.4	0.3	0.2	"
Alnus sp.	1.4	0.5	"	2.7	0.3	0.7	0.2	2.2
Ribes sp.	Nil	0.1	"	Nil	Nil	Nil	Nil	Nil
Ribes oxycanthoides	"	0.6	"	"	"	0.2	0.6	"

Table 17. Composition of Ground Cover by Percentages on Transects on Islands in the East Arm of Great Slave Lake.

(continued)

Item	Transect No. and Age of Burn in Years							
	1 (122)	2 (12)	3 (150)	4 (10)	5 (1)	6 (40)	7 (12)	8 (nil)
Potentilla fruticosa	Nil	0.1	Nil	Nil	Nil	Nil	0.2	1.1
Rubus idaeus	0.1	0.2	"	0.1	"	"	0.4	Nil
Rosa acicularis	0.3	1.9	0.8	2.9	0.3	0.6	5.1	1.2
Shepherdia canadensis	Nil	0.1	2.8	2.1	Nil	0.6	0.6	0.1
Ledum groenlandicum	5.5	2.7	2.8	0.2	"	4.5	0.1	1.6
Viburnum sp.	Nil	0.1	0.3	1.2	"	1.0	0.2	0.1
Perennial shrub	"	0.1	Nil	0.1	"	0.1	0.2	0.2
Total trees and shrubs[7]	22.0	25.7	20.9	29.7	7.2	23.2	23.6	17.4
Equisetum sp.	0.8	2.0	2.7	0.2	Nil	0.8	1.0	0.1
Juniperus horizontalis	0.8	3.2	Nil	Nil	"	0.3	Nil	2.0
Grasses (unidentified)	0.5	5.8	5.2	2.0	1.1	0.8	4.4	0.2

[7] More than one foot in height.

Table 17. Composition of Ground Cover by Percentages on Transects on Islands in the East Arm of Great Slave Lake.

(continued)

Item	Transect No. and Age of Burn in Years							
	1 (122)	2 (12)	3 (150)	4 (10)	5 (1)	6 (40)	7 (12)	8 (nil)
Carex sp.	0.7	4.5	0.9	1.8	Nil	0.1	0.1	0.2
Orchis rotundifolia	Nil	0.1	Nil	Nil	"	Nil	Nil	Nil
Saxifraga tricuspidata	1.0	1.1	0.3	"	0.3	1.1	0.5	0.5
Rubus Chamaemorus	0.7	Nil	0.5	"	Nil	Nil	Nil	Nil
Geranium Bicknellii	Nil	"	Nil	"	0.1	"	"	"
Empetrum nigrum	1.2	"	1.6	"	Nil	"	"	0.3
Epilobium angustifolium	Nil	2.5	Nil	1.7	0.4	0.2	1.9	Nil
Pyrola secunda	"	Nil	"	Nil	Nil	Nil	0.1	0.1
Arctostaphylos Uva-ursi	2.7	0.8	1.1	3.1	"	2.7	1.6	4.0

Table 17. Composition of Ground Cover by Percentages on Transects on Islands in the East Arm of Great Slave Lake.

(concluded)

Item	Transect No. and Age of Burn in Years							
	1 (122)	2 (12)	3 (150)	4 (10)	5 (1)	6 (40)	7 (12)	8 (nil)
Arctostaphylos rubra	0.3	0.4	Nil	Nil	"	Nil	0.3	4.3
Vaccinium uliginosum	0.2	Nil	"	"	"	0.5	Nil	Nil
Vaccinium Vitis-Idaea	1.5	0.6	4.6	0.2	"	0.8	"	1.7
Vaccinium macrocarpon	0.2	Nil	Nil	Nil	"	Nil	"	Nil
Linnaea borealis	Nil	1.0	1.1	1.6	"	0.2	1.3	1.7
Unidentified herbs	0.4	0.7	Nil	0.2	0.1	0.1	0.4	1.4
Total ground vegetation	11.0	22.7	18.0	10.8	2.0	7.6	11.6	16.5
Total percentages	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

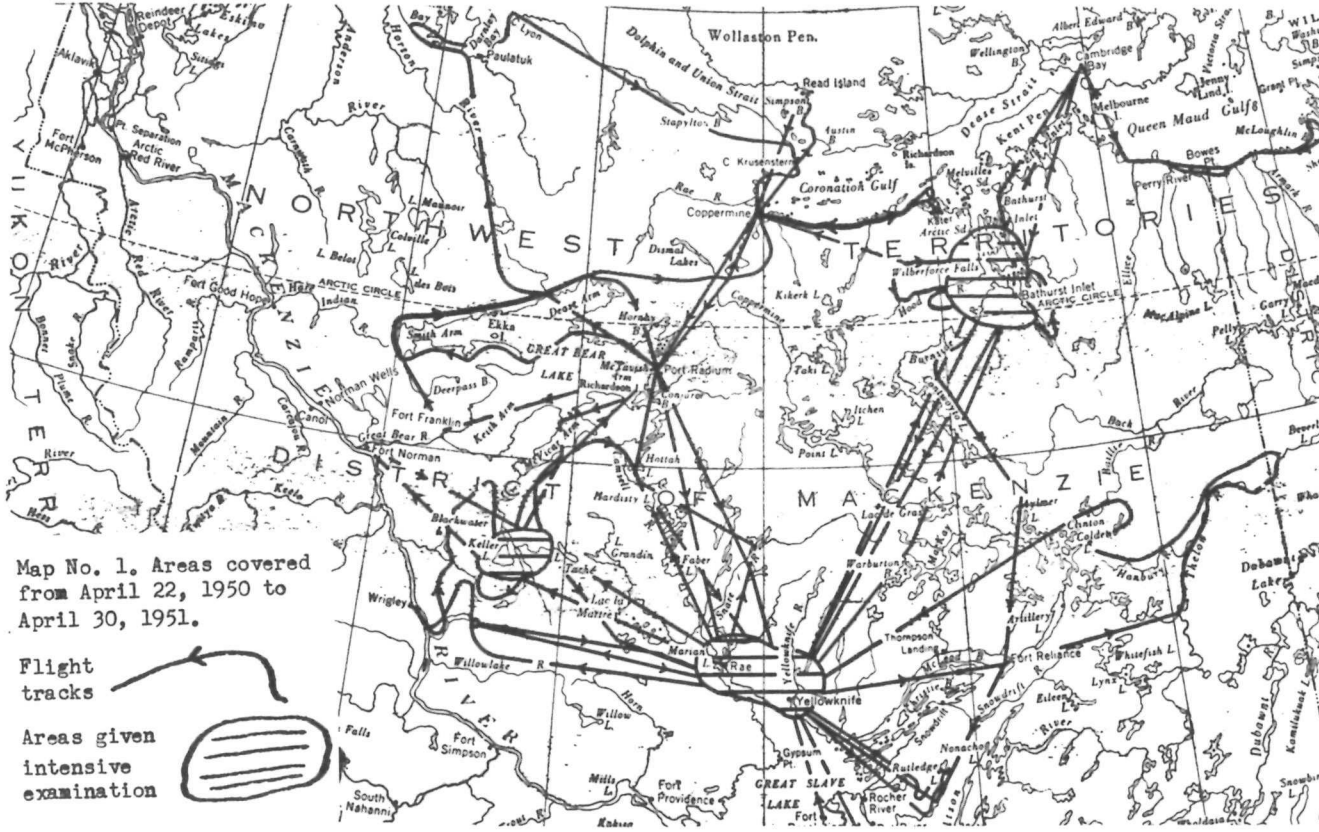
Table 18. Number of Faecal Pellet Groups Found and Percentages of Ground Covered by Lichens and by Significant-Sized Lichens on Eleven Transects.

NOTE:- Pellet groups counted in ten evenly-spaced plots of 600 square feet each along each transect.

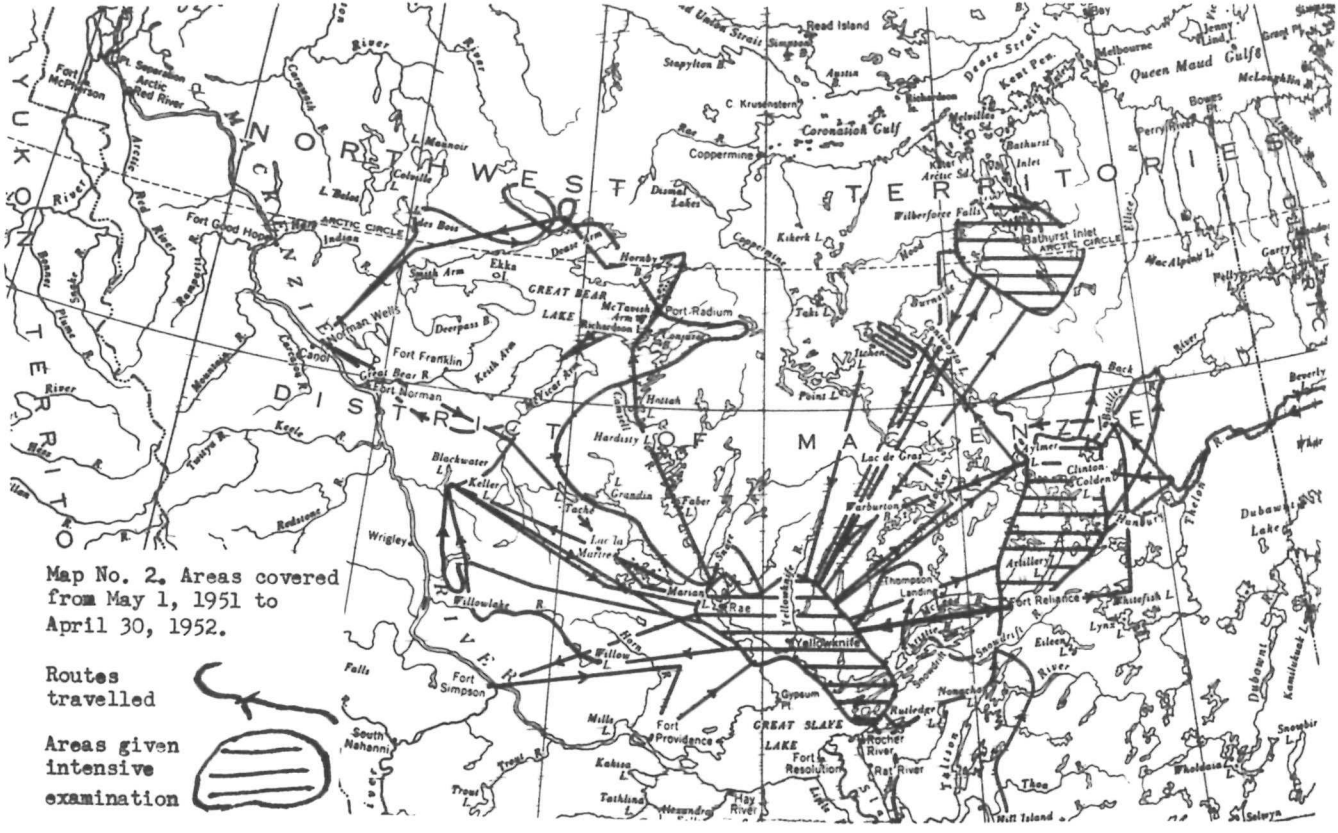
Transect No.	No. of Pellet Groups	Lichen Coverage (Per Cent)	Significant Coverage (Per Cent)
I-8	54	35.1	15.3
I-3	23	20.8	8.2
K-5	17	52.1	43.1
I-6	13	37.8	4.3
K-8	11	18.6	11.8
K-4	9	38.9	21.5
I-1	8	50.0	26.9
I-7	8	3.7	1.2
I-5	7	11.6	0.9
I-2	4	16.5	1.8
I-4	2	7.7	1.6

I - on the islands in the east arm of Great Slave Lake.

K - at Keller Lake



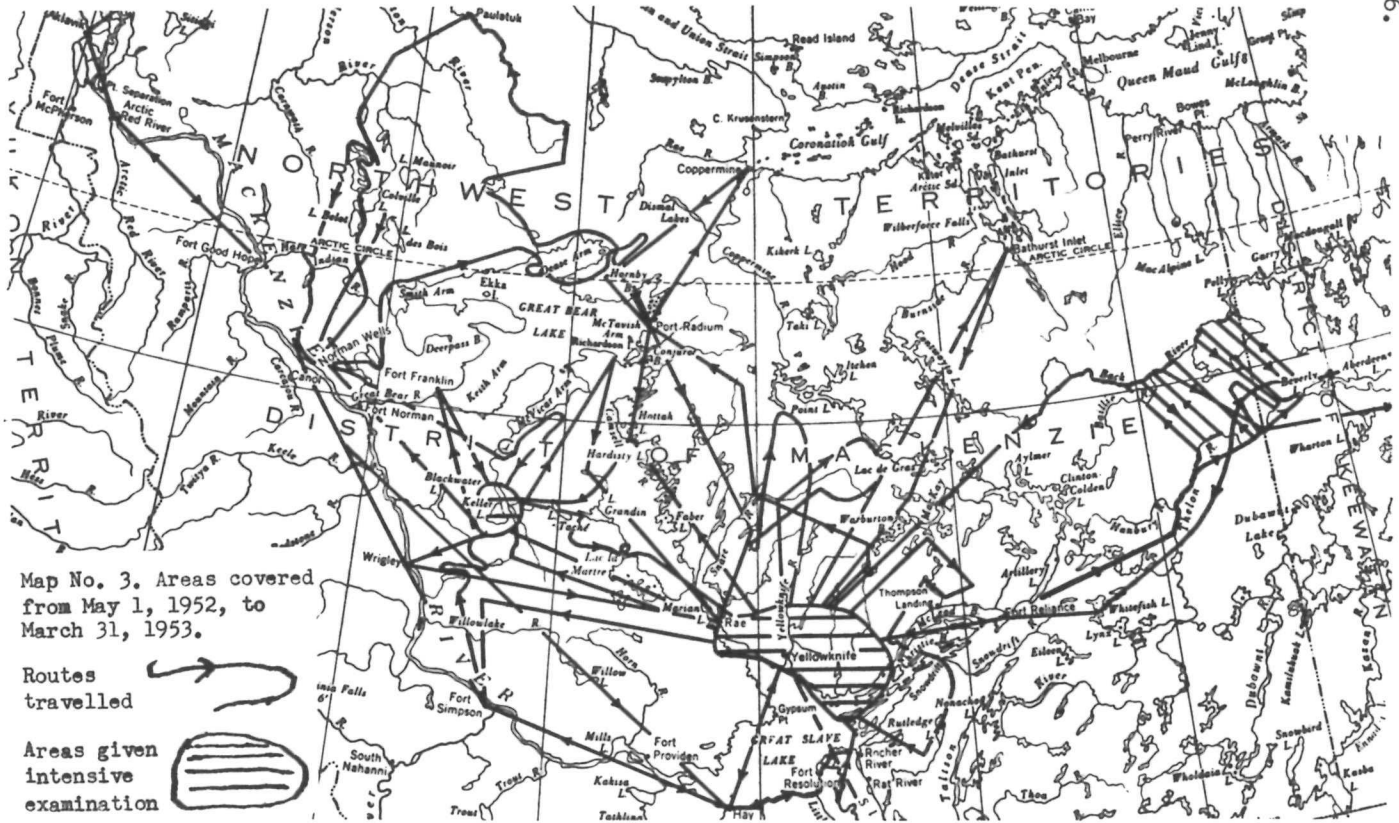
Map No. 1. Areas covered from April 22, 1950 to April 30, 1951.



Map No. 2. Areas covered from May 1, 1951 to April 30, 1952.

Routes travelled

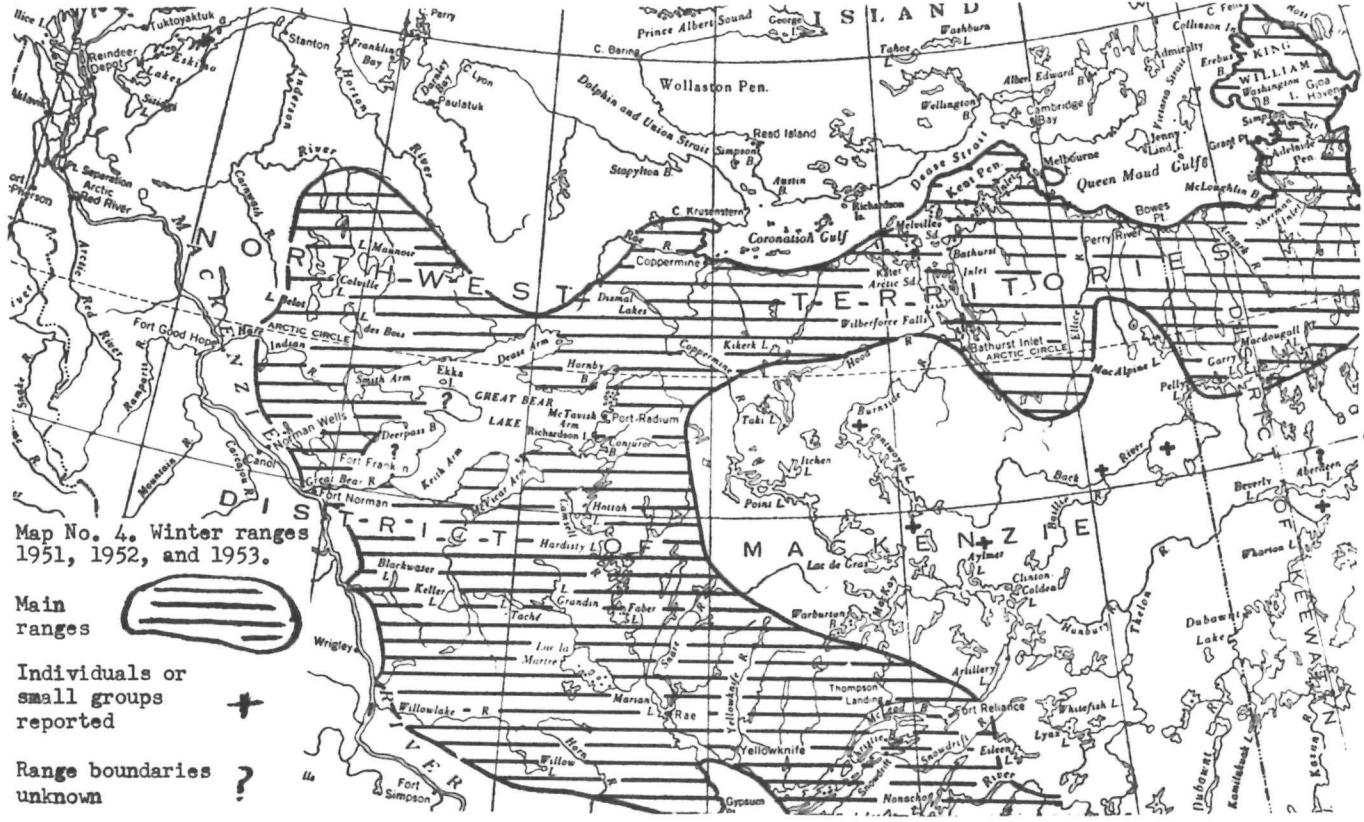
Areas given intensive examination



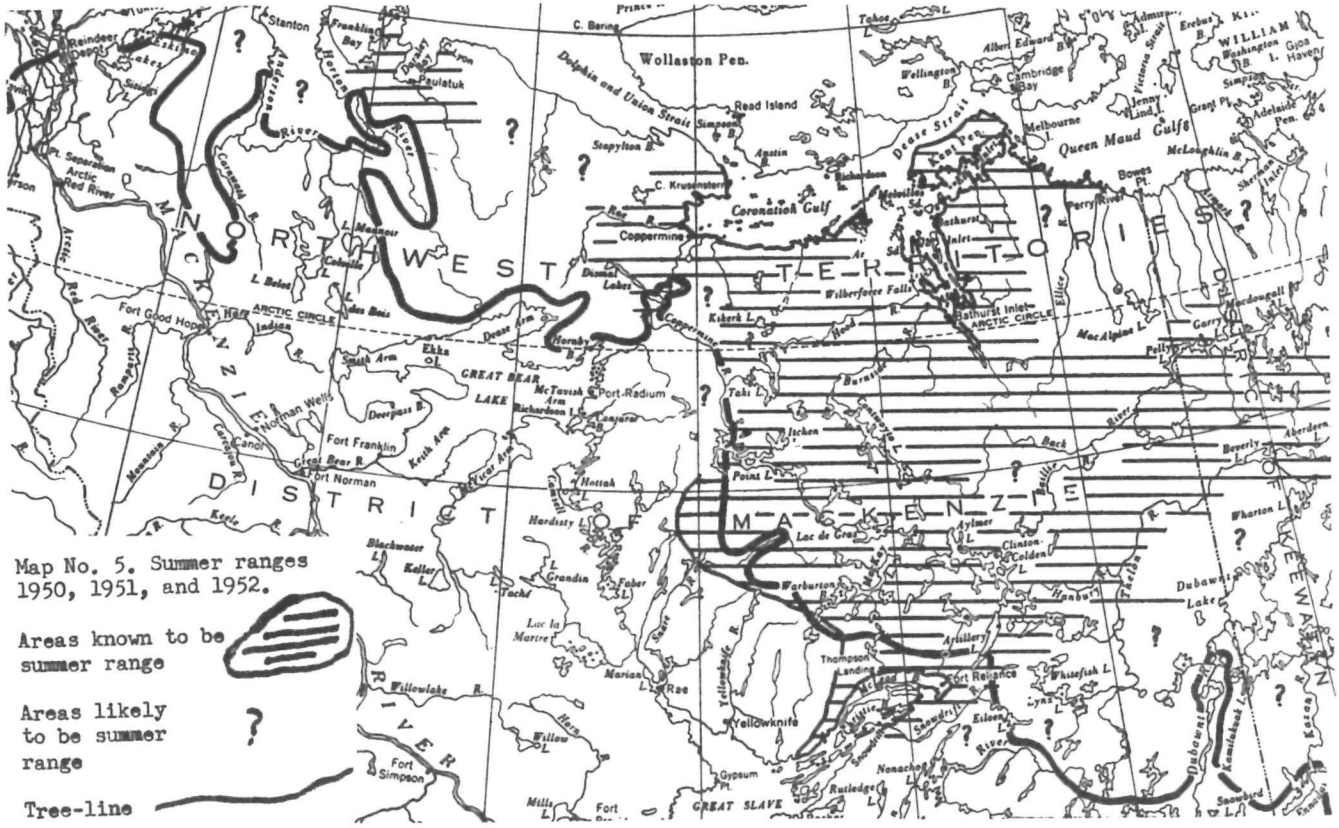
Map No. 3. Areas covered from May 1, 1952, to March 31, 1953.

Routes travelled

Areas given intensive examination



Map No. 4. Winter ranges 1951, 1952, and 1953.

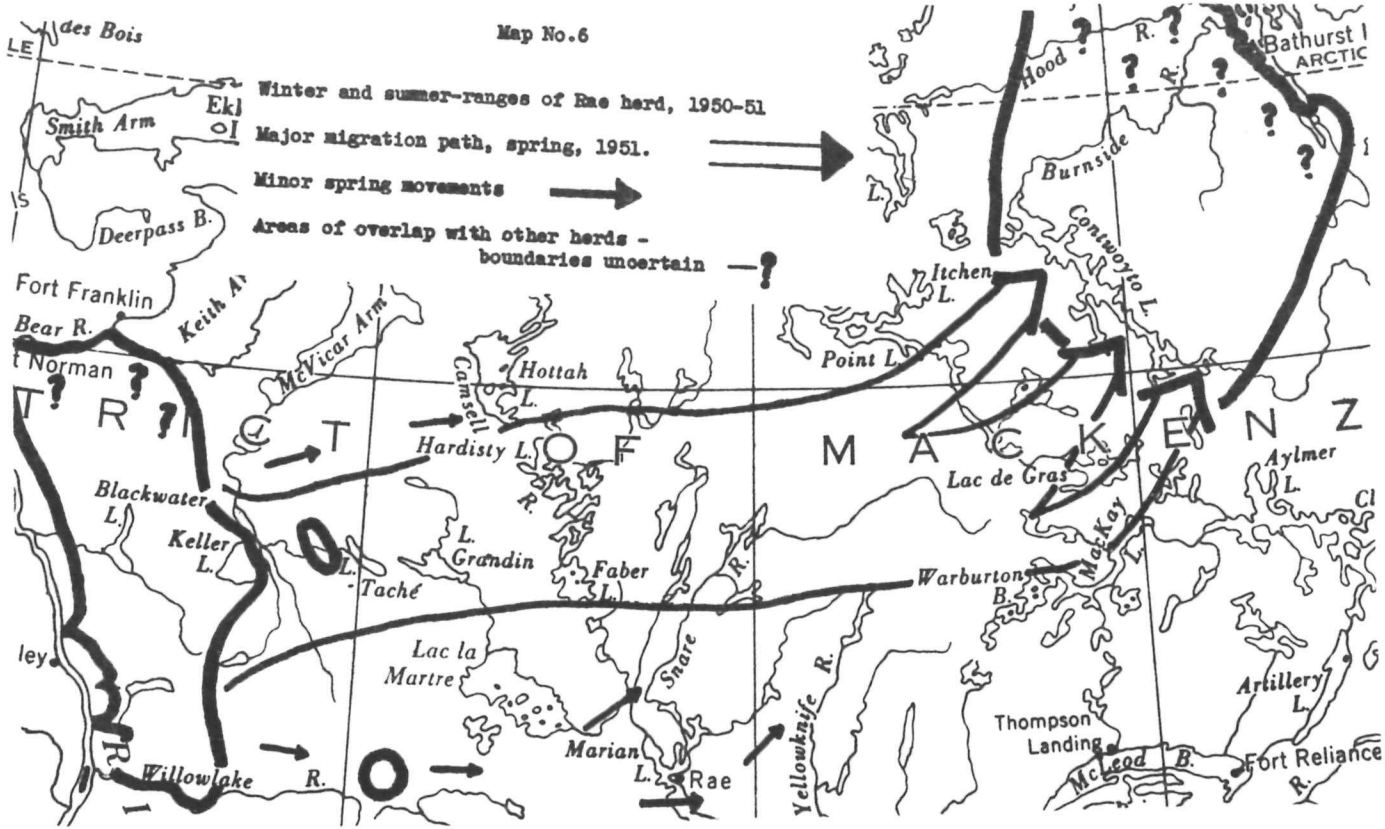


Map No. 5. Summer ranges 1950, 1951, and 1952.

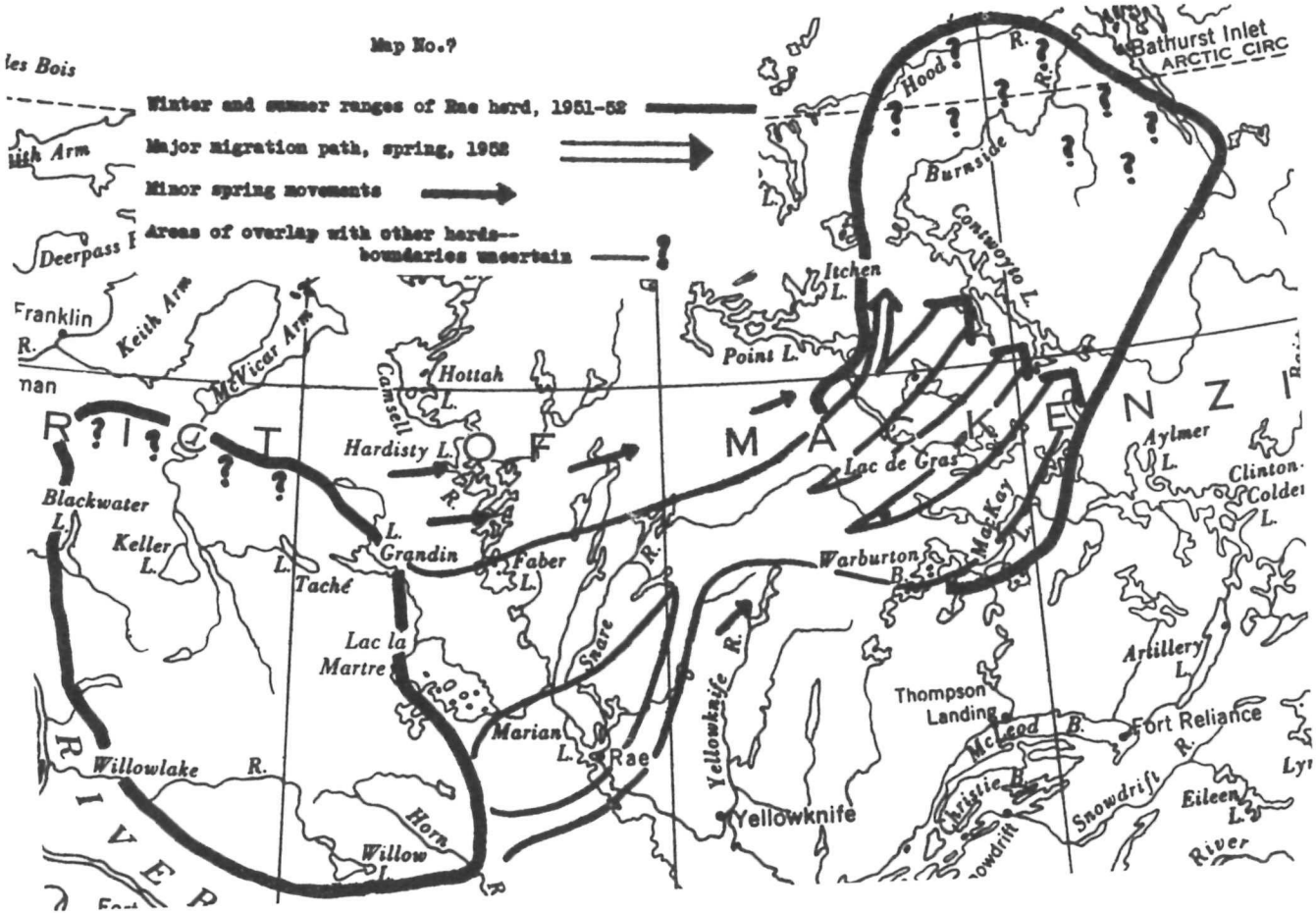
Areas known to be summer range ▨

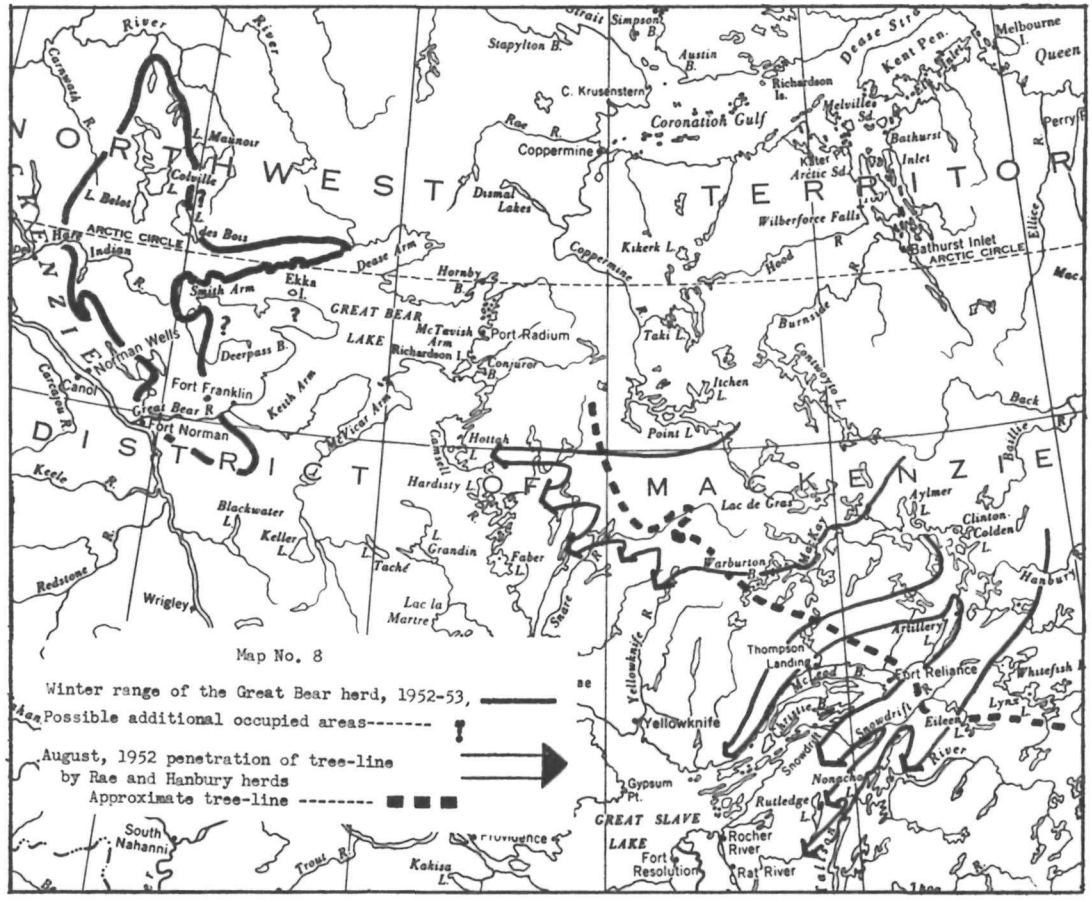
Areas likely to be summer range ?

Tree-line


Map No.6
Winter and summer-ranges of Rae herd, 1950-51
Major migration path, spring, 1951.
Minor spring movements
Areas of overlap with other herds - boundaries uncertain
des Bois
Smith Arm
Deerpass B.
Fort Franklin
Bear R.
Norman
Keith A
McVicar Arm
Camsell
Hottah
L.
Hardisty L.
Blackwater L.
Keller L.
L. Grandin
Faber L.
Taché
Lac la Martre
Snare
R.
Marian L.
Rae
Willowlake
R.
Yellowknife R.
Warburton B.
MacKay
Lac de Gras
Point L.
Itchen L.
Contwoyto L.
Burnside
Hood
R.
Bathurst I
ARCTIC
Aylmer L.
Artillery L.
Thompson Landing
McLeod B.
Fort Reliance
T R I C T O F M A C K E N Z I E

Map No.7


Winter and summer ranges of Rae herd, 1951-52
Major migration path, spring, 1952
Minor spring movements
Areas of overlap with other herds--boundaries uncertain
Bathurst Inlet
ARCTIC CIRC
Hood R.
Burnside
Contwoyto L.
Itchen L.
Point L.
Hottah L.
Camsell
McVicar Arm
Keith Arm
Franklin R.
Deerpass
Hardisty L.
Lac de Gras
Aylmer L.
Clinton-Colden L.
Blackwater L.
Keller L.
Grandin L.
Faber L.
Tache L.
Warburton B.
MacKay
Lac la Martre
Snare R.
Yellowknife R.
Artillery L.
Thompson Landing
McLeod B.
Fort Reliance
Marian L.
Rae
Willowlake R.
Horn
Willow L.
Yellowknife
Christie B.
Snowdrift
Eileen L.
River
R I V E R
M A C K E N Z I



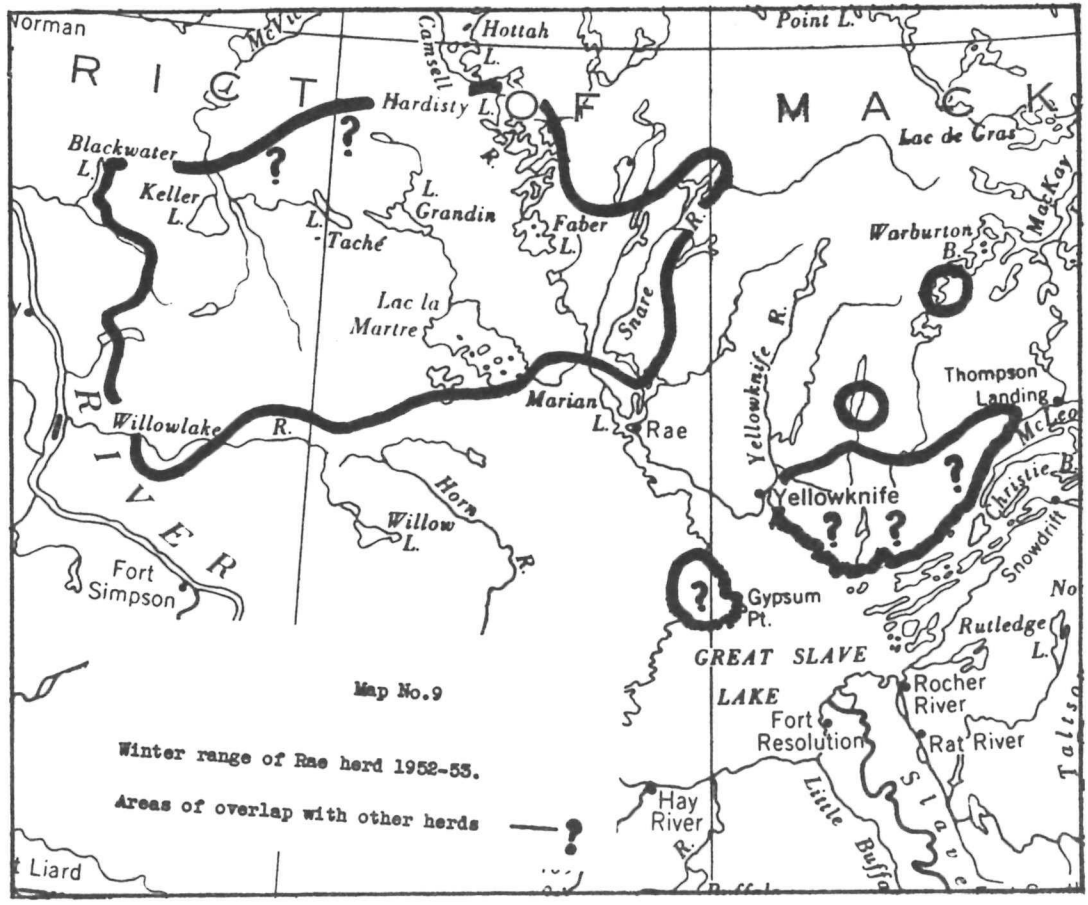
Map No. 8

Winter range of the Great Bear herd, 1952-53, ———

Possible additional occupied areas-------

August, 1952 penetration of tree-line by Rae and Hanbury herds

Approximate tree-line -------- ■ ■ ■

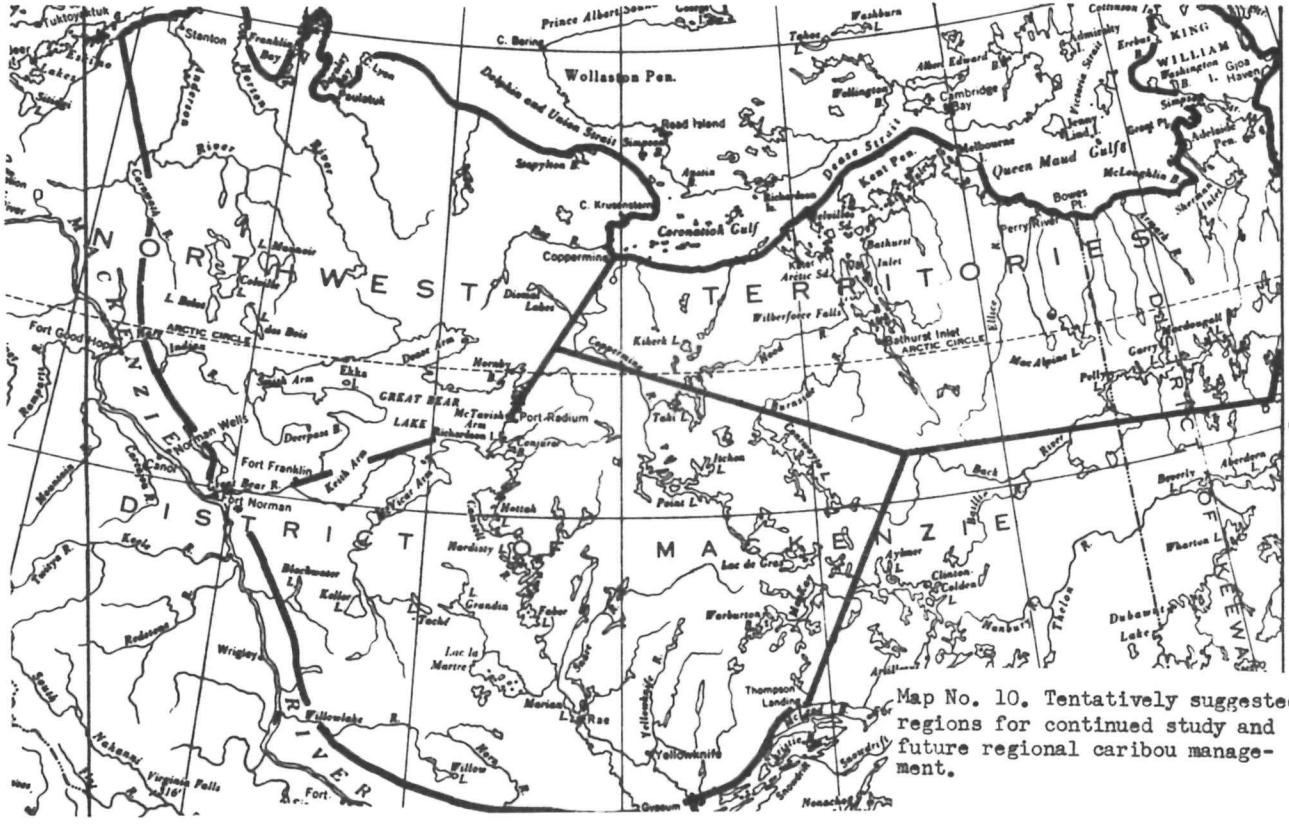


Map No.9

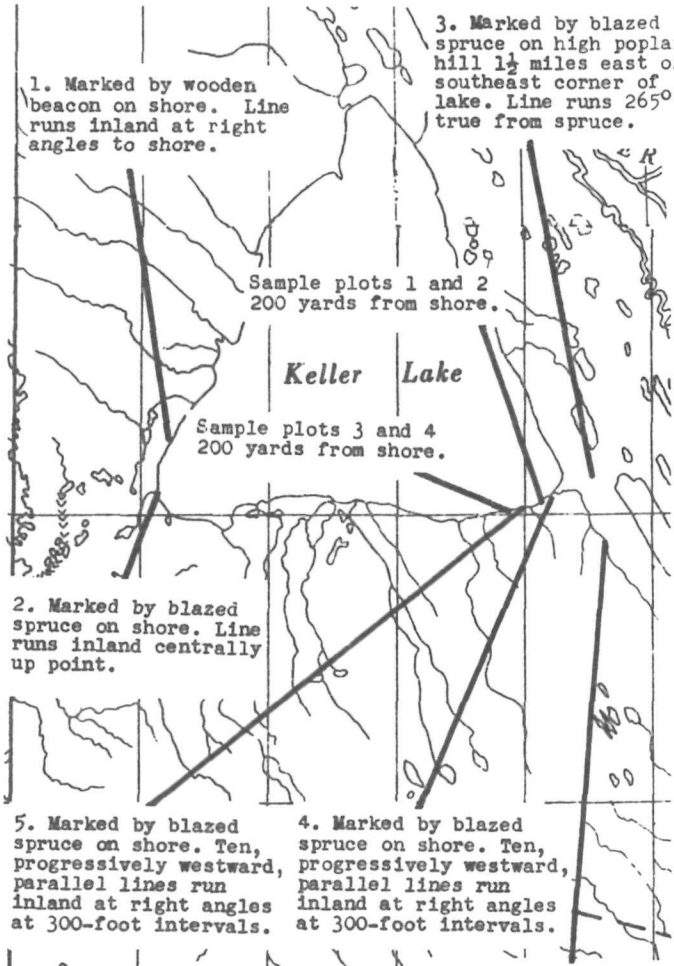
Winter range of Rae herd 1952-53.

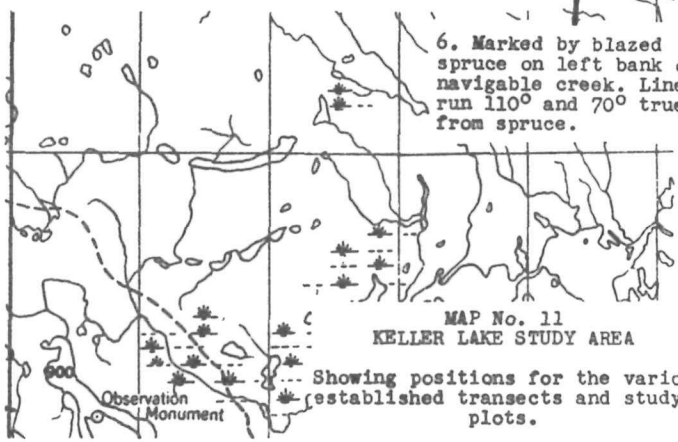
Areas of overlap with other herds —?

86629-10



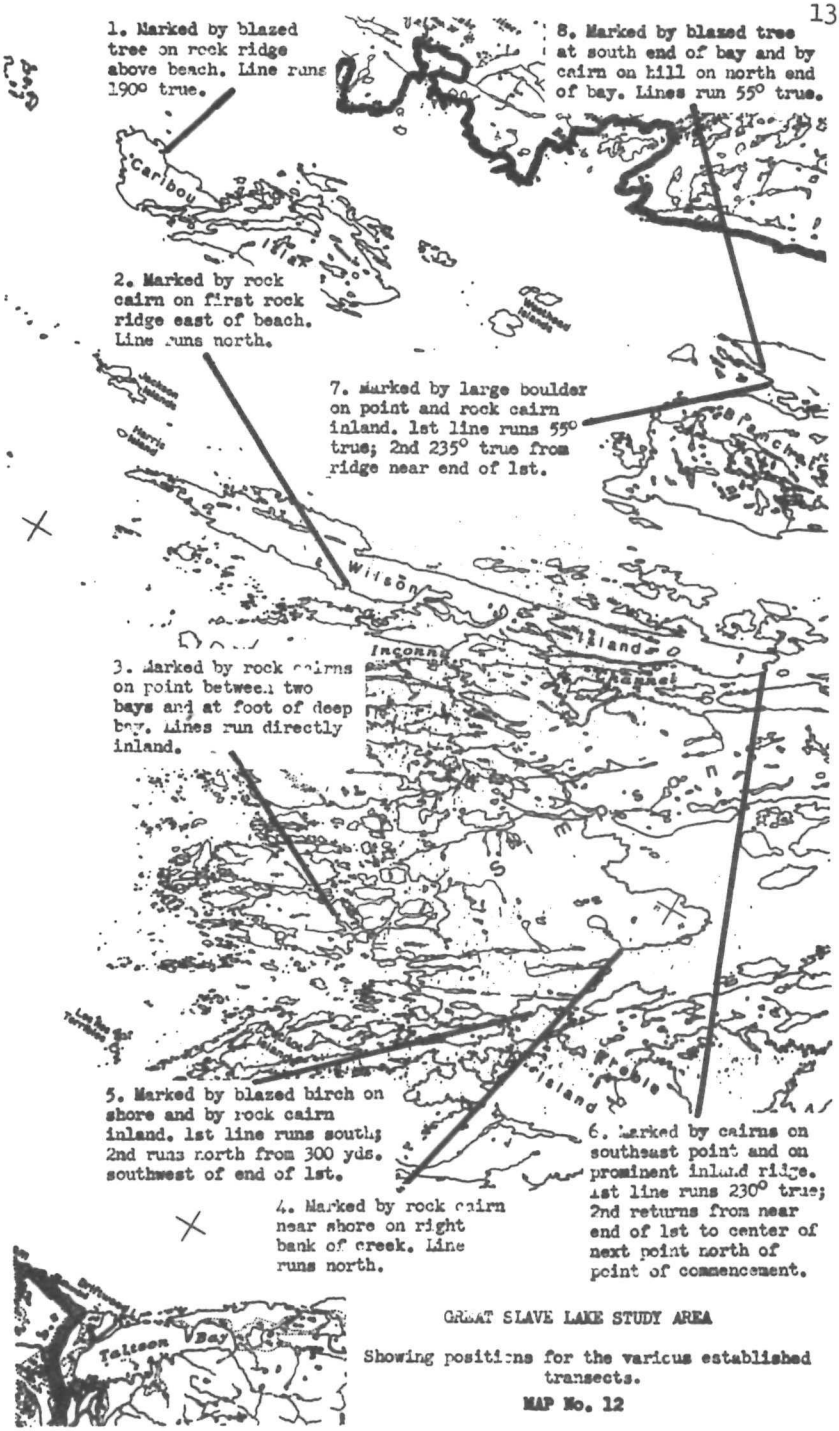
Map No. 10. Tentatively suggested regions for continued study and future regional caribou management.





MAP No. 11
KELLER LAKE STUDY AREA

Showing positions for the various established transects and study plots.



GREAT SLAVE LAKE STUDY AREA

Showing positions for the various established transects.

MAP No. 12

86629—10½

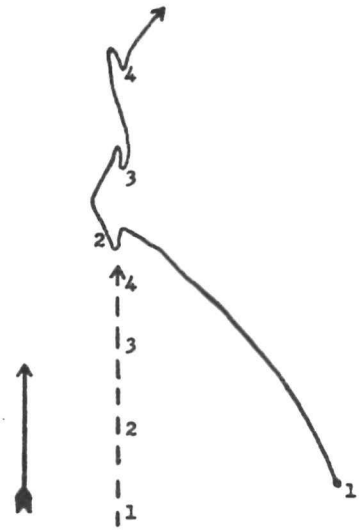


Figure 1. Caribou moved rapidly from original position (1) to watch observer from a downwind position (2). They moved ahead, twice turning back (3 & 4) to watch briefly before leaving.

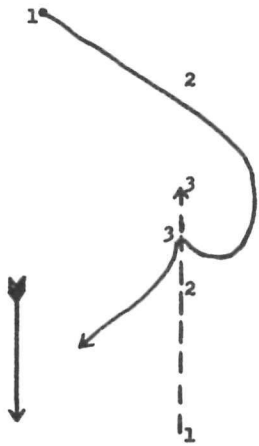


Figure 2. Caribou moved at a gallop upwind across observers' path (2) and then circled to a downwind position (3), standing briefly to catch the wind before moving off.

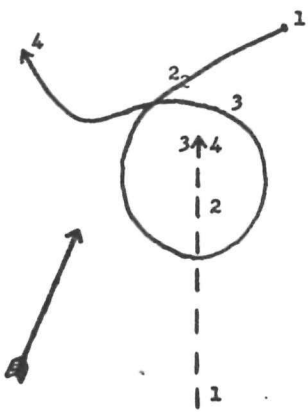


Figure 3. Caribou moved slowly across observers' path (1 & 2) and, breaking into a gallop, circled the observers completely (3) before moving off (4).

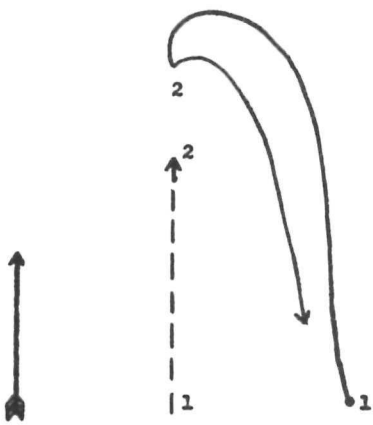


Figure 4. From original position (1) caribou paralleled observers, quickening pace to circle and stand (2) downwind before moving off to nearly their original position.

Wind direction ⟶ Caribou movement ⟶

Observers' paths — — → Relative positions 1,1: 2,2: etc.

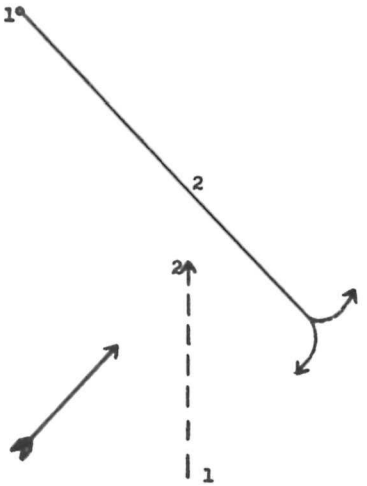


Figure 5. From original position (1) caribou galloped diagonally, downwind across observer's path (2) and split into two groups to move off.

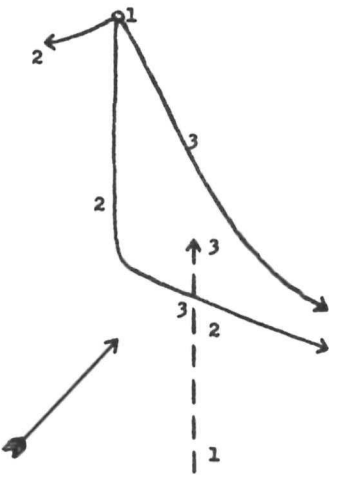


Figure 6. Caribou split into three groups (1): one moved directly off; one approached parallel to observers' left; one proceeded diagonally across observers' path (2). The 2nd group crossed upwind at a walk, the 3rd group downwind at a gallop (3).

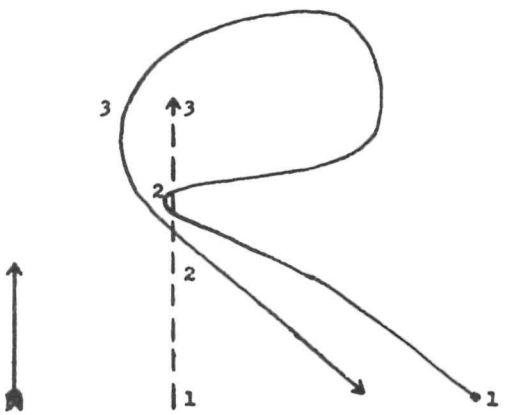


Figure 7. Caribou moved at a trot from original position (1) to a point downwind from the observer (2). They circled right and crossed downwind a second time, and upwind, at a gallop (3) which they maintained until out of range.

Wind direction ——→ Caribou movement ——→

Observers' paths — — — → Relative positions 1,1: 2,2: etc.

Fig. 8. Transect No. 3 at Keller Lake, showing thick young spruce growth, mostly less than 35 years old, and an abundance of standing and fallen dead spruce.

Fig. 9 Transect No. 3 at Kellar Lake, showing more or less typical ground detail. Lichens are nearly absent but dead and living spruce, dwarf birch, and sedges, all shown, are abundant.

Fig. 10. Transect No. 4 at Keller Lake, showing heavy but inferior-sized lichen growth under a heavy canopy of young jack pines, 39 years old and less.

Fig. 11. Transect No. 4 at Keller Lake, showing rather good and continuous lichen growth in open areas not dominated by jack pine. *Cladonia alpestris* is the major lichen species.

Fig. 12. Transect No. 5 at Keller Lake showing open, mature, tree growth dominated by spruce but with occasional jack pine. Almost continuous lichen cover can be seen.

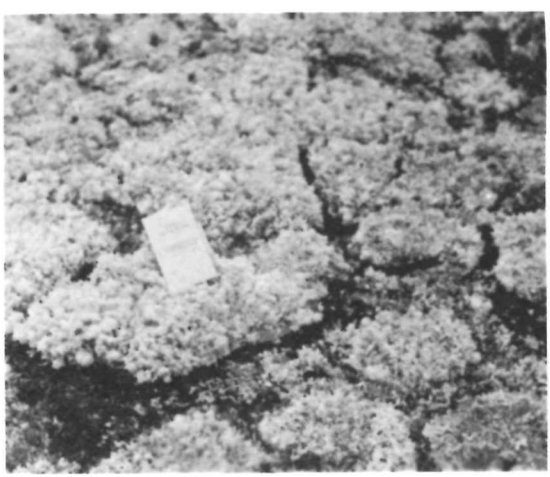


Fig. 13. Transect No. 5 at Keller Lake, showing excellent lichen cover. The dominant species is *Cladonia alpestris*, with which *Cetraria nivalis* and other less important species are intermixed. The marked "cracking" of the lichen cover is probably due to warm weather and dehydration.

Fig. 14. Transect No. 6 at Keller Lake, showing a dwarf birch-sedge swale in the stunted spruce forest. Such areas offer nothing to caribou but provide fair moose habitat.

Fig. 15. Transect No. 6 at Keller Lake, showing detail of more or less typical ground cover. Vegetation is heavy and close-growing. Small spruce, larch, glandular birch, and Labrador tea, all shown, greatly restrict the area available for lichen growth. Lichen in this case is *Cladonia alpestris*.

Fig. 16. Near the commencement of Transect No. 1 at Caribou Islands, showing mature, unburned, spruce forest giving good vegetative cover in an otherwise rocky area.

Fig. 17. Transect No. 1 on the Caribou Islands, showing excellent vegetative cover even on rocky hill-tops. The visible line, in the photograph is laid through an area of good lichen growth.

Fig. 18. Transect No. 2 on Wilson Island, showing the thoroughness of the 12-year-old burn on the rocky hills, and scattered refugia of spruce and deciduous trees.

Fig. 19. Transect No. 2 on Wilson Island, showing vegetative recovery on a badly burned rocky area. There is still much rock only partially covered by prostrate lichens of no value to caribou. *Juniperus horizontalis*, *Saxafraga tricuspidata*, and small sedges, all of little or no importance to caribou are also present.

Fig. 20. Transect No. 4 on Simpson Island, showing new nine-year-old poplar growth, two survivor spruce, and spruce, poplar, and jack pine snags. This country is now good moose habitat but offers little to caribou.

Fig. 21. Transect No. 4 on Simpson Island, showing ground detail and effect of multiple burning on jack pine sapling in centre. Small sedges, rose bushes, Epilobium and small mosses (all shown) provide scant vegetative cover.

Fig. 22. Transect No. 5 on Simpson Island, showing the effect of fire of the previous year on mature spruce forest. Trees have been almost completely destroyed, and soil has been so badly burned that rock ridges (background) have already been washed almost completely bare.

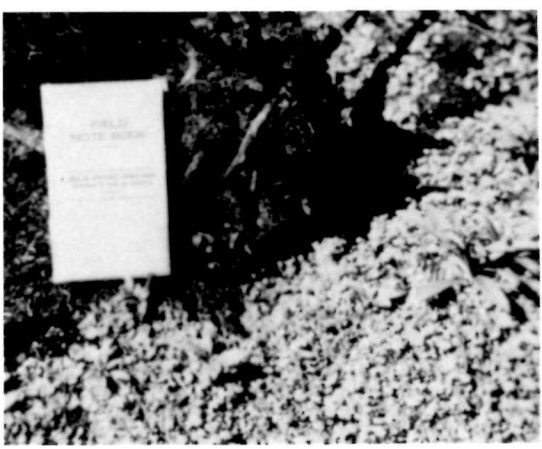


Fig. 23. Transect No. 5 on Simpson Island, showing one of the earliest forms of vegetative recovery following fire: a mat of fruiting Marchantia polymorpha with occasional plants of non-flowering Epilobium angustifolium.

Fig. 24. Transect No. 6 on Wilson Island, giving a general view of the 40-year-old burn. The large spruce showing clearly are survivors of the fire.

Fig. 25. Transect No. 6 on Wilson Island showing miscellaneous nature of the ground cover. Rocks are covered with insignificant lichens. Dead and living spruce, paper birch, and other forms of only incidental importance to caribou are shown.

Fig. 26. Transect No. 7 on Blanchet Island, looking west from the point of inland terminal. This 12-year-old burn was very thorough. Most of the unburned soil has been washed from the predominant rock surfaces and recovery of vegetation is slight. This should be compared with Figure 28.

Fig. 27. Transect No. 7 on Blanchet Island, showing details of ground cover. A great deal of earth and rock is only sparsely covered with rose, gooseberry, and twinflower. This should be compared with Figure 29.

Fig. 28. Transect No. 8 on Blanchet Island, showing mature, unburned spruce forest covering the same type of terrain as in Figure 19. Rocky hilltops are unforested but well vegetated.

Fig. 29. Transect No. 8 on Blanchet Island, showing ground detail. The forest floor is heavily carpeted with lichens and mosses. The dominant species is Cladonia mitis. This should be compared with Figure 27.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1957