

G. R. Parker

Biology of the Kaminuriak Population of barren-ground caribou Part I



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Biology of the Kaminuriak Population of barren-ground caribou

Part I: Total numbers, mortality, recruitment, and seasonal distribution

by G. R. Parker

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Canadian Wildlife Service
Report Series - Number 20

A series to consist of four parts:

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Total numbers, mortality, recruitment,
and seasonal distribution by G. R. Parker

Part 2:

Age and sex composition and segregation
of the population by F. L. Miller

Parts 3 and 4:

Growth, reproduction and nutritional
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Winter band of caribou before spring migration to their calving ground. Photo by Donald Thomas.



The author

Gerald R. Parker is a research biologist for the Canadian Wildlife Service in Ottawa, Ontario. He received graduate degrees (B.Sc., M.Sc.) from Acadia University, Wolfville, Nova Scotia, and his master's thesis was entitled "Moose Disease in Nova Scotia". Upon graduation in 1966 he was employed by CWS to participate in a study of the Kaminuriak barren-ground caribou population, the results of which appear in this report. From 1970 to 1972 Mr. Parker has continued barren-ground caribou research in northern Canada by carrying out a range appraisal of Southampton Island, N.W.T.

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Perspective

The number of barren-ground caribou in northern Canada in primitive times has been estimated at approximately 3 million. The annual kill of caribou rapidly increased, however, following the introduction of firearms and the arrival of the whalers during the mid-19th century and the demand for northern furs in the early 20th century. Reductions in local populations were reported as early as the mid-19th century, although range-wide decreases probably did not occur before 1900. The first range-wide aerial surveys in 1948-49 produced the alarmingly low estimate of 670,000 caribou. Studies continued throughout the 1950's and early 1960's. Barren-ground caribou numbers reached an all-time low around 1955, at which time the decline appears to have terminated with little change in their status over the past 15 years. Those early studies were successful in monitoring the trend in total numbers and identifying many of the factors responsible for the decline. However, such programs are now regarded as pioneer studies in the field of caribou research, and although they contributed much information on caribou ecology, most were restricted in time and space

and were inconclusive. In the early 1960's many conservation agencies felt an urgent need for a continuous study of a particular population for a period of several years to obtain detailed information on population dynamics, human utilization, and range condition. The Canadian Wildlife Service thus began an intensive study of the Kaminuriak Population in the spring of 1966. The results and conclusions of this study were presented to the Administrative and Technical Committees for the Preservation of Caribou for their advisement in 1970. The recommendations subsequently adopted were made available to the Game Management Service of the Northwest Territories and the provincial game branches of Manitoba, Saskatchewan, and Alberta. The Kaminuriak Population was selected for study mainly for its accessibility and relatively confined range limits. Although primarily a program designed and carried out by the Canadian Wildlife Service, the game agencies of Manitoba, Saskatchewan, Alberta, and the Northwest Territories all contributed assistance in the form of personnel at various periods throughout the study. Four Canadian Wildlife Service biologists were each responsible for one of the following segments of the study: 1. total numbers, mortality, recruitment, and seasonal distribution, 2. sex and age composition, 3. seasonal physical and reproductive condition, and 4. range evaluation. This is the first in a series of four Canadian Wildlife Service Report publications which present the results of that barren-ground caribou research program.

Abstract

Aerial surveys from June 1966 to October 1968 provided data on total numbers, recruitment, and seasonal distribution for the Kaminuriak barren-ground caribou, a population of the Canadian tundra race *Rangifer tarandus groenlandicus*. Human utilization figures were obtained each month from August 1967 to July 1968. The Kaminuriak Population ranges over southeastern District of Keewatin, in the Northwest Territory.

ries, and northern Manitoba and north-eastern Saskatchewan.

The areas for calving, post-calving, and late summer and early winter distribution were similar during this 3-year period. The area of late winter distribution may vary considerably and appears dependent on environmental conditions in January and February. Spring migration routes to the calving ground depend upon the areas utilized during late winter and early spring. Many caribou remain throughout the winter on the tundra, especially along the coastal area. Maximum winter penetration south of the tree-line is less than half that recorded 15 years earlier, when the total population was estimated double its present size. The extent of range utilized is believed dependent on the size of the population. During late summer and early winter the population consists of three geographically distinct entities. These three groups appear to share a common area of rut, but the extent of random breeding between groups is unknown. Adult males comprised 38.8 per cent of those caribou in the westernmost concentration and 17.2 per cent of those near the Hudson Bay coast. Conversely, calves comprised 9.9 per cent of caribou in the westernmost concentration, 16.3 per cent of those in the central concentration, and 14 per cent of those near the coast.

Five aerial linear transect surveys provided an estimate of $51,214 \pm 4,612$ (95 per cent confidence level) caribou within the taiga during the winter of 1967-68. An aerial survey over the calving ground in June 1968, on which all caribou on randomly selected 16-square-mile blocks were counted, provided an estimate of 33,962 caribou 1 year of age and older within the area of calving. Aerial and ground segregation suggested 80 per cent were adult breeding females, and extrapolation gives an estimate of 27,169 breeding females for the Kaminuriak Population in June 1968. Thirty-two post-calving aggregations were found and photographed south of Baker Lake, Northwest Territories, on July 17, 1968. A subsequent count showed there

were 51,332 caribou in the area. This total included all breeding females and surviving calves, 28 per cent of the estimated yearlings, and 33 per cent of the estimated adult males in the population. Aerial segregation of caribou in late September 1968 indicated the population contained 55 adult males per 100 adult females. The total number of males over 3 years of age in the population was estimated at 18,373. From these data the population was estimated to total 63,173 caribou prior to calving in June 1968. Males comprised 38.2 per cent and females 61.8 per cent of the population. Yearlings made up 9.4 per cent, 2-year-olds 8.5 per cent, females 3 years and older 52.8 per cent, and males 3 years and older 29.3 per cent of the population.

Community caribou kill records showed Indians and Eskimos killed 5.3 per cent of the population over 1 year of age from August 1967 to July 1968. A population of 550 wolves was estimated within the study area, based on aerial observations during caribou surveys. Existing information on daily meat requirement per wolf and composition of wolf-killed caribou examined suggested 4.8 per cent of the caribou population over 1 year of age was lost to wolf predation annually during the 3-year study period.

Spring surveys showed the average annual recruitment in the 3 years of the study was approximately 10 per cent of the population, or 6,000 to 6,500 caribou. Annual mortality and recruitment during the study period were very similar, and no substantial increase or decrease of the population was detected.

Monthly calf ratios showed that a high percentage of calves died during their first year of life. Sixty per cent of the calves were dead 4 to 5 weeks after birth in 1968. Similar calf ratios in July of 1967 and 1969 suggest this loss was typical for the 3-year period. Of those calves still alive in late July, only 55 per cent survived to the following calving period. Predation by wolves is believed the major cause for the 40 per cent calf mortality from October to May.

Résumé

Les relevés aériens effectués de juin 1966 à octobre 1968, ont fourni des données sur la population totale, le nombre de naissances et la distribution saisonnière des caribous des toundras de Kaminuriak, population appartenant à l'espèce canadienne *Rangifer tarandus groenlandicus*. Des données relatives aux usages que l'homme fait du caribou ont été accumulées mensuellement, du mois d'août 1967 au mois de juillet 1968. La population de Kaminuriak occupe le sud-est du district de Keewatin (Territoires du Nord-Ouest), le nord du Manitoba et le nord-est de la Saskatchewan.

Le territoire de parturition et de post-parturition et les aires de répartition des animaux à la fin de l'été et au début de l'hiver furent semblables au cours des trois années de l'étude. La répartition à la fin de l'hiver peut varier considérablement et semble dépendre des conditions du milieu, en janvier et en février. Les voies de la migration printanière vers la région de parturition dépendent des territoires occupés à la fin de l'hiver et au début du printemps. Plusieurs caribous passent l'hiver dans la toundra, en particulier le long de la côte. L'éloignement maximum vers le sud de la limite de la végétation arborescente en hiver n'est que la moitié de ce qu'elle était, il y a 15 ans, lorsque la population totale était évaluée au double de son chiffre actuel. L'étendue du terrain occupé semble être en fonction de l'importance numérique de la population. Cette dernière se divise, à la fin de l'été et au début de l'hiver, en trois groupes distincts du point de vue géographique. Ces trois groupes semblent partager le même territoire pendant le rut, mais on ne connaît pas dans quelle proportion les mâles et les femelles des différents troupeaux s'accouplent. Les mâles adultes formaient 38.8% du groupe le plus à l'ouest et 17.2% de celui qui se trouvait près de la côte de la baie d'Hudson. Par ailleurs, la harde la plus à l'ouest comptait 9.9% de jeunes, celle du centre, 16.3% et celle de la côte, 14%.

Cinq relevés aériens par virées transversales ont permis d'estimer à $51,214 \pm 4,612$

(95% étant considérés comme le seuil de confiance) le nombre de caribous qui habitaient la taiga au cours de l'hiver 1967-1968. Un relevé aérien effectué au dessus du territoire de parturition, en juin 1968, et au cours duquel tous les caribous rencontrés dans des aires de 16 milles carrés choisies au hasard ont été comptés, a permis d'estimer à 33,962 le nombre de caribous d'un an ou plus à l'intérieur du territoire de parturition. Une ségrégation effectuée par air et sur terre laisse supposer que 80% étaient des femelles adultes reproductrices et l'extrapolation chiffre à 27,169 le nombre des femelles reproductrices de la population de Kaminuriak, au mois de juin 1968. Le 17 juillet 1968, 32 groupements formés après la parturition furent aperçus et photographiés, au sud du lac Baker (Territoires du Nord-Ouest). Un dénombrement subséquent démontra qu'il y avait 51,332 caribous dans la région. Ce total comprenait toutes les femelles reproductrices et tous les jeunes qui avaient survécu, 28% des animaux d'un an et 33% des mâles adultes déjà dénombrés au sein de la population entière. Une ségrégation aérienne des caribous à la fin du mois de septembre 1968 a révélé que la population adulte comptait 55 mâles pour 100 femelles. Le nombre total de mâles dans le groupe des plus de trois ans a été évalué à 18,373. A partir de ces données la population totale des caribous avant parturition en juin 1968 a été estimée à 63,173. Les mâles constituent 38.2% de la population et les femelles, 61.8%. Les jeunes d'un an forment 9.4% du nombre total, les animaux de deux ans, 8.5%, les femelles de trois ans et plus, 52.8% et les mâles de trois ans et plus, 29.3%.

Les tableaux de chasse indiquent que les Indiens et les Esquimaux ont tué 5.3% de caribous de plus d'un an, du mois d'août 1967 au mois de juillet 1968. La population des loups, dans le territoire étudié, a été estimée à 550, d'après les observations aériennes poursuivies pendant l'étude sur les caribous. Les renseignements actuels sur les besoins quotidiens de viande pour chaque loup et l'examen de la composition des

caribous tués par les loups, portent à croire que 4.8% de la population de caribous de plus d'un an ont été victimes des loups chaque année, pendant les trois années de l'étude.

Les relevés du printemps ont révélé que la moyenne de naissances annuelles pour les trois ans représentait environ 10% de la population, soit de 6,000 à 6,500 caribous. Les taux annuels de mortalité et de natalité pendant l'étude, ont été presque identiques, et l'on n'y a découvert aucune augmentation ou baisse importante de la population.

Le nombre de jeunes relevé mensuellement a indiqué qu'un fort pourcentage de nouveaux-nés sont morts au cours de la première année de leur vie. En 1968, 60% des petits sont morts 4 ou 5 semaines après leur naissance. Des proportions semblables pour les mois de juillet 1967 et 1969, en ce qui a trait aux jeunes, indiquent que ces pertes étaient caractéristiques pendant les trois années. Des jeunes encore en vie à la fin de juillet, seulement 55% ont survécu jusqu'à la parturition suivante. On attribue aux activités des loups prédateurs, la majeure partie de la mortalité (40%) chez les jeunes, d'octobre à mai.

АБСТРАКТ

В результате аэрофотосъемок, проведенных между июнем 1966 года и октябрём 1968 года, получены данные об общем количестве, приплоде и сезонном распределении каминурьякского карibu по бесплодным землям канадского севера. Разновидность карibu, населяющего канадскую тундру, — *Rangifer tarandus groenlandicus*. Были получены ежемесячные цифры эксплуатации этих животных человеком с августа 1967 года по июль 1968 года. Популяция каминурьякского карibu распространяется на юго-западную часть области Киватин, Северо-западные территории, северную Манитобу и северо-восточный Саскачеван.

Районы молодняка, пастбищ отелившихся карibu, а также их распределения в конце лета и ранней зимой, оставались в течение этих трех лет в основном теми же. Область распространения карibu поздней зимой подвергается значительным колебаниям и зависит, повидимому, от местных условий в январе и феврале. Пути весенней миграции в районы отела зависят от местонахождения стад в конце зимы и начале весны. Значительное количество карibu проводит всю зиму в тундре, главным образом в прибрежном районе. Максимальная пенетрация зимой на юг от границы лесов сократилась до половины пенетрации, установленной 15-ю годами раньше, когда общая популяция была вдвое больше настоящей. Можно считать, что площадь распространения находится в прямой зависимости от размеров популяции. Население состоит поздним летом и ранней зимой из трех гео-

графически обособленных групп. Эти группы, повидимому, пользуются общими районами движения, но неизвестно, насколько они смешиваются при размножении. Количество взрослых самцов составляло в крайней-западной концентрации 38,8 процента, а на побережье Гудзонова залива 17,2 процента общего населения. Соответствующая пропорция телят составляла 9,9 процента в крайней западной концентрации, 16,3 процента в промежуточной концентрации и 14 процентов на побережье.

На основании пяти линейных аэрофотосъемок подсчитано, что зимой 1967-68 гг. в тайге пребывало 51.214 ± 4.612 (95 процентов вероятности) штук карibu. Аэрофотосъемка, проведенная в июне 1968 года в районе отела, при которой были подсчитаны все карibu на выделенных наугад участках по 16 квадратных миль, установила во всем районе наличие 33.962 карibu, годовалых и старше. Воздушная и наземная сегрегация позволила определить, что количество зрелых самок каминурьякского населения в июне 1968 года составляло 27.169. 32 стада отелившихся карibu были обнаружены и засняты к югу от озера Бейкера в Северо-западных территориях 17 июля 1968 года. При позднейшем подсчете в них оказалось 51.332 головы. Эта общая цифра включила всех зрелых самок и выживших телят, 28 процентов подсчитанных годовиков и, по расчету, 33 процента взрослых самцов. При воздушной сегрегации в конце сентября 1968 года было найдено, что на каждые 100 самок приходилось 55 взрослых самцов. Общее количество самцов

старше 3 лет было, согласно подсчету, 18.373. Отсюда было вычислено, что перед отелом в июне 1968 года популяция составляла 63.173 карibu. Из этого количества 38,2 процента были самцы, а 61,8 процента — самки. Годовики составляли 9,4 процента, двухлетки 8,5 процента, самки трех лет и старше — 52,8 процента, а самцы трех лет и старше — 29,3 процента популяции.

Ведущиеся записи убоя показывают, что от августа 1967 года до июля 1968 года индейцами и эскимосами было убито 5,3 процента популяции старше одного года. В то же время в данном районе находилось примерно 550 волков — опять-таки по подсчету воздушной разведки. На основании имеющихся данных о ежедневном потреблении мяса волками и проверки загрызенных волками карibu удалось подсчитать, что в течение трех лет 4,8 процента карibu шло на пищу волкам ежегодно.

Весенние подсчеты показали, что ежегодный прирост за 3 года наблюдений составил около 10 процентов популяции, т. е. от 6.000 до 6.500 карibu. Ежегодно потери почти соответствовали естественному приросту, так что изменений в общем количестве не происходило.

Пропорции месячных отелов показали, что значительная доля телят не переживает первого года жизни. В 1960 году 60 процентов телят погибли в течение первых 4-5 недель своего существования. Подобные же цифры были добыты в июле 1967, 1968 и 1969 годов. Из оставшихся к концу июля в живых телят только 55 процентов дожили до следующего отела. Причиной

40-а-процентных потерь от октября до мая является, повидимому, нападение волков.

Introduction

Alarming decreases in the number of barren-ground caribou of northern Canada have prompted a long series of investigations by the Canadian Wildlife Service, starting in 1948. The first comprehensive report (Banfield, 1954) documented the evidence for the decrease and its causes and estimated the mainland populations totalled no more than 668,000 animals. It was clear that severe decreases had occurred over the previous one hundred years, probably initiated by the whalers who wintered along the arctic coast during the later 19th and early 20th centuries. Numbers of barren-ground caribou on mainland Canada in primitive times have been estimated at several million (Anderson, 1924; Clarke, 1940).

The 1948 study led to more research to attempt to determine the factors responsible for this drastic decline in total numbers. Meanwhile the mainland populations continued to decline, and by 1957 had reached the alarmingly low figure of 200,000 animals (Kelsall, 1960). The annual kill by Indians and Eskimos was far exceeding the annual recruitment. Forest fires were destroying much of the prime winter range. The barren-ground caribou was placed on the endangered species list; conservation practices were introduced to the Indians and Eskimos; and an extensive wolf control program was initiated in an attempt to reduce total mortality. Limited aerial surveys and reports from many sources suggested the decline in Canadian barren-ground caribou populations terminated around 1960. Lack of credible, up-to-date information gave rise to unfounded reports that barren-ground caribou were increasing at an alarming rate. A range-wide survey in the spring of 1967 resulted in a total estimate for the mainland populations of approximately 400,000 caribou (Thomas, 1967). A critical analysis of the interpretation of raw data used in the 1967 and earlier surveys suggests there has been little change in total numbers over the past decade (Parker, 1971).

Prior to the 1967 estimate, the Canadian Wildlife Service initiated an intensive study

of the Kaminuriak barren-ground caribou population of northern Manitoba, north-eastern Saskatchewan, and the southern District of Keewatin, N.W.T. The main objective of this study was to obtain detailed information, from a particular population for 2 years, on caribou biology, human utilization, and range conditions. It was assumed that all of the mainland caribou populations were subject to nearly equal environmental problems; the Kaminuriak Population was selected for study because of logistic problems and to conserve limited resources. The program combined the efforts of four biologists, each allotted a particular field of research, but working together as a team when circumstances permitted. Field work began in the spring of 1966 and terminated in the fall of 1968, although this report also includes the results of several aerial surveys flown in 1969.

The objectives of the project were as follows:

1. To determine the size of the population, to record seasonal movements, and to relate population size to range capacity, annual mortality, and natality.
2. To determine the sex and age composition from large representative samples of the population.
3. To obtain detailed information on reproductive rate, growth, physical (nutritional) condition, mortality rates (both by hunting and natural causes), and the pathological conditions of the caribou.
4. To determine the relationship of forage use by caribou on the taiga winter range to forage abundance, distribution, and availability.

This publication reports on the first of these objectives; publications are in preparation on the remaining three.

My responsibilities included estimating the total population, its annual recruitment and mortality rates, and its seasonal distribution, movements, and migration routes. It was obvious that aerial census surveys would be subject to considerable error unless we had detailed information on seasonal distribution and the extent of segregation

by sex and age. Aerial surveys were therefore restricted during the first year to obtaining data on seasonal distribution, migration routes, and recruitment figures. Kill statistics were obtained from native Indians and Eskimos from August 1967 to July 1968. Surveys to estimate caribou numbers were flown throughout the winter of 1967-68, over the calving ground in June 1968, and over the area of post-calving distribution south of Baker Lake, N.W.T., in July 1968. The results of these surveys were then evaluated and adjusted according to prior knowledge of extent of caribou segregation and distribution at the time of the survey.

Banfield (1954) first estimated the Kaminuriak Population to number 120,000 animals in 1950. Five years later Loughrey (1955) estimated it to number 149,000 caribou. Kelsall (1968) reported an all-time low figure of 40,000 caribou during the winter of 1957-58. McEwan (1959) estimated 30,000-50,000 caribou in the winter of 1958-59 and 70,000 caribou in 1959-60. Malfair (1963) estimated some 30,000 caribou on the calving ground in June 1963. Ruttan (1965) estimated the population to number between 30,000 and 50,000 in 1964.

Estimates of the annual kill of caribou from the Kaminuriak Population were as varied as the estimates of total numbers. Lawrie (1948) estimated a total kill of 42,250 in 1948-49, Loughrey (1955) estimated 20,000 were killed in 1955, and the Territorial and Manitoba records show a kill of only 4,000 caribou by 1960.

Study area

Location and dimensions

Our study area was the area bounded by the extreme summer and winter range limits of the Kaminuriak barren-ground caribou population as observed from June 1966 to October 1968. Its total area is 109,000 square miles, and it includes portions of the two provinces of Manitoba (40,550 square miles) and Saskatchewan (6,440 square miles), and the districts of Mackenzie (4,900 square miles) and Keewatin (57,100 square miles), N.W.T. (Fig. 1). The normal summer (June to October) range (62,010 square miles) of the population approximates the tundra portion of the study area, while the winter (November to May) range (46,990 square miles) usually lies south of the tree-line. Summer and winter ranges occupy 56 per cent and 44 per cent respectively of the total range of the population.

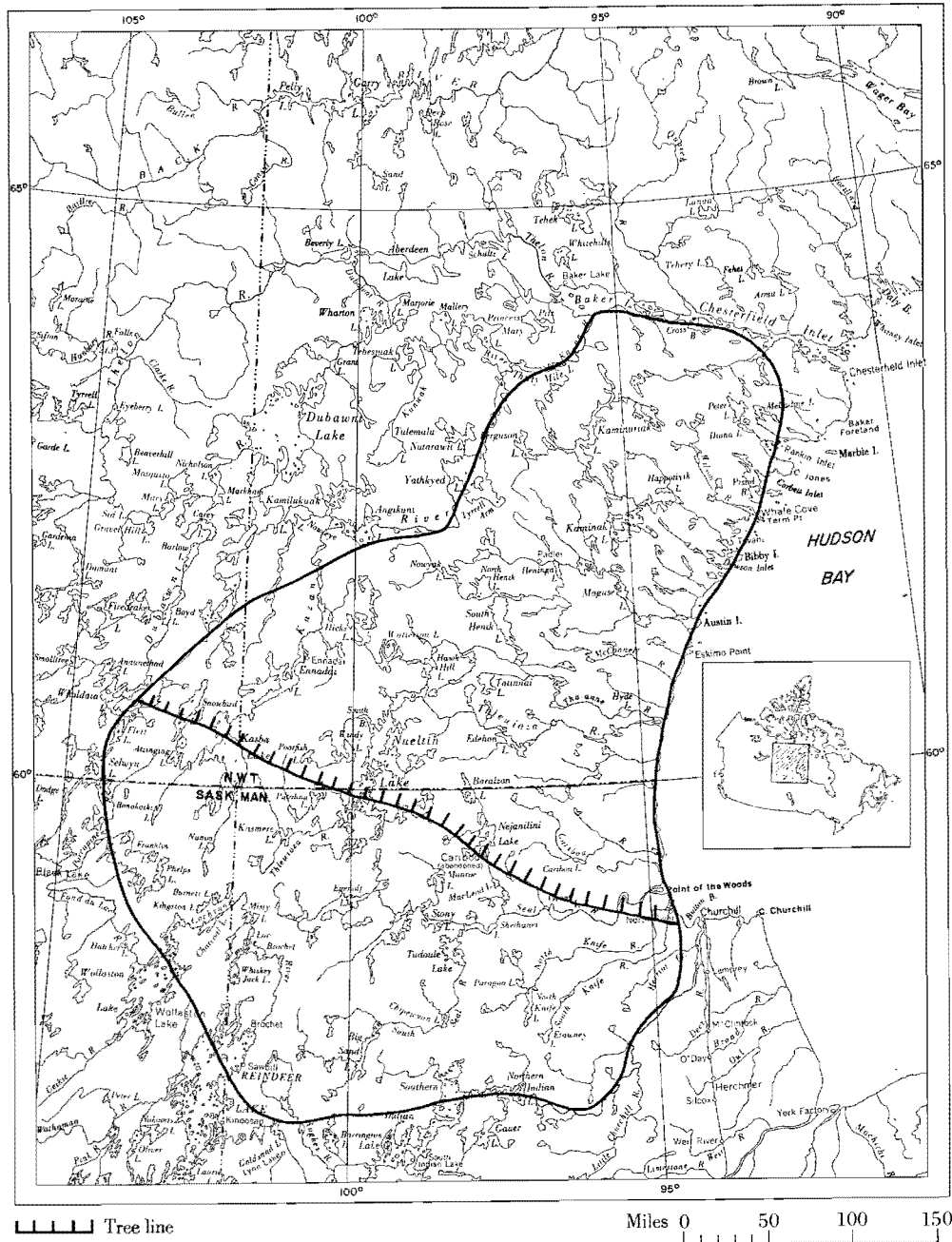
Climate

The tundra of southeastern District of Keewatin is characterized by cool summers, extreme cold and persistent winds during the winter, and low annual precipitation. Temperatures along the coastal areas of Hudson Bay are slightly milder than farther inland. The mean monthly temperature at Baker Lake (inland) is -14°F and at Chesterfield Inlet (coastal) -10°F . The mean monthly maximum temperatures for these two communities are $+36^{\circ}\text{F}$ and $+37^{\circ}\text{F}$ respectively. In northern Manitoba temperatures are more moderate. At Churchill the mean monthly maximum and minimum temperatures are $+48^{\circ}\text{F}$ and -4°F , and at Norway House (slightly south of the normal winter range) the mean monthly temperatures are $+59^{\circ}\text{F}$ and -3°F . The extremes in temperature for the tundra portion of the study area are among the largest on the continent. Inland, temperatures may range from -60°F in the winter to $+80^{\circ}\text{F}$ in the summer (Kendrew and Currie, 1955).

Total annual precipitation throughout the study area seldom exceeds 15 inches. The maximum precipitation occurs in the

Figure 1. The maximum range of the Kaminuriak caribou population from May 1966 to October 1968.

Figure 1



warmest months (July and August) and the minimum in February and March (Kendrew and Currie, 1955). The mean annual total precipitation is less inland than near the Hudson Bay coast (Ritchie, 1962). Mean annual snowfall over most of the range is between 50 and 60 inches (Kendrew and Currie, 1955).

Vegetation

The northern limit of trees lies close to the 50°F isotherm for the warmest month, as does also the southern limit of continuous permafrost (Larsen, 1965). At the extreme southern portion of the range is the closed boreal forest intergrading with tundra through the transition zone until true tundra persists over the northern one third of the study area (Fig. 2).

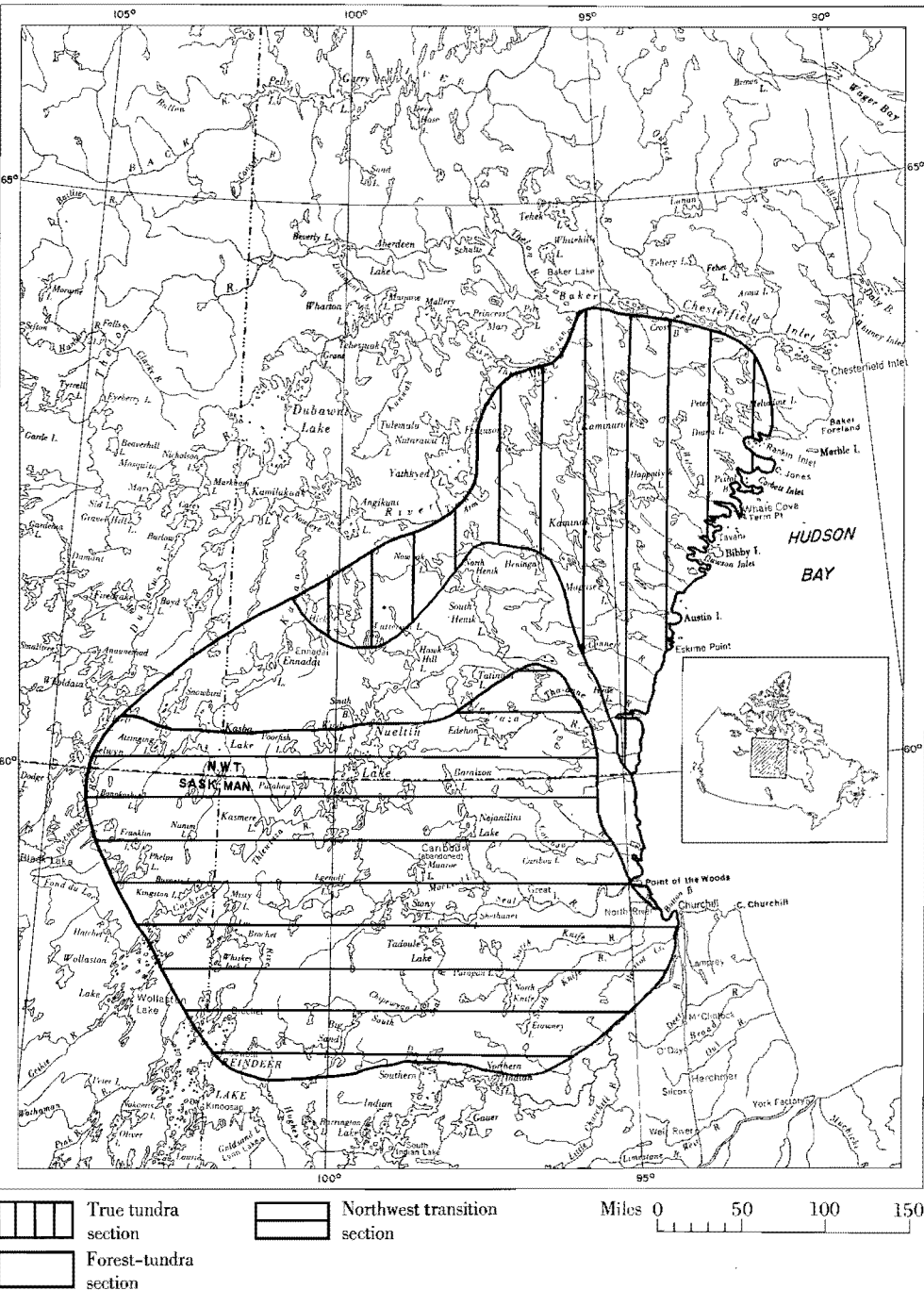
The Northwest Transition Section includes the forested winter range of the Kaminuriak Population. The dominant tree species is black spruce (*Picea mariana*), and on the most favourable soils can be found white spruce (*P. glauca*). Other tree species are white birch (*Betula papyrifera*), tamarack (*Larix laricina*), jack pine (*Pinus banksiana*), stunted aspen (*Populus tremuloides*), and balsam poplar (*P. balsamifera*) (Rowe, 1959).

The forest-tundra section is characterized by tundra intermixed with patches of stunted forest, the latter usually along the shores of lakes and rivers and the former on the upland interfluvies. Dominant tree species are black spruce and tamarack accompanied by alder (*Alnus crispa*) and willow (*Salix* spp.) shrubs. White birch, aspen, and balsam poplar are infrequent (Rowe, 1959).

The true tundra portion of the study area consists of frequent rock outcroppings, eskers and glacial drift, tussock muskeg sites, and low flat *Carex* meadows. The area immediately south of Chesterfield Inlet is a vast expanse of granite outcropping, giving way to the coastal Hudson Bay lowlands from Rankin Inlet south to Manitoba. The coastal lowlands consist of poorly drained *Carex* meadows and tussock muskeg, inter-

Figure 2. The three general vegetative regions within the range of the Kaminuriak caribou population (after Rowe, 1959).

Figure 2



mixed with glacial drift and eskers. To the west of the lowlands, boulder fields, glacial drift, and drier conditions prevail. *Carex* meadows and muskeg are found in the depressed, poorly drained sites. The poorly drained *Carex* and muskeg plant communities are dominated by species of *Carex*, *Eriophorum*, and mosses intermixed with *Betula glandulosa*, *Salix* spp., *Ledum decumbens*, and *L. groenlandicum*. The drier sites support *Empetrum nigrum*, *Vaccinium vitis-idaea*, *V. uliginosum*, *Ledum* sp., mosses, and lichens. A more detailed description of the inland tundra plant communities and bioclimatology is provided by Larsen (1965).

This historical review was undertaken to guide my own studies and surveys and to obtain some perspective on present population distribution and status. Most early accounts of caribou south of the Churchill River appear to refer to a population of woodland caribou (*Rangifer tarandus caribou*), whereas those from north of the river concern the barren-ground caribou.

Early records

Exploration of the Hudson Bay region began with the voyage of Henry Hudson in 1610. This led the way for others through Hudson Strait, and in 1684 a Hudson's Bay Company Post was established at York Factory at the mouth of the Nelson River. Previous to this there had been posts at Moose Factory, Fort Albany, and Fort Severn. The post at York Factory, however, was the first near the range of the Kaminiuriak barren-ground caribou population.

South of Churchill River

Perhaps the earliest description of caribou in the York Factory area is that of Father Marest in 1695:

All winter long there is abundance of patrigges of which we killed at least twenty thousand. . . . But the best hunting is that of the caribou; it lasts all the year; but especially in the spring and autumn, there are herds of three or four hundred or upwards at a time together. M. de Serigny told us that on All Saints Day [Nov. 1] and on All Souls Day [Nov. 3] more than ten thousand passed by in sight of the huts occupied by the crew of the Poli, on the other side of Bourbon [Nelson] river. (Tyrrell, 1931, p. 127)

La Potherie in 1697 (Tyrrell, 1931, p. 221) also mentions caribou near the mouth of the Nelson and Hayes rivers. Both these accounts refer to herds of several hundred animals each and to a spring and fall migration past York Factory. Neither describes the caribou or the direction of migration.

Jérémie, writing from 1694 to 1714, provides greater detail on the migrations of caribou in the York Factory region:

In the intervening country [between the Nelson and Churchill rivers] there is nothing worth noting except that, during the summer, enormous bands of caribou are seen. These are driven from the woods by the great multitude of mosquitoes and horse flies, as we call them, and come out to the sea coast for relief. Bands containing over ten thousand may be seen, and this continually for forty or fifty leagues. (1926, p. 22)

During this season [April at York Factory] caribou are plentiful. These animals pass twice a year. The first time is in the months of April and May, on which occasion they come from the north and go south. The number of them is almost countless. They occupy an extent of country of more than sixty leagues from the sea coast along these rivers. . . . These animals return to the north in the months of July and August and, when they are crossing the rivers, the natives in their canoes spear as many of them as they please. (1926, p. 38)

The fact that spring migration was from north to south suggests these animals were woodland caribou.

The next noteworthy record was by James Isham in 1743 as he described the Churchill - York Factory region:

Deer here is of three sorts, the smallest deer, are of the size of our forrest Deer, in England, But not so finely for shape and make, another sort their is something larger, Both these are very Numerous, in most parts of the Country, and Very fatt at Seasons of the year's being in august and septr. four inches fatt on the Rump part of the beast,—their is another sort of a Deer, which is Large as a horse of 8 or 9 hands high, they are not so numerous as the aforementioned Deer, they Rutt at the Latter End of Septr. and october at which time they cast their horns . . . these Deer Lives Entirely upon a sort of white mawse the pick of the Dry Ridges, and hill's, and uses the Barren Ground Especially the small Deer. (p. 151)

. . . the Uskemau's Kills these Deer with Launces in the water, and upon the Land with bows and Arrow's. (p. 154)

The smallest deer was undoubtedly the barren-ground caribou, the second was the woodland caribou, and the third was probably the north American moose (*Alces alces*). Isham does not define the range of each, but his contact with barren-ground caribou undoubtedly occurred north of Churchill and with the latter two in the York Factory area.

Drage (1748) first mentions caribou scarcity near York Factory. Once again, migration is southerly in spring. Although he had been north of Churchill and probably in contact with barren-ground caribou, Drage does not differentiate between those caribou observed at York Factory.

The People only saw three Deer all the Winter [York Factory], none of which they killed. (Vol. 1, p. 177)

The latter part of this month [April] the Deer began to cross the Hay's River, twenty Miles above the Factory; where there were Indians waiting for to kill them. One year, they passed in four Columns or in four different Tracks, all within three Miles space, one of the Columns passing near the Factory, and the whole four Columns did not contain less in Number than eight or ten thousand Deer. This happened in the month of April, and the Indians by reason of the moist Weather that there was, not being able to keep their Powder dry, kill'd but few of them. In other Years they have kill'd Numbers for the sake of their Tongues only, which is the most delicious Part leaving the Carcasses to rot, and for the Beast to prey on . . . At these Times the Does passing to the Southward to Fawn or drop their Young, the Numbers thus uselessly destroyed before they drop their Fawns, without doubt, occasion, the Scarcity of Deer they have of late been sensible of in these parts. . . . (Vol. 2, p. 17)

These Deer, are about four Feet and a half in Height, about the same size of an Ass, and nearly of the same Colour, but their Horns are much loftier, and wider than those of that Animal. (Vol. 2, p. 18)

These Deer feed on the Moss in the Winter, scraping away the Snow. They are of the Species which the French call Caribous, and their Skins are made of by the Indians . . . (Vol. 2, p. 19)

In 1747, Henry Ellis describes the caribou near the mouth of the Nelson River and for the first time mention is made that the spring migration is from south to north. Because of the uniqueness of this observation, it is probably an error on the part of the observer. It is possible, however, he was assuming the migrations near York Factory were similar to those of the barren-ground caribou which he had observed north of Churchill.

These Creatures cross a vast Extent of Country, from South to North, in the Spring of the Year, in order to bring forth their young in Places of Safety; that is, in the more Northerly Parts, which are either entirely uninhabited, or at least but very thinly planted. (p. 85)

Samuel Hearne made three journeys on foot into the country west of Fort Prince of Wales (mouth of the Churchill River) during the period 1769 - 72. On his third journey Hearne reached the mouth of the Coppermine River on the arctic coast. Hearne unhesitatingly distinguishes between woodland caribou as "Southern deer" or "Indian deer" and barren-ground caribou as "Northern deer" or "Northern Indian deer".

This rule, therefore, [males wintering in the bush and females on the barrens] only stands good respecting the deer to the North of Churchill River; for the deer to the Southward live promiscuously among the woods, as well as in the plains, [presumably referring to the strip of barrens from Cape Churchill south to the Nelson River along the coast of Hudson Bay] and along the banks of river, lakes, the whole year. (1795, p. 129)

Indian deer are so much larger than those which frequent the barren-grounds to the North of Churchill River, that a small doe is equal in size

to a Northern buck . . . This is that species of deer which are found so plentiful near York Fort and Severn River. They are also at times found in considerable numbers near Churchill River; and I have seen them killed as far North, near the sea-side, as Seal River: But the small Northern Indian deer are seldom known to cross the Churchill River . . . (1795, p. 145)

The records from 1695 to those of Hearne in 1772 consistently report a large population of woodland caribou south of the Churchill River, near the Nelson and Hayes rivers. The smaller deer, or barren-ground caribou, remained north of the Churchill River.

We now encounter considerable confusion as to the taxonomic status of those caribou near York Factory, beginning with the narratives of David Thompson in 1792. It should be remembered there is a span of 20 years since the last records by Hearne. Thompson first provides his impression of a caribou migration across the Nelson River in late May 1792, some 20 miles upriver from York Factory.

. . . the herd of the first day to one hundred and twenty miles in length and the herd of the second day to half as much more, making the whole length of the herd to be one hundred and eighty miles in length, by one hundred yards in breadth. . . . By the above space, allowing each deer, ten feet by eight feet; an area of eighty square feet, the number of Rein Deer that passed was 3,564,000, an immense number; without including the many small herds. (1916, p. 87)

The estimate of herd strength provided by Thompson is perhaps a reflection upon his abilities as an objective observer of wildlife, which should be considered when evaluating his records of later observations. Thompson does remark that ". . . the Deer were more numerous than usual [summer of 1792], but only near the sea side" (p. 87).

The confusion occurs when Thompson refers to another species of deer, found only near Hatchet Lake, Saskatchewan.

... there is another species of Deer, which I take to be a nondescript, by the Nahathaway Indians it is called Mahthee Mooswah, (the ugly moose) ... found only on a small extent of country mostly about the Hatchet Lake (Saskatchewan) ... This deer seems to be a link between the Moose and the Rein Deer; it is about twice the weight of the latter; and has the habits of the former; its horns are palmeated somewhat like those of a Moose, and its colour is much the same; it feeds on buds and the tender branches of Willows and Aspens, and also on moss. (1916, p. 88)

Thompson refers to elk (*Cervus canadensis*) as Red Deer, or Wapiti, thus distinguishing them from this species. He must be referring to woodland caribou around Hatchet Lake, but it is unlikely that they differed from those caribou observed near York Factory, if indeed, the latter were woodland caribou. Hearne, however, had previously recorded how those deer near York Factory were twice as large as the northern deer or barren-ground caribou.

On October 21, 1814, while on the Columbia River in British Columbia near Arrow Lake, Thompson adds to the confusion by his description of the caribou in that area.

... we came to a herd of eight Rein Deer, they were not shy, and we shot a good Doe, and might have killed two or three more.

The hunters often mentioned to me that they had seen Rein Deer, but I doubted if they were of the same species that is found around Hudson's Bay and the interior country; upon examination I found no difference. (1916, p. 384)

This record would indicate those caribou near York Factory had indeed been woodland caribou. There is the possibility, however, that during the 20-year lapse between the records of Hearne and those of Thompson, barren-ground caribou extended their fall migration south across the Churchill River and wintered near the York Factory area. Morice (1928) writes that nine tenths of the northern Chipewyans died from

smallpox shortly after the overland journey by Hearne. Such a decrease in the Indian population would have eased the hunting pressure on the Kaminuriak barren-ground caribou population. This may have resulted in an increase of barren-ground caribou, causing an extension of winter range to near York Factory. Such a range extension has been well documented during the mid-20th century by Banfield (1954). The records before and after those by Thompson, however, suggest that his observations were inaccurate.

In 1829, Sir John Richardson provides a detailed account of those caribou in the York Factory area at the beginning of the 19th century:

Contrary to the practice of the Barren-Ground Caribou the woodland variety travels to the southward in the spring. They cross the Nelson and Severn Rivers in numerous herds in the month of May, and pass the summers on the low marshy shores of James Bay, and return to the northward, and at the same time retire more inland in the month of September. From November to April it is rare to meet with one within ninety or a hundred miles of the coast. ... Mr. Hutchins mentions that he has seen eighty carcasses of this kind of deer brought into York Factory in one day, and many others were refused, for want of salt to preserve them.

These were killed when in the act of crossing the Hayes River, and the natives continued to destroy them, for the sake of the skins, long after they stored up more meat than they required. I have been informed by several of the residents at York Factory that the herds are sometimes so large as to require several hours to cross the river in a crowded phalanx. (p. 250)

Richardson's impression that caribou were still very plentiful near York Factory in the early 19th century is contrary to the reports of Drage in 1746 that these animals were becoming scarce. Richardson also clarifies the question of barren-ground and woodland caribou distribution in the Churchill - York Factory area.

On the coast of Hudson's Bay the Barren-Ground Caribou migrate further south than those on the Coppermine or MacKenzie Rivers, but none of them go to the southward of Churchill. (p. 243)

By the mid-19th century the population of caribou near York Factory was becoming depleted in number, the inevitable result of excessive human exploitation. In 1849, John McLean writes the following from York Factory:

Not many years ago this part of the country was periodically visited by immense herds of reindeer; at present there is scarcely one to be found. Whether this disappearance is owing to their having changed the course of their migrations, or to their destruction by the natives, who waylaid them on their passage, and killed them by hundreds, is a question not easily determined. (p. 20-21)

The situation had changed little by the turn of the century. On November 6, 1893, J. W. Tyrrell travelled from Fort Churchill south to York Factory. His party was able to shoot only 13 caribou on a 19-day trip, and most of these were between the Owl River and Fort Churchill. At the mouth of the Nelson River on November 19 the hunters of the party searched for 4 days but were unsuccessful in obtaining any caribou (Tyrrell, 1908). However, this does not indicate the population was near extermination. Sir John Richardson had written over a half century before that from November to April caribou were seldom encountered less than 90 to 100 miles from the coast.

Preble (1902) conducted a biological investigation of the Hudson Bay region in 1900. His description of the caribou south of the Churchill River is surprisingly similar to that provided by Jérémie nearly 200 years earlier:

The woodland caribou is found throughout the region traversed between Norway House and Hudson Bay. It seems to be more common toward the Bay, but is occasionally killed (usually

in the winter) near Norway House. Mr. William Campbell, of Oxford House, reported the species much less common than formerly ... (p. 40)

Between York Factory and Fort Churchill a few small bands are found throughout the year on the 'Barrens'. Tyrrell saw them here early in the winter of 1893. We saw none, but noted a great many tracks on the 'Barrens' between Stony and Owl Rivers on July 19, and were told by some Indians we met that they had killed several within a week.

... Dr. Milne informs me he has seen them between Fort Churchill and Cape Churchill, and that the latter point is considered a good point for hunting them at any time of the year. He thinks these small bands form the 'northern fringe' of the bands which migrate to the coast in the spring, the great majority of which in their journey cross to the south of the Nelson River; an opinion which has weight from his fourteen years residence at York Factory. (p. 41)

By the early 20th century the status of caribou south of the Churchill River, near the Nelson and Hayes rivers, appears to have been very similar to the present situation. Scattered caribou can be found from Cape Churchill south to the mouth of the Nelson River, their precise taxonomic identity unknown. Local populations of woodland caribou still exist near the York Factory area, but it appears their extensive seasonal migrations have been curtailed.

Banfield (1954) believed these early records of caribou near York Factory referred to the barren-ground variety, and "... that Hearne and Preble erroneously believed these to be woodland caribou ..." (p. 30). He also asserts that Tyrrell reported bands of barren-ground caribou along the route from Churchill to the Nelson River in November 1893. Tyrrell (1908), however, makes no distinction as to the identity of caribou observed and shot. Banfield again records David Thompson observing herds of barren-ground caribou crossing the Hayes River in May 1792. Thompson (1916), however, refers to these animals as "Rein Deer", a term commonly used by

the early explorers for the caribou inhabiting the York Factory area. In 1962, Banfield realized the impossibility of taxonomically identifying those caribou formerly abundant near York Factory.

The taxonomic status of the caribou herds that formerly inhabited the southern Hudson Bay coast from Cape Henrietta Maria, Ontario, to Cape Churchill, Manitoba, has remained a puzzle. ... Whether those herds were migratory woodland caribou or the southernmost herd of tundra caribou is uncertain. (p. 85)

On examination of caribou specimens from near the Shamattawa and Hayes rivers, however, he found they resembled the woodland caribou and the "... reduction of the local population has apparently curtailed the migratory habit." (p. 85)

There are records of caribou observations south of the Churchill River which suggest an extreme southern extension of barren-ground caribou winter range about the turn of the century.

Warburton Pike (1892) who travelled in the western Arctic in 1889, mentions that caribou were shifting farther east than formerly:

One point that seems to bear out the theory of a more easterly movement is that within the last three years the caribou have appeared in the thousands at York Factory on the west side of Hudson's Bay, where they have not been seen for over thirty years. (p. 47)

Chambers (1914) provides the following account of barren-ground caribou in the Churchill area:

Within a few miles of Churchill, in the fall and winter, large herds of barren-ground caribou were encountered. These herds supply fresh meat of an excellent quality for the residents of Churchill. ... Referring especially to his exploration of that part of the country between Churchill and Owl River in December 1906, Mr. Thiboudeau states: 'For one whole day we passed through an immense herd of barren-

ground caribou. There must have been thousands of them'. (p. 93)

More evidence is available of the southern range extension which began in the mid-1930's. A letter to J. D. Robertson (Manitoba Dept. of Mines and Natural Resources) from H. C. Pienowsky in 1959, who trapped near Mile 442 on the Canadian National Railway, provides the following information:

In the fall of 1936 the migration came as far south as the Churchill River but did not cross. In the fall of 1937 they wintered in this (Mile 442) area, they also wintered here in 1938, thereafter they wintered farther south. ... We are unable to tell you when the caribou migrated through this area last previous to 1937, anyway, we came here in the fall of 1928 and it must have been some years before that by all appearances. I might add that there always has been a herd (small herd) along the east side of my trap line since 1930 when I first trapped there, these were 'natives' as they did not migrate to my knowledge.

This southern extension of winter range is again mentioned in a letter to Robertson from Jim Spence, long-time resident of the York Factory area:

The first year they [barren-ground caribou] went through [York Factory area] was in 1943 and first three years they went as far as Hayes [River] and last three years they turned back from Nelson [River]. So they went through six times.

George Lush trapped the barren-lands north of Churchill from 1930 to 1950. When he first trapped the lower Thanne River area in 1930-31 there were no caribou in the region. In 1931-32 a few caribou appeared and in 1932-33 they arrived in large numbers. From then until he left in 1950 caribou were continuously present in this coastal area during the fall and early winter. He detected no decrease in caribou numbers during this 18-year period.

Lawrie (1948), who studied caribou under the direction of Banfield, wrote the following in his report to the Canadian Wildlife Service:

In 1942 caribou first appeared in some numbers at the south end of the lake [Reindeer] near the post. Along the Hudson Bay Railway and in the eastern portion of the Province generally the conviction is that the caribou are far more plentiful than formerly. The first heavy southward migrations along the railway began in 1935 and have continued every year since. At York Factory natives were unanimous in answering that caribou were much more plentiful than they were ten years ago. In the Oxford House, God's Lake and Cross Lake Sections the 1945-46 winter brought the first caribou to the areas for 40 years — and they came in numbers. This invasion has been both diminishing in numbers and receding in extent of southerly penetration so that there were everywhere said to be fewer caribou in the winter of 1948-49 than in the preceding three winters.

The first published evidence of barren-ground caribou wintering south of the Churchill River was by Banfield (1954). He estimated that in the winter of 1947-48 elements of the Kaminuriak Population wintered in the lower Nelson and Hayes rivers area and in the Shamattawa, Split Lake, and Oxford House regions.

North of Churchill River

The first record of caribou north of the Churchill River is by Jens Munk, who spent the winter of 1619-20 at the mouth of the Churchill River.

... on the same day [January 27, 1620], the men saw the tracks of five reindeer which had been chased by a wolf. ... (p. 38)

This is the only record by Munk of caribou during his winter at Churchill, although his crew travelled extensively during the early winter trapping and shooting hares (*Lepus americanus*) and ptarmigan (*Lagopus* sp.).

Until the travels of Samuel Hearne, beginning in 1769, there are only a few incidental references to caribou north of the Churchill River. The first of these is by Dobbs (1744), who referred to caribou inland and north of Churchill. Henry Ellis (1747) saw several caribou on Marble Island on August 19, 1746. In July 1746, Drage (1748) entered Rankin Inlet and examined some of the small islands, observing several fox (*Alopex lagopus*) and caribou.

In November and December 1769, Hearne travelled west and northwest from Fort Prince of Wales at the mouth of the Churchill River, crossing the Seal River and heading towards the forest. Crossing the tundra west of Button Bay, a distance of 50 miles, he saw tracks of deer and shot a few.

On his second trip from Fort Prince of Wales near the end of February 1770, Hearne found caribou plentiful for a few days as he followed the Seal River across the barrens toward the forest. He found no caribou from March 8 to April 10, when several were shot near Shethane Lake. On June 1, 1770, while travelling up the Wolverine River his party shot two caribou, the first since April 10. Hearne reached the south end of Yathkyed Lake on June 30, 1770, and spent July and most of August northwest of Yathkyed and Dubawnt lakes. During this time Hearne was in continuous contact with large groups of caribou, which were being hunted by some 600 northern Indians. Hearne began his return journey to Fort Prince of Wales from Dubawnt Lake on August 19, 1770, and found caribou plentiful until he reached the area of Baralzon Lake on November 20, after which they became scarce.

Hearne began his third journey from the Fort on December 7, 1770. He immediately found caribou scarce as he proceeded along the Seal River. On December 18, near Baralzon Lake, he saw where many caribou had recently crossed but was not able to kill any. From December 19 to 27 as his party moved towards Nueltin Lake they had

nothing to eat, but finally shot four caribou on December 27. On January 3 they shot two more near Nueltin Lake. They travelled northwest 100 miles to Kasba Lake before caribou were once again plentiful and they shot 12 on January 16. On his return journey, caribou were very scarce west of Wholdaia Lake and from May 11 to 21, 1772, none were seen at all. From June 8, 1772, they had plenty of caribou until they reached the area of Baralzon Lake at which time the animals became scarce.

The narratives by Hearne emphasize several important facts regarding caribou distribution during the late 18th century. Barren-ground caribou seldom penetrated south of the Churchill River during the winter months. The main herds of caribou were found west of Baralzon Lake, being relatively few in number near Churchill and the coastal area. Large numbers of northern Indians (Chipewyans) relied upon barren-ground caribou for their survival.

John Rae (1850), during an expedition north of Churchill in 1846-47, remarks on the Eskimos spearing caribou which crossed Chesterfield Inlet at the narrows near Baker Lake. Rae makes only two brief references to caribou between Churchill and Chesterfield Inlet, and these were several shot along the coast.

The regular wintering of barren-ground caribou in the Reindeer Lake area is emphasized by the records of MacFarlane (1905), who provides dates of the seasonal migration through the Lac du Brochet area as recorded by an employee at the Hudson's Bay Company Post from 1873 to 1890.

	1 st deer seen going north	1 st deer seen coming south
1873	None were observed passing the post	
1874	May 9	Nov. 14
1875	April 26	Oct. 27
1876	May 17	Oct. 29
1877	April 21	Dec. 28
1878	April 27	Nov. 12
1879	April 24	Nov. 18
1880	May 12	Nov. 26
1881	April 22	Oct. 24
1882	April 26	Dec. 15
1883	April 26	Nov. 6
1884	May 1	—
1885	None within many miles of the settlement	
1886	None observed in the spring or autumn of the season	
1887	None observed in the spring or autumn of the season	
1888	None observed in the spring or autumn of the season	
1889	None observed	Dec. 21
1890	April 16	

George Simpson McTavish provides observations of caribou near Churchill during the years (1879-89) he worked for the Hudson's Bay Company:

I made a trip to the Fishing Lakes ... [Feb. 12, 1883] and on this trip I saw the largest number of reindeer I ever met, and in fact for many years it was the largest migrating herd at Churchill, and during the years I spent there we were never so favoured again.

The cause was attributed later to an indiscriminate slaughter by the Chipewyan Indians and Esquimaux at the crossing place on Egg River, on the Barren Grounds, when for days the animals were speared and shot, till the river ran blood and was blocked with carcasses. ... Not until I left Churchill in 1889, were there any migrating movements encountered, and the reindeer before reaching Egg River wheeled to

the North and West again. We suffered accordingly in our reindeer meat supply, and one winter only one deer weighing 45 pounds was killed by the Fort hunters, consequently we were often scratching for a bare living all the time I was at Churchill. ... On this occasion, however, we passed through hundreds, probably thousands. ... (1963, p. 165)

This is further evidence of the scarcity of barren-ground caribou around the Churchill area. It is surprising McTavish observed the only large migration of caribou in February, the same month Hearne reported caribou being abundant inland from Churchill over 100 years earlier.

David Hanbury (1904) lived and hunted with the Eskimos of the Baker Lake - Chesterfield Inlet district near the turn of the last century. He records observations in the Churchill area made on his arrival in the summer of 1898:

I found the country about Churchill not without attractions; in some places the scenery is pretty, and, now and then, caribou are to be found not far off. (p. 1)

I spent five weeks [Fort Churchill, April 1899], the monotony being broken by the arrival of Huskies with loads of caribou, which were reported to be abundant all along the coast. Chipewyan Indians also came in with tales of starvation during the winter months. (p. 7)

He travelled north to Chesterfield Inlet by dog team and on June 8, 1898, records how most of the caribou had left the coast and moved inland. On reaching the mouth of the Kazan River on July 12, 1898, he encountered large numbers of caribou, which were being harassed by insects.

From Hanbury's observations it appears that during the winter of 1897-98 large numbers of caribou remained on the tundra along the west shore of Hudson Bay. By June 5 they had moved inland towards the calving ground near Kaminuriak Lake. By July, large aggregations were along the south shore of Baker Lake near the Kazan

River. These movements are identical to those I observed in 1966-67, when large numbers of caribou wintered along the coastal barrens, moving inland in early June and then north to the south shore of Baker Lake in July.

Hanbury reports caribou being plentiful along the coast in early September 1901, but by September 20 they were leaving the coast and moving inland. This fall movement inland from the coast is similar to that observed in 1967 and 1968. Occasionally caribou were observed after this date in the Chesterfield Inlet area, until on October 26, 1901, Hanbury records thousands along the south shore of Baker Lake during the height of the rut.

On September 13, 1893, J. W. Tyrrell (1908) and his brother began a 5-week canoe trip from Chesterfield Inlet south along the coast to Churchill. They were unable to shoot any caribou and almost perished. In 1901, Hanbury remarked that although caribou were abundant along the coast in the early fall, by September 20 they had moved inland. When Tyrrell was working his way down the coast, the main body of animals had presumably moved inland to begin the rut.

Preble (1902) saw only a few caribou at the mouth of the McConnell River from August 8 to 13, 1900. In his report he refers to the distribution of barren-ground caribou:

The southern range of barren-ground caribou, on the west coast of Hudson Bay, may be said to be limited by Churchill River. Even in former years these caribou were seldom known to cross the river, and they are still killed within a few miles of Fort Churchill. Further inland they reach the south end of Reindeer Lake. (p. 42)

In late September 1903, A. P. Low (1906) describes a caribou crossing place at the south end of Baker Lake:

Four tents of Eskimos were at this place [the southern channel past Howell Island, some 30 miles from the mouth of the inlet] which is a

noted crossing place of the deer in their annual migration to the north and south. Great numbers had already been killed, and half putrid heads were scattered in all directions about the tents. (p. 21)

Frederick Alcock (1916) mentions the wintering distribution of barren-ground caribou during a study of the Churchill River:

... large herds [of barren-ground caribou] come south in winter as far as Northern and Southern Indian Lakes and as a rule they come close to Fort Churchill. (p. 447)

William McInnes (1913), conducting a study of the Nelson and Churchill rivers, also speaks of the winter range of barren-ground caribou:

... large herds come as far south as Reindeer Lake and the middle of Southern Indian Lake during the period of their annual migration southwards.

At the very north end and down the northwest shore [of Southern Indian Lake] for 20 miles the land is quite low and covered with a thick growth of moss and stunted black spruce and tamarack. Into this part of the lake come great herds of barren-ground caribou, which on their annual winter migration come into the north end of the lake from the northwest, travel down about half its length, and, if the snow is not too deep, strike from there westerly to Reindeer Lake. In winters when the snowfall has been unusually great the herds partly break up, large bands, in order to escape the deep snow, turning off to the north again instead of following the customary circuit.

J. B. Tyrrell (1897) reports that caribou were moderately plentiful in early September 1894 along the Ferguson River and Kaminuriak Lake.

Lofthouse (1922) walked from York Factory to Churchill between August 3 and 12, 1885, but reported game was very scarce and that he encountered no caribou. Lofthouse provides a brief account of

barren-ground caribou distribution in the Churchill area during the latter part of the 19th century:

In former years up to 1882 deer had been so abundant at Churchill that they used to run around about the place like rabbits, but that year there were some terrible fires around, all the moss was burnt up, and the deer left the region altogether. During my ... years at Churchill (1884-1899) I only once saw a band of deer near the place, but since 1900 they have returned, the moss having grown up again, and there is never any difficulty in getting all the meat required. (p. 100)

Lofthouse travelled from Churchill to Split Lake in February 1895, but saw no caribou and found all the Indians north of the Split Lake area on the verge of starvation.

Thierry Mallet (1926) travelled extensively throughout the north as president of the fur trading company Reveillon Frères, and found caribou abundant:

In winter, when one travels through that enormous country which lies between Cree Lake and Pakatewagen, through Bear Lake, Wollaston Lake farther north to Nueltin Lake, further southwest to Reindeer Lake, one is liable to meet, any one day, hundreds and hundreds of these deer. (p. 79)

Crossing Ennedai Lake in August, Mallet (1930) reports caribou migrating to the south, presumably during their mid-summer migration.

Weeks (1929) mentions the fauna between Churchill and Mistake Bay during July 1929:

Inland, a few barren land caribou were encountered. ... In general the traveller cannot depend on game animals for food. ... (p. 173)

Kitto (1930) mentions caribou abundance during the winter of 1928-29:

Blanchet reports that during the winter of 1928-1929 the caribou were plentiful from 50 miles

north of Churchill to some distance north of Eskimo Point, but that they were scarce in the north, particularly about Baker Lake. Their northward migration starts about the first of April and their southerly migration during August. (p. 110)

These historical accounts of barren-ground caribou suggest that seasonal movements and total numbers were very similar to those which exist today. The movements inland from the coast before calving in June, and again in mid-September before the rut, are identical to those observed during this study. The records of large post-calving aggregations near the mouth of the Kazan River, the description of the Reindeer Lake country as a traditional wintering area, and the identification of the Churchill River as the usual southern limit of barren-ground caribou winter distribution all are similar to my records of seasonal movements and distribution between 1966 and 1969.

Recent studies

Banfield (1954) provided the first detailed information on total numbers, seasonal distribution, and mortality of the Kaminuriak Population. He found the Kaminuriak Population to be composed of three main herds, each retaining its individual identity throughout most of the year but sharing a common calving ground. These herds were named the Churchill, Duck Lake, and Brochet herds. The Brochet Herd was estimated to number 40,000 caribou in 1950 and was the most westerly of the three. This herd moved south from Baker Lake in July and spent the summer and fall months in the Ennedai-Nueltin-Hicks lakes area, moving south to Reindeer Lake in November. The Duck Lake Herd numbered 25,000 animals in 1950 and spent the summer and fall months in the Edehon-Henik-Nejanilini lakes area. It moved south in November through Duck Lake and wintered in the Southern Indian Lake country and south to the vicinity of Nelson House. The Churchill Herd numbered 55,000 car-

ibou by 1950 and utilized the area near the Hudson Bay coast. In the late summer and fall it moved south along the coast as far as Churchill River and then moved back north, being distributed from Nunalla to Eskimo Point. The winter months were spent south of the Churchill River near the lower Nelson and Hayes rivers. The three herds were estimated to number 120,000 caribou.

In the spring of 1955, Loughrey (1955) conducted aerial surveys over the Kaminuriak Population and estimated it to number 149,000 caribou. Although there appeared to be a slight increase over the estimates by Banfield in 1950, the Eskimo Point (Churchill) Herd decreased in strength from 55,000 caribou in 1950 to 35,200 in 1955. From August to October 1956, Loughrey (1956) again flew surveys over the population. He estimated the Churchill Herd at 35,200 and the Duck Lake Herd at 20,000 but was unable to obtain figures for the Brochet Herd.

Kelsall (1968) reports that this population reached an all-time low of 40,000 caribou during the winter of 1957-58. McEwan (1959, 1960) estimated the population to number between 30,000 and 50,000 animals in the winter of 1958-59 and 70,000 in 1959-60. These estimates were not based upon systematic aerial surveys. Malfair (1963) estimated 30,000 caribou east of Kaminuriak Lake between Padlei and McQuoid Lake in June 1963. This area closely represents the calving ground and the estimate by Malfair is very similar to my estimate from aerial surveys over the calving ground in June 1968.

The last systematic aerial surveys of this population before 1967 were those by Loughrey in 1955 when he estimated 149,000 caribou in the population. The distribution and migration routes reported by Loughrey were similar to those documented by Banfield in 1950.

Discussion

Historical records suggest a continuous fluctuation in total numbers of caribou

inhabiting the southeastern District of Keewatin and northern Manitoba since the late 17th century. Before 1900 there were substantial numbers of caribou in the region of the lower Nelson and Hayes rivers. Although the exact taxonomy of this population, now virtually exterminated, will never be known, it appears fairly certain they were woodland caribou. These caribou performed regular seasonal migrations. In the spring they moved south-southeast past York Factory, crossing the Nelson and Hayes rivers and continuing east towards the Hudson Bay coast. Here they spent the summer in the coastal transition-type habitat. In the fall they moved back to the west, passing by York Factory and then moving northwest into the more heavily forested region. They wintered as far as 80 to 100 miles or more inland from the coast, so the distance from summer to winter quarters must have approached 200 to 300 miles. Overexploitation by the residents of the area appears the major factor which contributed to their decline.

There is some evidence suggesting barren-ground caribou migrated south past the Churchill River around 1900. There is no reason to suspect such an extension of range limits was not a periodic phenomenon. The first reasonably well documented extension of the normal range began around 1935, probably induced by an immigration of caribou from the west.

Banfield (1954) directed the first study of this population at a time of unusual high total numbers and greatly extended winter range limits. The results of that study have been accepted as the norm for the Kaminuriak Population. Historical records suggest the opposite, that the present status of the population closely approaches that which existed in primitive times. Barren-ground caribou were seldom known to cross the Churchill River before 1900 (Hearne, 1775; Richardson, 1829; Preble, 1900). The distribution of caribou observed by Hanbury (1904) at the turn of the century is similar to that found during the present study.

The area utilized by the Kaminuriak Population appears to vary with population size. An increase in the Kaminuriak Population to 120,000 caribou (Banfield, 1954) during the late 1940's resulted in greater penetration south into the forested winter range. The present population was estimated to number 63,000 caribou before calving in 1968, and the winter range is much smaller than found by Banfield. Because the present range and distribution of the Kaminuriak Population resemble those described by the early historical records, it is reasonable that the size of the present population is also similar.

Seasonal movements and distribution

Spring migration

The first sign of the annual spring migration north from the taiga usually appears in late April. The predominantly cow, calf, and yearling groups begin a gradual movement to the north or northeast, and the sizes of the individual bands steadily increase. Groups numbering in the hundreds, and sometimes thousands, build up on lakes and river systems to high densities, usually in one or more areas toward the limit of the taiga. On the southern perimeters of such areas, adult antlerless males begin appearing, having moved north from their more southerly wintering ranges. As the main concentrations build up, small bands move continuously towards the tree-line in the general direction of the calving ground. Quite often, these small bands, after travelling for 10-20 miles, reverse their direction and rejoin the main concentration. The choice of particular areas for pre-migratory concentration depends on the areas utilized within the taiga during the late winter and early spring, which in turn depends on the weather and snowfall during the winter. These areas of pre-migratory concentration varied considerably between 1967 and 1968. The environmental and/or physiological stimuli which initiate the spring migration are largely unknown. In 1967, the main body of caribou, excluding adult males, had wintered in north-eastern Saskatchewan and the southeastern corner of the District of Mackenzie (Fig. 3). These animals began migration to the tundra in one large movement, following a straight northeast route from the vicinity of Snowbird and Kasba lakes to the east side of Kaminuriak Lake. An estimated 20 per cent of the Kaminuriak Population had wintered on the coastal tundra near Eskimo Point, N.W.T. (Fig. 3). This tundra-wintering concentration contained all sex and age classes. During the latter part of May 1967, these animals moved northwest towards the northern portion of the calving ground, arriving while the taiga-wintering animals were moving past the Henik lakes

Figure 3. The two main areas of caribou distribution on May 1, 1967, and the spring migration routes to the calving ground by pregnant females of the Kaminuriak caribou population from May 1 to June 9, 1967.

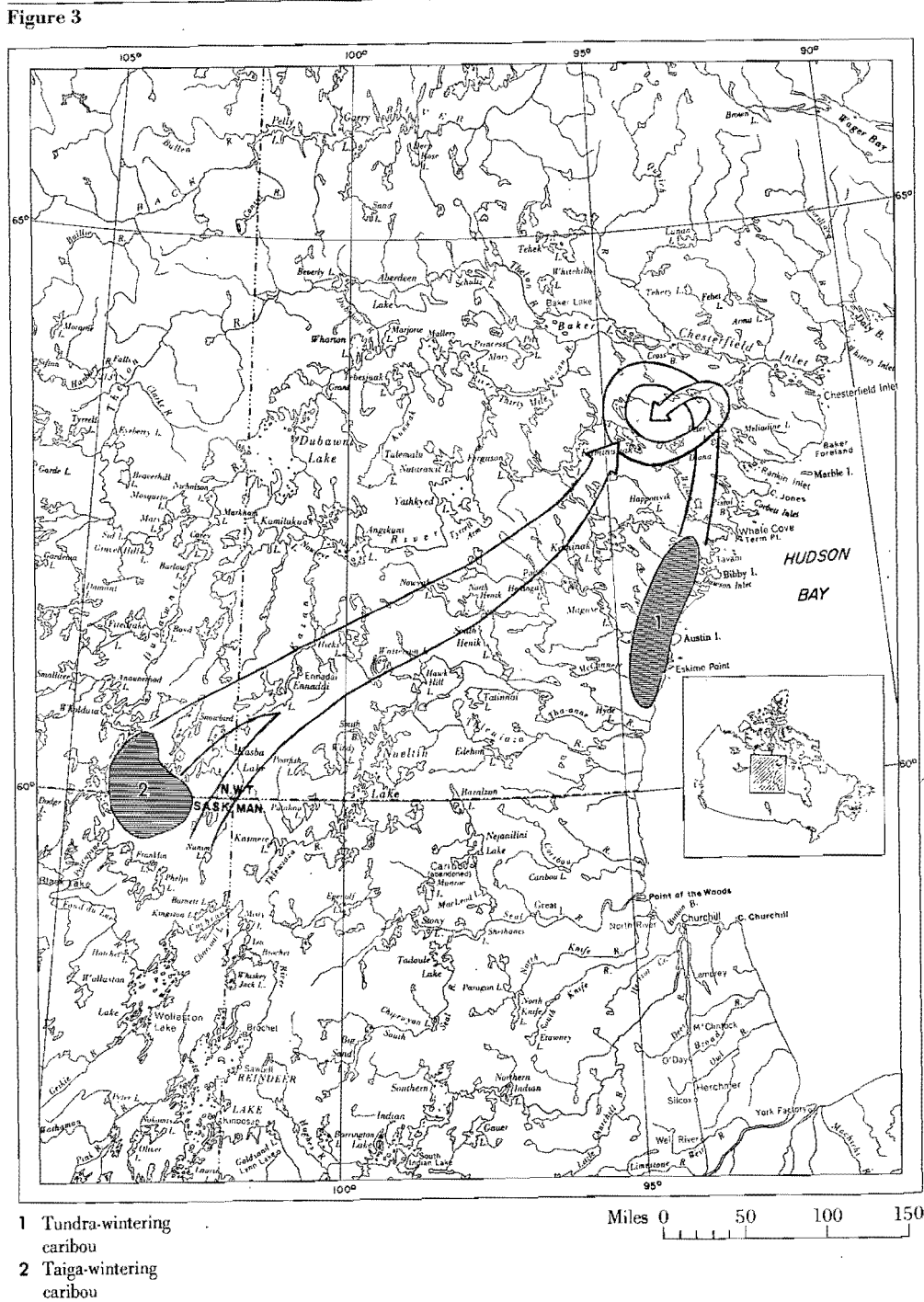
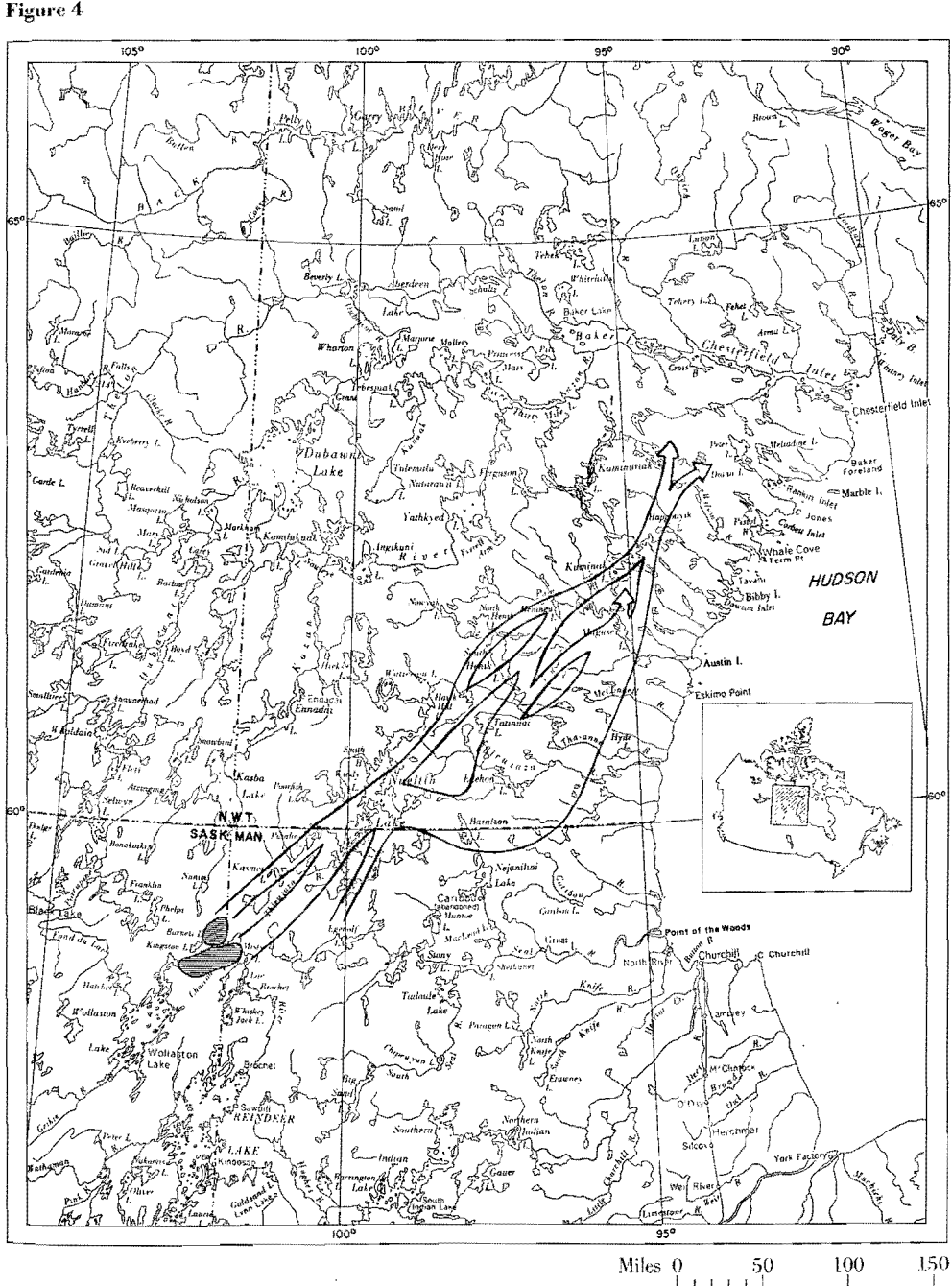


Figure 4. The two main areas of caribou distribution on May 1, 1968, and the spring migration routes to the calving ground by pregnant females of the Kaminuriak caribou population from May 1 to June 7, 1968.



over 100 miles to the southwest. The two main spring migration routes for 1967 are shown in Figure 3. In 1967-68 the majority of the Kaminuriak Population wintered within the taiga. There were two main areas of caribou concentration by late April (Fig. 4). The more southerly concentration in the Charcoal Lake area began moving rapidly northeast during the first week of May. By May 15, these animals had reached the tree-line near Hearne Bay on Nueltin Lake. Here the animals turned east and southeast, slowly following the tree-line towards Baralzon Lake. It is believed the excessively deep snow encountered when the animals reached the tundra was responsible for this sudden change in migratory behaviour. The second wintering concentration, near Hara Lake, Saskatchewan, did not move northeast until the second week of May and the route followed was more westerly than that followed by the first. The second movement passed through Putahow Lake and reached the west shore of Nueltin Lake during the third week of May. Here the main body of animals turned east, following the route taken by the earlier movement towards Baralzon Lake. By June 1, these animals were situated between Edehon and Ray lakes, the majority having not yet crossed the Tha-anne River. One week later, on June 7, they were moving past Maguse Lake and northwest towards the southern portion of Kaminuriak Lake. Meanwhile, a smaller group which had split off from the second movement at Nueltin Lake continued north-northwest. By June 1, these caribou had reached the vicinity of Padlei, crossing at the south end of South Henik Lake and also between North and South Henik lakes. By June 7, they crossed the Ferguson River and the frontrunners were approaching Derby Lake, N.W.T., near the southwestern periphery of the calving ground. Spring migration routes for 1968 are shown in Figure 4. During April 25 to 28, 1967, 32 caribou were captured by nets in the area of Snow-

bird Lake, N.W.T. Coloured collars were placed on these animals. Two of these collars were observed in subsequent aerial surveys, providing information on the rate of migration during the spring of 1967.

On May 18, a collared animal was observed near Ennadai Lake, N.W.T. Although the collar number could not be identified, this animal had migrated 130 miles in approximately 3 weeks for an average rate of travel of 6 miles per day. On June 9, an antlered cow wearing collar number 205 was observed crossing a lake (63°30'N, 93°40'W) in the extreme northerly portion of the calving ground 408 miles from the point of capture. This caribou was collared on April 25, 45 days before the date of observation, and had moved at an average rate of 9 miles per day measured in a straight line.

At the time of capture, in late April 1967, the spring migration was not yet in full swing. By May 18, as the first collar observation substantiates, the vanguard of the migration was then moving past Ennadai Lake. If we assume the caribou wearing collar number 205 was also near Ennadai Lake on May 18, this animal then travelled 288 miles in 22 days for an average migration rate of 13 miles per day.

In 1968, the caribou which migrated towards the calving ground on the more westerly route took approximately 27 days to travel 432 miles, an average of 16 miles per day. The main body of migrating animals, from the time they first left Charcoal Lake until they reached the southern portion of the calving ground near Kaminak Lake, traversing a straight-line distance of 368 miles in 34 days, averaged approximately 10.8 miles per day. From the first week of May to June 1, they travelled approximately 13 miles per day, and from June 1 to 7, they moved an average of 17 miles per day.

Andreev (1961) reports wild reindeer in northern Russia moving towards the calving ground in late May at a rate of 6 to 9 miles per day. Those reindeer, however, were part of the non-calving portion of the

population, and were moving behind the cows which had already migrated and dropped their calves. Kelsall (1968) says the rate of spring migration may vary from 15 to 32 miles per day and is perhaps greater as the pregnant cows approach the calving ground. This study found the average rate of travel, from the initiation of full-scale migration usually in early May, to when the caribou are settled on the calving ground, is about 13 miles per day. Rate of movement increases as the animals approach the calving ground and parturition nears.

The migration leaves the tree-line composed of all sex and age classes except the majority of males over 23 months of age. Many of the yearlings, immature males, and non-pregnant females drop out of the migration before reaching the calving ground.

Ground segregation near Baralzon Lake from May 24 to 26, 1968, revealed that 82 per cent of all observed animals (n = 474) were adult females. Only 4 per cent were males older than 23 months, 3.7 per cent were yearlings, and 10.3 per cent were calves born the previous spring. Of the females older than 23 months, 68 per cent carried at least one antler, 32 per cent being antlerless.

Ground segregation on the calving ground showed that approximately half of the 11-month-old animals dropped out of the migration as it progressed north across the tundra (5 per cent of total segregated on calving ground). I believe the proportion which drops out depends upon the travelling conditions during migration. On the calving ground only 19 per cent of the adult females segregated were antlerless. Most unantlered adult female caribou in spring are not pregnant. Thus most of the non-pregnant adult females also dropped out of the migration before reaching the calving ground.

Aerial surveys south of the spring migration in 1967 and 1968 found groups of yearlings, non-pregnant females, and immature males, numbering from 1 to 20 each, scattered along the main migratory

route. These scattered bands are joined by adult males during the month of June and many of these groups slowly move north towards the post-calving area near the south shore of Baker Lake, joining the post-calving cow and calf aggregations.

In 1967 and 1968, the spring migration to the calving ground was in full momentum by the end of the first week of May. Although there is much local movement during the last 2 weeks of April, the main migration does not usually leave for the tundra until early May. Spring migration by the calving portion of the population was completed by June 12 in both years.

While spring migration routes in both 1967 and 1968 were in a northeasterly direction, the exact routes varied considerably, owing to the fact that the pre-migratory concentration within the taiga was located 100 miles farther northwest in 1967 than in 1968.

There has been no evidence that migrating animals seek out specific geographical landmarks during migration. In 1967, although the main body of caribou was located far to the northwest of the usual winter range, a straight-line course was taken to the traditional calving ground.

Calving ground

The area used by the Kaminuriak Population for calving lies near the west shore of Hudson Bay, between Rankin Inlet and Kaminuriak Lake. The southern extremity of the calving ground is the northwest portion of Maguse Lake and Kaminak Lake, where the topography is very rocky and broken. The northern extremity, near Brown and Gibson lakes, is also very rocky, while between the two extremities, near Banks Lake, the terrain consists of much glacial debris and prominent eskers generally running in a northwest direction.

Calving may be distributed over the entire area described or concentrated in one section, depending upon the climatic conditions during the spring migration and the areas occupied during the late winter months. The boundaries of the calving

grounds for 1966, 1967, and 1968 are shown in Figure 5.

The tendency of pregnant female barren-ground caribou to choose rocky terrain for calving and to return to the same area year after year has been documented by Kelsall (1968) for mainland caribou and by Skoog (1968) for Alaskan caribou.

Whereas the caribou of mainland Canada tend to calve in very rocky, elevated terrain, Alaskan caribou choose a less rugged, although mountainous, calving area. Skoog (1968, p. 441) describes a typical Alaskan calving ground as "... gently sloped, rolling terrain, dominated by herbaceous vegetation and small shrubs ...".

Kelsall (1968) suggests the following reasons why caribou of the Canadian mainland populations traditionally seek out elevated, rocky terrain for calving:

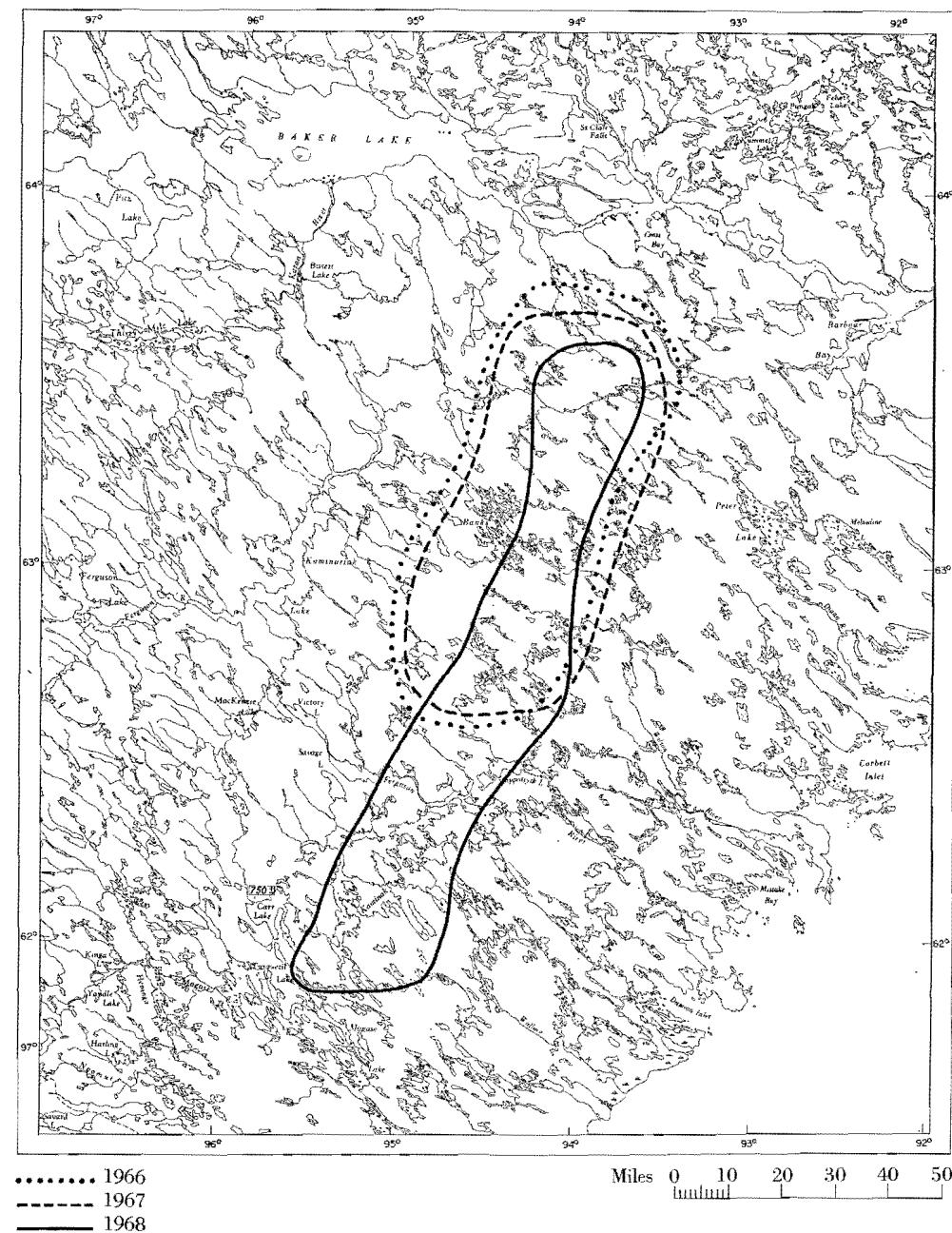
High, rugged country is probably chosen for calving because it provides a cool, insect-free environment during the period when calves are being born and learning to graze and travel. It may also provide an environment free from predators, who may be at a disadvantage due to the extremely difficult travelling conditions which prevail on high country in spring. (p. 180-181)

It is difficult to apply the above speculation to the Kaminuriak Population. Insects are not abundant until early July, and by then the calves are 2 weeks of age or older and the animals have moved north and north-east down from the calving ground to the flat, meadow-like terrain south of Baker Lake. The escape from predators is obviously an advantage, but I do not believe it can be regarded as one of the main motivating forces influencing the choice of the calving area.

The reasons for caribou traditionally calving in an elevated, rocky terrain are obviously related to the survival of the calf. Since caribou are adapted to survival in a northern environment, the choice for calving sites should be directly related to favourable environmental factors resulting

Figure 5. The three approximate areas utilized for calving by caribou of the Kaminuriak Population from 1966 to 1968.

Figure 5



..... 1966
----- 1967
———— 1968

Miles 0 10 20 30 40 50

from such a choice. I believe the best answer is provided by Zhigunov (1961) in his publication on reindeer husbandry in Russia.

If calving occurs under unfavourable climatic conditions (rains, fogs) and in areas exposed to wind, the herd will contain a great number of fawns suffering from catarrhal and purulent-catarrhal bronchopneumonia. . . . The disease is aggravated by overheating of the body, by drastic changes in weather from warm to cold, and by rains accompanied by strong winds. It follows that bad weather on the day of calving and inadequate protective measures against chills have a negative effect on further growth and development of the reindeer.

A herd, which includes a number of sick animals, grazing in summer in tundra pastures should be kept (during drastic changes from heat to cold and rain) behind elevations which protect young animals from the wind. Fawns kept under cover practically never suffer from aggravation of the disease. (p. 262-263)

During spring breakup, when calving is in progress, elevated, rocky terrain provides the driest possible conditions and also the maximum shelter available from high winds and sudden rain and snowstorms. In Alaska the calving grounds are typically located in mountainous terrain and the slopes used for calving may also be the driest areas and probably the first free of snow.

Movement prior to calving

Pregnant females must reach the calving area before breakup has advanced too far, thus avoiding flooding streams and deep slush on the lake shores. In most years the ice in the larger lakes remains solid until late June, providing a convenient means of travel for the migrating animals. In years of deep snow cover on the tundra, such as 1968, excessive slush along the lake shores can cause much difficulty. The physiological strain spring migration has upon pregnant cows is unknown. Although no adult mortality directly related to the deep snow in 1968 was observed, the weakened

condition of the cows may have had an indirect effect upon the survival of the young calves.

Total snow cover on the tundra by June 1, 1966, was light owing to a very early breakup. The first caribou arrived at the calving ground in late May and, owing to the easy travelling conditions, the calving ground extended farther north than in 1967 or 1968 (Fig. 5). The exact migratory routes to the calving ground in 1966 were not determined, but reports suggested the animals moved north on a wide front from northern Manitoba.

In 1967, as described in the previous section, caribou arrived on the calving ground by two routes. The coastal-wintering animals reached the northern portion of the calving ground near Gibson Lake by May 20. They continued to travel in a circular route until June 4 (Fig. 3). By June 4, most had ceased migration and were scattered over the northern portion of the calving ground. This distribution involved approximately 7,000 to 10,000 animals.

By June 6, 1967, the first of the taiga-wintering animals reached the northern section of the calving ground and began intermingling with the coastal, calving concentration. The main body of migrating caribou, however, was still south of Banks Lake by June 6, crossing the Ferguson River southeast of Kaminuriak Lake. The taiga-wintering females finally became settled on the calving ground by June 9, most being scattered to the south of the earlier-calving coastal animals.

In 1968 there were no major concentrations wintering on the tundra, practically all of the migrating animals coming from northeastern Saskatchewan. As described in the previous section, some of the last pregnant females to leave the wintering area were the first to arrive on the calving ground and in fact calved at the extreme northern portion of the calving ground. These caribou crossed the southern portion of the calving ground, near Kaminak Lake, on June 5 and reached the northern portion by June 10 when they ceased migration. The

main body of migrating caribou reached the southern portion of the calving ground by June 8 and ceased moving by June 14. Due to excessively deep snow in 1968, the animals were later than usual reaching the calving ground and it was extended considerably in a north-south axis.

Calving

In 1966 and 1967 the north-south length of the calving ground was about 85 miles and the total area was about 2,500 square miles. In 1968 the total length of the calving ground was 130 miles and the total area 2,333 square miles.

The first calves are usually born during the first week of June. The peak of calving occurs between June 10 and 15, after which the number of calves born decreases steadily. Aerial segregation in 1967 found only 34 per cent (n = 178) of caribou on the calving ground by June 11 were with calves. Most calves observed were in the northern section where the coastal animals had already reached the peak of calving. In 1968, 80 per cent (n = 654) of caribou observed from the ground during June 15 to 16 were with calves. On June 18, 79 per cent of the animals observed from the air north of Kaminak Lake were also with calves (n = 201).

According to Skoog (1968), in central Alaska the first observation of newborn calves is usually between May 12 and 15 and no newborn calves are observed after June 12. The peak of calving in central Alaska occurs between May 24 and 26. In 1957, Skoog found that just after the peak of calving, 70 per cent of the caribou seen were with calves, after which the proportion of calves continued to decline. He attributed this decline to an influx onto the calving ground by non-calving caribou and also to early calf mortality. Kelsall (1968) gives the peak calving period for the Beverly Population as the second week of June. This is very similar to that observed for the Kaminuriak Population. Bergerud (1957) observed the first woodland caribou calves in the interior of Newfoundland on

May 24 and the last newborn calf on June 7. Banfield (1954) reports newborn calves in southern Labrador from June 8 to 14, 1952.

The first calf observed in 1966 was on June 3, in 1967 on June 4, and in 1968 on June 6. The first calves observed are usually with animals still moving towards the calving ground, having been born during migration. Aerial observations suggest few calves were born before the dates for the first calf observation in 1966 and 1968. In 1967, although the first calves were observed on June 4, it is believed calving began in late May. As previously described, in 1967 the coastal-wintering caribou were on the calving ground much earlier than the taiga-wintering caribou. On June 4, 1967, a large number of calves were observed within the distribution of the coastal-wintering caribou on the northern portion of the calving ground. The large number suggests the first calves were probably born in late May, or at the latest June 1.

By June 9, 1967, the coastal-wintering caribou had reached the peak in calving while the taiga-wintering caribou were just beginning to reach the northern portion of the calving ground and to intermingle with the coastal animals. Most taiga-wintering caribou calved to the south of the coastal animals, near the Banks Lake area, and appeared to be nearly a week later in reaching the peak in calving. In 1966 and 1968, such a pronounced variation in time of calving was not observed. In these 2 years, few caribou spent the previous winter on the coastal tundra.

The factors responsible for earlier calving in the coastal-wintering animals than in the taiga-wintering caribou are largely unknown. Those caribou which remain on the tundra during the winter are subjected to a different photoperiod than those wintering 200-250 miles farther south in the taiga. If the animals bred at the same time, then the only answer lies in the differing winter environment which must in some way cause parturition to occur approximately

1 week earlier in those animals which wintered on the barrens. Verme (1969) found that female white-tailed deer (*Odocoileus virginianus*) on a high nutritional diet required a shorter gestation period to produce larger fawns than females on a low nutritional diet. Possibly those pregnant female caribou which wintered on the coastal tundra in 1966-67 remained on a higher nutritional plane and consequently calved earlier than those caribou which wintered in northern Manitoba and Saskatchewan. It is also possible that the coastal-wintering animals came into earlier breeding condition the previous fall. This could have been caused by a shorter photoperiod if the animals bred farther north than the taiga-wintering animals. The exact areas of rut were not determined in 1966, although it is believed breeding occurred in the Henik lakes area.

Caribou density on the calving ground, during the peak of calving, averaged between 12 and 14 animals per square mile with extremes of from 0 to 50 per square mile in 1968. Because the area of calving has remained relatively stable (2,000 to 2,500 square miles) over the 3-year study period, I believe this average density of 12 to 14 caribou per square mile has also remained constant.

The proportion of calving females decreases in a north-south gradient across the calving ground. This is particularly true just after peak calving. On June 18, 1968, aerial observations found that north of Kaminak Lake 79 per cent (n = 201) of those caribou 1 year of age and older were with calves. South of Kaminak Lake only 53 per cent (n = 344) of caribou were with calves. This north-south gradient is due to the northward ingression onto the calving ground of non-breeding caribou which remained south of the calving ground during the first 2 weeks of June.

The dispersal of calving females on the calving ground prior to calving, behaviour of caribou during calving, and formation of "nursery bands" will not be described in this report. These subjects are discussed by

Kelsall (1968), Skoog (1968), McEwan (1954), and de Vos (1960).

Aerial (n = 201) and ground (n = 654) segregation samples in 1968 agreed that approximately 80 per cent of the caribou 1 year of age and older on the calving ground before and during peak calving were adult breeding females. That class which may vary considerably from year to year in its representation on the calving ground is the yearling class. In 1968 approximately 5 per cent of the caribou on the calving ground (excluding calves) were yearlings (n = 671). This variation may be due to one or more of the following factors:

1. the actual survival of this age class the previous year;
2. the climatic conditions during spring migration; and,
3. the distance travelled during the spring migration.

Although most yearlings left the taiga with pregnant females in 1968, less than half were on the calving ground during the peak of calving. The remainder dropped out of the migration and formed small bands with 2-year-old males and non-breeding females which also remained south of the calving ground during peak calving. Some of these bands moved onto the calving ground by June 18 while others moved northwest towards the area west of Kaminuriak Lake and still others moved east towards the coast near Eskimo Point.

Post-calving distribution

Calving is completed by the Kaminuriak Population by June 20. Only a few calves are born after this date, possibly on into July. After calving, females and their calves form small units, or "nursery bands". Movement by these bands is limited shortly after calving, and much time is spent nursing and grazing on new plant growth on the hillsides and meadows which are rapidly becoming free of snow. Small groups of yearlings are common near the peripheries of these bands, in company with calfless females and the occasional male over 1 year of age.

Calving
Labrador

By late June these bands grow larger and join other nursery bands. A slow northerly movement begins, usually originated by the more southerly animals. Soon one or several large herds are moving north across the calving ground, absorbing all the nursery bands along the route. Seldom will one of these large post-calving herds number over 5,000 animals before mid-July. As a herd builds up in numbers, a division into two or more smaller herds will occur. By the first of July there may be as many as 10 or 12 such herds approaching the northern portion of the calving ground, each numbering from 1,000 to 5,000 animals.

In 1966, these large post-calving aggregations formed earlier than usual. By June 15, five separate herds, totalling approximately 12,000–13,000 animals, were approaching the northern portion of the calving ground, southeast of McQuoid Lake. South of these herds only a few scattered caribou could be found, most identified as adult males. North of these herds, caribou were still in the small nursery bands. One herd which passed by our camp, between Gibson and McQuoid lakes, on June 20, numbered approximately 3,000 adult caribou, most being cows with calves. Before the appearance of this herd, bands of caribou were continuously near our camp. After it moved north on June 21, only a few scattered caribou were observed until we left the area on July 10.

In 1967 and 1968, the formation of the post-calving herds was later than in 1966, probably due to a delay in the spring thaw. In 1967 there were no aerial observations over the calving ground from June 11 to July 14, but calves were still being born by the former date. In 1968, aerial observations ceased over the calving ground on June 18, at which time no large herds had yet been formed. At the extreme southern end, near Kaminak Lake, herds of several hundred caribou were beginning to move north, believed to be the beginning of the post-calving aggregations.

By late June most post-calving aggregations consist almost exclusively of cows

with calves, calfless adult females, and yearlings. Very few males over 1 year of age have yet joined these herds.

Non-calving segment of population
The first two sections of this chapter have described the movements and distribution of the calving segment of the population during the period early May to mid-June. I will now describe the distribution and movements of the non-calving segment of the population from early May to mid-July.

The non-calving segment of the population includes all yearlings, males, and non-calving females 2 years of age and older. The yearlings and non-pregnant females move out of the taiga onto the tundra in late May with the pregnant females, migrating towards the calving ground. As previously discussed, they tend to drop out of the migration south of the calving ground. Most males over 2 years of age leave the tree-line by mid-June and move slowly north and northeast. Their migration appears to follow closely the retreat north of the snow. The majority of males remain south of the post-calving aggregations but join these herds as they move south towards the tree-line in late July and early August.

The main route north toward Baker Lake for the non-calving segment of the population is on the west side of Kaminuriak Lake. During late June and the first 2 weeks of July, bands of males and non-calving females 2 years of age and over, and yearlings, move slowly north along this route. During this period other non-calving caribou may move north across the calving ground and join the post-calving groups south of Baker Lake, while others move northeast towards the coastal area, from Rankin Inlet south to the Manitoba border. It is believed that the males taking the more westerly route are those which winter in the Wollaston and Hatchet lakes area, Saskatchewan. Those adult males wintering near Horseshoe and Big Sand lakes, Manitoba, are believed to follow the more northeasterly route. Some of these males

move across the calving ground and join the large aggregations consisting predominantly of cows and calves, while others move towards the coastal area.

These non-calving caribou are very scattered during June and early July and few observations of their bands are available. On June 19, 1968, a few scattered bands were found during aerial surveys west of Kaminuriak Lake and south to the tree-line. One band of nine caribou on the west shore of Kaminuriak Lake included one yearling, five antlerless females, and three young males. In other bands found near Carr Lake, just southwest of the calving ground, 68 caribou were counted, 11 (17.6 per cent) of which were yearlings. The others were antlerless adult females and young males. Adult males were observed more to the west and southwest, near the Henik lakes and Yathkyed Lake. Most caribou observed here were solitary or in small groups numbering 10 or less.

By the third week of July, approximately one third of the adult males are distributed east of Kazan River and south of Baker Lake to the northern end of Kaminuriak Lake. The remaining adult males (approximately 12,000 in 1968) are scattered to the south as far as the tree-line and along the west coast of Hudson Bay from Rankin Inlet to the Manitoba border. During the same period about one third (28 per cent in 1968) of the yearlings are south of Baker Lake with the post-calving aggregations while the remainder (4,285 in 1968) are scattered farther south, many along the coastal tundra strip with the adult males.

In late July 1968, 21,812 of the caribou photographed south of Baker Lake on July 17 were unidentified adults. This class could have included 2-year-old males, non-calving females 2 years and over, and females which had lost their calves. Results of the 1968 calving ground survey, combined with observations from July photographs, indicate a loss of calves from birth to July 17 of 16,272. All cows which had lost their calves were believed to be within the herds photographed in July, leaving 5,540

(21,812–16,272) unidentified adults, either 2-year-old males or non-calving females 2 years and over. These two classes accounted for 11,631 caribou in the population by June 1968 (see "Total numbers and composition" section). Subtracting the 5,540 unidentified adults in the post-calving aggregations results in an additional 6,091 caribou, either 2-year-old males or non-calving females 2 years and over, scattered to the south of the post-calving area. The distribution of the non-calving portion of the Kaminuriak Population during June and early July is shown in Figures 6 and 7.

During the first 2 weeks of July, the post-calving aggregations are joined by scattered non-calving animals moving north across the calving ground. By mid-July these herds are usually in the area between the north end of the calving ground and Chesterfield Inlet. At the same time, approximately July 15, the herds of non-calving caribou, usually numbering from 50 to several hundred each, which have slowly moved up the west side of Kaminuriak Lake, approach the area east of Kazan River near Bissett and Martel lakes. These non-calving aggregations now begin to combine and form larger groups numbering up to several thousand each.

In mid-July (July 14 to 20 in 1968), a very interesting movement pattern occurs south of Baker Lake. A number of the mainly cow and calf post-calving aggregations move west towards Kazan River and join the non-calving groups located in that area. The remaining cow and calf aggregations stay relatively stationary south of Chesterfield Inlet, near the north end of the calving ground. By July 20, there are usually two main areas of caribou concentration. One is the area northwest of Kaminuriak Lake north to the delta of the Kazan River. The other is to the east and northeast of Kaminuriak Lake north to Chesterfield Inlet. The exact location of aggregations within these two areas may vary annually, but I believe the pattern of geographical separation is relatively constant.

Figure 6. The broad migratory route north from the taiga to the tundra by adult males (3 years and older) from June 1 to July 20, 1968, and approximate distribution by July 20, 1968.

Figure 6

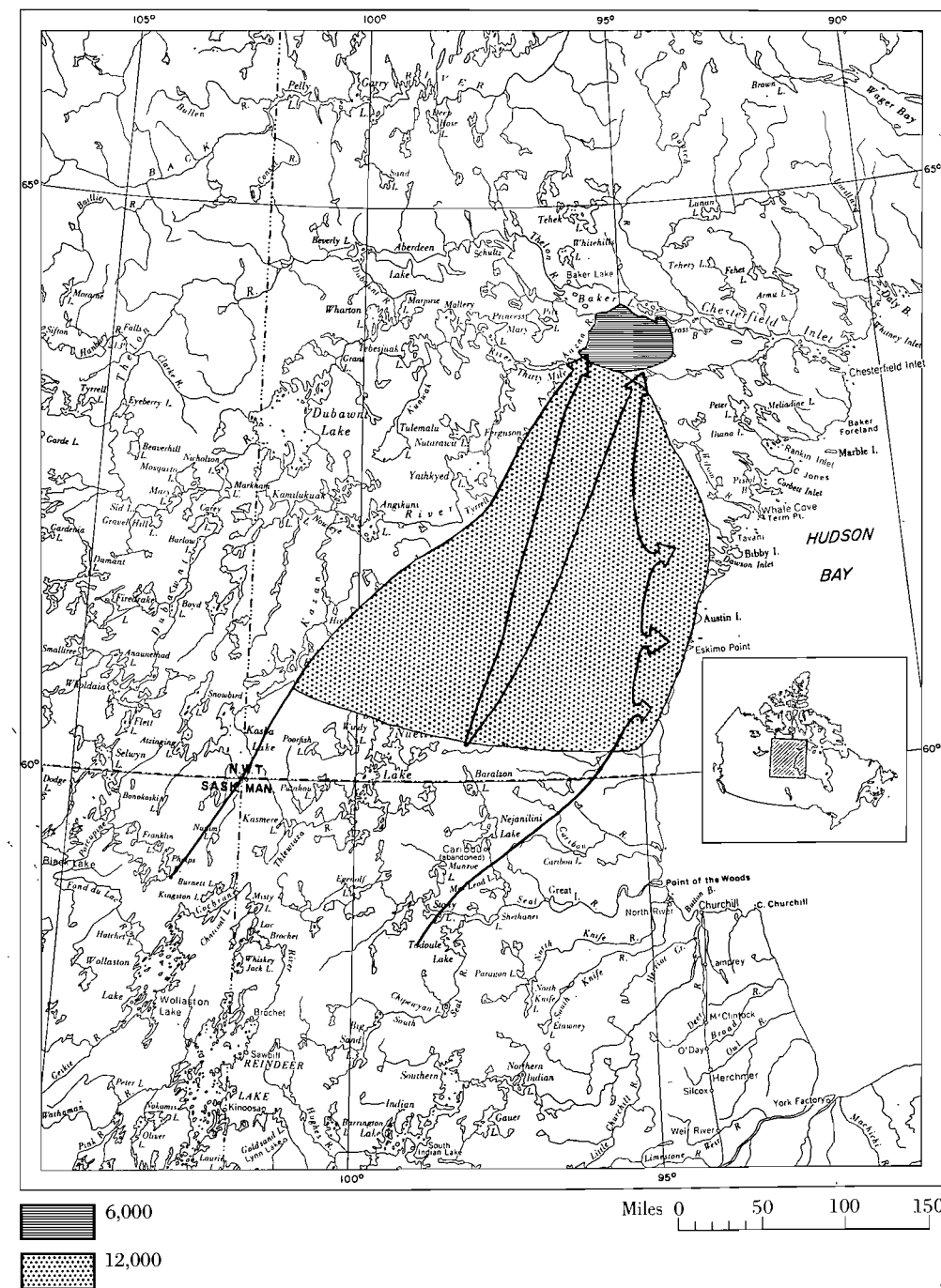
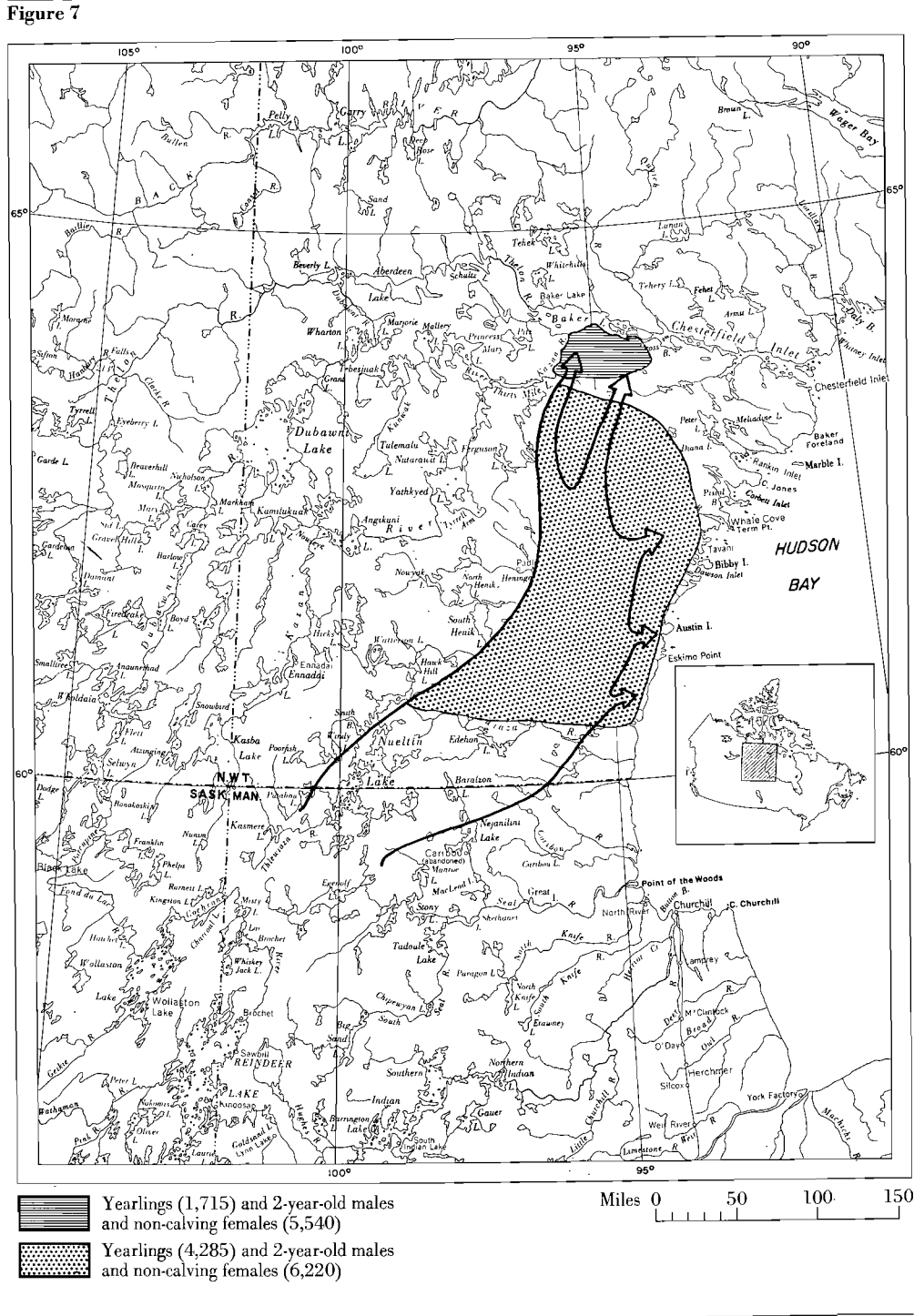


Figure 7. The migratory route north from the taiga to the tundra by the majority of yearlings, 2-year-old males, and non-calving females from June 1 to July 20, 1968, and approximate distribution by July 20, 1968.



Post-calving aggregations

From July 12 to 18, 1966, scattered post-calving aggregations, numbering from 75 to 15,000 each (personal estimates), were located south of Baker Lake from Kazan River to Cross Bay on Chesterfield Inlet (Fig. 8). Aerial photographs were not taken and a comparison of the composition between aggregations is not possible.

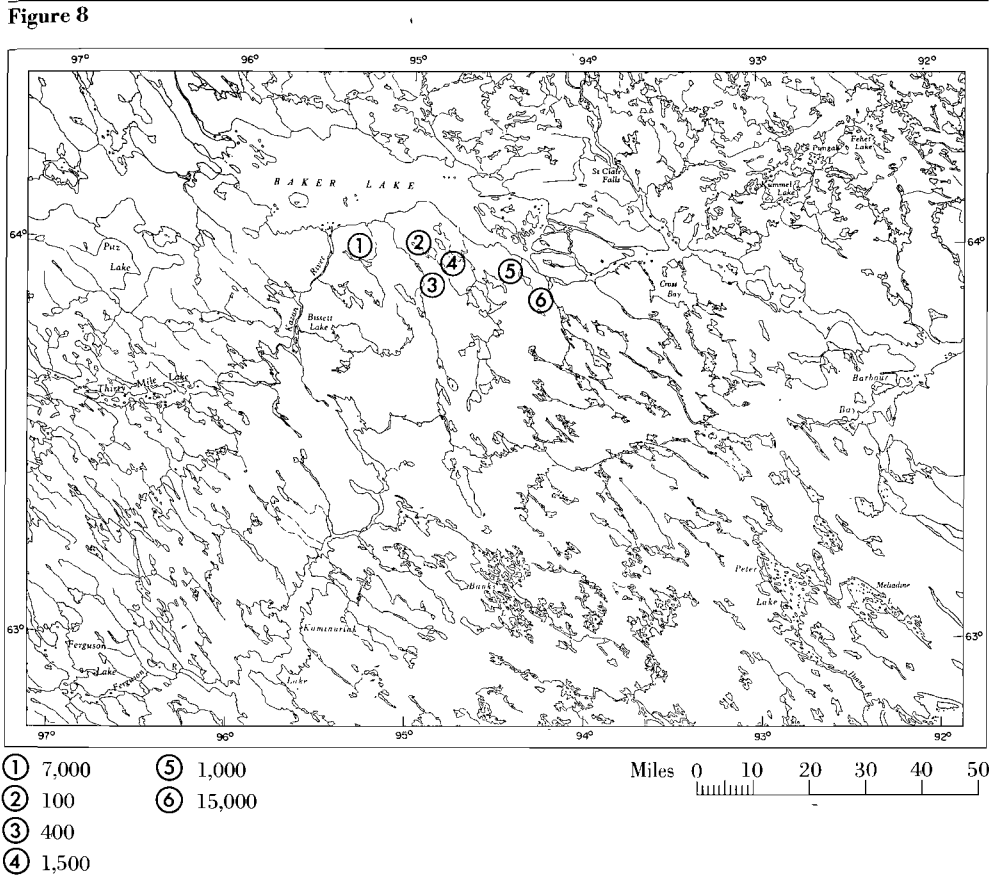
On July 14, 1967, post-calving aggregations were again observed south of Baker Lake. Those groups plotted on this date are shown in Figure 9. It was not possible to separate the aggregations observed in 1966 and 1967 into distinct areas based on individual group composition, as it was in 1968 and 1969.

In 1967, all groups moved down the west side of Kaminuriak Lake during their mid-summer migration toward the tree-line. From limited aerial photography on July 18, 1967, the proportion of calves was found to be very high. Of the total photographed ($n=1,740$), 30.2 per cent were calves, 2.3 per cent were adult males, and 37.3 per cent were unidentified (includes yearlings). The high proportion of calves suggests that in 1967 many of the cow and calf aggregations moved west towards Kazan River in early July and then south to the west of Kaminuriak Lake. In July 1966, the reverse occurred. All the post-calving aggregations moved south to the east of Kaminuriak Lake. We have no calf percentage figures for those herds observed in 1966.

On July 17, 1968, extensive aerial coverage of the area south of Baker Lake and Chesterfield Inlet resulted in the location of 32 post-calving groups. Aerial photography resulted in a total count and estimated composition of the groups observed. The results of this aerial photography are described in detail in the section "Post-calving photography".

On July 17, 1968, on the basis of composition and geographical location of these aggregations, the area occupied by caribou could be divided into three. These three areas and the herds within each are shown in Figure 10. Caribou in Area No. 2 were

Figure 8. The distribution of post-calving caribou aggregations observed south of Baker Lake, N.W.T., on July 17, 1966.



moving from Area No. 1 to Area No. 3, and had in fact joined these animals by July 21. Comparative composition figures of the groups within the three areas on July 17, 1968, are provided in Table 1. An increase in adult males and yearlings and a decrease in calves is evident from Area No. 1 to Area No. 3. In 1969, an aerial survey from July 18 to 22 found a similar situation to that in 1968. The post-calving aggregations were located in two distinct areas (Fig. 11). Prior to aerial photography, a small movement from east to west occurred across the narrows north of Kaminuriak Lake, providing a parallel to the movement through Area No. 2 in 1968. Results of representative aerial photography of the groups in the two areas in 1969 are given in Table 2.

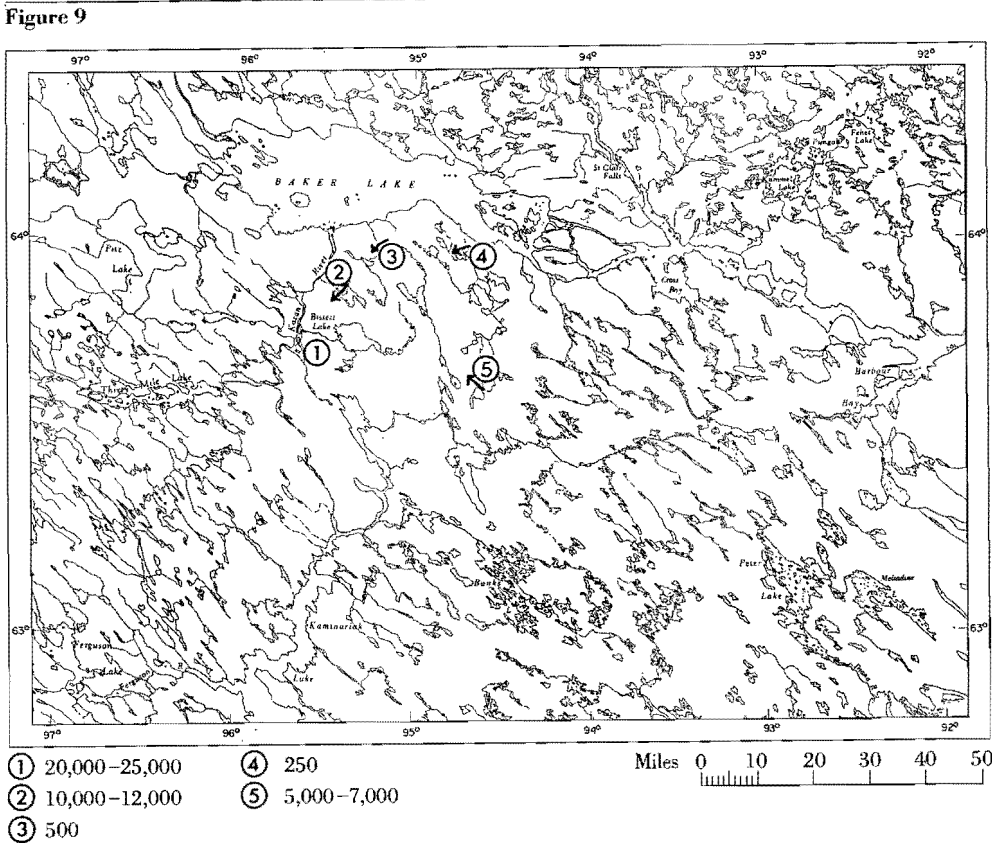
Photographs taken in Area No. 1 in 1968 can be compared to those taken in Area No. 1 in 1969. Although the location of the groups differed, the composition figures are very similar. In 1968, photographs were taken on July 21 after the caribou in Area No. 2 joined those in Area No. 3 near the Kazan River. Of the total photographed ($n=1,521$), 18.3 per cent were calves and 18.6 per cent were adult males. The composition was thus comparable to that of groups in Area No. 2 in 1969, after the movement from east to west across the north end of Kaminuriak Lake. Both the percentages of calves and of adult males were nearly identical for the 2 years (Tables 1 and 2). The formation of large post-calving aggregations shortly after the birth of calves

is a widespread phenomenon throughout the northern hemisphere for reindeer and barren-ground caribou. For example, Kelsall (1968) reports one such aggregation near the Dubawnt River numbering between 80,000 and 100,000 animals. Skoog (1968) also documents this behaviour in the central Alaskan barren-ground caribou populations. Andreev (1961) reports similar post-calving behaviour in wild reindeer populations of the Taimyr Peninsula in northern Russia.

The forces motivating this post-calving behaviour are unknown. Kelsall suggests three possible reasons: (1) the natural tendency for cows and calves to regroup after the dispersal during calving; (2) the concentration of caribou at natural barriers, such as water crossings, frequently encountered shortly after calving; and, (3) insect harassment. The latter two reasons suggested by Kelsall do not apply to the Kaminuriak Population. No major rivers or physical barriers are encountered by the post-calving aggregations as they move north from the calving grounds towards Baker Lake. Post-calving groups are already formed by the time the insects emerge, usually the first week of July. In 1966, cow and calf aggregations numbering several thousands of animals each were moving north towards Baker Lake on June 15. This was 2 weeks before the first mosquitoes appeared. The first reason postulated by Kelsall, "...the natural tendency for cows and calves to form progressively larger groups..." does not explain the formation of groups numbering in the tens of thousands or the formation of large aggregations by the non-calving segment of the population. Skoog (1968) refers to this post-calving phenomenon as a "regrouping behaviour" but offers no further explanation.

As previously mentioned, the Kaminuriak Population has been found to consist of three components, distinguishable often as concentrations, geographically separated at certain times of the year but indistinguishable at others. As the caribou move south from the Baker Lake area to their late

Figure 9. The distribution of post-calving caribou aggregations observed south of Baker Lake, N.W.T., on July 14, 1967.



summering grounds in late July, these three concentrations follow separate migratory routes and become distinctly separable geographically. There is also a noticeable variation in the composition of the caribou between these three late summering areas. This post-calving period possibly serves to allow the majority of the population to re-group into these three late summering concentrations, and, on a smaller scale, into maternal social units.

The late summer separation of the population into three concentrations is possibly due to the low carrying capacity of the late summer range. At the present size of the population, this factor does not appear to be critical. The two easterly herds, however, spend the summer near the Hudson

Bay coast, and both contain higher proportions of cows and calves than the most westerly herd, which contains a high proportion of mature males and few calves. I believe the flat, sedge and grass terrain along the coast is more favourable range for nursing cows and young calves than is the more rocky, less vegetated interior. Cool winds off Hudson Bay give the coastal animals some relief from insect harassment. Caribou ear-tag returns suggest there is considerable interchange between the two easterly late summering concentrations.

Mid-summer migration

Near the third week of July, the mid-summer migration of those caribou within the area of post-calving distribution begins.

Figure 10. The distribution of post-calving caribou aggregations observed south of Baker Lake, N.W.T., on July 17, 1968.

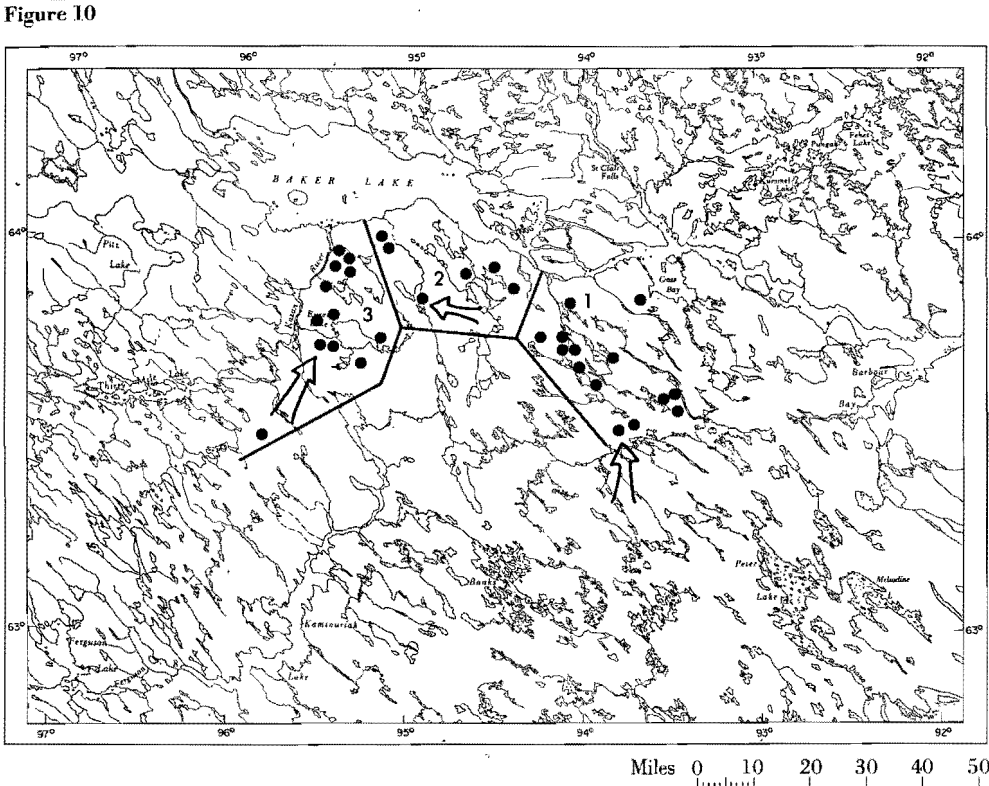


Table 1
Average composition of the post-calving aggregations photographed south of Baker Lake, N.W.T., on July 17, 1968.

Area no. (see Fig. 10)	Calves	Cows with calves	Yearlings	Adult males	Unidentified	Total segregated
1	1,198 (27.6%)	1,198 (27.6%)	90 (2%)	234 (5.3%)	1,619 (37.5%)	4,339
2	221 (17.4%)	221 (17.4%)	37 (2.9%)	77 (6%)	714 (56.3%)	1,270
3	173 (6.7%)	173 (6.7%)	163 (6.3%)	646 (25.3%)	1,395 (55%)	2,550

The onset of the mid-summer migration south towards the tree-line by the Kaminuriak Population has been observed from 1966 to 1969. The date of commencement of this migration has been surprisingly regular over the 4-year period. In 1966 the

migration began on July 18, in 1967 on July 14, in 1968 on July 21, and in 1969 on July 22.

Before the actual migration south, there is considerable local, erratic movement by the many post-calving aggregations south

of Baker Lake and Chesterfield Inlet. On warm, calm days when the insects are tormenting the animals, aggregations are in tight formation and usually moving rapidly about. On windy days the groups are usually stationary and spread out over a large area. One day an aggregation may number 10,000 animals and the next day it may be broken up into several smaller groups.

Besides these local, erratic movement patterns there is usually a movement from east to west by a number of the cows and calves from northeast of Kaminuriak Lake as described in the previous section. These animals move west towards the area near the lower Kazan River where the predominantly non-calving aggregations are located. Once this east-west shift occurs, the migration south begins. At the initiation of the migration there are usually several large aggregations in the vanguard with many smaller groups following rapidly behind attempting to catch up.

The pre-migratory east to west shift was most noticeable in 1968 and 1969, and the subsequent migration south began on two routes, one on either side of Kaminuriak Lake. In 1966, all post-calving aggregations, including the non-calving groups, joined near Andrews Lake and began moving south along one route, that being east of Kaminuriak Lake. In 1967, on the contrary, the main route taken was down the west side of Kaminuriak Lake, although several smaller cow and calf aggregations took the eastern route. These latter animals moved south-east towards the Eskimo Point area.

After travelling south for approximately 100 miles the large groups begin to disperse into smaller groups and the routes followed extend over a much larger area. Once the migration reaches the southern end of Kaminuriak Lake there are usually three main migratory routes followed, each taking a portion of the population to one of three late summering areas. Although three main routes can be defined, small bands and solitary caribou move south on a very wide front, from Kazan River to the Hudson Bay coast.

Figure 11. The distribution of post-calving caribou aggregations observed south of Baker Lake, N.W.T., from July 18 to 22, 1969.

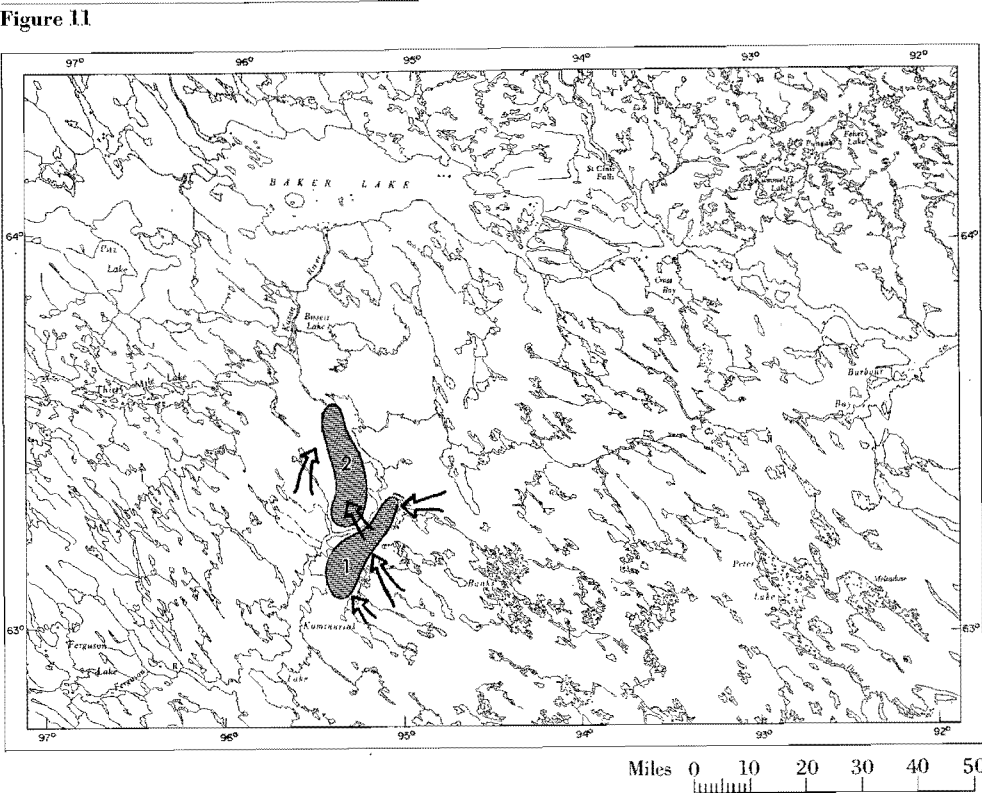


Table 2
Average composition of the post-calving aggregations photographed south of Baker Lake, N.W.T., from July 18 to 22, 1969.

Area no. (see Fig. 11)	Calves	Cows with calves	Adult males	Unidentified (includes yearlings)	Total segregated
1	1,173 (27.5%)	1,173 (27.5%)	169 (3.1%)	1,748 (41.1%)	4,258
2	269 (17.6%)	269 (17.6%)	270 (17.6%)	719 (47.2%)	1,527

In 1966, the mid-summer migration south from Baker Lake began on July 18. A division of this movement occurred at the southern end of Kaminuriak Lake. One group continued south reaching Baralzon Lake on July 30, while the other turned southeast towards the Hudson Bay coast (Fig. 12). By August 15 the momentum of

mid-summer migration had terminated and a leisurely drift back to the northwest was evident. In 1967, the mid-summer migration began on July 14 and most animals moved south to the west of Kaminuriak Lake. A smaller movement progressed south to the east of Kaminuriak Lake reaching the Eski-

Figure 12. The mid-summer migration routes south from Baker Lake, N.W.T., by caribou of the Kaminuriak Population from July 18 to August 15, 1966.

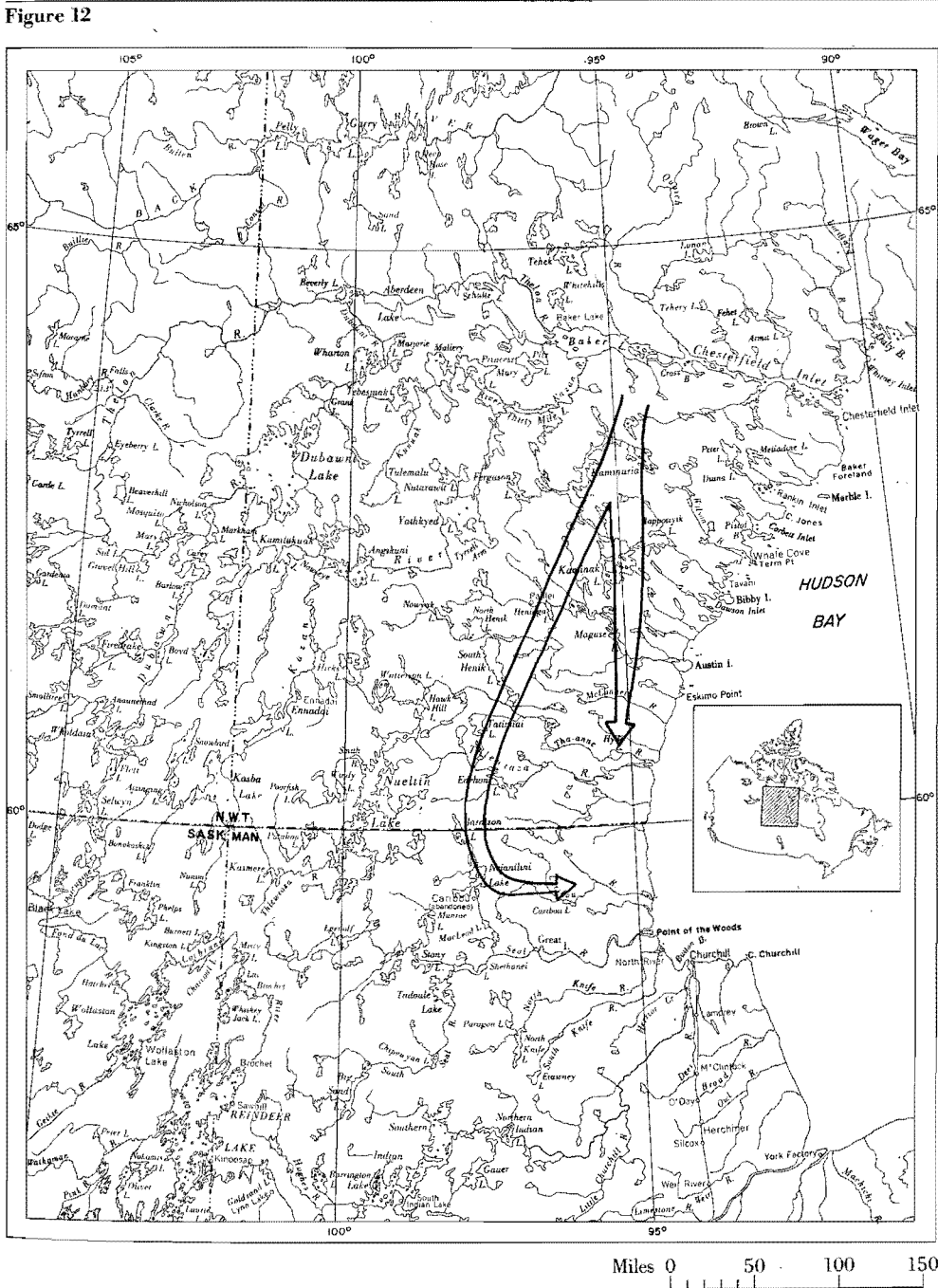


Figure 13. The mid-summer migration routes south from Baker Lake, N.W.T., by caribou of the Kaminuriak Population from July 14 to August 15, 1967.

Figure 13

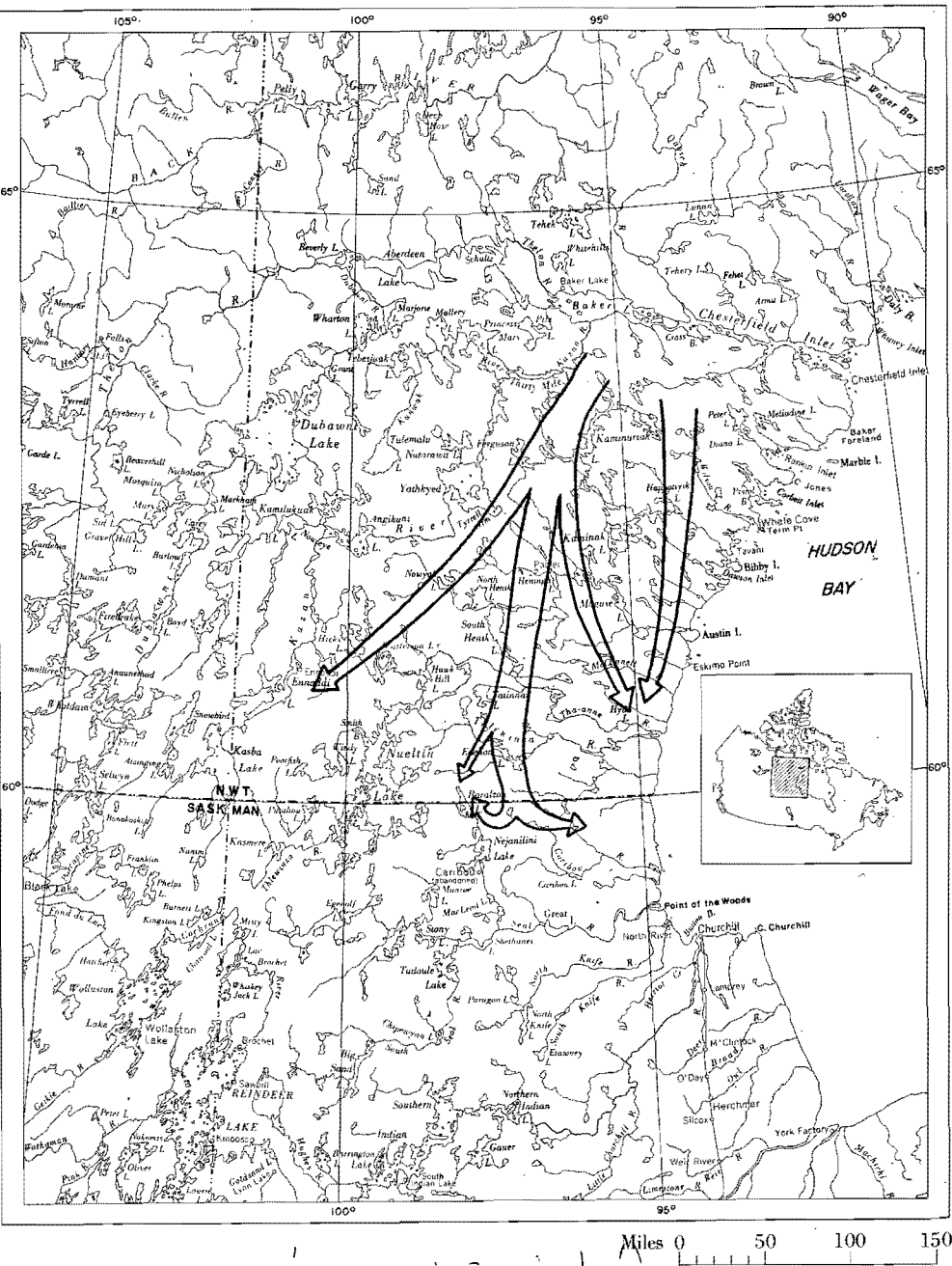
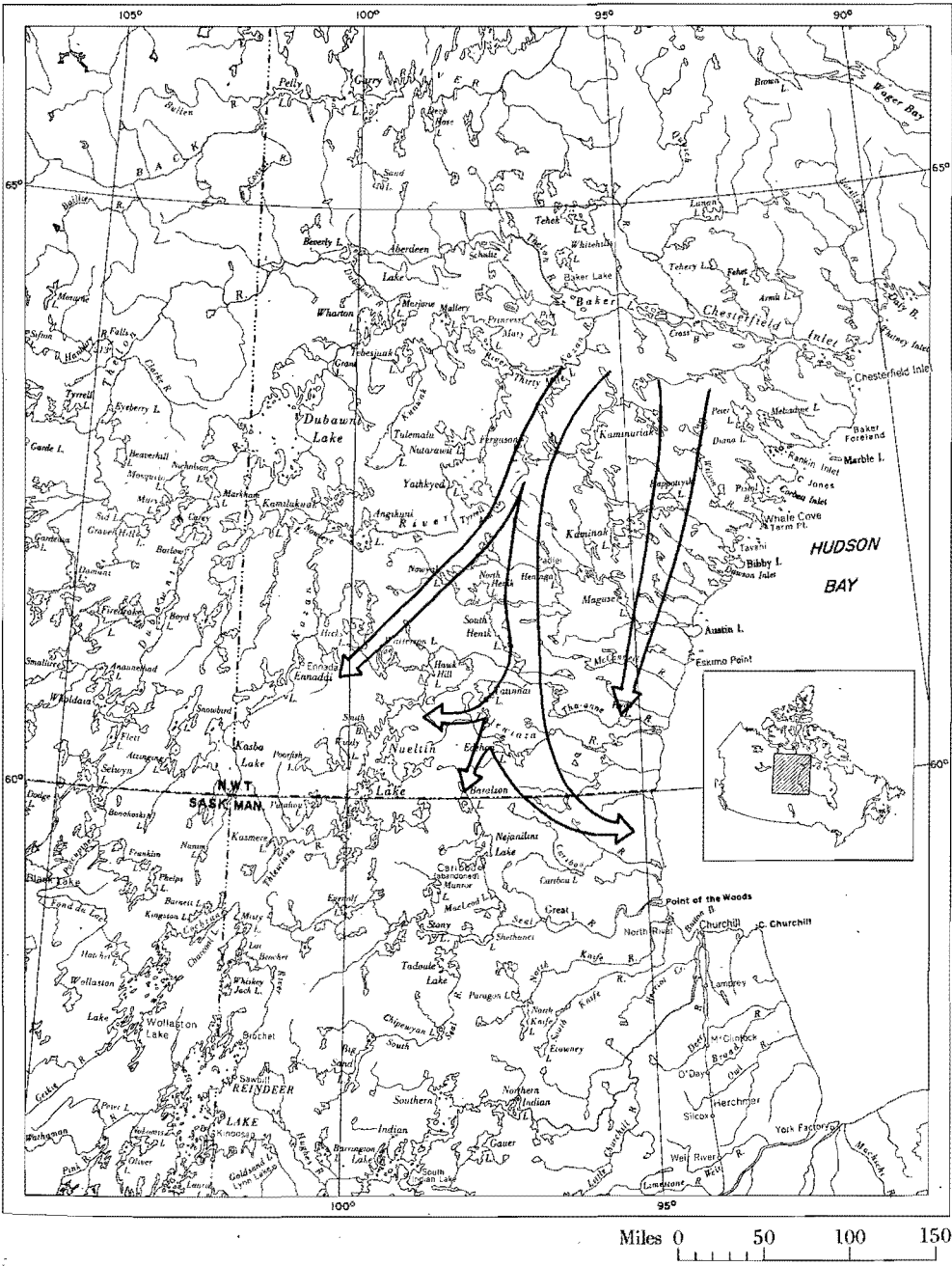


Figure 14. The mid-summer migration routes south from Baker Lake, N.W.T., by caribou of the Kaminuriak Population from July 21 to August 15, 1968.

Figure 14



mo Point area in early August. The main migration west of Kaminuriak Lake split into three segments near Fergusson Lake, the main movements dispersing into small bands near the tree-line, and the migratory momentum giving way to erratic local movement patterns by early August (Fig. 13).

In 1968, the mid-summer migration began on July 21. As in 1967, caribou moved south to the east and west of Kaminuriak Lake, and again the western movement divided at Fergusson Lake (Fig. 14). Southern penetration terminated by August 15 at which time a northerly and leisurely drift back to the tundra began.

The rate of movement during mid-summer migration may vary but appears to average between 10 and 15 miles per day. The mid-summer migration south is usually over by mid-August.

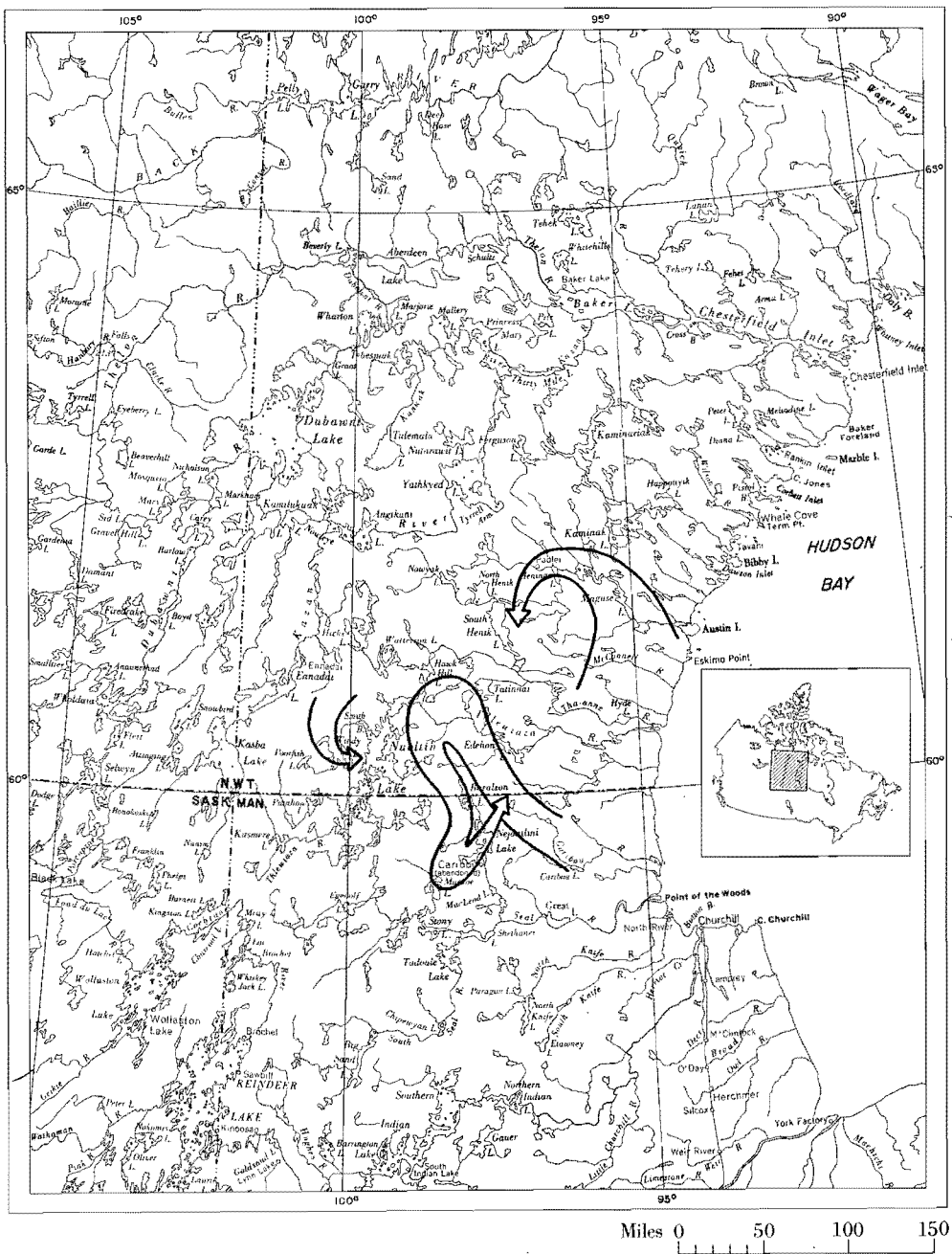
Mid-summer migration routes are not as well defined as those used during spring and winter migrations. As migration progresses, the delineation of definite routes becomes more difficult. Many animals slow down or cease their southern movement along the route and small groups disperse over a wide area. It is also very difficult to determine routes taken by groups of caribou from the sign made during migration. By early August most caribou are very dark in colour and solitary animals or small bands are most difficult to see from the air, especially if they remain motionless and the weather is overcast.

Late summer and autumn distribution

By August 15 the mid-summer migration south has terminated, and there are typically three main areas of caribou concentration. Banfield (1954) called these, from east to west, the Churchill or Eskimo Point Herd, the Duck Lake herd, and the Brochet or Windy Bay Herd. Loughrey distinguishes the same concentrations in September and early October, 1956. Owing to the periodic shifts in areas used by these concentrations (to be discussed later in this section), I prefer to designate these summering concentrations as eastern, central, and western.

Figure 15. The distribution and movement by caribou within the three areas of late summer distribution from August 15 to October 1, 1967.

Figure 15



The eastern concentration remained distributed along the coast between the Thanne River and Eskimo Point. By mid-September a westerly movement began

which took these coastal animals inland towards North Henik Lake and Padlei.

The central concentration spent the latter part of August and early September near the Manitoba-Keewatin border extending from the coast inland to Boundary Lake. By mid-September these animals began moving northwest towards Edehon Lake and by September 28 were scattered from Geillini Lake along the Thlewiaza River to Edehon Lake and north to Hopton and Thuchonilini lakes. Those animals near Hopton Lake were moving north-northwest while a smaller movement turned east-southeast near Edehon Lake.

The western concentration was distributed in the Hicks-Watterson lakes area by mid-August, remaining in this general area until late September. During this period caribou moved back and forth in a southwest-northeast direction. Results of ground segregation of 598 caribou from this western concentration during August 21 to 26, 1968, are presented in Table 3.

By September 28 most of these westerly animals began a rapid movement southeast towards South Henik Lake. Several thousand animals remained behind, however, in the Hicks-Watterson lakes area. By September 28 these remaining animals were moving in various directions and showing no evidence of following the main movement east. Small bands were moving east from Ennedai Lake while a larger number of caribou was moving south-southeast down the west side of Sterns Lake. Caribou were also moving west along the south shore of Hicks Lake while scattered small bands were moving west from the area of Watterson Lake. Other animals were moving directly south towards Windy Bay. Those animals remaining to the west contained a relatively high percentage of adult males (38.8 per cent) and a low percentage of calves (9.9 per cent).

By the last week of September 1968, there were four main areas of caribou concentration (Fig. 16). Three of these, containing most of the caribou in the population, were moving towards a focal point in

Table 3

Results of ground segregation of barren-ground caribou at Elliot Lake, N.W.T., in late August 1968.

Date	Number segregated	Adult males	Yearlings	Calves	Unclassified *
21/8/68	1	1			
23/8/68	142	89	4	10	39
24/8/68	274	136	32	26	80
26/8/68	181	36	17	30	98
Total	598	262 (44%)	53 (9%)	66 (11%)	217 (36%)

*This class includes all 2-year-olds and adult females 3 years and over.

Table 4

Results of aerial segregation of caribou within the four areas of caribou distribution from September 26 to 29, 1968

Area no. (see Fig. 16)	Caribou segregated	Adult males (3 yr. +)		Calves		Unclassified	
		No.	%	No.	%	No.	%
1	463	180	38.8	46	9.9	237	51.3
2	466	98	21.0	64	13.7	304	75.3
3	1,311	296	22.3	215	16.3	800	61.4
4	833	144	17.2	117	14.0	572	68.8
Total	3,073	718	23.3	442	14.3	1,913	62.4

the South Henik Lake area, as in 1967. The westernmost caribou showed no evidence of moving east towards South Henik Lake. No aerial surveys were made to determine caribou numbers in each of the four areas. Aerial segregation data on 3,073 caribou from the four areas are presented in Table 4.

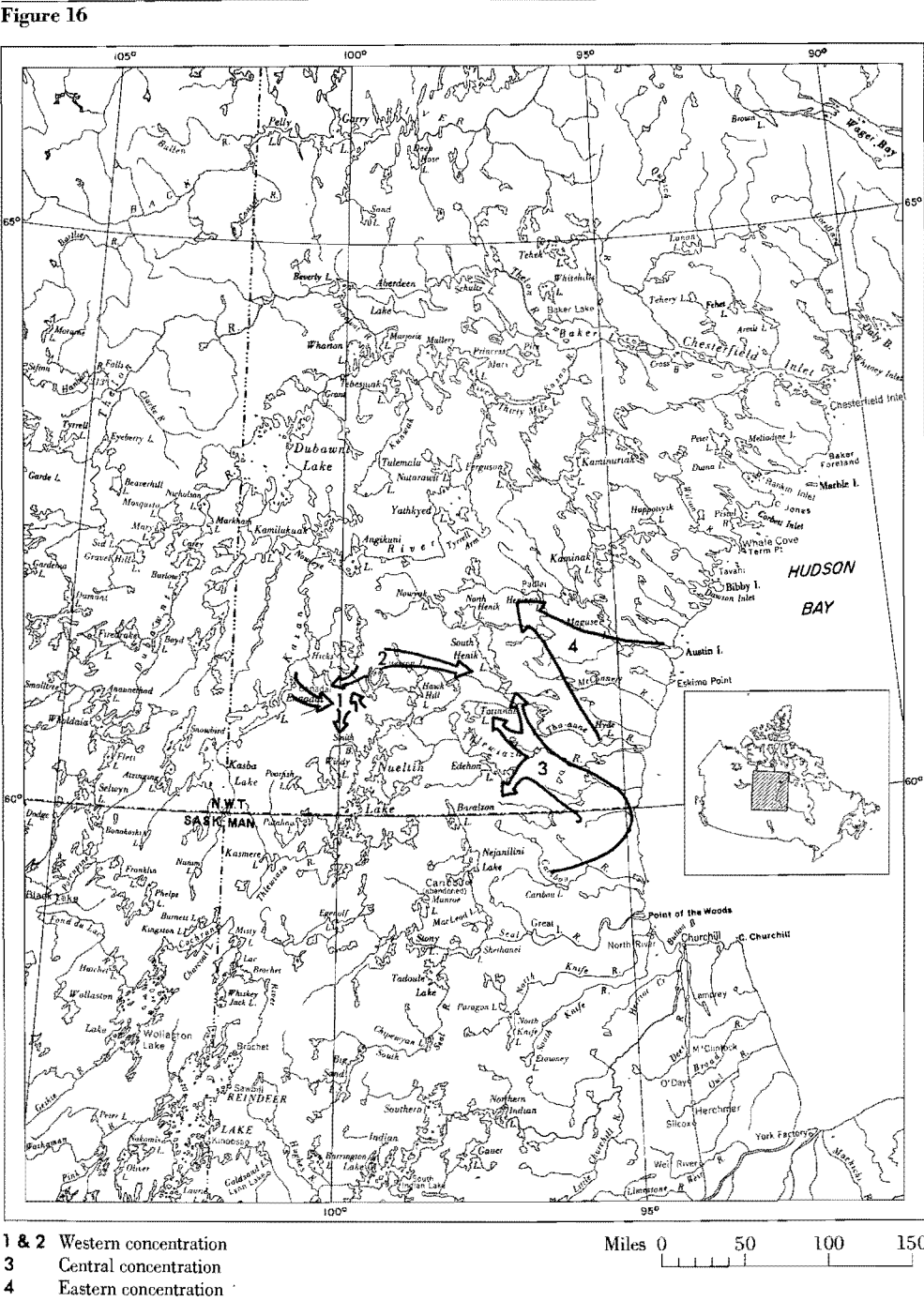
In late August 1968, ground segregation (Table 3) showed the western concentration contained 44 per cent adult males (39 months or older) and 11 per cent calves ($n = 599$). By late September 1968, the proportion of calves in those animals segregated from the air in Areas 1 and 2 (Fig. 16) was 11.8 per cent ($n = 929$), a very similar figure to that determined in late August. The adult male proportion in late September for Areas 1 and 2 was down to 28 per cent compared to the August figure of 44 per cent. Areas 1 to 4 showed a progressively lower percentage of adult males and higher percentage of calves.

During early October 1956, Loughrey segregated caribou within these three areas

of concentration. The eastern concentration contained 7.5 per cent calves, the central (Duck Lake Herd) 8.5 per cent calves, and the western (Brochet Herd) 5.7 per cent calves. Although these calf percentages are much lower than those observed in 1968, it is interesting to note that the western concentration contained the lowest percentage of calves.

In late September 1968, the only caribou which were not moving towards South Henik Lake were those in Area 1. This area contained the highest proportion of adult males (38.8 per cent) and the lowest of calves (9.9 per cent). These may have been animals which would not be participating in the rut. Perhaps the numerous adult males were animals past their prime breeding age. Those caribou with calves may have been young breeding females, the strain of pregnancy the previous year and of nursing a calf during early summer having prevented them from entering breeding condition in 1968. The unclassified caribou (51.3 per

Figure 16. The distribution and movement of caribou within the four areas of late summer distribution from August 15 to October 1, 1968.



cent) possibly were juveniles (yearlings and 2-year-olds) which also would not be participating in the 1968 breeding season.

There were 1,913 unidentified caribou in the total segregated ($n=3,073$) (Table 4). These caribou were yearlings, 2-year-olds, or females 3 years of age and older. Yearlings and 2-year-olds were estimated to comprise 20 per cent of the population. Subtracting these from the 1,913 unclassified leaves 1,299 adult females. Adult males (3 years or older) in the sample numbered 718. The adult male to adult female ratio was therefore estimated to be 55:100. This is similar to the range-wide adult sex ratio in 1957–58 of approximately 54 to 60 males per 100 females (Kelsall, 1968).

The total number of caribou before calving in June 1968 was estimated to be 63,173. By late July calves numbered 10,897, or 14.6 per cent of the total. Calves made up 14.3 per cent of the September segregation sample. On October 1, 1967, calves comprised 16.3 per cent ($n=508$) of the central concentration, and again exactly 16.3 per cent ($n=1,311$) in late September 1968. On October 1, 1967, calves made up 15.6 per cent ($n=792$) of the eastern concentration, and at the same period in 1968 14 per cent ($n=833$).

The division of the Kaministiquia Population into three areas of late summer dispersion appears to be a consistent phenomenon (Banfield, 1954; Loughrey, 1956). Banfield (1954) also documents the same three concentrations wintering in separate areas in northern Manitoba and northeastern Saskatchewan. From 1966 to 1968, these population segments retained their identity until after the fall migration into the taiga.

The exact areas utilized during late summer by these three concentrations may vary annually, although caribou of the eastern concentration consistently disperse along the coastal area near Eskimo Point.

The central concentration, formerly called the Duck Lake Herd, appears periodically to shift the area utilized during late summer. In 1957, Pruitt (1957) documented its movements during September

and early October. The movements he saw during the fall of 1957 resemble those observed in 1967. From 1960 to 1965, caribou tagging operations at Nejanilini Lake by the Manitoba Government usually began in early August. At this time caribou moved southeast through the Baralzon–Nejanilini lakes area on their mid-summer migration. From 1966 to 1968 the mid-summer migration followed a more easterly route and in 1968 no caribou were observed during late summer or fall near the southern end of Nejanilini Lake. This is possibly a temporary change and in a few years the caribou migration may again shift back towards Nejanilini Lake.

Caribou of the western concentration also appear periodically to change their area of late summer distribution. By October 1, 1967, these caribou were centred in the Windy Bay area on the west side of Nueltin Lake. On the same date in 1968 they were farther north and moving rapidly southeast towards Henik lakes.

I believe a decrease in numbers within each of the three concentrations over the past 20 years has reduced the extent of their seasonal migrations. Banfield (1954) documents the eastern concentration penetrating as far south as the Churchill River during late summer before moving slowly back north prior to the rut. The central concentration penetrated as far as the Seal River while the western animals reached as far south as the Cochrane River. In 1968 the eastern and western concentrations did not reach the taiga, while the central animals penetrated the extreme northern portion of the taiga near Boundary and Caribou lakes.

The rut

Peak breeding activity within the Kaministiquia Population was not observed during the present study. The latest aerial observations prior to the rut were made on October 2. The breeding season occurs during the period of freeze-up, which makes it difficult to survey the animals by fixed-wing aircraft.

On October 1 of 1967, the Kaministiquia Population was still separated into three

distinct groups. Two of these were separated by 150 miles but were moving towards a common area between Edehon and South Henik lakes, where it is believed the rut occurred. The third concentration was stationary on October 1 and between 110 and 150 miles to the west of the other two groups. By November 3, 1967, all three groups had moved south into northern Manitoba, passing between Nejanilini Lake and the Hudson Bay coast. This suggests the westernmost caribou moved rapidly east during early October to join the other two concentrations.

On October 1, 1968, the population was again divided into three. The most westerly consisted of two sub-groups, one moving east while the second, smaller and containing a high proportion of adult males, remained behind near Ennedai Lake. By October 1, 1968, the majority of caribou, as in 1967, were moving towards a common area which appeared to be near South Henik Lake.

The rut in Canadian barren-ground caribou populations has been described by Kelsall (1968), Lawrie (1948), McEwan (1957), Wilk (1958), and Pruitt (1957).

One of the earliest records of the rut within the Kaministiquia Population is by David Hanbury (1904). On October 26, 1901, Hanbury observed large herds of caribou near the south shore of Baker Lake: "I could see deer by the thousands away to the west. . . . It was now the height of the rutting season, and many fierce combats were taking place between the old bulls" (p. 73). Hanbury also mentions that those caribou which were distributed in late summer along the coastal area had moved inland by September 20, a phenomenon which I observed in 1967 and 1968.

A. H. Lawrie observed the rut during the fall of 1948 at Windy Bay on the west side of Nueltin Lake. The first sign of the rut he noted was on October 12 and "the first real evidence of sexual excitement on the part of bulls [was] on the 17th" (p. 22). He recorded that the peak of the rut occurred on the 24th with rutting behaviour declining thereafter.

In early October 1956, Loughrey (1956) reported the "Eskimo Point Herd" and the "Duck Lake Herd" were on the coastal tundra between the Churchill and Maguse rivers. He believed the rut occurred within this area. The location of the westerly concentration was not observed, but reports indicated a movement south through the Ennedai Lake area in mid-September. At Duck Lake on September 19, 1956, Loughrey observed two adult males exhibit antagonistic behaviour by making "a few quick passes at each other" (p. 14). On the same date he saw "a bull making an unsuccessful attempt to mount a cow" (p. 14). Inland from Eskimo Point near Camp Lake, Loughrey observed "a more prolonged sparring contest between two bulls on October 4" (p. 14).

Pruitt (1957), studying caribou during the rut at Duck Lake, Manitoba, in 1956, reports that "The male caribou observed around Duck Lake the last five days in September carried antlers that were freshly cleaned of velvet, being still bloody in some cases" (p. 2). Sparring between adult males was first observed by Pruitt at Duck Lake on September 27, 1956.

In 1967 and 1968, caribou distribution and movement by October 1 suggested the rut probably occurred near South Henik and Edehon lakes. The cow segment within each of the three concentrations initiates the movement to the breeding area in late September. The bulls rapidly catch up as they approach the area of rut.

By November 1 of 1966 and 1967, the majority of caribou had penetrated south into the taiga on their fall migration. Aerial surveys during the first week of November 1967, found approximately one third of the adult males still carried their antlers and were travelling in typical bull bands. The peak of breeding activity was obviously past but limited breeding undoubtedly continues as the fall migration is in progress during early November.

Three instances of males fighting were recorded during the third week of November 1967. All males involved were within

Figure 17. The fall migration routes (November 1 to 17, 1966) and distribution of the Kaminuriak caribou population on November 17, 1966.

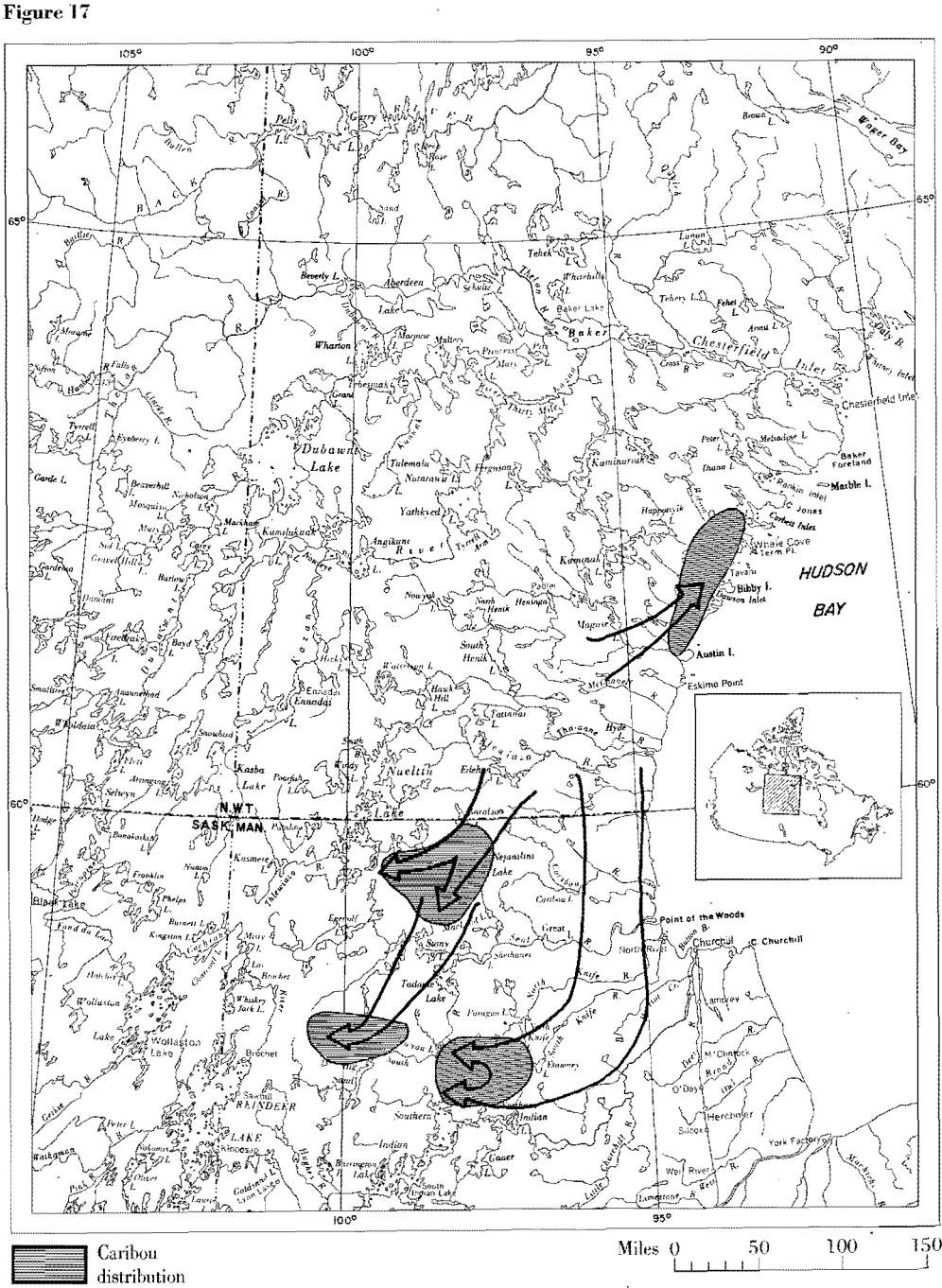


Figure 17

Figure 18. The early winter migration routes (November 17, 1966, to January 20, 1967) and distribution of the Kaminuriak caribou population on January 20, 1967.

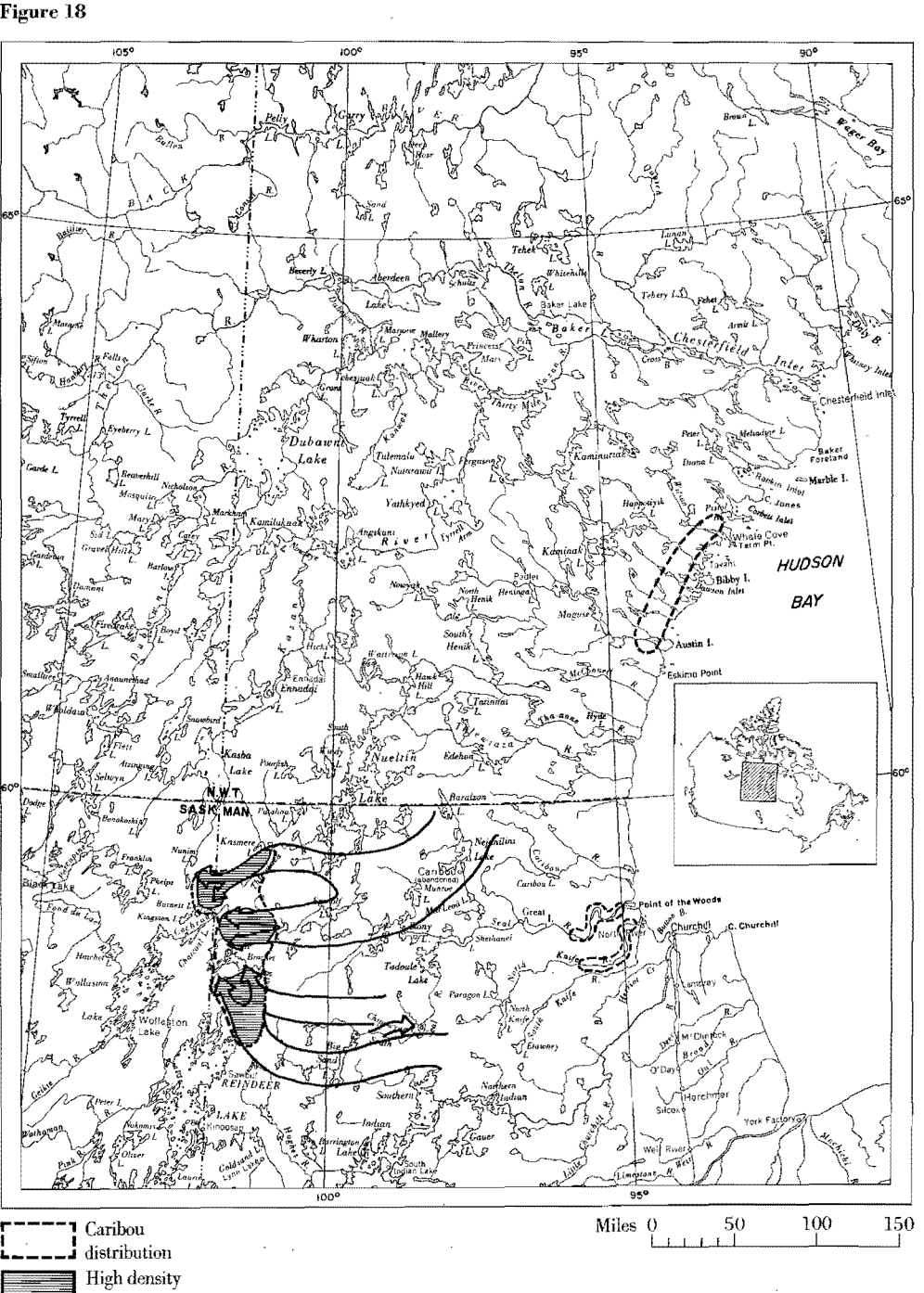


Figure 18

Fall migration and early winter distribution

The fall migration south into the taiga begins in late October or early November. Rutting activity is still in progress as the migration moves into northern Manitoba, although the peak of activity is past. The fall migration and winter distribution were observed in 1966-67 and 1967-68. In both years the three late summer concentrations appeared to retain their identity until late January.

In the fall of 1966, two of these concentrations moved into Manitoba during the first week of November. One moved southwest through Nejanilini Lake, continuing west towards the northern end of Reindeer Lake. The other moved south near the coast, turning west as the animals approached the Churchill River. It then moved down around the southern end of Big Sand Lake and northwest towards Brochet, joining the other concentration which had moved slowly west. Upon joining in mid-January these two concentrations then moved up the Cochrane River towards Whisky Jack Lake and Lac Brochet.

The third movement south followed the route of the first through Nejanilini Lake, entering Manitoba at the end of the second week of November. These animals immediately swung west and southwest as they entered the taiga. This group then split, following two main routes while moving towards Saskatchewan during late November, December, and early January. One group moved northwest, past the south end of Nuektin Lake, west past Kasmere and Fort Hall lakes and then southwest, the vanguard crossing into Saskatchewan by mid-January 1967. Caribou following the second route proceeded straight west into the Misty Lake country.

In mid-November 1966, another concentration of caribou moved into the Eskimo Point area from the southwest. These animals remained on the coastal tundra all winter, moving back and forth between Rankin Inlet and Eskimo Point. There were also small scattered bands which remained

the area of cow and calf distribution near the Cochrane River, Manitoba, and from their antler development appeared to be approximately 41 months of age.

There are no observations to indicate the three concentrations did not move to a common area for the peak of the rut during late September and October of 1967 and 1968. All three concentrations moved south during the fall migration in 1966 and 1967 into northern Manitoba at approximately the same time and along the same route between Duck Lake and the Hudson Bay coast. This suggests all caribou were in the same general area during the latter part of October.

The question whether a common area of rut is utilized by the three concentrations is important when determining whether they belong to the same population, in the strict sense of the word. The one stipulation essential for a local population or deme is random breeding during the rut. Returns from the tagging program at Duck Lake, Manitoba, suggest considerable annual interchange between the central and eastern concentrations (Miller and Robertson, 1967). If there are three main rutting areas each year, but with considerable interchange of animals annually between the three concentrations, it is conceivable that gene flow between concentrations is still sufficient to link all into a common population.

In the earliest stages of the rut (late September and early October) the three concentrations are separated geographically. As the rut increases in intensity, these three concentrations approach a common area, and breeding activity is believed to occur between animals of the three groups. The actual extent of interbreeding between the groups is unknown.

Some breeding activity undoubtedly occurs before the groups merge in mid-October. More information is required on the possibility of individual animals traditionally returning to the same late summering concentration before each could individually be designated a local population or deme.

Figure 19. The fall migration routes (November 1 to 20, 1967) and distribution of the Kaminuriak caribou population on November 20, 1967.

along the lower Seal and Knife river systems near the Hudson Bay coast. The fall migration routes and distributions of the Kaminuriak Population on November 17, 1966, are shown in Figure 17. Early winter migration routes and distribution on January 20, 1967, are shown in Figure 18.

In 1967, the entire population moved south into northern Manitoba with the exception of a few scattered animals which remained to winter on the coastal tundra. By October 25, 1967, all three concentrations entered northeastern Manitoba. The migratory routes were farther east than in 1966, with most animals moving south near the Hudson Bay coast. As in 1966, the more southerly group swung west when it approached the Churchill River. The remaining two groups appeared to join near the southern end of Tadoule Lake but immediately separated again, one moving northwest towards Egenolf Lake, the other west towards Lac Brochet. The migratory routes followed and caribou distribution by November 20, 1967, are presented in Figure 19.

By the third week of November 1967, the penetration west across Manitoba by the Kaminuriak Population was farther advanced than in 1966. As in 1966-67, those animals which moved northwest towards Egenolf Lake swung west, passing through the Fort Hall Lake area and then southwest into Saskatchewan. Here they joined the other two movements which had also proceeded west and northwest into Saskatchewan towards Charcoal Lake and the Cochrane River. The migratory routes followed during late November, December, and early January and the distribution of the population on January 20, 1968, are shown in Figure 20.

The preceding comments and distribution maps concern only the non-adult male segment of the population. The wintering distribution of adult males will be discussed in a separate section.

Aerial observations in 1966-67 and 1967-68 suggest that the fall migration and early winter distribution (November 1 to

Figure 19

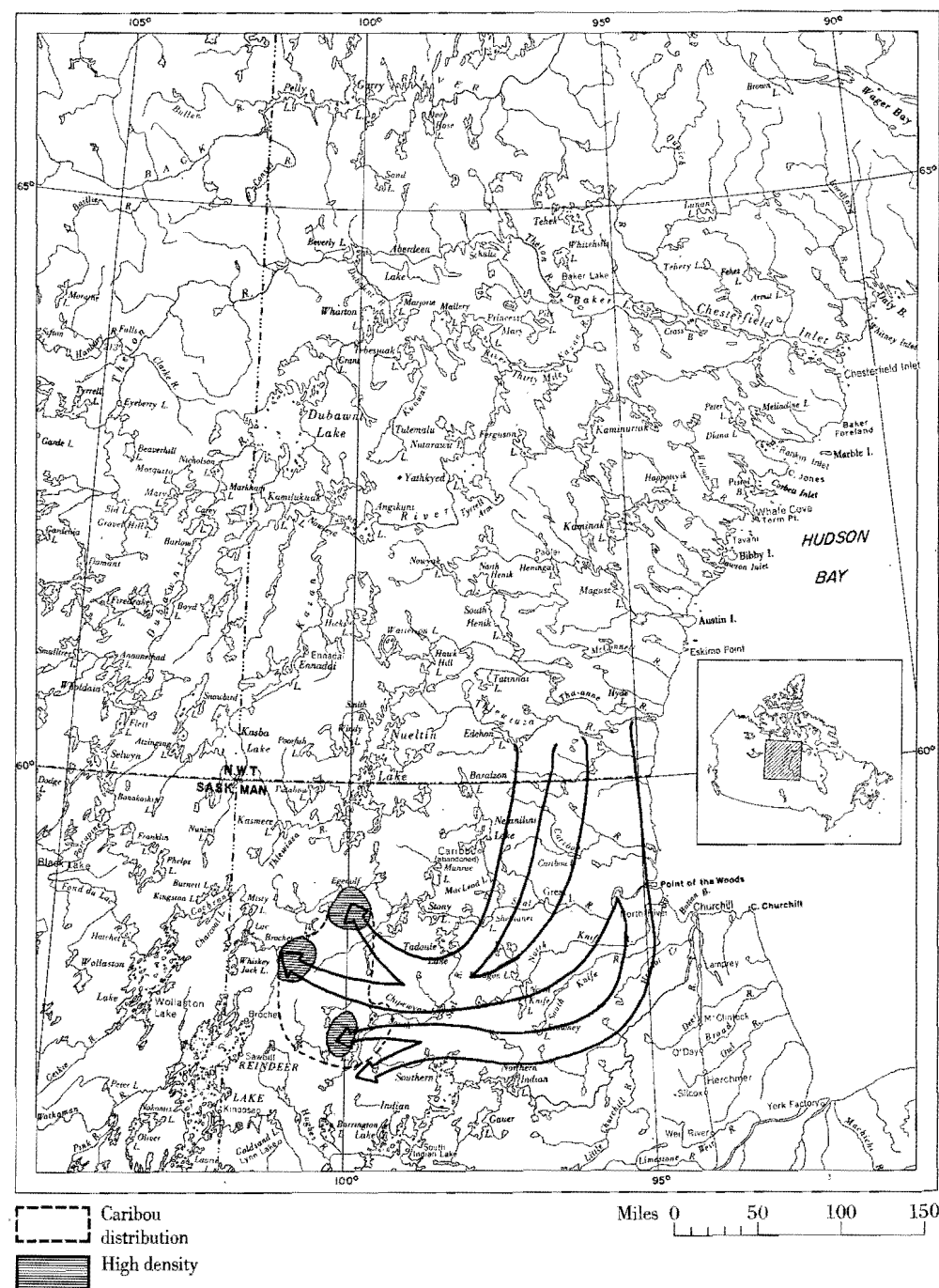
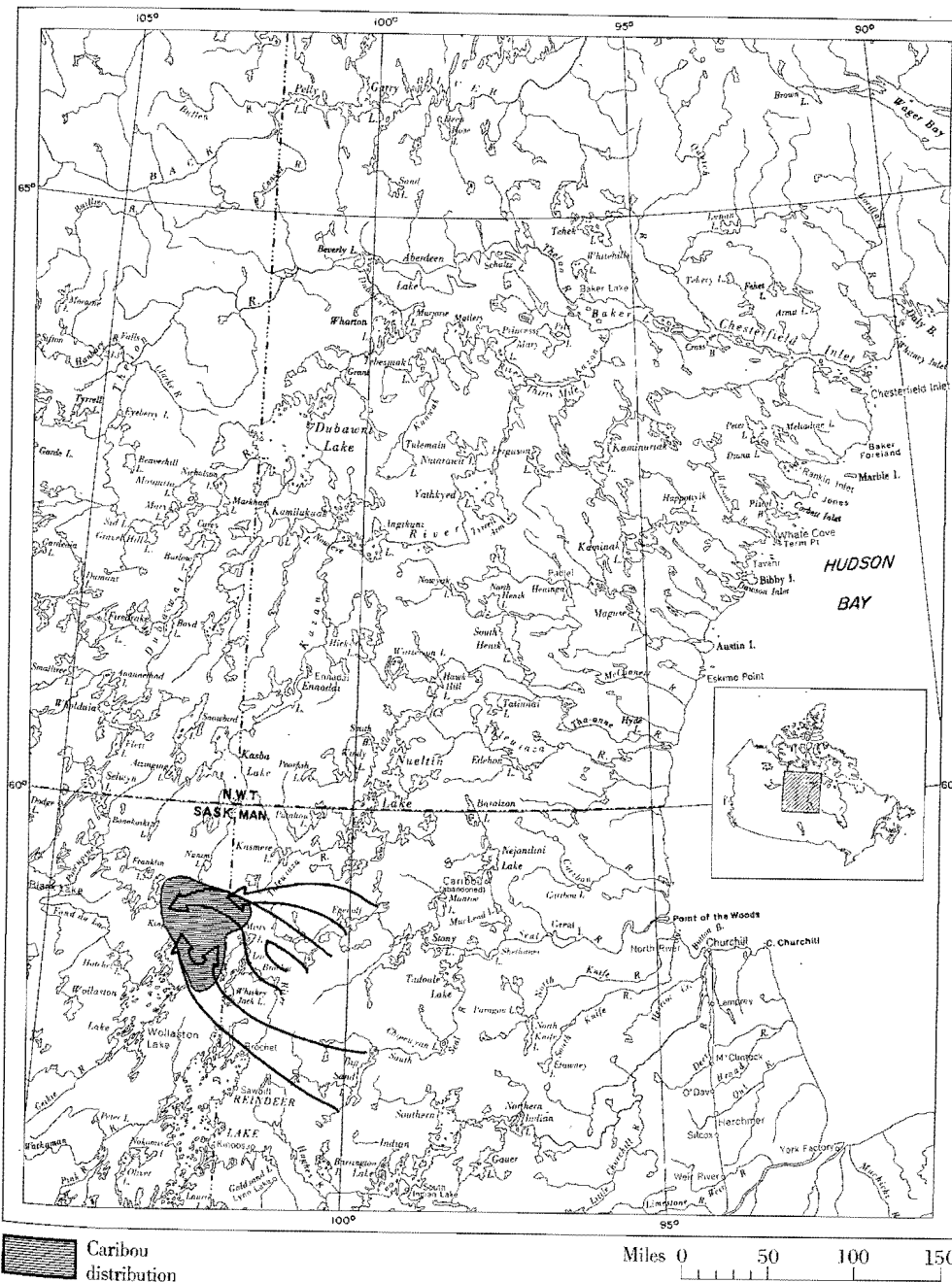


Figure 20. The early winter migration routes (November 20, 1967, to January 20, 1968) and distribution of the Kaminuriak caribou population on January 20, 1968.

Figure 20



January 31) are relatively consistent from year to year. There are typically three concentrations which move south into north-eastern Manitoba during late October or early November and continue west to the Saskatchewan border, north of Reindeer Lake, from late November to the end of January. As in spring migration, the vanguard of the early winter movement across northern Manitoba contains the highest density of caribou.

It is difficult to distinguish between fall migration and the period of early winter distribution. The term "fall migration" usually refers to the period when a caribou population moves from the area of rut, often in a southerly direction, to a wintering area within the taiga. With reference to the Kaminuriak Population, based on winter surveillance during 1966-67 and 1967-68, I consider the fall migration terminates when the migrating animals cease their southerly penetration into north-eastern Manitoba and begin to move west towards Saskatchewan. In 1966-67, the fall migration terminated at the end of the second week of November, whereas in 1967-68 it was slightly earlier, approximately November 10.

At the conclusion of the southerly penetration into Manitoba a westerly swing occurs. The three main concentrations continue at a more leisurely pace towards Saskatchewan, finally combining in the latter part of January. This westerly movement coincides with the period of early winter distribution, from mid-November to late January. Movement during this period is much slower than that characterizing the fall migration.

The fall migration in 1966 averaged 17 miles per day and in 1967 12 miles per day. From November 10 to 20, 1967, the three concentrations averaged 11 miles per day as they moved west towards Saskatchewan. From November 20 to late January, 1967-68, the average daily rate of travel was only 2-3 miles per day. As I will describe in the next chapter, in 1966-67 the movement west continued until March and April, tak-

Table 5
Snow depth measurements (in inches) taken at Brochet, Manitoba, from 1955-56 to 1967-68 from the Department of Transport meteorological records.

	Nov.		Dec.		Jan.		Feb.		March		April		Total snowfall (Nov.-Apr.)
	Snow-fall	Total on ground	Snow-fall	Total on ground	Snow-fall	Total on ground	Snow-fall	Total on ground	Snow-fall	Total on ground	Snow-fall	Total on ground	
1955-56	1.65	12	4.8	14	.7	18.2	2.4	19.6	4.9	11	6.5	3	20.9
1956-57	13.1	4.8	20.7	19.3	4.9	18	7.7	20	6.5	20	.4	9	53.3
1957-58	9.7	11	7.1	16	3	17	1.8	18	7.2	12	4	Tr.	32.8
1958-59	15.8	9	9.7	13	5.9	14	5.7	17	17.6	21	8.9	11	63.6
1959-60	9.8	13	6.2	?	2.9	21	4.7	?	13.4	25	10.8	8	47.8
1960-61	18.8	17	5.5	18	32.6	36	5.1	32	27.4	41	35.5	15	124.9
1961-62	19.6	27	25.3	44	6.3	48	7.1	52	16.9	60	9.3	43	84.5
1962-63	11	9	14.4	19	11.1	25	7.1	25	10.9	25	1.7	6	56.2
1963-64	8.4	6	7.2	10	15	18	8	22	8.5	19	10.1	6	57.2
1964-65	10.4	8	3.4	7	10	11	5.4	13	4.8	13	5.9	1	39.9
1965-66	13.1	8	14	17	8.4	22	2.4	23	14.2	25	8.9	12	61.0
1966-67	14.3	12	15.5	23	14.2	33	7.4	37	6.6	42	6.1	20	64.1
1967-68	14.2	14	12	22	13.1	31	5.9	30	7.8	22	10.1	10	63.1
Average	12.2	11.6	11.2	18.5	9.8	24	5.4	25.7	10.4	24	8.4	10.2	54.9

ing some of the animals into the south-eastern corner of the District of Mackenzie.

One obvious question is, are the three fall and early winter concentrations composed of the same individuals as the eastern, central, and western concentrations of late summer? Due to climatic conditions it was impossible to determine the isolation of the three late summering concentrations during the rut. Whether all three concentrations did join in 1966 and 1967, prior to the fall migration, is unknown. I feel the evidence supports the possibility that the three late summering concentrations retain their identity throughout the rut and remain discrete during the period of early winter distribution. It is also possible that a common area of rut is shared for a short period of time in October, but as the stimulus for fall migration increases the three aggregations separate and move south independently.

One method for determining their discreteness might be to mark a sample of caribou from each summering concentration and to make later aerial observations of marked animals during fall migration and early winter distribution.

In August 1967, 11 caribou belonging to the late summer central concentration were captured at water crossings near Nejanilini Lake, Manitoba, and marked with brightly coloured collars. On January 20, 1968, one of these collared caribou was observed at Fort Hall Lake, Manitoba. This animal was with the northerly concentration which had moved south in early November to the east of Nejanilini Lake, then west past Tadoule Lake and northwest to Fort Hall Lake. This one observation suggests caribou comprising this early winter movement belong to the late summer central concentration.

Caribou appear to have little difficulty travelling or feeding when snow depths are less than 23 inches (Pruitt, 1958). This depth is not usually exceeded until the end of January (Table 5), the average depth at that time being 24 inches. During November, December, and most of January the caribou are in three concentrations moving independently towards northeastern Saskatchewan. As snow depths increase, restricting ease of movement, the three aggregations combine, usually near the Cochrane River system. Their movement pat-

terns and distribution during late winter and early spring (February to May) depend on environmental conditions encountered in late January. In years of excessive snow depth (1966-67) movement may continue, usually to the northwest, until more favourable snow depths are found. When snow depths are near the average, the animals may remain relatively stationary until the spring migration (1967-68). When snow depths are less than average, caribou tend to disperse over a wide area and erratic movement patterns may occur. In March 1969, an aerial survey found caribou widely scattered in northeastern Saskatchewan and northwestern Manitoba. Caribou within the one concentration observed in Manitoba were moving northeast just to the south of Nejanilini Lake. The depth of snow was very light at this time, and Brochet recorded only 16 inches at the end of January 1969. There are undoubtedly many other environmental factors affecting caribou behaviour and distribution during the winter months. Pruitt (1958) elaborates on how various snow characteristics affect caribou in different ways.

Although the Cochrane River area has traditionally been a favoured wintering area for barren-ground caribou, the fall migratory routes and early winter distribution have altered within the past 10-15 years. Banfield (1954) distinguishes three fall migratory routes into northern Manitoba, but his concentrations remained separate throughout the winter and caribou penetrated much farther south than during the present study. In the late 1940's and early 1950's, barren-ground caribou wintered as far south as Gods Lake and Cross Lake, some 400 miles south of the Territorial border. During the present study, maximum penetration into Manitoba was less than 200 miles south of the Territorial border. Banfield reports the fall or autumn migration commencing in early November and terminating by January. The eastern fall migratory route, as documented by Banfield in the late 1940's and early 1950's, followed the coast, crossing the Churchill River and continuing south into the Gods Lake, Cross Lake, and York Factory area. The central route passed south through Nejanilini Lake to the southwest side of Southern Indian Lake. The western route followed the western shore of Nueltin Lake south into the Reindeer Lake country. The total population was estimated by Banfield (1954) at 120,000 animals.

I have presented evidence earlier which suggests this extreme penetration south by the Kaminuriak Population is a periodic phenomenon. The last extreme winter range extension south appears to have begun in the late 1930's, reached a peak in the late 1940's, and thereafter receded in extent, until by the late 1950's very few caribou crossed to the south of Churchill River during the fall migration. During the present study, there was no evidence of caribou crossing the Churchill River or wintering south of 57°N. With the extension of winter range limits in the late 1930's and 1940's there was an apparent sharp increase in caribou numbers, probably caused by an influx of animals from one or more of the western populations.

The western route through Nueltin Lake and south into the Reindeer Lake country appears to have been abandoned by the mid-1950's. In the early 1950's, caribou from the Duck Lake movement began swinging west and northwest into the Brochet area. This western swing increased in intensity until by the early 1960's the entire population followed fall and early winter migratory routes similar to those described for the present study.

Late winter and spring distribution

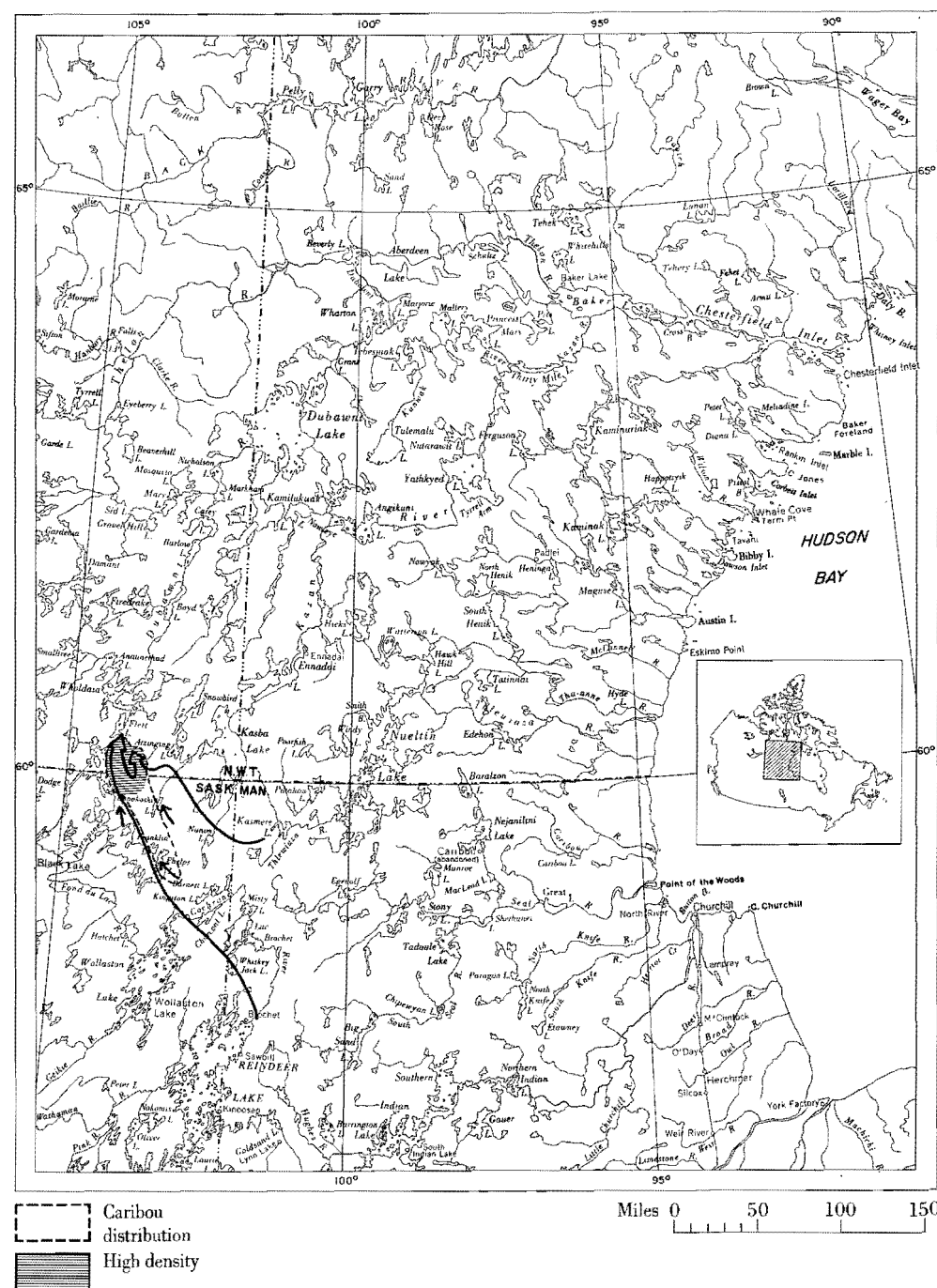
The late winter distribution varied considerably between 1966-67 and 1967-68. In 1966-67, many caribou remained on the coastal tundra throughout the winter. Those that migrated south into the taiga continued a westerly penetration into northeastern Saskatchewan until mid-April. This westerly movement took the vanguard into the District of Mackenzie as far as the southeast end of Wholdala Lake. This was well within the normal winter range of caribou belonging to the Beverly Population. Caribou of the latter population had moved southwest through this area in November and December but were located to the south as the Kaminuriak Population approached the east side of Selwyn Lake. There was little contact between the two populations even in late winter.

The vanguard of the late winter movement west during 1966-67 travelled an average of 3 miles per day during February, 2 miles per day during the first 2 weeks of March, and slightly less than 1 mile per day from mid-March to the first of April.

By the last week of February 1967, the vanguard had pushed across the northeast corner of Saskatchewan and crossed the Territorial border near Bailey Lake. Upon entering the Northwest Territories, the vanguard immediately turned southwest, moved back into Saskatchewan and continued moving west towards Selwyn Lake. By late February most caribou had crossed over into Saskatchewan, while only scattered adult males remained in Manitoba between Brochet and Southern Indian Lake.

Figure 21. The area of late winter distribution (February to April 1967) of the cow, calf, and juvenile segment of the Kaminuriak caribou population which wintered within the taiga, and their location in late April 1967.

Figure 21



By mid-March 1967, the vanguard had turned on approaching Selwyn Lake and here the westerly movement ceased. From mid-March to late April caribou continued to build up in numbers in the area east of Selwyn Lake along the Striding River and the Saskatchewan-Territorial border. Those caribou distributed southeast of the vanguard continued to move to the northwest and by late April most caribou, excluding adult males, were concentrated in the area east of Selwyn Lake. The spring migration northeast towards the calving grounds began during the last week of April 1967.

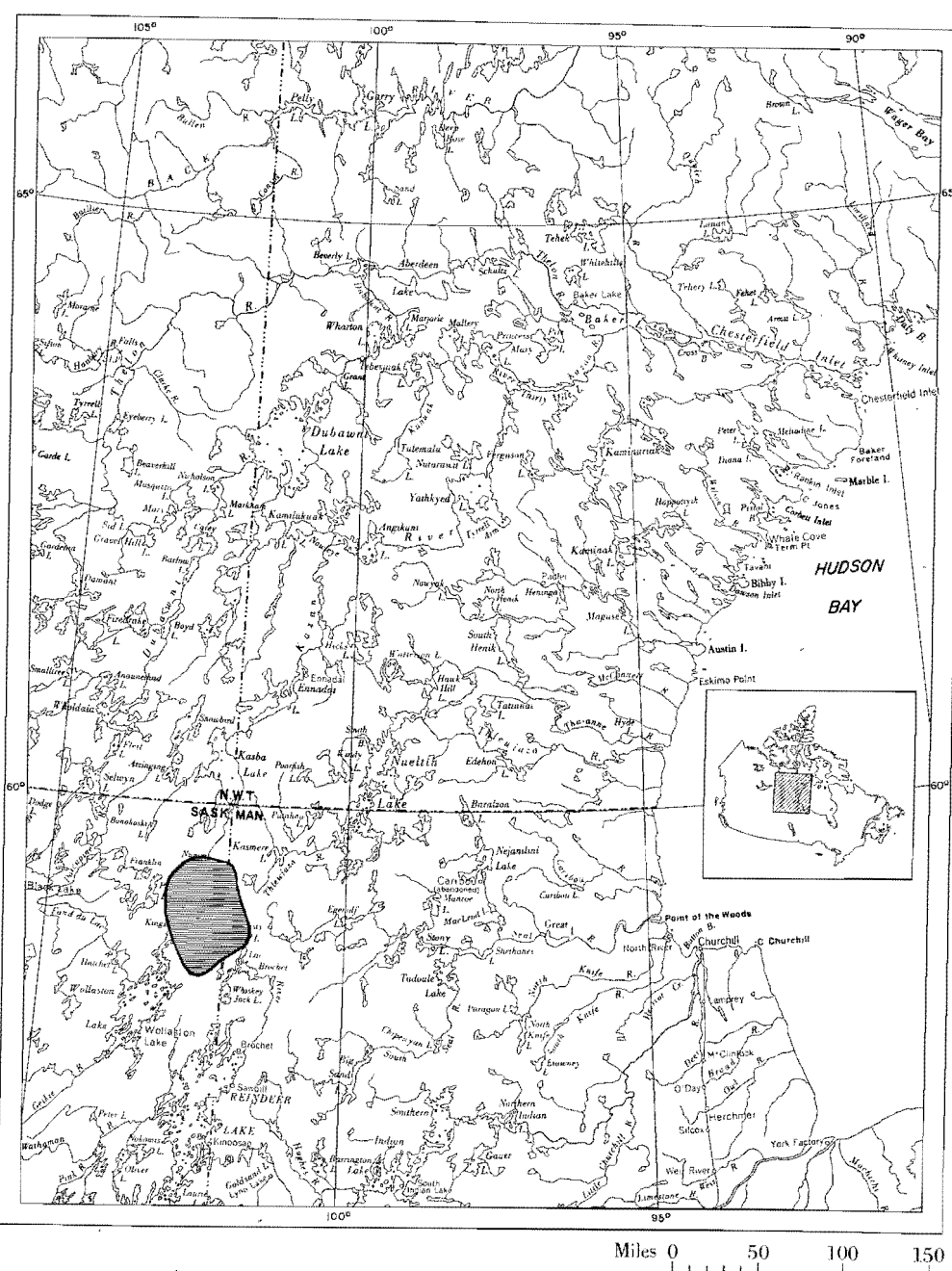
Snow depths from January to April 1967 were considerably greater than the 13-year average recorded at Brochet, Manitoba. The excessive depth of snow possibly motivated the animals to continue to the northwest seeking more favourable conditions. Snow depth measurements taken in early April indicated a considerable break between Brochet and the east side of Selwyn Lake, approximately 200 miles to the northwest. The snow depth at Brochet at the end of March was 42 inches (Table 5). At Obre Lake, east of Selwyn Lake, the snow depth in the bush was recorded at 33 inches. The late winter distribution by the cow, calf, and juvenile segment of the population from February to late April 1967 is shown in Figure 21.

In 1968 the late winter distribution varied considerably from that of 1967. The early winter movements and distribution, as previously described, were very similar in the 2 years.

In January 1968, the main concentration of cows, calves, and juveniles moved west across the border into Saskatchewan. As described previously, this movement consisted of three separate concentrations which had followed individual routes across northern Manitoba. The northern two concentrations joined and moved towards Phelps Lake. They then turned south and back east, reaching the Charcoal Lake area and here joined the third concentration which had recently penetrated

Figure 22. The area of late winter distribution (February to April 1968) of the cow, calf, and juvenile segment of the Kaminuriak caribou population which wintered in the taiga in 1967-68.

Figure 22



into Saskatchewan, having moved northwest from Big Sand Lake. By mid-February, a northerly movement was in progress and caribou were moving north across Charcoal Lake, past Hara and Kingston lakes and swinging northeast. Near the end of February a reverse movement occurred, the northernmost caribou moving south and southeast towards Misty Lake and southwest towards Sava and Waspison lakes. By mid-March a northerly movement was again in progress and the wintering caribou were separated into two distinct concentrations. One moved into the Hara-Neyanun lakes region while the other remained in the Charcoal Lake area. There was also a small concentration which remained near Misty Lake. This concentration remained relatively stable until late April when the southerly concentration moved northwest past Misty Lake and began the spring migration to the calving ground. The northern concentration remained stationary while the Charcoal Lake caribou were migrating northeast to Nueltin Lake in mid-May. Although the area of late winter distribution was restricted in 1968, local movement patterns were occurring continuously.

From February to May there were two local areas of high caribou density. One of these areas was centred near Hara Lake while the other was slightly more to the south, near Charcoal Lake. Caribou were distributed between and around these two areas, and with continuous local movement patterns, considerable interchange of caribou occurred. The area of late winter distribution from January to May 1968 is shown in Figure 22.

Five surveys were flown over the area of caribou distribution from January to April 1968, and the number of caribou was estimated at $51,214 \pm 4,612$ at the 95 per cent confidence level. This included the majority of adult females, calves, and juveniles within the population plus a small number of the adult males.

The area of caribou distribution decreased and densities increased from Janu-

ary to April 1968. The area of distribution decreased from 3,594 square miles in January to 682 square miles by April. Caribou densities during this same period increased from 14 caribou per square mile to 68.5 caribou per square mile. This is an extremely high density of caribou for such an extended period of time. Kelsall (1968) recorded a density of 65.3 caribou per square mile near the north shore of Great Slave Lake in 1954-55 but thought the herd had been on that range for only a few weeks. Although surveys were not flown in 1966-67 to obtain a total estimate, densities in March and April near Selwyn Lake certainly must have approached 50 to 60 caribou per square mile. Kelsall (1968) suggests densities approaching 60 or more caribou per square mile on winter range for an extended period are uncommon. My observations suggest such densities may occur frequently during the winter months, depending on environmental conditions during the mid and late winter period.

Snow depths in the late winter of 1967-68 were greater than the 13-year average at Brochet (Table 5), but did not reach the depths recorded for 1966-67. Snow depth in late January 1969 was only 16 inches, far below the 13-year average of 24 inches, and the depth in March did not exceed 18 inches. A short survey flown in March 1969 found caribou distributed over a vast area.

During winters of excessively deep snow in the taiga, caribou continue to move, generally back toward the tree-line, seeking out areas containing favourable snow conditions, particularly areas with minimum snow depths. During such winters, caribou may move back onto the tundra, or remain north of the tree-line all winter. When snow depths are not much greater than average, caribou wintering in the taiga may become relatively sedentary, with densities increasing throughout the late winter months. Caribou tend to disperse over a wide area when winter snow depths are less than average and restrictions on movement and feeding are minimal. The preceding generalities on caribou movement

and distribution are based on only a few years' observations and there are undoubtedly many nival characteristics other than depth which influence late winter movement and distribution patterns.

Adult male winter distribution

Unlike the cow, calf, and juvenile segment of the population which usually forms large winter concentrations, adult males remain in small bands, usually distributed to the south of the main wintering area. As the fall migration from the tundra into the eastern portion of the forested winter range is in progress, most adult males move south with the main body of caribou. The rut may still be in progress, and although many bulls have regrouped into segregated bands, others are still engaged in breeding activity. By mid-November the rut has terminated, except for a few younger males, and the main body of caribou has ceased its southerly movement and is moving west towards the Saskatchewan border. Bands of adult males, although many still carry their antlers, begin dropping out of the main body of animals, and drift southwest. They also drop behind the vanguard and set a more leisurely pace as they cross northern Manitoba. By January segregation of adult males from the main wintering concentration is complete, and bull bands are distributed from Southern Indian Lake west to Reindeer Lake and northwest to northern Wollaston Lake. A few adult males may remain on the eastern perimeter of the cow, calf, and juvenile distribution, along the lower Cochrane River and the Lac Brochet-Whisky Jack lakes region. The wintering distribution of adult males becomes quite restricted. Favoured adult male wintering areas are Big Sand Lake, Horseshoe Lake, lower Cochrane River, and the north and northeast side of Wollaston Lake east to Whisky Jack Lake and southeast to Reindeer Lake (Fig. 23).

Although the main body of wintering cows, calves, and juveniles may remain discrete from the nearby Beverly Population, there is contact between adult males from

the two populations in the area north of Wollaston Lake. The extent of interchange by males between populations is unknown, but it is probable that adult males are not as loyal to a particular population as adult females appear to be.

Kill statistics from the coastal communities suggest a high percentage of those caribou wintering on the tundra are males over 1 year of age. From November to May of 1967-68, 58 per cent of the caribou over 1 year of age shot by Eskimos from Rankin Inlet, Whale Cove, and Eskimo Point were males. At these same communities males over 1 year of age made up only 45 per cent of the summer and fall kill.

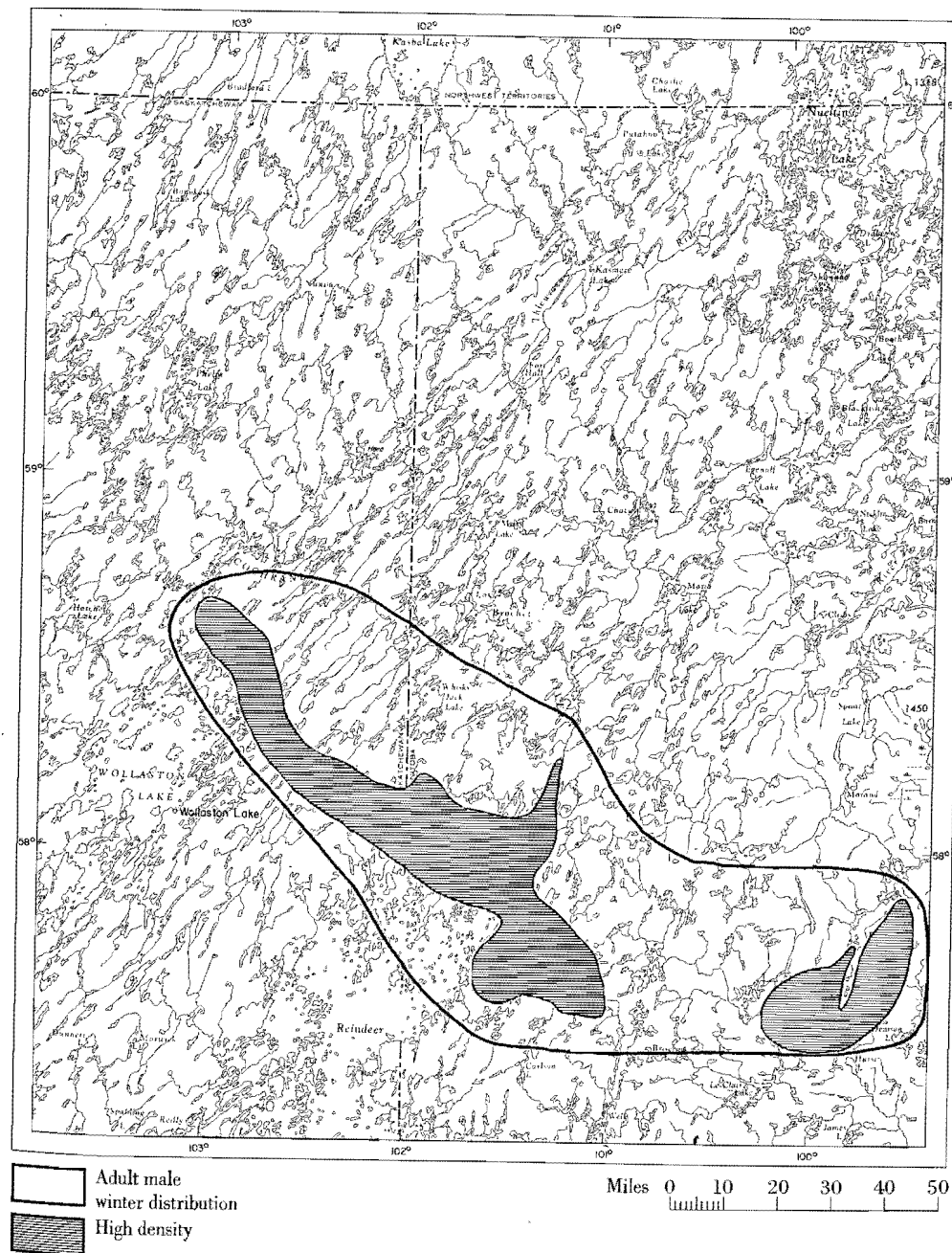
Males in their first, second, and third winter usually remain with the predominantly cow concentrations. Males in their fourth winter may join the bull bands or remain with the cow and calf groups. Males in their fifth winter and older usually remain south of the cow, calf, and juvenile groups.

The reason for adult males wintering south of the main wintering groups is largely unknown. This segregation of adult sexes benefits the females, calves, and juveniles as they undoubtedly concentrate on the prime winter range under the most favourable existing conditions without competition from adult males. Adult males are capable of sustaining themselves in deeper snows and less favourable conditions due to their superior body size and physical strength. This winter segregation phenomenon may be the result of social dominance between the adult classes. Adult males are antlerless while adult breeding females carry their antlers until the following calving period. Adult males may winter away from the cow bands not from choice but from necessity. Most 2-year-old males and many of the 3-year-olds carry their antlers throughout much of the winter which places them close in dominance to the adult females and permits them to remain within the cow groups.

As the spring migration to the calving ground begins in late April and early May, many adult males have moved north into

Figure 23. Important wintering areas (January to May) for adult male caribou of the Kaministiquia Population during the winters of 1966-67 and 1967-68.

Figure 23



the southern fringe of cow, calf, and juvenile distribution. They do not, however, move north out of the taiga with the cows but rather follow the retreating snow line north, moving at a leisurely pace and spreading out over much of the range north of the tree-line.

Introduction

A comprehensive literature review of aerial surveys used in wildlife research and management would be a monumental task, which this report will not attempt. Practically every state and province in North America has used aerial surveys to obtain population estimates of various species of game birds and mammals. Most surveys can be classified by method into one of the following six general categories.

1. Linear strip transect survey

This technique consists of flying spaced transects over a predetermined area of animal distribution. A standard altitude and angle of observation result in a constant strip beneath the plane within which all animals are counted. The number of animals per square mile is calculated and extrapolation provides an estimate of the population within the area surveyed. The area surveyed may be divided into strata depending upon the distribution of the animals on transect. The total number of animals within each stratum is then calculated from the results of the enclosed transects. This has been the most frequently used technique for caribou inventories. Banfield (1954), Kelsall (1957, 1960), Loughrey (1955, 1956, 1957), Williams (1966), Tener (1963), Kelsall and Hawley (1966), and Thomas (1969) used this technique for estimating caribou populations in the Northwest Territories, and Bergerud (1963) used it in Labrador and Newfoundland.

2. Stratified random sampling survey

The occupied range of the population is divided into strata based on varying densities. Each stratum is then divided into a grid of standard sampling units. The numbers of animals on randomly chosen units are counted. Intensity of sampling depends on the estimated density within each stratum. Standard statistical methods are used to calculate the total population. This technique has been used to census moose (Evans *et al.*, 1966) and caribou (Siniff and Skoog, 1964) in Alaska.

3. Total count census

This technique consists of counting all the animals within the area occupied by a population. This method is difficult and therefore rarely used. It has been used, with limited success, for determining elk populations in Montana (Lovaas *et al.*, 1966). The total count census has been used successfully in areas where animals are usually in groups and not obscured by vegetation, such as elephants on the plains of Africa (Buss and Savidge, 1966). This technique has never been applied to caribou populations, although total counts of parts of populations, combined with sampling surveys of the rest, have been used during seasonal migrations (Thomas, 1969).

4. Aerial photography

Aerial photography has been used extensively for determining the size of animal populations, mainly as an aid during sampling surveys. Photography of waterfowl nesting colonies and areas of seasonal concentration has long been used, usually for obtaining an annual index of species abundance to assist in management programs. Milton and Darling (1966) summarize the uses of aerial photography in wildlife management and research and provide examples of its application. Aerial photography has been used extensively in Africa to determine the size and composition of large game animal populations (Watson, 1966).

Aerial photography is essential for determining the size of large aggregations of many hundreds or thousands of animals. It can be most effective in areas void of heavy forest cover, such as the open grasslands of Africa or the northern tundra.

Banfield (1954) first used photography to assist in estimating size and composition of herds of barren-ground caribou in northern Canada during the late 1940's. Loughrey (1955, 1956, 1957) used aerial photography to obtain composition data for barren-ground caribou in the District of Keewatin. Thomas (1969) relied on aerial photography during his spring survey of the three western caribou populations for composi-

tion data and as an aid in determining total numbers during spring migration.

5. Infra-red and heat-sensitive photography
Although depending on similar search and photographic techniques as standard photography, heat-source sensing applied to wildlife inventory differs sufficiently to require separate discussion.

Some of the wide range of application of remote sensing devices are described in the Proceedings of the Fourth Symposium on Remote Sensing of Environment (1966). The possibilities for its application in wildlife inventories appear virtually unlimited. Croon *et al.* (1968) had partial success with remote sensing equipment applied to the white-tailed deer herd on the George Reserve in Michigan.

... the inability of infra-red to penetrate green leaf canopy, variability of animal and background apparent temperatures depending upon weather and other factors, difficulty in distinguishing between species of animals, and high initial cost of the scanning device are substantial limitations to the use of the technique. (p. 751)

The use of remote sensing devices for censusing barren-ground caribou has not yet been attempted. Once suitable applications have been developed, it can be expected to provide more accurate population inventories than any existing technique.

6. Habitat sampling survey

This census technique is typically applied to animals which are restricted to a very limited type of habitat, e.g. furbearers such as muskrat (*Ondatra zibethica*) and beaver (*Castor canadensis*). A sample of the total drainage systems within a restricted area can be flown, counting all beaver lodges in use; knowing the average number of beaver per lodge, one can estimate the total population. It is necessary to classify the drainages into strata, based on the habitat, using recent aerial photographs.

A variation of this technique was used for determining the number of brown bears

(*Ursus arctos*) along the Chignik-Black lakes drainage of the Alaska Peninsula (Erickson and Siniff, 1963).

This technique cannot be applied to barren-ground caribou populations. It should be noted, however, that because caribou use particular areas of the range depending on the season, their populations can be inventoried by sampling an extremely small portion of the total range. In particular, a large and important segment of the herd can be surveyed on the calving ground, which comprised approximately 2 per cent of the total range of the Kaminuriak Population from 1966 to 1968.

Present study

The problems encountered in attempting to estimate the size of a barren-ground caribou population are many and varied. Brief mention will be made of several of the more important.

Perhaps the most important is the remoteness of the study area and the extreme climatic conditions there. Aircraft must operate under severe conditions, and mechanical failure may ground one for days. At certain seasons of the year, especially during spring and fall, weather conditions may prevent a small aircraft from flying for several consecutive weeks. In our study area, the maritime influence of Hudson Bay accentuates extremely unfavourable climatic conditions.

The gregarious and migratory behaviour of barren-ground caribou creates the problem of locating the animals before any survey. As mentioned, the calving ground comprised only 2 per cent of the study area, and the proportion of total range utilized by the main wintering concentration from January to May 1968 varied from 3 per cent to .6 per cent. Locating that particular .6 per cent of the range in an area of approximately 109,000 square miles can be a major accomplishment.

The first year of the study was devoted to determining the seasonal distribution and degree of segregation of the population. Several surveys were attempted during

the first year but the results were not satisfactory. A survey of the calving ground in June 1967 and surveys over two of the late summer concentrations in 1967 did not prove successful, but provided experience for future surveys.

The first successful aerial surveys were conducted during the winter of 1967-68. They were followed by a survey over the calving ground in June 1968 and aerial photography over the area of post-calving distribution in July 1968. Data from these surveys, combined with information obtained on fall adult sex ratios, adult female pregnancy rates, and annual recruitment and mortality resulted in a total population estimate.

Winter surveys

It was fortunate that in 1967-68 the main body of cows, calves, and juveniles wintered within a very small proportion of the total range and remained relatively stationary from mid-winter until spring migration. Very few caribou wintered along the coastal tundra as they may do in certain years.

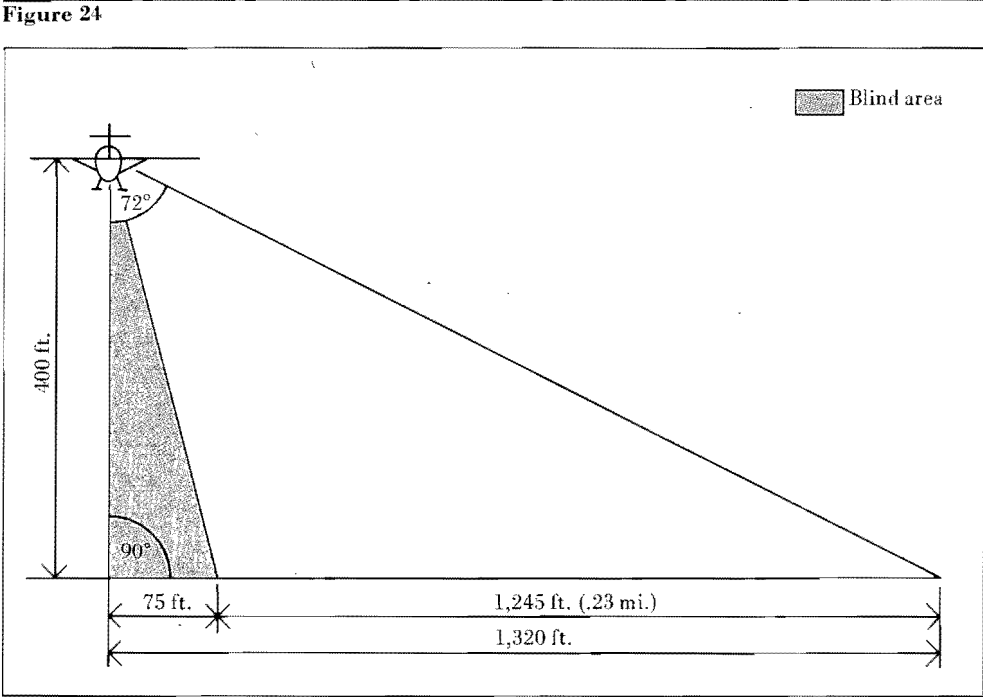
By January 1968, the main caribou concentration was located north of Reindeer Lake, near the Manitoba-Saskatchewan border, where it remained until May (Fig. 22). The majority of adult males (36 months or older) were outside this area, although within the taiga.

Methods

The first survey was conducted during mid-January 1968. Distribution of the animals within the taiga eliminated the possible use of photography as a census method. A stratified random sampling survey would not have proven satisfactory due to the high density of caribou within the taiga. The method chosen was the linear strip transect survey. A transect width of one half mile could be adequately covered by two observers at an altitude of 400 feet.

By spacing markers on a frozen lake surface, it was determined that a blind spot 75 feet wide existed beneath each observer. This was excluded in the calculations, so

Figure 24. A sketch showing the specifics for the transects flown during caribou surveys of the Kaminuriak Population from January to April 1968.



that the total width of the transect on which caribou were counted was .46 of a mile. The plane window and wing strut were marked with tape at an angle of 72° with the line of vision to the ground, assisting each observer in determining the transect width (Fig. 24). The aircraft used on all aerial surveys was a Cessna 180 with long-range fuel tanks and an air speed on transect of approximately 100 mph. I always acted as the first observer and three different individuals acted as second observer during the winter surveys. The approximate boundaries of caribou distribution were determined by preliminary flying before each survey. Before beginning each survey, transects were drawn over the area of distribution on 4 mile = 1 inch topographic maps. Transects were divided into equal sections, each marked with a letter. A line was drawn on a notebook page representing the transect, with equivalent lettered sections. As a transect was being flown, observations were recorded in the notebook at the appropriate spot on transect. This pre-

vented the map from becoming cluttered with observations and allowed for later stratification of the area based upon similar caribou densities. Surveys were completed in 1 day except for the January survey which required 2 days.

Results
Monthly aerial transect surveys were flown over the main wintering concentration of the Kaminuriak Population from January to April 1968. Two surveys were flown on consecutive days in February, resulting in a total of five winter surveys over a concentration of caribou which experienced little change in total numbers over this 4-month period. The proportion of occupied range surveyed was 11.4 per cent except for the two February surveys when it was increased to 18.3 per cent and 22.7 per cent.

January survey
The total area occupied by caribou in January was 3,594 square miles. The linear transects flown are shown in Figure 25. The

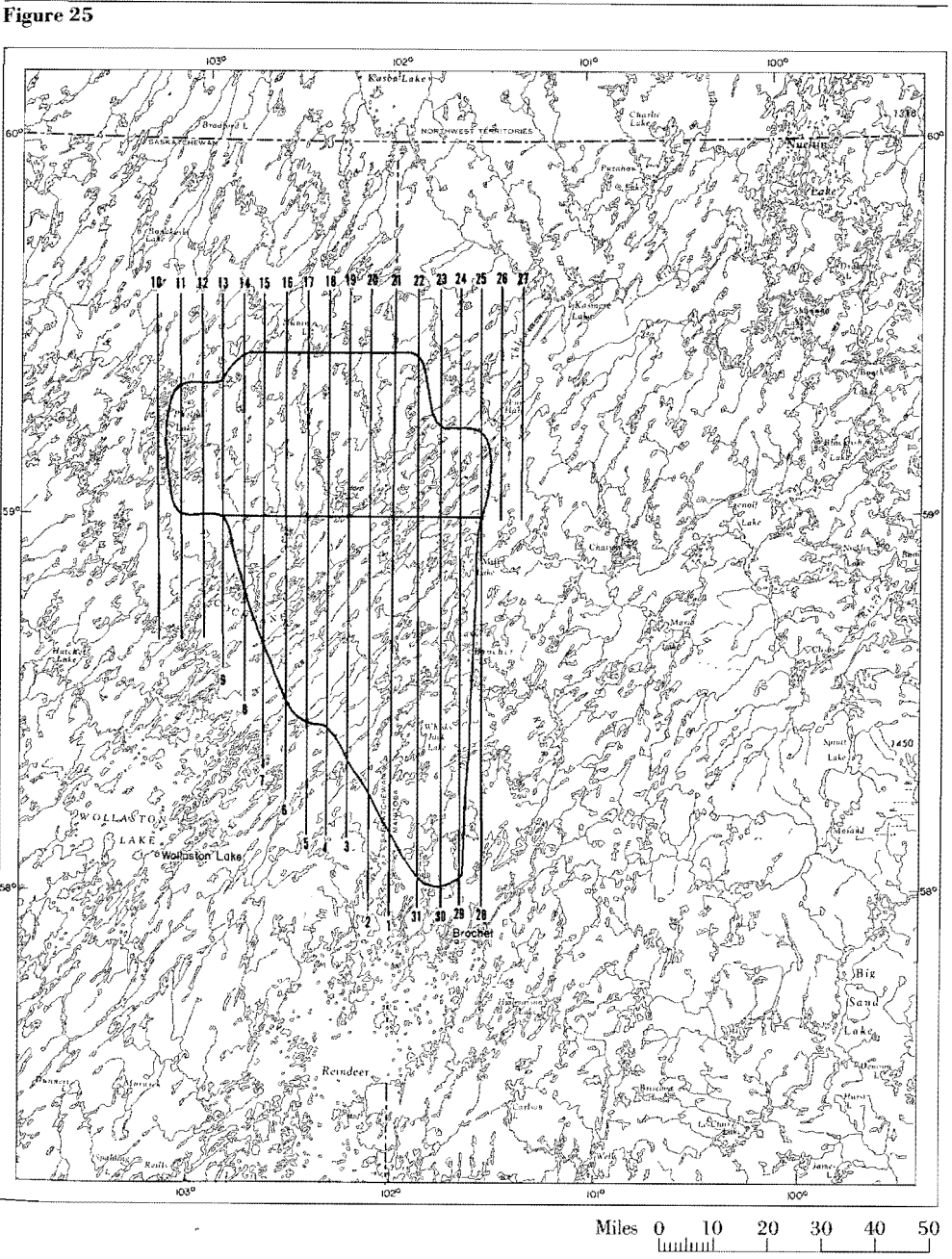
occupied area, divided into strata based on caribou density, is shown in Figure 26. Results from the survey and calculations of caribou numbers are provided in Tables 6 and 7.
The average density was 14 caribou per square mile, with extremes of 2.4 and 40.5 per square mile. The number of caribou in the area was calculated to have been 51,545.

February survey
The area occupied by caribou had decreased considerably by the time of the February survey. The total area occupied was calculated at 1,274 square miles, less than one third the extent of the January distribution. The survey technique and method of estimating total numbers were similar to the January survey. The average density had increased to 39.4 per square mile (range 1.6 to 108.4). The total number of caribou was estimated to be 50,204.

A second survey was flown the following day over the area of high density, the transects being north-south rather than east-west as the earlier ones were. This second survey was flown to determine if the direction of transects possibly influences visibility and thus results in a substantial variation between estimates of total caribou numbers, and also to provide a check on the accuracy of the previous survey. It was found that the estimated number of caribou in the area surveyed twice varied only by 230 animals (47,998 vs 48,228).

March survey
The area of distribution by March had decreased to only 870 square miles. The average caribou density had increased to 65.6 per square mile (range 6.4 to 245.2). The total number of caribou was estimated to be 57,110, an increase believed due to a movement from the south by a number of adult males. Composition figures are not available to substantiate this belief, however.

Figure 25. The area of caribou distribution and transects flown during the aerial survey in January 1968.



April survey
The area of caribou distribution was becoming very irregular by mid-April 1968, with the onset of spring migration, resulting in the total estimate of caribou in the area decreasing to 46,779 animals. Some caribou are believed to have already moved out of the main area of distribution and drifted to the north. The area of distribution had decreased to 682 square miles, only 18 per cent of the area occupied in January. The average density of caribou was 68.5 per square mile.

Discussion
The estimate of total caribou within the area of occupied range surveyed from January to April 1968 varied from 46,779 to 57,110.
Using the Student's t distribution adapted for a small sample with 4 degrees of freedom and the standard deviation from the formula

$$\bar{Sx} = S / \sqrt{n}$$

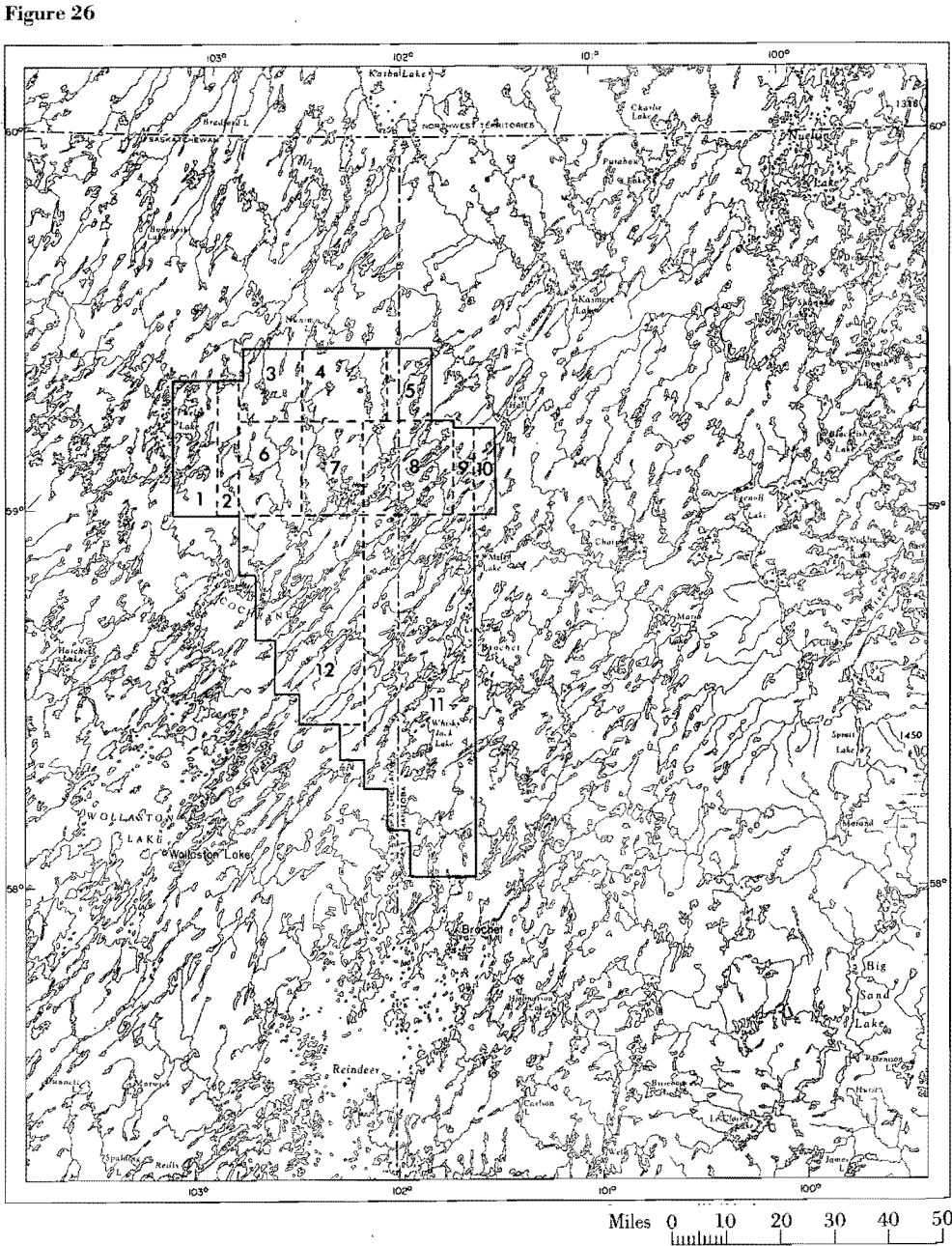
where

$$S = \sqrt{\sum (x - \bar{x})^2 / n - 1}$$

the mean number of caribou within the area occupied as delineated for each survey is estimated to have been 51,214 ± 4,612 at the 95 per cent confidence level. At the 90 per cent level the number was 51,214 ± 3,542. At the latter level the number was estimated to be between 47,672 and 54,756, the limits being ± 6 per cent of the mean.

Using a quadrat sampling method in two areas of Alaska, Evans *et al.* (1966) estimated the extent of possible variations from the mean sizes of moose populations, at the 90 per cent confidence level, to be between ± 21 and ± 32.17 per cent of the mean. Siniff and Skoog (1964), using a stratified random sampling survey technique, estimated that the Nelchina caribou herd in Alaska numbered 54,452 ± 11,867 at the 95 per cent confidence level. The results of five winter surveys over the Kaminuriak Population are in close agreement with a standard deviation of only ± 3,542 animals at the 90 per cent confidence level.

Figure 26. The area of caribou distribution surveyed in January 1968 divided into density-dependent strata used in calculating an estimate of total caribou numbers.



My results are not adjusted to account for caribou possibly unrecorded on transect. During mid-day, when the surveys were flown, most caribou were resting on lakes and were certainly counted when on transect. It is estimated that at least 80 per cent of all caribou were on the lakes when the surveys were flown. Since some animals in the bush were also counted, the number unrecorded on transect was probably less than 10 per cent.

The estimates of Observer 1 were consistently higher than those of Observer 2, probably owing to the former's experience at observing caribou in the bush from the air. Observer 1 recorded 56 per cent of all caribou observed on transect during the five winter surveys, varying from 51 per cent during the April survey to 60 per cent during the second February survey. During the calving ground survey over the open tundra in June 1968, Observer 1 recorded 53 per cent of the caribou observations.

The majority of females 36 months and older, calves, yearlings, and 2-year-old animals in the population are believed to have been within the area surveyed. Most adult males 36 months and older were excluded from the winter estimates.

The winter caribou distribution in 1967-68 was such that an estimate was possible from aerial surveys. When snow depths are light the population may be distributed over much of the forested winter range and the coastal tundra area. Deep snow, such as occurred in 1966-67, appears to keep the animals moving throughout the winter and many may also remain on the tundra. Caribou might be extremely difficult to survey when a general movement is under way as those passing through the bush would possibly be hidden from view. This problem of detecting caribou in the bush may be overcome when remote sensing techniques have been further developed.

Calving ground survey
One of the few predictable behavioural patterns in the annual movement cycle of barren-ground caribou is the affinity of

Table 6
Recorded caribou observations during a linear aerial transect survey over the main area of wintering distribution of the Kaminuriak Population in January 1968.

Transect no.	Transect length	Sq. mile coverage			Caribou counted			Caribou per sq. mile		
		Obs. 1	Obs. 2	Both	Obs. 1	Obs. 2	Both	Obs. 1	Obs. 2	Both
Stratum 1										
11	24	5.5	5.5	11	32	37	69	5.8	6.7	6.2
12	24	5.5	5.5	11	46	44	90	8.3	8	8.1
Stratum 2										
13	24	5.5	5.5	11	225	221	446	40.9	40.1	40.5
Stratum 3										
14	12	2.8	2.8	5.6	70	10	80	25	3.5	14.2
15	12	2.8	2.8	5.6	62	13	75	22.1	4.6	13.3
16	12	2.8	2.8	5.6	37	11	48	13.2	3.9	8.5
Stratum 4										
17	12	2.8	2.8	5.6	90	13	103	32.1	4.6	18.3
18	12	2.8	2.8	5.6	103	65	168	36.7	23.2	29.9
19	12	2.8	2.8	5.6	134	56	190	47.8	20	33.9
20	12	2.8	2.8	5.6	45	106	151	16	37.8	26.9
Stratum 5										
21	12	2.8	2.8	5.6	0	19	19	0	6.7	3.3
22	12	2.8	2.8	5.6	58	0	58	20.7	0	10.3
Stratum 6										
14	19	4.4	4.4	8.8	70	72	142	15.9	16.3	16.1
15	19	4.4	4.4	8.8	207	64	271	47	14.5	30.7
16	19	4.4	4.4	8.8	81	86	167	18.4	19.5	18.9
Stratum 7										
17	19	4.4	4.4	8.8	30	53	83	6.8	12	9.4
18	19	4.4	4.4	8.8	29	51	80	6.5	11.5	9
19	19	4.4	4.4	8.8	97	21	118	22	4.7	13.3
Stratum 8										
20	19	4.4	4.4	8.8	265	193	458	60.2	43.8	52
21	19	4.4	4.4	8.8	109	106	215	24.7	24	24.3
22	19	4.4	4.4	8.8	259	137	396	58.8	31.1	44.9
23	19	4.4	4.4	8.8	65	116	181	14.7	26.3	20.5
Stratum 9										
24	16	3.7	3.7	7.4	81	11	92	21.8	2.9	12.3
Stratum 10										
25	16	3.7	3.7	7.4	23	21	44	6.2	5.6	5.9
Stratum 11										
1	58	13.3	13.3	26.6	16	25	41	1.2	1.8	1.5
2	50	11.5	11.5	23	27	36	63	2.3	3.1	2.7
3	6.5	1.4	1.4	2.8	4	7	11	2.8	5	3.9
29	67	15.4	15.4	30.8	28	46	74	1.8	2.9	2.4
30	67	15.4	15.4	30.8	53	25	78	3.4	1.6	2.5
31	67	15.4	15.4	30.8	11	42	53	.7	2.7	1.7
Stratum 12										
3	38	8.7	8.7	17.4	121	185	306	13.9	21.2	17.5
4	38	8.7	8.7	17.4	107	132	239	12.2	15.1	13.7
5	38	8.7	8.7	17.4	417	287	704	47.9	32.9	40.4
6	33	7.5	7.5	15	130	213	343	17.3	28.4	22.8
7	23	5.2	5.2	10.4	94	143	237	18	27.5	22.7
8	11	2.5	2.5	5	97	20	117	38.8	8	23.4
Total				413.6	3,359	2,657	6,016			

Table 7
Estimate of total caribou numbers within the area of wintering caribou distribution surveyed in January 1968.

Stratum no.	% of area surveyed			Density (caribou per sq. mile)			Area (sq. mile)	Estimated no. of caribou		
	Obs. 1	Obs. 2	Both	Obs. 1	Obs. 2	Both		Obs. 1	Obs. 2	Both
1	5.7	5.7	11.4	7	7.3	7.1	192	1,344	1,401	1,363
2	5.7	5.7	11.4	40.9	40.1	40.5	96	3,926	3,849	3,888
3	5.8	5.8	11.6	20.1	4	12	144	2,894	576	1,728
4	5.8	5.8	11.6	33.1	21.4	27.2	192	6,355	4,108	5,222
5	5.8	5.8	11.6	10.3	3.3	6.8	96	988	316	652
6	5.75	5.75	11.5	27.1	16.7	21.9	228	6,178	3,807	4,993
7	5.75	5.75	11.5	11.7	9.4	10.5	228	2,667	2,143	2,394
8	5.75	5.75	11.5	39.6	31.3	35.4	304	12,038	9,515	10,761
9	5.75	5.75	11.5	10.9	1.4	6.1	64	697	89	390
10	5.75	5.75	11.5	3.1	2.8	2.9	64	198	179	185
11	5.7	5.7	11.4	2	2.8	2.4	1,262	2,524	3,533	3,028
12	5.7	5.7	11.4	24.6	22.1	23.4	724	17,810	16,000	16,941
Total							3,594	57,619	45,516	51,545

the pregnant females to return each spring to a traditional calving area.

The Kaminuriak Population had not been as intensively studied before 1966 as the more westerly mainland caribou populations. The exact calving area was unknown. Loughrey (1956) believed it was east of Kaminuriak Lake but had limited observations to support his theory. Malfair (1963) flew surveys in early June and found the area of calving to be east of Kaminuriak Lake and south towards Maguse Lake. Although spring migratory routes varied, the calving grounds in 1966, 1967, and 1968 were within the area described by Malfair.

There have been few attempts to determine the number of barren-ground caribou within the calving area by aerial surveys. Williams (1966) surveyed the calving ground of the Bathurst Inlet Population utilizing the standard strip census method. Hemming and Glenn (1969) used aerial photography for censusing calving areas in Alaska.

Methods

Surveys were flown to determine the migration routes from the taiga to the calving ground during May and early June 1968. By

June 11, most pregnant females were on the calving ground and many had already given birth.

On June 12, east-west transects, 6 miles apart, were flown to delineate the exact boundaries of the calving ground. These boundaries were outlined on 4 mile = 1 inch topographic maps. The calving area was then divided into a grid of 16-square-mile plots, numbered from 001 to 168. Using a table of random numbers, 30 of these were selected. It was later found that two of these plots lay outside the calving area, and only the remaining 28 were used in the sample.

All flying was performed in a Cessna 180 aircraft with long-range fuel tanks, permitting a maximum of 6 hours between refueling stops. An Eskimo assistant from Rankin Inlet acted as second observer, and was situated at the left rear window. The windows and struts were marked as described for the winter surveys, to assist each observer in recording all caribou within a strip of one quarter mile from the plane at an altitude of 400 feet. Although the plane was thus marked, due to the brevity of each transect (4 miles) it was not difficult for each observer to remember the location in relation to topographic features

of caribou previously counted. The transects were flown at one half mile intervals, providing total coverage of each sample plot. The blind area directly beneath the plane was calculated at .9 square mile for each plot, or 5.6 per cent of the total area. Many caribou ran out from under the plane and were thus counted. The pilot also assisted in observing caribou directly in front of the plane. This theoretical error of 5.6 per cent was therefore reduced.

The survey began on June 13. Calves were not included when calculating number of animals on the calving ground. Snow covered approximately 30 per cent of the ground, producing a brown and white mosaic appearance. Some caribou undoubtedly escaped observation against this variegated background. In the calculations, I allow for 20 per cent of the caribou not being recorded. This includes animals missed directly under the plane and those unobserved due to observer error.

A second survey was to be flown at the conclusion of the first survey to provide a comparison of techniques and results. The second survey was to be based on a division of the calving area into a grid of 36-square-mile plots of which 20 were to be randomly selected. On each selected plot, linear transects were to be flown providing approximately 30 per cent coverage. Owing to unfavourable weather and to the gathering of the caribou into nursery bands, thus changing distribution and calving ground boundaries, this second survey was not completed. Before cancellation, however, five of the 36-square-mile plots were sampled, permitting the results to be compared to the earlier survey over the same area.

Results

Deep spring snow and a late breakup resulted in difficult travelling conditions for the migrating caribou in 1968. Because of this, many cows dropped their calves farther south than in the previous 2 years, producing an extended north-south axis across the calving ground (Fig. 5). The

north-south extension of the calving ground measured 130 miles and the average width approximately 22 miles. The total area was 2,333 square miles. The calving ground, divided into the 16-square-mile grid and the 28 blocks randomly selected for the sample, is shown in Figure 27. The numbers of caribou counted on these 28 randomly selected plots are presented in Table 8. Allowing for 20 per cent of the caribou being unrecorded on each plot, the average number of caribou per square mile is 14.7.

The results of this survey can be fitted to a Poisson distribution (Table 9). The Poisson distribution with mean 2.82 was used to calculate the frequency of each class expected in the sample of 28 plots.

$$P(x) = \frac{m^x e^{-m}}{x!}$$

In a Poisson distribution the mean is equal to the variance. The difference between the mean and the variance in this distribution is .89. In sampling a caribou population this difference is considered negligible. The Chi-Square

$$\chi^2 = \frac{(O_i - E_i)^2}{E_i}$$

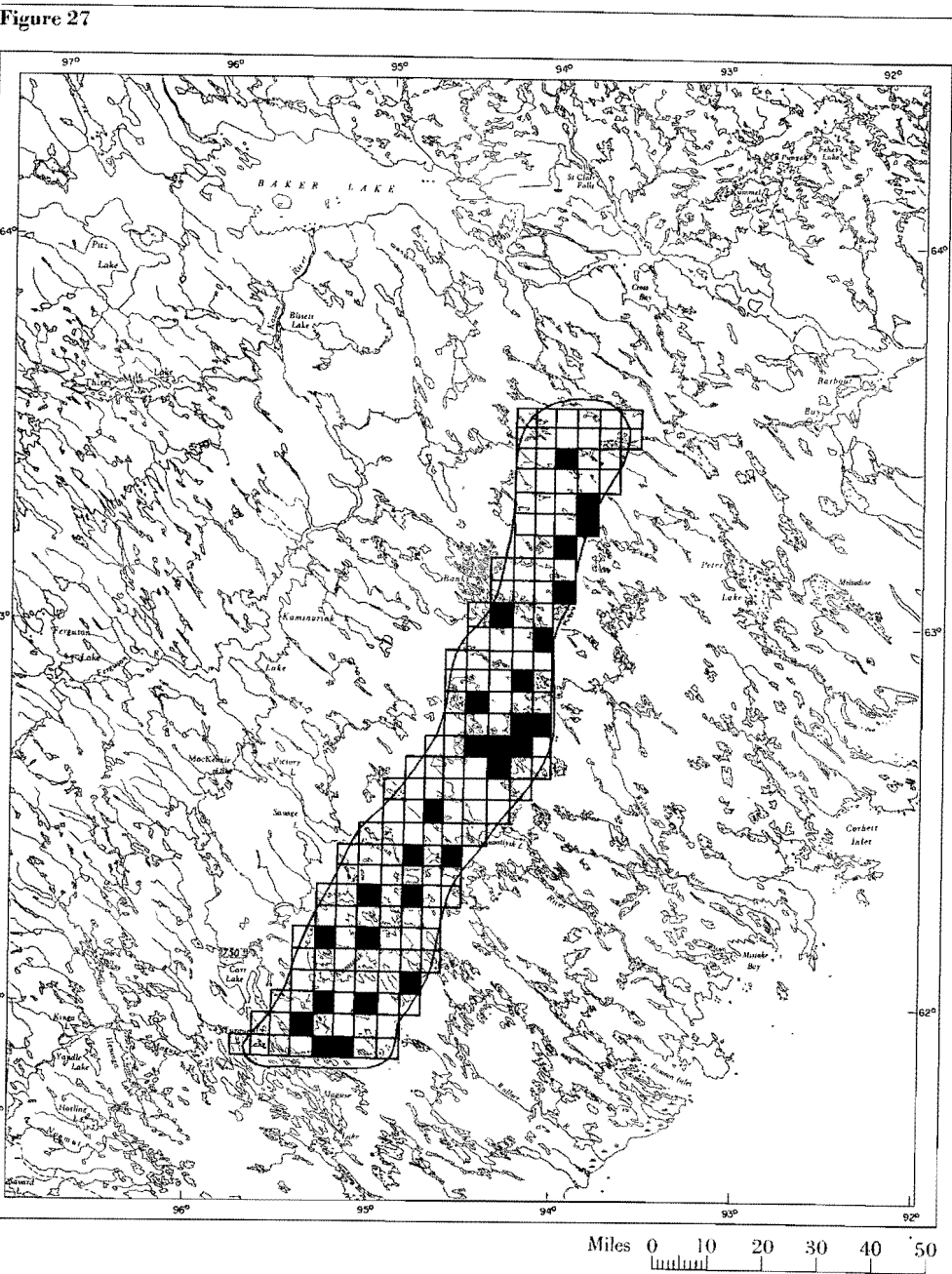
tests the observed data with the expected data (Fig. 28).

The percentage expected in each class was used to determine the number of caribou in the entire 2,333 square miles of calving ground, using the mean of each class as the number of caribou per square mile (Table 10).

The number of caribou (excluding calves) on the calving ground, estimated by fitting the observed data to a Poisson distribution, was 27,178. Adjusting for the estimated 20 per cent error, the total number of caribou on the calving ground was estimated to be 33,962.

As mentioned, a second survey was attempted but abandoned owing to unfavourable caribou distribution. Before this second survey was terminated, five of the 36-square-mile plots in the extreme northern portion were sampled. Each plot was sampled by flying east-west transects which

Figure 27. The 1968 calving ground divided into a grid of 16-square-mile plots, and the 28 plots randomly selected for a total count of caribou.



gave approximately 30 per cent coverage of each. The average caribou density, based on the five 36-square-mile plots sampled, was 10.3 caribou per square mile. The estimated number of caribou within the 475-square-mile area sampled was 4,892. Four of the 16-square-mile sample plots from the first survey were also situated within this 475-square-mile area. The average density from these four plots was 9 caribou per square mile, yielding an estimate of 4,274 caribou present. These calculations are strictly for comparison of the two techniques and are unadjusted for observer error. Estimates from the second survey are 12 per cent less than from the first.

Discussion

The most suitable time for estimating the number of breeding females within a barren-ground caribou population is during the period of calving. The affinity of pregnant females for a traditional calving ground assists the researcher in planning the survey. The lack of forest cover, the relative randomness of distribution, and the short sedentary period during calving all contribute to the accuracy of the survey estimate. Aerial and/or ground segregation can provide the composition of those caribou on the calving ground and the proper adjustments will result in an accurate estimate of the number of breeding females within the population. This is the basic figure necessary when studying the population dynamics of a caribou population. An estimate of caribou numbers in a population can be calculated using only the information obtained from a calving ground survey.

A survey similar to that flown over the 1968 calving ground is well adapted for the existing conditions. Any variation of a random sampling survey can be utilized, although I suggest stratifying the area first and adjusting the intensity of sampling accordingly. The use of two aircraft would enable an increase of sampling intensity, which would result in a more accurate estimate. Due to the relatively short period

Table 8

Caribou recorded during a random sampling aerial survey over the calving ground of the Kaminuriak Population in June 1968.

Plot no.	Area (sq. mile)	Sq. mile per observer	Caribou counted			Caribou per sq. mile		
			Obs. 1	Obs. 2	Both	Obs. 1	Obs. 2	Both
1	16	8	97	86	183	12.1	10.7	11.3
2	16	8	72	97	169	9	12.1	10.5
3	8*	4	25	24	49	6.2	6	6.1
4	16	8	69	63	132	8.6	7.7	8.2
5	16	8	100	76	176	12.5	9.5	11
6	16	8	18	39	57	2.2	4.8	3.5
7	16	8	60	72	132	7.5	9	8.2
8	16	8	164	150	314	20.5	18.7	19.6
9	16	8	31	20	51	3.8	2.5	3.1
10	16	8	232	227	459	29	28.3	28.6
11	16	8	12	14	26	1.5	1.7	1.6
12	16	8	307	457	764	38.3	57.1	47.7
13	16	8	261	181	442	32.6	22.6	27.6
14	16	8	11	13	24	1.3	1.6	1.5
15	16	8	56	46	102	7	5.7	6.3
16	16	8	92	110	202	11.5	13.7	12.6
17	16	8	88	77	165	11	9.6	10.3
18	16	8	10	17	27	1.2	2.1	1.6
19	16	8	123	88	211	15.3	11	13.1
20	16	8	371	111	482	46.3	13.8	30.1
21	16	8	24	51	75	3	6.3	4.6
22	16	8	150	217	267	18.7	27.1	22.9
23	16	8	23	0	23	2.8	0	1.4
24	16	8	66	76	142	8.2	9.5	8.8
25	16	8	106	3	109	13.2	.3	6.8
26	16	8	47	34	81	5.8	4.2	5
27	16	8	48	45	93	6	5.6	5.8
28	16	8	94	32	126	11.7	4	7.8
Totals	440	220	2,758	2,428	5,186	12.3	10.8	11.5
Adjustment for 20% error			3,477	3,055	6,482	15.8	13.7	14.7

*One half plot outside area of distribution.

during calving when the survey is feasible and to the frequently unfavourable weather, the use of two or more planes is highly recommended.

A survey over the calving ground must be performed in a few days before, during, or after the peak of calving. This period may last less than 1 week. Before and after this period the animals are in larger groups, do not approach a random distribution, and many are moving considerable distances daily. I do not wish to imply these condi-

tions are completely satisfied during the period of peak calving. I do not believe such conditions as randomness of distribution or sedateness are ever completely realized in barren-ground caribou populations. The period of calving, however, appears to be the one time when such conditions are most nearly fulfilled.

Post-calving photography

Barren-ground caribou of the Kaminuriak Population have not penetrated north past

Table 9

Results of a random sampling survey over the calving ground of the Kaminuriak Population in June 1968, fitted to a Poisson distribution.

Class	Caribou per sq. mile	No. of plots in class	No. of plots expected by Poisson distribution	X ²
0	0	0	1.6688	.042
1	0-5	7	4.7085	
2	5-10	9	6.6390	.840
3	10-15	6	6.2468	
4	15-20	1	4.4044	.835
5	20-25	1	2.4850	
6	25-30	2	1.1687	
7	30-35	1	.4712	
8	35 +	1	.1652	
Total		28	27.9576	1.727*

*X².05 = 7.83 for 3 d.f. Result is not significant, but indicates observations agree with the expected.

Chesterfield Inlet and Baker Lake during the past 10 to 12 years. To the west, the Kazan River forms another boundary, although not much of an obstacle if the animals desired to cross.

After calving, most females and calves and some yearlings move north across the calving grounds into the area south of Baker Lake and east of the lower Kazan River. In early July they are joined here by adult males, 2-year-old animals, and non-breeding adult females. The herds remain within this northern portion of their summer range until approximately the third week of July. It is during this 4- to 5-week period following calving that the large post-calving aggregations are formed. The concentrating of a large proportion of the population within a relatively small portion of the summer range creates an ideal situation for aerial photography of each aggregation. Thomas (1960) used aerial photography to assist him in estimating a large post-calving aggregation of approximately 100,000 caribou near Beverly Lake, N.W.T., during mid-July 1960. Andreev (1961) experimented with the use of aerial photography during July 1958, counting large summer concentrations of wild reindeer in the northern parts of the Taimyr Peninsula,

Russia. The post-calving area used by the Kaminuriak Population is unique in that it is relatively small and is bounded by natural barriers which the animals appear reluctant to cross.

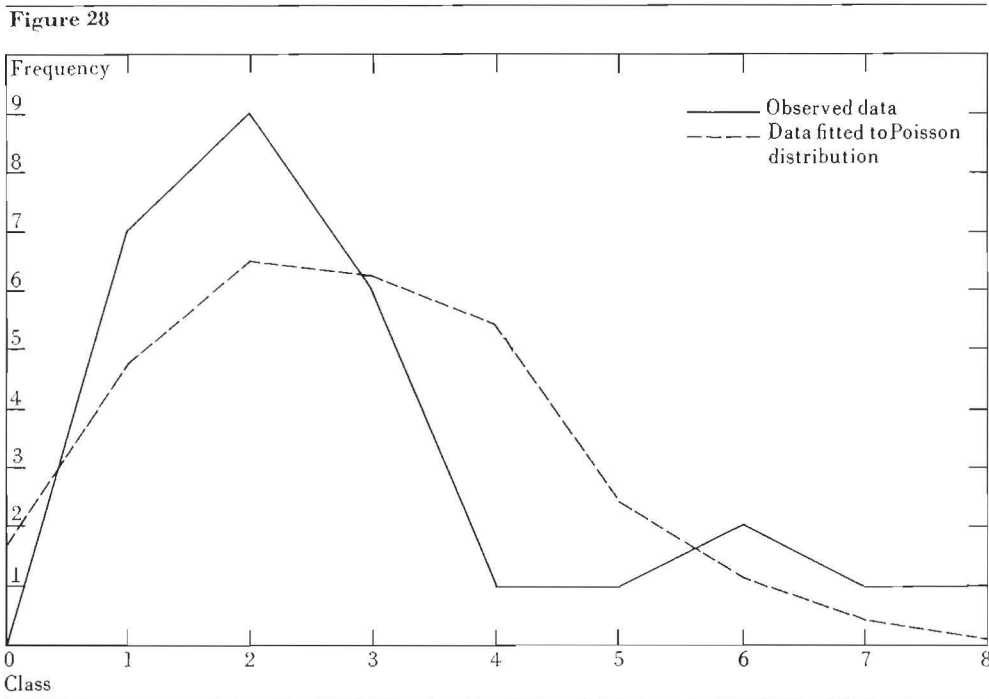
Photography of post-calving aggregations will not result in a total population count. The main objective is to determine the extent of calf mortality during the 4 to 5 weeks following birth. All calves should be present within this area of post-calving distribution although a proportion of other sex and age classes may be absent.

Methods

Aerial photography to obtain a total count and composition estimate for those caribou south of Baker Lake in mid-July was first attempted in 1967. Composition data were successfully obtained for some groups but circumstances prevented a total count of the aggregations in the area. In 1968, aerial photography was again attempted and the results were much more satisfactory. Photography had to be completed in 1 day due to the continuous shifting of the individual aggregations.

On July 16, 1968, the area south of Baker Lake was surveyed to determine the approximate distribution of the post-calv-

Figure 28. Results of a random sampling aerial survey over the calving ground of the Kaminuriak Population in June 1968, fitted to a Poisson distribution.



ing groups. On July 17, 1968, linear transects were flown 4 miles apart in an east-west direction over the area of known distribution at an altitude of 1,500 feet. At this height post-calving groups could be observed up to 2 miles on either side of the plane, permitting total coverage of the area flown. Duplication of observation was prevented by plotting each aggregation on 4 mile = 1 inch topographic maps.

The plane was a Cessna 180 with long-range fuel tanks providing a maximum of 6 hours between refueling stops. The pilot acted as second observer as he was not occupied with the navigation and handling problems which are encountered at low elevations over snow-covered terrain. The high altitude allowed considerable time to examine the ground for caribou aggregations. Due to the long hours of daylight in July at latitude 64°N, a survey of this type can be performed in 1 day.

Each transect was flown until an aggregation was observed. Photographs were first taken at altitudes varying from 1,000

to 1,500 feet, depending upon the size and formation of the aggregation, to obtain a total count (Fig. 29). In some instances all animals could be photographed on one frame, but others required a series of overlapping pictures. Most pictures were taken at an angle of 30° to 45°. Estimates of the size of each aggregation were made before photographs were taken. Estimates alone were recorded for those groups so openly distributed that photography was not practical. Adjustments were made to estimates of those groups assessed but not photographed, based upon the accuracy of estimates for groups later checked by counting from photographs. Sample low level photographs (Fig. 30) were taken to obtain the estimated sex and age composition of each group after high altitude photographs for total counts were completed. The results were then combined to include the total area of post-calving distribution.

Aerial photography was repeated south of Baker Lake in July 1969. The intent of this survey was to obtain comparable data

Table 10
Expected number of caribou 1 year of age and older on the calving ground in June 1968 when the observed data are applied to a Poisson distribution.

Class no.	Caribou
0	—
1	980
2	4,149
3	6,505
4	6,410
5	4,660
6	2,675
7	1,274
8	525
Total	27,178
Adjustment for 20% error	33,962

on first-month calf mortality for 1968 and 1969. In 1969 the post-calving aggregations did not move as far north as in 1968, remaining scattered to the east of Kaminuriak Lake. This scattered distribution ruled out high level, total count photography.

Cameras used in 1968 were a 35-mm Pentax Asahi S-V and a Fairchild K-20. Kodachrome II film was used in the former and Kodak Ektachrome Aero Film type 8442 in the latter. The Ektachrome provided negative transparencies from which both black and white and colour prints could be produced. The 35-mm camera was used only for low level composition photography while the K-20 was used for both high level total count and low level composition photography. Both the 35-mm Pentax and the K-20 were used in 1969. Film used in the 35-mm camera was Kodak Plus-X and in the K-20 Kodak Tri-X aerographic film. The latter film provided superior results over the Ektachrome film used in 1968.

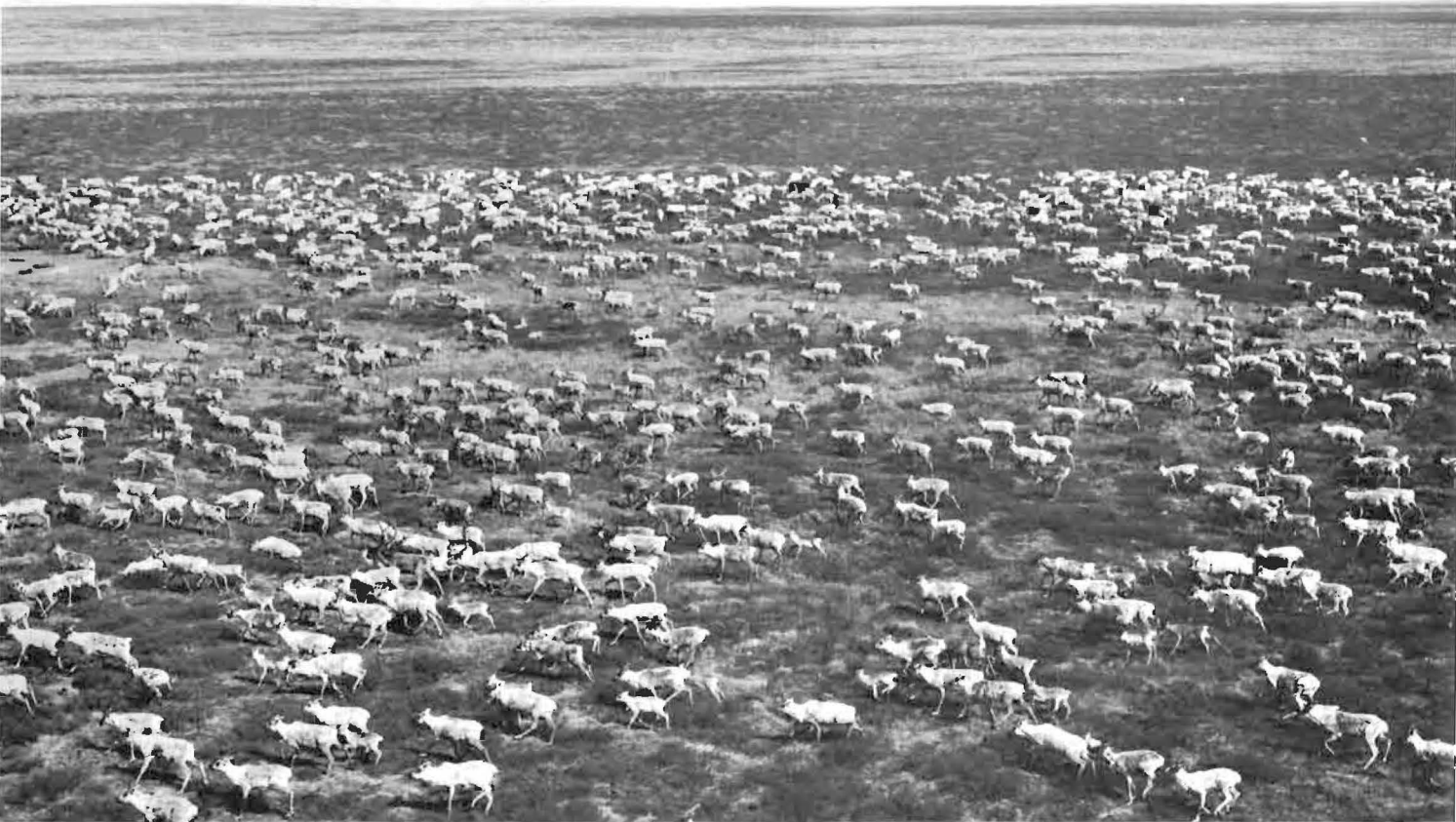
Results

A total of 32 aggregations were recorded within the area of post-calving distribution surveyed on July 17, 1968 (Fig. 31). The resulting data on total caribou and group composition are provided in Table 11. Nine of the 32 groups could not be photographed for a total count due to their scattered dis-

Figure 29. A post-calving aggregation of caribou south of Baker Lake, N.W.T., photographed at an altitude of 1,500 feet using a K-20 camera and Kodak Tri-X aerographic film. G. R. Parker.



Figure 30. A low-level aerial photograph for determining the sex and age composition of July post-calving aggregations south of Baker Lake, N.W.T. Photo by G. R. Parker.



tribution. Calf mortality during the 4 to 5 weeks following birth was estimated at 60 per cent. Comparable figures for 1969 suggest this high mortality of calves is probably a consistent phenomenon.

Discussion

Calves and adult males (37 months or older) are the only two classes which can be easily identified from aerial photographs. The identification of yearlings (13 months) is susceptible to considerable error. Yearlings can usually be identified only if the animal is so situated in the photograph that physical features such as relative body size, muzzle length, and pattern of moult are easily discernible. I suspect many yearlings are mistaken for adult animals and some 2-

year-old caribou (25 months) are classified as yearlings.

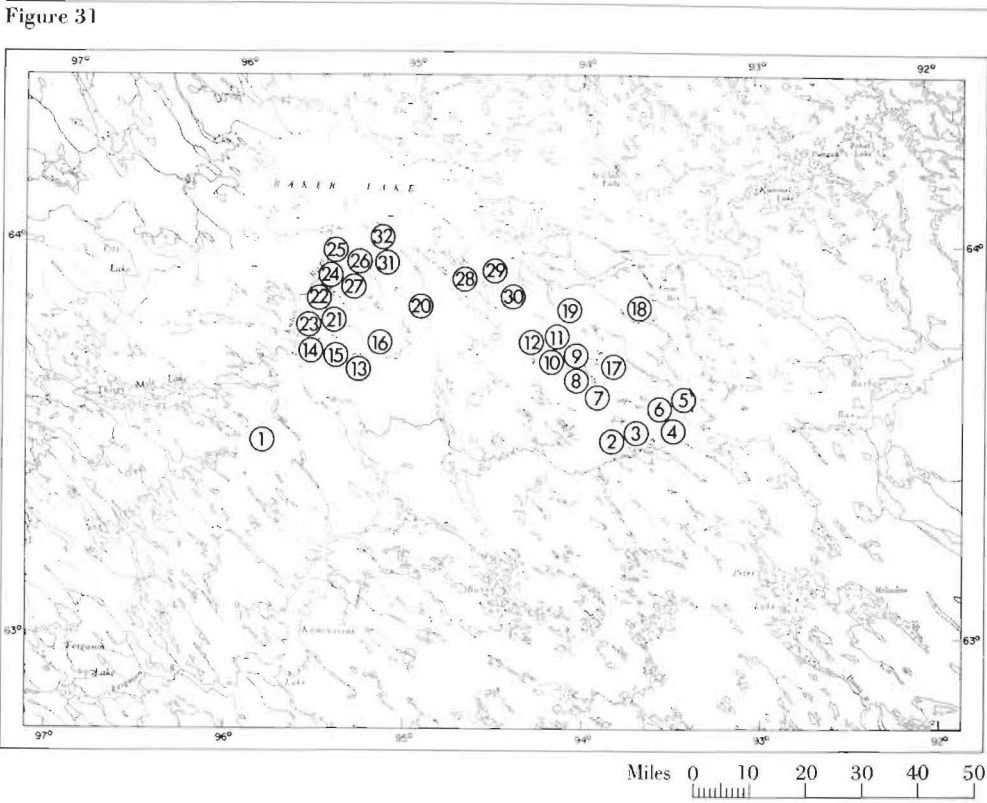
July photography will not result in a total population count as many animals are south of the area of post-calving distribution. Calculations in the section "Total numbers and composition" show the total population prior to calving in 1968 was approximately 63,000 caribou. Aerial photography showed there were slightly over 40,000 caribou over 12 months in the area of post-calving distribution in July. Approximately 23,000 animals, or 36 per cent of the population over 1 year of age, were scattered south of the post-calving area.

Aerial photography indicated approximately 6,000 adult males were within the area surveyed during late July. Aerial segre-

gation prior to the rut in 1968 suggested an adult male to female ratio of 55:100, or a total of approximately 18,000 males over 3 years of age in the population. Thus, only one third of the total adult males were within the area surveyed on July 17, 1968. It was also calculated that only one fourth of the yearling class was photographed. This possibly was due to many not being recognized as yearlings.

Standard-image photography cannot be used for determining caribou numbers over large areas of the Kaminuriak Population range, with the exception of the area of post-calving distribution. Thomas (1967) used aerial photography as an aid in censusing the three western mainland populations as they migrated out of the taiga during the

Figure 31. The distribution of 32 post-calving aggregations photographed south of Baker Lake, N.W.T., on July 17, 1968.



spring of 1967. This was possible, however, only when large groups were encountered, and linear transect surveys were relied upon for most of the population estimates.

Standard-image photography can be used for sample composition data for barren-ground caribou populations at any time of the year. Although relied on by Banfield (1954), Loughrey (1955, 1956, 1957), Kellsall (1968), and Thomas (1960, 1967) as an aid in caribou segregation, the use of aerial photographs for studying barren-ground caribou populations has certain limitations. Aerial segregation of small winter bands can just as easily be performed by the observer if only calves and adult males need to be identified. The identification of calves is usually much easier and more reliable when

the observer can see the animals running in relation to one another. This is not possible with still-image photography and many times an animal is obscured from view by another. This is especially true with calves which keep close to the adult female.

The use of remote sensing equipment for surveys over the calving ground or areas of late summer and winter distribution will undoubtedly be possible in the near future. The cost of such surveys and the many problems involved may, however, make this type of population survey impracticable.

Autumn adult sex ratio

A survey was flown September 26 to 29, 1968, to determine the distribution of the population and the ratio of adult males (39

Table 11
Size and composition of post-calving aggregations south of Baker Lake, N.W.T., on July 17, 1968, based on sample photography of herds from high and low elevations.

Herd no.	Total caribou	Area* no.	Ad. Bulls		Yearlings		Calves		Cows with calves		Unclassified	
			%	No.	%	No.	%	No.	%	No.	%	No.
1	77	3	19.4	15	6.4	5	0	0	0	0	74.2	57
2	4,943	1	3.9	292	1.1	54	29.2	1,443	29.2	1,443	36.6	1,711
3†	5,110	1	2.2	112	0.9	49	36.2	1,849	36.2	1,849	24.4	1,251
4†	3,650	1	3.1	113	3.5	128	31.2	1,138	31.2	1,138	31.0	1,133
5 ‡	3,154	1	5.4	170	2.0	63	27.5	867	27.5	867	37.6	1,187
6 ‡	554	1	5.4	30	2.0	11	27.5	154	27.5	154	37.6	205
7	3,128	1	9.1	284	3.2	100	20.1	628	20.1	628	47.5	1,488
8 ‡	1,080	1	5.4	58	2.0	22	27.5	297	27.5	297	37.6	406
9 ‡	2,681	1	5.4	145	2.0	54	27.5	737	27.5	737	37.6	1,008
10†‡	270	1	5.4	15	2.0	5	27.5	64	27.5	64	37.6	122
11†‡	1,000	1	5.4	54	2.0	20	27.5	275	27.5	275	37.6	376
12†	1,617	1	5.4	87	2.0	32	27.5	444	27.5	444	37.6	610
13	439	3	52.9	232	5.8	25	0	0	0	0	41.3	182
14†‡	675	3	29.0	196	6.4	43	6.8	46	6.8	46	51.0	344
15†‡	50	3	29.0	15	6.4	3	6.8	3	6.8	3	51.0	26
16	552	3	4.0	22	2.2	12	22.3	123	22.3	123	49.2	272
17†‡	135	1	5.4	7	2.0	3	27.5	37	27.5	37	37.6	51
18†‡	2,000	1	5.4	108	2.0	40	27.5	550	27.5	550	37.6	752
19†‡	1,200	1	5.4	65	2.0	24	27.5	330	27.5	330	37.6	451
20	1,189	2	2.1	25	2.5	30	19.3	229	19.3	229	56.8	676
21	775	3	26.6	206	9.2	71	1.7	13	1.7	13	60.8	472
22	2,829	3	20.7	585	8.8	249	4.2	118	4.2	118	62.1	1,759
23	3,555	3	31.2	1,109	6.2	220	5.0	177	5.0	177	52.6	1,872
24	2,233	3	33.3	743	3.8	85	9.4	209	9.4	209	44.1	987
25 ‡	345	3	29.0	100	6.4	22	6.8	23	6.8	23	51.0	177
26 ‡	873	3	29.0	253	6.4	56	6.8	59	6.8	59	51.0	446
27 ‡	2,174	3	29.0	630	6.4	139	6.8	147	6.8	147	51.0	1,111
28 ‡	625	2	6.0	38	2.9	18	17.4	120	17.4	120	56.3	329
29 ‡	1,933	2	6.0	116	2.9	56	17.4	373	17.4	373	56.3	1,015
30 ‡	885	2	6.0	53	2.9	26	17.4	170	17.4	170	56.3	466
31 ‡	749	2	6.0	45	2.9	22	17.4	144	17.4	144	56.3	394
32	852	2	10.3	88	3.3	28	15.3	130	15.3	130	55.8	476
Total	51,332		11.7	6,011	3.3	1,715	21.3	10,897	21.3	10,897	42.4	21,812

*For location of post-calving aggregations see Figures 10 and 31.
†Herd not photographed for total count. Estimates were made of all herds and adjustments of those herds estimated but not photographed are as follows:
1. Herds estimated from 4,000 to 5,000 = average overestimate of 27%.
2. Herds estimated from 1,000 to 3,000 = average error was insignificant.
3. Herds estimated from 300 to 700 = average underestimate of 26%.

‡Herd not photographed for composition: average sex and age ratios are from other photographed herds in that area.

months or older) and calves (3 months) just before the rut. Four concentrations were found, one near Hicks Lake, one inland from Eskimo Point, one near Cullaton Lake, and one near Edehon Lake (Fig. 16).

Adult male and calf ratios varied significantly between the four areas of concentration. Adult male ratios varied from 17.2 per cent to 38.8 per cent and calf ratios varied from 9.9 per cent to 16.3 per cent. The overall proportion of adult males in the sample was 23.3 per cent.

The overall adult male to female ratio is calculated in Table 12. The September ratio was estimated at 55 adult males to 100 adult females. This ratio is comparable to those in other barren-ground caribou populations.

Kelsall (1968) estimated the adult sex ratio for the western barren-ground caribou populations in mainland northern Canada in 1957-58 at 54 to 60 males per 100 females. Skoog (1968) found the adult male to female ratio for the Fortymile Herd, Alaska, to be 65:100 in early October 1961. He estimated the ratio for the Nelchina Herd at 59:100 in late October 1956 and for the same herd at 43:100 in October 1962. Klein (1968) determined from skeletal remains that the sex ratio of reindeer over 1½ years of age on St. Matthew Island, Alaska, was 57:100. Hemming and Glenn (1969) found the sex ratio of caribou in the Arctic Herd, Alaska, minus calves and yearlings, in October 1968, to have been 62:100. Bergerud (1969) estimated the adult sex ratio of woodland caribou in Newfoundland at 56 males to 100 females.

Kill statistics from August 1967 to July 1968 showed 56 per cent of the harvest of caribou 12 months and older were males and 44 per cent females. This may contribute to the uneven adult sex ratio, although since the phenomenon exists in all caribou and wild reindeer populations, there must be more important factors than hunter selectivity involved.

Results

Transect surveys over the wintering concentration in 1967-68 resulted in an esti-

Table 12
Calculations used for obtaining the adult male to female ratio of caribou within the Kaminuriak Population from aerial composition data obtained from September 26 to 29, 1968.

Sample size	3,073
Calves	442
Yearlings (15 mo.)	20%* + 614
2-yr.-olds (27 mo.)	
Immatures in sample	1,056
Adults in sample (39 mo. +)	2,017
Adult males in sample	718
Adult females in sample	1,309
Adult male : female ratio = 718:1,309 or 55:100	

*The spring calf ratio of 1967 and 1968 indicates the yearlings and 2-yr.-olds should comprise approximately 20% of the population by September 1968.

mate of approximately 51,000 caribou. Extensive aerial reconnaissance verified that this concentration contained virtually all of the calves, yearlings, 2-year-olds, and females 3 years or over in the population.

From the results of the calving ground survey in June 1968, it was calculated that there were 33,406 females 36 months or older in the population. It was estimated that there were approximately 12,000 calves and yearlings in the wintering concentration of 51,000 caribou. The remaining 39,000 were caribou over 2 years of age. Although the majority of males 36 months or older were absent from the caribou concentration surveyed, a small but undetermined number were distributed within the southern extremity. Subtracting the estimate of total females 36 months or older for the June survey (33,406) from the figure of 39,000 leaves 5,594 caribou which must have been males over 2 years of age. This figure coincides with those from survey observations, and thus the winter surveys, although not providing a total population estimate, verify the estimate derived from the calving ground survey.

Another check of the 1968 calving ground survey comes from the results of July photography. A total of 51,332 caribou were photographed within the area of post-calving distribution south of Baker Lake on

July 17, 1968. Of this total, 21,812 were unidentified animals over 1 year of age. This unidentified class consisted of 2-year-old males and females 2 years of age and older without calves.

The number of females which gave birth in June 1968 was estimated at 27,169. On July 17, 1968, there were 10,897 calves in the population; 16,272 females had thus lost their calves but remained scattered within the area of post-calving distribution. Subtracting these females from the 21,812 unidentified leaves only 5,540 animals unclassified.

The total number of 2-year-old males and non-calving 2-year and older females in the population was estimated at 11,631. July photography indicated approximately one half (5,540) were within the area of post-calving distribution. The representation of adult males (one third of total) and yearlings (approximately one quarter of total) suggests this representation of one half the total 2-year old males and non-breeding females 2 years of age or older within the area of post-calving distribution approaches the theoretical ratio expected.

Discussion

A systematic aerial survey over the predetermined area of calving is essential for calculating the total number of animals in a barren-ground caribou population. A systematic survey at the peak of calving, combined with aerial and/or ground segregation, provides an estimate of the total number of breeding females in the population. The majority of breeding females in the four mainland Canadian populations can be expected to be 48 months of age older. Using the minimum figure of 80 per cent of females 3 years of age or older breeding, an estimate of the number of females 48 months or older in the population during calving can be calculated. Aerial segregation before or during the rut can provide an adult male to female ratio which can then be reduced to absolute numbers.

The most reliable aerial survey appears to be some form of random sampling. Results

are more accurate if the area of distribution is previously stratified according to apparent densities, with greater sampling effort afforded the area of high density.

Winter aerial transect surveys within the taiga can be valuable if the majority of animals are concentrated and relatively stationary. This situation, however, appears to be the exception rather than the rule. The composition of wintering concentrations may vary annually for each population. More than one winter survey is necessary for a statistical analysis of results. Winter aerial transect surveys therefore require considerable preliminary flying to determine exact areas of caribou concentration and the composition within each. Due to the dispersion of the population over much of the total summer range, late summer surveys are neither economically nor practically feasible.

A survey during spring migration, similar to that performed by Thomas (1969), can be successful only under exceptional circumstances. Thomas was fortunate that all the wintering concentrations, minus adult males, moved out onto the tundra in force, which allowed the surveys to be completed in a relatively short period of time. There are, however, many hazards involved with this type of survey. During migration, when animals may move 20 or more miles a day, surveys of each concentration must be completed in 1 day. A short delay due to unfavourable weather conditions could negate the value of any results already obtained and make it necessary to repeat the survey. In some years a large proportion of the population may remain on the tundra all winter; locating the concentrations would require a great amount of reconnaissance flying prior to the actual surveys. The spring migration period is a difficult time for the survey for other reasons. Navigation over snow-covered tundra is uncertain, weather conditions are often unfavourable, and the caribou display extreme non-randomness of distribution. Whenever possible, more than one survey should be conducted to permit a comparison of results.

The kinds of aerial surveys and calculations best adapted for estimating barren-ground caribou populations depend upon the population to be assessed. A total count of populations on small islands may be possible. Populations with extensive migrations and displaying an incomplete segregation of adult sexes on the calving ground must be surveyed with due regard for these varying factors. Not all populations have the same parameters: in Alaska, for example, a much higher percentage of caribou give birth at the ages of 2 and 3 years than in the Kaminuriak Population (Skoog, 1968). The surveys and calculations by which the total number of caribou within the study population has been calculated are believed applicable to all four of the mainland Canadian populations.

Recruitment

Recruitment can be defined as the number of young under 1 year of age in the population at any one time, and annual recruitment as the number of young animals within the population which survive their first year of life. Annual recruitment provides an increment to the population only if it exceeds the mortality of animals over 1 year of age for that particular year.

Recruitment may be expressed numerically, that is, the actual number of young of the year within the population. It may also be expressed as a percentage of young of the year to total number of animals, or to that segment of the population over 12 months of age. The ratio of calves to females over 1 year, or to only the breeding females in the population, can also be used. The latter provides the most accurate index of the productivity of the population and of the extent of first-year mortality.

The most frequently used method for expressing calf survival in caribou populations is the percentage of calves in the total population. Due to the habitual segregation of certain sex and age classes of barren-ground caribou at most seasons of the year, results of aerial and/or ground composition samples must be corrected to account for those classes not represented in their actual ratios with the sample.

This study combined aerial surveys and a seasonal collection program which provided information on total caribou numbers, seasonal distribution, adult sex ratio, productivity, and age class pregnancy rates. This permitted the expression of seasonal calf recruitment numerically and proportionately. The estimated seasonal survival of calves presented in Table 13 is believed to have been "typical" for the Kaminuriak Population from 1966 to 1969.

The reproductive potential of barren-ground caribou is low compared to other North American cervids. Female barren-ground caribou do not become reproductively mature until 36 months of age. No female caribou were found to have bred when 5 months of age during this study. The pregnancy rate for females breeding

Table 13
Estimated first-year seasonal survival of calves within the Kaminuriak Population of barren-ground caribou, utilizing data from June 1967 to March 1969.

Season	Months after calving	Total calves	Calves in total population, %	Calves: caribou 12 mo. +	Calves: females 12 mo. +	Calves: breeding females	Calf mortality, %	Calf survival, %
Calving	0	27,169	30.0	43:100	69:100	100:100	0	100.0
Post-calving	1	10,897	14.7	17:100	27:100	40:100	60.0	40.0
Autumn	3-4	10,266	14.2	16:100	26:100	38:100	62.3	37.7
Spring	12	6,000	9.0	10:100	16:100	22:100	78.0	22.0

Seasonal mortality on caribou 12 mo. + included in calculation.

when 17 months of age was only 2.2 per cent and for 39 months it was 50 per cent (April and June collections). The proportion of females breeding at the age of 51 months and older was 86.4 per cent (Dauphiné, 1970).

In contrast, the proportion of female white-tailed deer breeding their first year may reach as high as 32 per cent (Severinghaus and Cheatum, 1961). Female mule and black-tailed deer (*Odocoileus hemionus*) do not usually breed until their second year (Asdell, 1964; Robinette *et al.*, 1955). Moose are not known to breed before their second year (Asdell, 1964), and elk do not normally breed until the third rutting season after birth (Murie, 1957).

In June 1968, aerial surveys over the calving ground indicated a calf crop of 27,169 animals. By June 1968, it was also calculated there were 39,103 females 12 months of age or older in the population, a ratio of 69:100. The total number of caribou in the Kaminuriak Population before calving in 1968 was estimated at 63,173. The ratio of calves to total animals 12 months or older immediately after calving was therefore 43:100. The ratio of calves to females 36 months or older was 81:100. Theoretically, with no mortality, the population could increase by 43 per cent in 1 year.

Approximately 78 per cent of the calves born annually from 1966 to 1968 did not survive their first year of life. The proportion of calves in the population by spring of 1968 and 1969 was 9 or 10 per cent. The

greatest loss of calves occurs during the first 4 to 5 weeks following birth. Aerial photography over the area of post-calving distribution on July 17, 1968, found only 10,897 calves remaining from the total of 27,169 estimated born in early June. This is a loss of 60 per cent of the calf crop during the first 4 to 5 weeks. Of those calves surviving the first month of life, only 55 per cent survived until the following spring. The ratio of calves to total females 12 months or older dropped from 69:100 at birth to 27:100 by mid-July 1968. In September 1968, the percentage of calves in the sample segregated (n = 3,073) was 14.2. Wolf predation during the summer months was estimated to account for 590 adults and human predation for approximately 1,000 adults (over 12 months). The number of caribou over 1 year of age thus dropped from the estimated 63,173 in early June 1968 to 61,583 by late September 1968. Calves in the population by late September (14.2 per cent) thus numbered 10,192. This figure is only 700 less than that calculated for the population on July 17, 1968 (10,897). Allowing for the estimated loss of 300 calves to wolf predation and another 100 to human predation during the summer months, calf mortality from mid-July to late September from sources other than predation appears to be almost negligible. The ratio of calves to total females 1 year or older decreased from 27:100 in mid-July to 26:100 by late September 1968. Segregation of caribou during the

winter months (December to May) of 1967-68 found the proportion of calves varied from 13.8 to 10 per cent.

The number of calves surviving their first year of life in 1968 is estimated at approximately 6,000 animals. Due to the similar calf to total caribou ratios for September to March of 1967-68 and 1968-69 (Table 14), the total number of calves by the spring of 1969 is also estimated to have been 6,000. The ratios of calves to total caribou for March, July, and September of 1968 and 1969 are very similar. The low calf ratios for 1966-67 are believed due to the small sample size. The projected mortality of calves from June 1968 to May 1969 is presented in graph form in Figure 32. Similar seasonal calf ratios suggest this mortality is representative for the 3-year study period. From birth until mid-July there is an average loss of 542 calves per day, from mid-July to late September a loss of 8 calves per day, and from October to the following calving period a loss of 17 calves per day.

On the Kola Peninsula in Russia, Semenov-Tyan-Shanskii (1948) found yearling wild reindeer comprised 23 per cent of those segregated ($n=351$) during April of 1936, 1937, and 1938. During the rut of 1937 and 1938, he found calves of the year composed 31 per cent of those segregated ($n=149$). At the end of the winter he calculates the number of 11-month-old calves to be 59 per cent of the number of adult females. During the present study, using only females 36 months or older, the number of calves was only 20 per cent of the adult females before calving. Michurin (1967) states: "Calf losses in the wild reindeer herds (Russia) are comparatively high" (p. 1,840). However, by the end of July, Michurin documents calves in the Taimyr Peninsula comprising about 26 per cent of the population. This is much higher than the mid-July 1968 figure for the Kaminuriak Population of 14.7 per cent.

Klein (1968) estimated the recruitment of calves prior to calving on St. Matthew Island in 1957 was 29 per cent but in 1963

Table 14
Proportion of calves found by monthly aerial and ground sample composition counts of caribou of the Kaminuriak Population from June 1966 to July 1969.

Month	1966-67		1967-68		1968-69		1969-70	
	%	No.	%	No.	%	No.	%	No.
June	36.0	125	34.0	178	40.0	361		
July			28.0	2,708	19.5	8,159	24.0	5,785
August					11.0	599		
September					14.0	833		
Eastern			15.6	792				
Central			16.3	508	16.3	1,311		
Western			—	—	11.8	929		
Total			15.9	1,300	14.3	3,073		
October								
November	12.0	300	17.8	883				
December			13.8	2,478				
January			10.3	3,239				
February	8.9	813	13.8	3,504				
March			10.0	2,418	11.4	967		
April	5.0	250	11.0	852				
May	7.0	490	10.3	474				

it had dropped to 17 per cent. In Alaska, Skoog (1968) obtained calf to total caribou ratios for the Nelchina Herd during October from 1956 to 1962. These ratios varied from 19 to 22.3 per cent with the 6-year average being 20.6 per cent. Skoog states: "The average of 21 per cent is considered the 'expected' proportion of this age group in the Nelchina Herd for the October period" (p. 509). This is considerably higher than the "expected" proportion in the Kaminuriak Population for the October period of 14 to 15 per cent. Hemming (1969) records a yearling to cow ratio during May for the Alaskan Peninsula Herd of 39:100. This is considerably higher than the estimated 16:100 ratio of calves to females 12 months or older in May of 1968 and 1969 for the Kaminuriak Population.

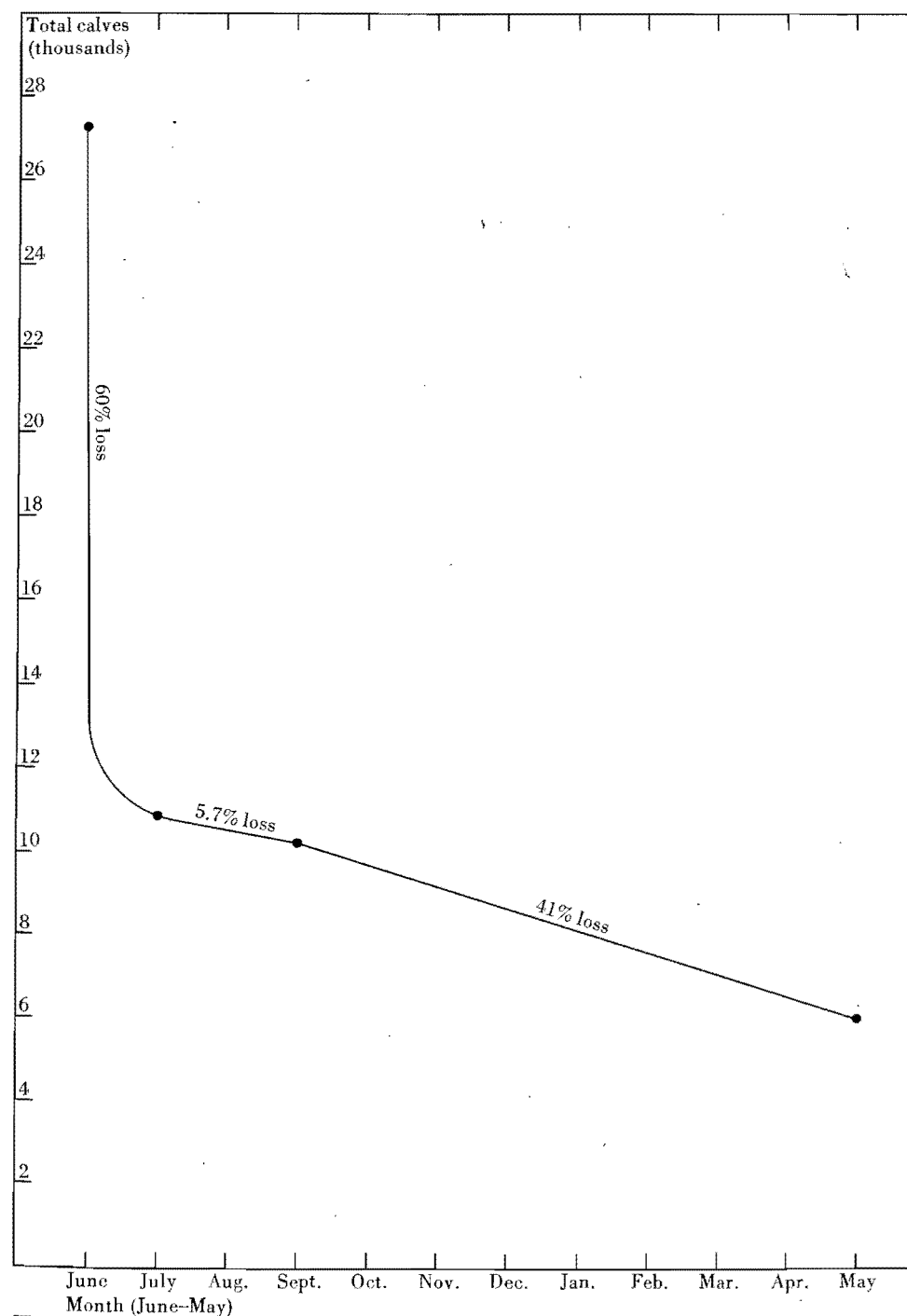
Banfield and Tener (1954) found 34 calves to 100 females in Labrador during April 1954 ($n=142$). Bergerud (1967) records the percentages of calves in the population of two Labrador caribou herds from 1959 to 1963. These varied from 4 to 17, with the average being 11.2 per cent. Aerial segregation of woodland caribou along the On-

tario and Hudson Bay coastal tundra belt in August of 1962 and 1963 found the calf to total caribou percentage was 22.5 per cent ($n=320$). Winter surveys in northern Ontario from 1960 to 1964 resulted in an average calf to total caribou ratio ($n=1,103$) of 16.7 per cent (Simkin, 1965).

Kelsall (1968) provides calf to total caribou spring ratios from 1947 to 1961 for caribou on the western ranges in northern Canada. These figures range from 6.9 to 26.6, with the average being 15.9 per cent. Thomas (1969) obtained calf to total caribou ratios from March to May 1967, for those populations on the western ranges in mainland northern Canada. These figures varied from 9 to 14:1, with the average being 11 per cent. Loughrey (1955) found 13.4 per cent ($n=194$) of caribou near Brochet, Manitoba, in April 1955 were calves, and 12.8 per cent ($n=999$) of those animals segregated during March 1955 in the Southern Indian Lake and Churchill areas were calves. In May 1957, Loughrey (1957) found the calf to total caribou ratio within the Kaminuriak Population was only 4.8 per cent ($n=3,685$). He documents a loss

Figure 32. The estimated extent of annual calf mortality for the Kaminuriak Population from 1966-67 to 1968-69.

Figure 32



of calves from October 1956 to May 1957 of 37.6 per cent. The loss over this period in both 1967-68 and 1968-69 was estimated at approximately 41 per cent, very similar to the estimate by Loughrey in 1957. At Duck Lake, Manitoba, during October 1957, Pruitt (1957) found 19 per cent of those caribou segregated ($n=?$) were young of the year.

Skoog (1968) documents a low first-year calf mortality of 40 per cent for the Alaskan Nelchina Herd. Seventy per cent of this total mortality occurred from birth to October. The average calf to cow ratio for the Nelchina Herd at birth from 1955 to 1962 was 60:100, lower than the 69:100 ratio calculated for the Kaminuriak Population. By October, this ratio was 43:100 and by April 36:100. Mortality from June to October averaged 28 and from October to April 16 per cent. Kelsall (1957) estimated a 50 per cent loss of calves during the first month of life for the western caribou population in mainland northern Canada.

There is a substantial variation in documented first-year calf survival for populations of *Rangifer tarandus* in the Northern Hemisphere. Some of this variation is possibly due to calf count samples being taken from segregated portions of that particular population. At no time during the present study were all sex and age classes represented in any one area in a ratio that actually existed within the population.

Aerial segregation during the period of rut provides the most accurate information on sex and age representation in the population. Results of aerial surveys just before the rut in 1968, however, suggest even then the composition between concentrations may vary considerably. Ratio of calves to total caribou during September 26 to 29, 1968, varied from 9.9 for the western concentration to 16.3 per cent for the central concentration. Adult males varied from 38.8 in the western concentration to only 17.2 per cent in the east.

Calf to total caribou ratios on the calving ground or within the area of post-calving distribution are misleading as most

adult males and non-breeding caribou are scattered to the south. Aerial segregation during the winter months invariably excludes the majority of adult males. It is therefore necessary to know the distribution of the population at the time of composition sampling. It is also necessary to have an estimate of the number of caribou over 1 year of age within the population and within the particular area of distribution being sampled.

First-year calf survival rates for other populations of *Rangifer tarandus* are on the average higher than that found for the Kaminuriak Population during the present study. Summer calf mortality of caribou in Alaska and reindeer in Russia is much lower than that in the Kaminuriak Population. Calf mortality from June to October is over 30 per cent higher than that recorded for Alaskan caribou (Skoog, 1968). Calf mortality for caribou populations in western Canada, although relatively high, appears to be slightly lower than that recorded during the present study. The factors contributing to this high calf mortality, particularly during the first month of life, are unknown.

The two major sources of mortality affecting the study population are predation on caribou 12 months or older and the loss of calves during their first year of life. The latter subject is discussed in the chapter on recruitment. The two most important sources of predation on caribou over 1 year of age are man and wolves. The loss to native kill can be adequately determined. I have attempted to evaluate the effect of wolves but due to the magnitude of the interrelated factors the results are speculative.

Human predation

The Chipewyan Indians and Caribou Eskimos have traditionally relied on caribou of the Kaminuriak Population to provide them with food, clothing, and shelter. As recently as 25 years ago, much of the range of this caribou population was inhabited by families of natives belonging to these two northern races. By 1963, few Eskimos remained on the land, most having moved into permanent government-built homes within the communities of Baker Lake, Chesterfield Inlet, Rankin Inlet, Whale Cove, and Eskimo Point. The population of those settlements in 1968 was 546, 192, 375, 145, and 442, respectively; total 1,700. The Chipewyan Indians have also deserted their former hunting territories, and by 1966 most were living in the communities of Churchill, Brochet, and Wollaston Lake. The Chipewyan Indians of Wollaston Lake (pop. 970 in 1968) and Brochet (pop. 670 in 1968) still depend to some extent on caribou and harvest 2,000–2,500 each winter. Although dependency on caribou is declining in favour of commercial fishing, those kill figures should not change appreciably in the next few years.

Historical

Many people are under the impression that the primitive Indian was a dedicated conservationist. Nothing could be further from the truth. The primitive Indian was limited to weapons which would not allow him to kill much more than he actually required. With the introduction of firearms to the

northern Indian during the 18th century, the numbers of caribou killed increased substantially. Many travellers commented on the wasteful native slaughter, e.g., Isham, 1743; Ellis, 1747; Umfreville, 1790; Hearne, 1795; Richardson, 1829; Whitney, 1896.

Warburton Pike (1892) left particularly vivid accounts of early Indian caribou slaughters. One such incident occurred where the Lockhart River leaves Aylmer Lake:

Just below the camp we saw plain evidence of the slaughter . . . made among the swimming caribou, what we took at first for a bunch of remarkably big willow sticks proved to be the horns of fifty or sixty bucks, lying in shallow water at the edge of the stream; and enough meat to keep an Indian family for a year, if properly cured, was rotting in the sun. (p. 201)

Pike describes another wasteful slaughter of caribou just south of Artillery Lake:

Only four days before there had been one of those big slaughters, which one would think could not fail in a short time to exterminate the caribou. A large band had been seen to start from the opposite bank, and was soon surrounded by seven hunting-canoes; the spears were kept going as long as there was life to take, with the result that three hundred and twenty-six carcasses were hauled ashore and fully two hundred of these left to rot in the shallow water. (p. 204)

But it is with the spear that the vast slaughter in the summer is annually made. The best swimming places are known and carefully watched, and woe betide a herd of caribou if once surrounded in a lake by the small hunting-canoes. There is no idea of sparing life, no matter what the age or sex of the victim may be; the lake is red with blood and covered with sometimes several hundred carcasses of which fully one-half are thrown away as not fat enough to be eaten by men who may be starving in a month. Surely this should exterminate the game: but, if one remonstrates with the Indians at the waste,

the ready answer comes: 'Our fathers did this and have taught us to do the same: they did not kill off the caribou, and after we are gone there will be plenty for our children'. (p. 48)

Both the northern Chipewyan and the Caribou Eskimo relied almost exclusively on caribou for food, clothing, and shelter. Estimates of the number of caribou required by each primitive family vary.

Lawrie (1948) estimated a family of four plus a team of dogs would require 250 caribou annually. Harrington (1952) estimated that an Eskimo in the Padlei area would need approximately one caribou per day throughout the year to feed his family and a team of 8 to 10 dogs. Macpherson (1959) estimated between 100 and 150 caribou were killed annually by a family of six with five dogs in the Baker Lake area. Since the primitive Eskimo had few dogs (three dogs per family without a rifle, Stefansson, 1921) and obviously all families did not meet their requirements each year, an average of 150 caribou per year seems reasonable.

Based on a Caribou Eskimo population of 110 families in 1922 (Birkett-Smith, 1929), the total caribou killed annually to meet their requirements would have been 16,500. The kill by the northern Chipewyans, numbering approximately 650 (130 families), would have approached 19,500 caribou. Excluding those caribou lost through crippling and others intentionally left to waste, the total native kill from the Kaminuriak Population from 1920 to 1945 is estimated at 35,000 to 40,000 caribou annually. Henry Linklater, a Cree Indian who has lived at Brochet since 1927, believes the total kill by the Brochet Band during the 1930's and 1940's was never over 20,000 a year, and probably a good deal lower.

Wright (1944) estimated the kill by the Caribou Eskimo for his economic survey of Canada's eastern Arctic:

It may be reasonable to assume that about 400 inland natives in Keewatin use about 30 caribou per head, and the remaining 1,000 mainland coastal natives use about 9 caribou per head

in addition to seafood. The white residents take about 200 head, and, in 1942–43, the traders took about 500 head to provide skins for export to regions of scarcity farther east. The total annual drain upon the caribou by all residents of the Keewatin mainland is therefore probably not less than 22,000 head.

The native populations by 1920 were smaller than in former years and the annual kill of caribou was consequently less. However, with the increase in numbers of firearms, more caribou were lost due to crippling. Large numbers of caribou were killed before the use of firearms but few escaped when speared at water crossings or captured in corrals. With the introduction of firearms, in particular the small-calibre .22 rifle, the number of caribou wounded and lost was possibly as high as the total number recovered and utilized. Since the extent of crippling loss is unknown, it is only mentioned as one of the possible factors responsible for the reported drastic decline in caribou after the turn of the century.

Recent

In the winter of 1948–49, Lawrie (1948) estimated the total barren-ground caribou kill in northern Manitoba was 32,250. He also estimated the kill by Eskimos of Kaminuriak caribou to be 10,000. This results in a total kill from the Kaminuriak Population in 1948–49 of 42,250.

During the 1930's and 1940's there were approximately 38 white trappers within the range of the Kaminuriak Population. They also took a certain number of caribou each year, but by 1948 they had virtually all left the area (Lawrie, 1948).

By 1955, Loughrey (1955) estimated the annual kill of the Kaminuriak Population at 30,000 caribou. By 1960, the total kill was reported to be only 4,000 animals (records from N.W.T. and Manitoba Game Branch). This sharp drop in the annual caribou kill from 1945 to 1960 is a direct result of a decrease in the caribou population and the centralization of the Indians and Eskimos from scattered camps into communities.

Present

The native kill of caribou from the Kaminuriak Population has remained relatively constant from 1960 to 1968. There are two sources from which community caribou kill figures are available. One is the annual report by the Northwest Territorial Game Service, giving kill reported by purchasers of general hunting licences. The other is the R.C.M. Police annual game reports for the areas within their jurisdiction. There are substantial discrepancies between these two sources. Furthermore, they provide only the total kill per year. For the present study it was necessary to learn the kill per month, composition of the kill, number of hunters from each community, and areas from which caribou were being taken. For the above reasons a program of collecting community kill statistics was initiated.

Methods

Indians and Eskimos are often reluctant to reveal the number of caribou killed to an "outsider", especially if he cannot communicate in their language. A program of issuing caribou kill calendars to the Indians had been attempted in the early 1960's but this had not proved satisfactory. Instead, someone from each community was hired to obtain the desired information each month. At the three Eskimo communities which affected the Kaminuriak Population—Rankin Inlet, Eskimo Point, and Whale Cove—Eskimo assistants made house-to-house checks at the end of each month. At Brochet, an Indian community at the north end of Reindeer Lake in northeast Manitoba, statistics were most efficiently collected by Henry Linklater, an employee at the Hudson's Bay Company store.

No kill statistics were collected from Baker Lake, Chesterfield Inlet, Churchill, or Southern Indian Lake. The majority of caribou killed from Baker Lake are taken from the Beverly Population, although a few are killed from the Kaminuriak Population near the mouth of the Kazan River. In recent years, Eskimos from Chesterfield Inlet have restricted their hunting to the country

Table 15

The number of caribou from the Kaminuriak Population reported to have been killed by Indians and Eskimos from August 1967 to July 1968.

Community	Total kill	Females 12 mo. +	Males 12 mo. +	Calves
Rankin Inlet	207	49	137	21
Whale Cove	130	27	99	4
Eskimo Point	1,233	678	423	132
Brochet	790	210	567	13
Sub-total	2,360	964	1,226	170
Per cent		40.8	51.9	7.3
Wollaston Lake	1,000*			
Baker Lake	200†			
Southern Indian Lake				
Total	3,560			

*Estimate from Conservation Officer.

†No records but estimated maximum figure.

Table 16

The recorded monthly kill of caribou for the community of Brochet, Manitoba, from August 1967 to July 1968.

Month (1967-68)	Females 12 mo. +	Males 12 mo. +	Calves	Total
November	43	29	1	73
December	39	29	3	71
January	7	76	0	83
February	15	169	0	184
March	41	136	6	183
April	65	128	3	196
Total	210	567	13	790

Table 17

The recorded monthly kill of caribou for the community of Rankin Inlet, N.W.T., from August 1967 to July 1968.

Month (1967-68)	Females 12 mo. +	Males 12 mo. +	Calves	Total
August	3	13	2	18
September		5		5
October	2	11		13
November	3	19	1	23
December				
January		13	1	14
February	12	5	7	24
March	1	13	2	16
April	1	18	1	20
May	7	17	1	25
June				
July	20	23	6	49
Total	49	137	21	207

Table 18

The recorded monthly kill of caribou for the community of Eskimo Point, N.W.T., from August 1967 to July 1968.

Month (1967-68)	Females 12 mo. +	Males 12 mo. +	Calves	Total
August	152	44		196
September	405	157	53	615
October	53	43	8	104
November				
December	1			1
January			6	6
February	2	1	2	5
March				
April	5	13	12	30
May	54	34	12	100
June	1	66	20	87
July	5	65	19	89
Total	678	423	132	1,233

north of the inlet. Due to a change in the wintering distribution of the Kaminuriak Population, Indians from Southern Indian Lake have killed very few barren-ground caribou within the past 4 to 5 years. In recent years, Indians from Churchill have not hunted barren-ground caribou.

The one community from which Indians made a large winter caribou kill in 1967-68, and where monthly kill figures were not collected, was Wollaston Lake, Saskatchewan. This was due to an unexpected western penetration into the province by the

Table 19

The recorded monthly kill of caribou for the community of Whale Cove, N.W.T., from August 1967 to July 1968.

Month (1967-68)	Females 12 mo. +	Males 12 mo. +	Calves	Total
August		23	2	25
September	3	7		10
October	2	6		8
November				
December				
January	16	4		20
February				
March		2	1	3
April	1	8		9
May	2			2
June				
July	3	49	1	53
Total	27	99	4	130

Kaminuriak Population and an eastern movement by 20 Wollaston Lake families for commercial fishing on lakes within the area of caribou distribution. An estimate of the winter kill by Wollaston Lake Indians was supplied by the local provincial conservation officer.

Results

The total number of caribou killed by Eskimos and Indians from the Kaminuriak Population from August 1967 to July 1968 is estimated at 3,560 (Table 15). Monthly kill statistics for each community are shown in Tables 16 to 19.

Of the total recorded kill of 2,360 caribou, 40.8 per cent were females 12 months or older, 51.9 per cent were males 12 months or older, and 7.3 per cent were young of the year (Fig. 33). In the absence of data to the contrary it is believed that Wollaston Lake hunters took a harvest of similar composition to that taken from Brochet. If so, the total kill of males 12 months or older was 57.8 and of females 12 months or older 36.5 per cent. Seventy-one per cent of the reported Indian kill consisted of males 12 months or older whereas only 41 per cent of the Eskimo kill consisted of males 12 months or older. Of the total kill

Figure 33. The recorded composition of caribou killed by hunters of Brochet, Manitoba, and of Eskimo Point, Rankin Inlet, and Whale Cove, N.W.T., from August 1967 to July 1968.

Figure 33

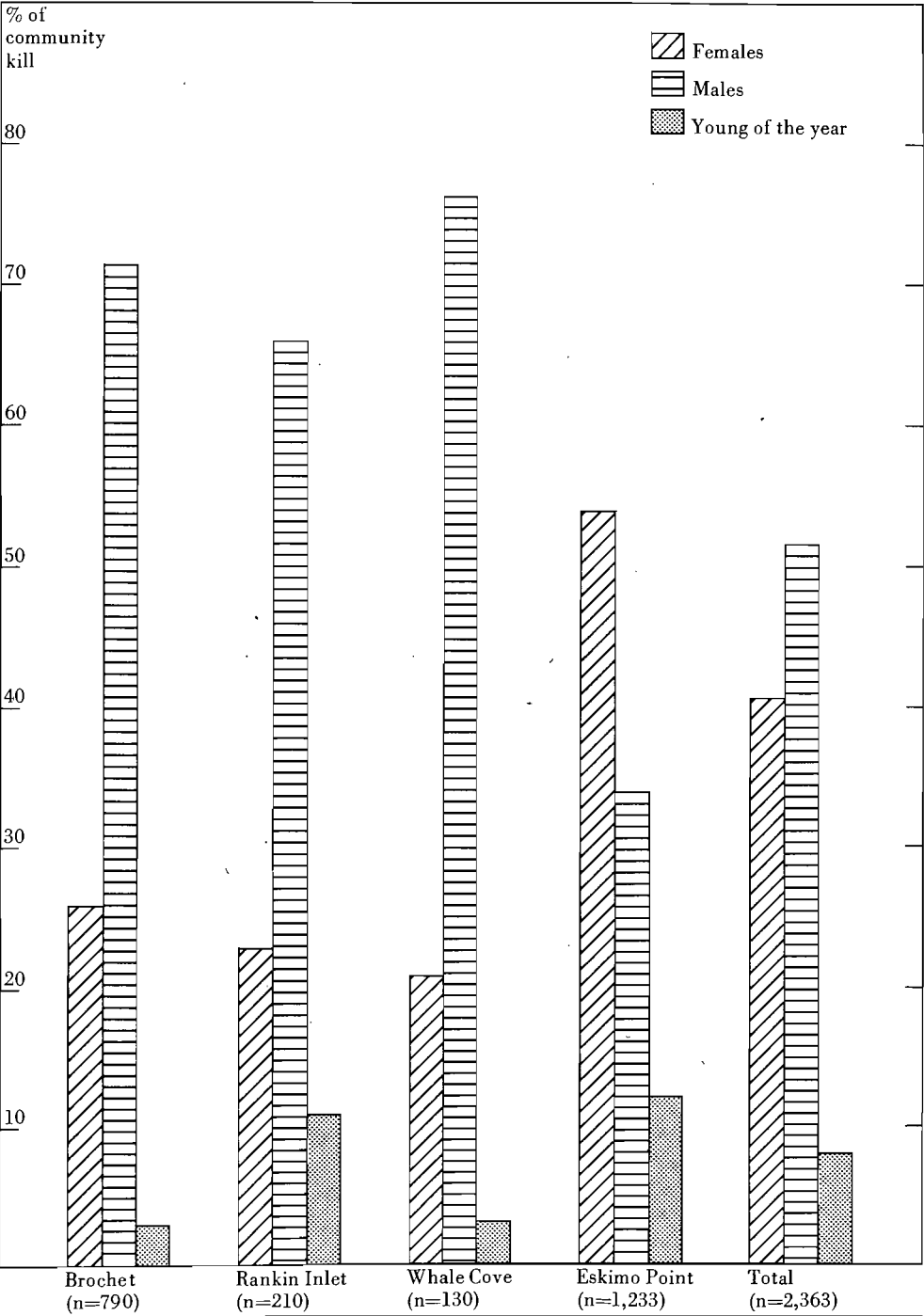


Table 20

The distribution of Eskimo and Indian hunters according to the number of caribou killed from the Kaminuriak Population from August 1967 to July 1968.

Community	Number of caribou killed						
	1-5	6-10	11-20	21-30	31-40	41-50	51-65
Rankin Inlet (n = 47)	34(72%)	9(19%)	3(7%)	1(2%)			
Whale Cove (n = 24)	14(59%)	8(33%)	2(8%)				
Eskimo Point (n = 93)	27(29%)	21(22%)	25(27%)	10(11%)	7(8%)	2(2%)	1(1%)
Brochet (n = 59)	20(34%)	19(32%)	10(17%)	7(12%)	1(2%)	2(3%)	
Total (n = 223)	95(42.6%)	57(25.5%)	40(17.9%)	18(8%)	8(3.9%)	4(1.7%)	1(.4%)

n = number of hunters.

Table 21

Total caribou killed by hunters at four communities, average number of caribou killed per family and per hunter, and estimated amount of fresh caribou meat obtained per family and per person from August 1967 to July 1968.

Community	Total reported hunters	Total families	Total population	Caribou killed	Caribou killed per hunter	Caribou killed per family	Meat* per family, lb.	Meat* per person, lb.
Rankin Inlet	47	90	375	210	4.5	2.3	175	42
Whale Cove	24	34	145	130	5.4	3.8	286	67
Eskimo Point	93	121	442	1,233	13.3	10.2	764	209
Brochet	59	134	670	790	13.3	5.9	442	88
Total	233	379	1,632	2,363	10.5	6.2	467	108

*Estimated average of 75 lb. of meat per caribou.

of 3,560 caribou, Indians accounted for 53 per cent and Eskimos for 47 per cent. Approximately 68 per cent of all hunters killed 10 or fewer caribou and only 5 (2.1 per cent) reported killing 40 or more caribou (Table 20).

There is a consistently greater monthly kill from January to April (Fig. 34). Indians kill most of the winter-killed caribou. The large kill in September consists mainly of females 12 months or older (64 per cent) taken by hunters from Eskimo Point. During fall migration and early winter (October to December) few animals are killed. By January the migrating animals reach Brochet and Wollaston Lake. The kill begins then and remains high until the spring when the animals move onto the tundra towards the calving ground. A high kill of females in September and of males in the

winter is evident by comparing Figures 34 and 35.

The area from which caribou are hunted is only 20 per cent of the total range of the Kaminuriak Population (Fig. 36).

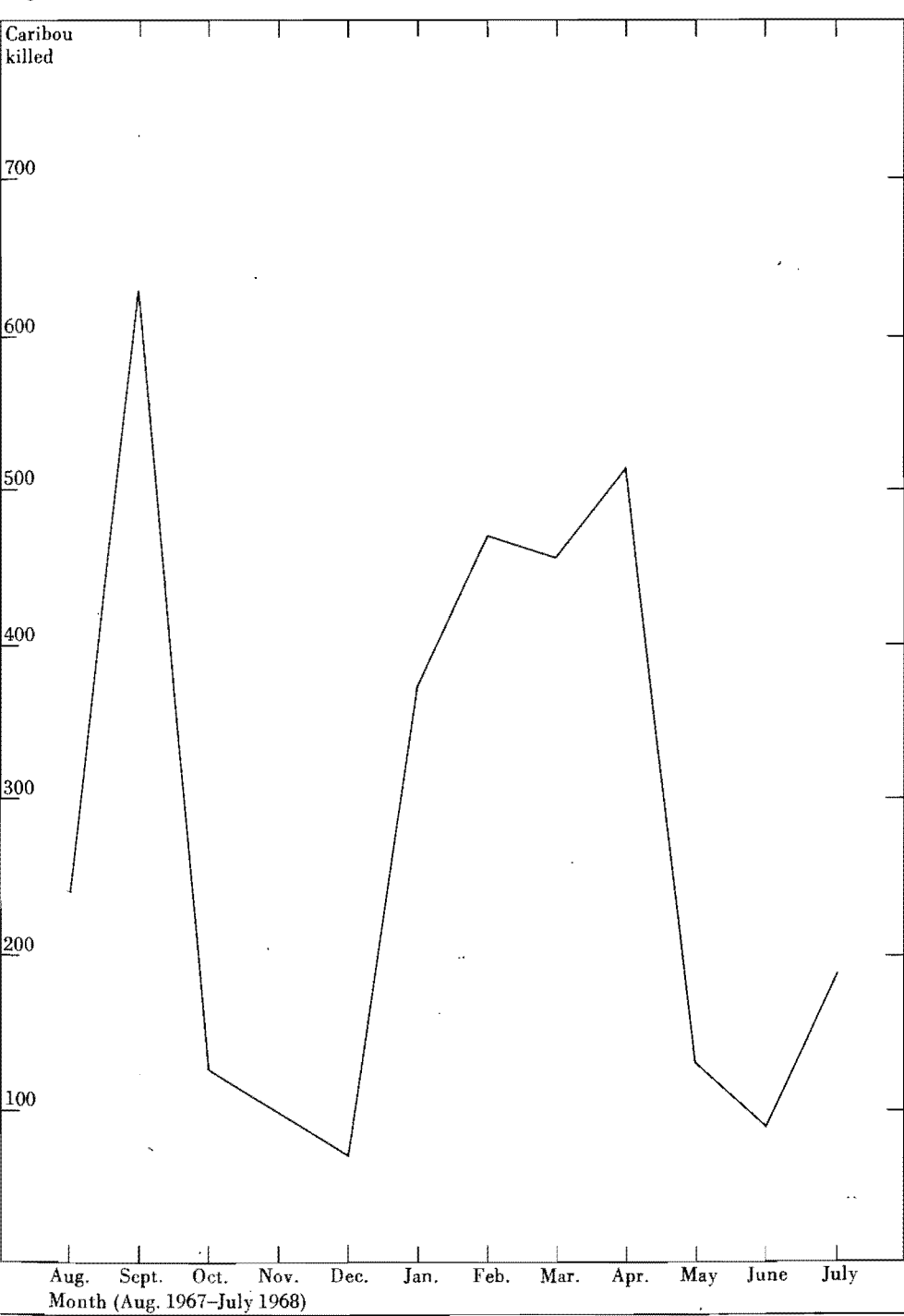
Of the total recorded kill, the average number of caribou killed per native family was 6.2. The average number of pounds of caribou meat per family was 467 and per person was 108 (Table 21). The estimated total kill of caribou over 1 year of age was approximately 5.3 per cent of the population (over 12 months) in 1967-68.

Discussion

An annual native harvest of 5.3 per cent of the population over 1 year of age seems at first sight a conservative kill. However, with the relatively low annual recruitment of 9 to 10 per cent, the kill combined with all

Figure 34. The number of caribou killed each month by hunters of Brochet, Manitoba, and of Eskimo Point, Rankin Inlet, and Whale Cove, N.W.T., from August 1967 to July 1968.

Figure 34



other mortality factors is preventing any substantial population increase.

Skoog (1968) reports a loss of 8 per cent of the Nelchina Herd in Alaska, excluding calves, to hunting mortality from 1955-56 to 1962-63. During this period the herd increased by 77 per cent. The average annual recruitment, however, was 20 per cent, compared to 9 to 10 per cent for the Kaminuriak Population.

The present loss of caribou to human predation is considerably lower than that documented for the same population 15 years earlier. Banfield (1954) reported a 29 per cent loss of this population in 1947-48 from hunting alone, resulting in a deficit of 14 per cent, excluding other sources of mortality. In the early 1950's, when thousands of caribou migrated south in the winter across the Churchill River, animals were killed by Indians of Split Lake, Nelson House, Gods Lake, Cross Lake, York Factory, Shamattawa, Oxford House, Pukatawagan, Island Lake, Churchill, Southern Indian Lake, Brochet, and Duck Lake. From 1966 to 1968, the only Indian communities having any appreciable effect on this population were Brochet and Wollaston Lake.

The number of caribou lost through crippling is unknown. Many of the animals wounded undoubtedly fall prey to wolves and are included in total mortality as that proportion allotted to wolf predation.

Over a vast amount of the caribou range no mortality from hunting occurs. During the summer and fall, only those caribou near the coast are subjected to hunting pressure. Unfortunately, a high proportion of these are cows, calves, and juveniles. Those caribou inland, west as far as Ennedai Lake, do not have a shot fired at them from spring to mid-winter. These western concentrations consist of a high proportion of adult males and a low percentage of cows and calves.

In the winter months, the adult males are subjected to the heaviest hunting, which should not adversely affect the population. In some years, large numbers of cows and calves remain on the coastal

Figure 35. The extent of monthly hunting mortality on males and females over 1 year of age as a percentage of the total mortality by hunting from August 1967 to July 1968.

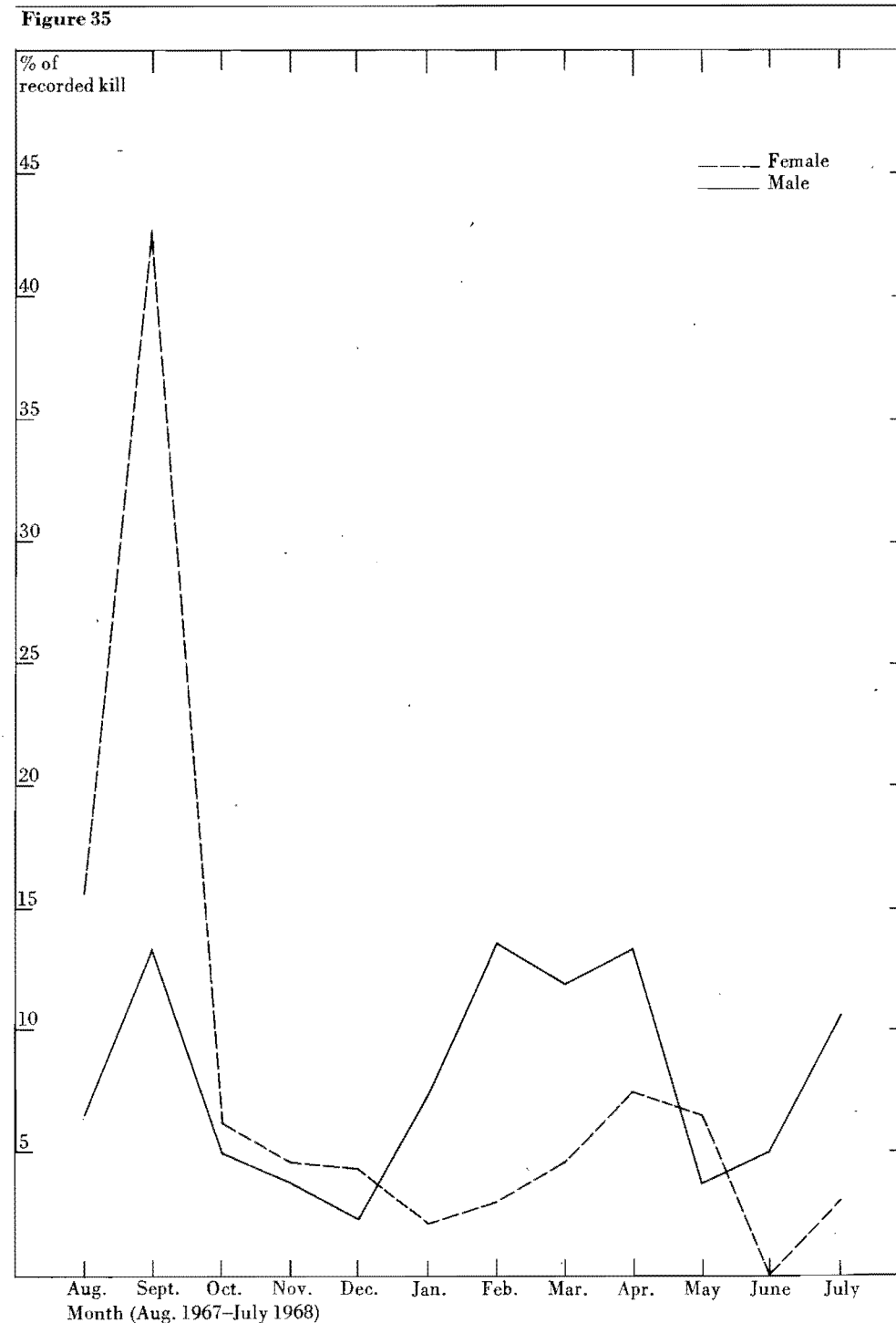
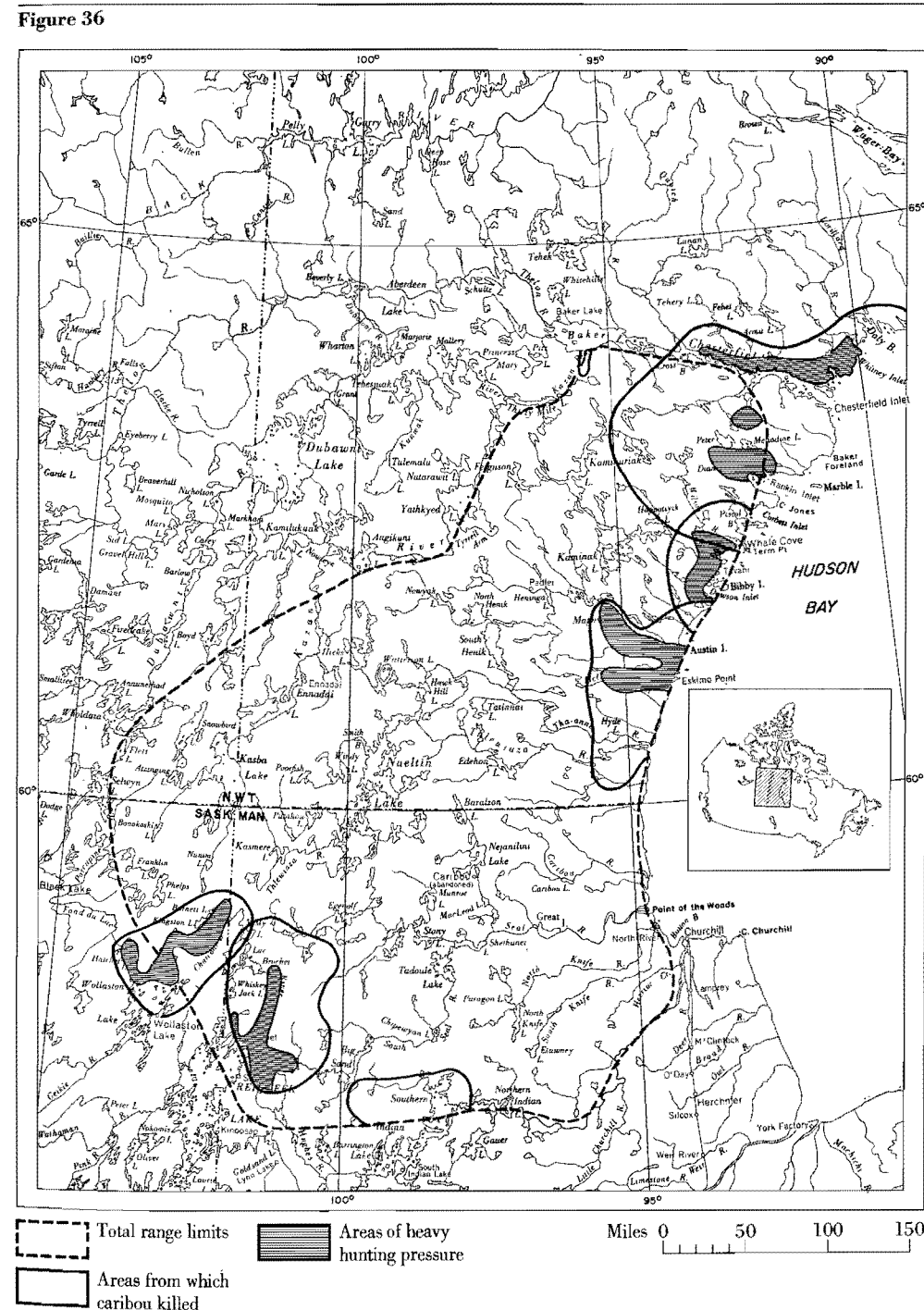


Figure 36. The approximate areas from which caribou were killed by Indian and Eskimo hunters within the range of the Kaministiquia caribou population from August 1967 to July 1968.



in northern Canada was by Clarke (1940). Clarke allotted 100 square miles per den, six wolves per den, and a total area of 600,000 square miles, resulting in a total population of 36,000 wolves. This results in an average wolf density of approximately one wolf per 16 square miles. Banfield (1954) believed Clarke's figure was much too high. He observed 82 wolves over 50,000 square miles of aerial coverage, for a wolf density of approximately one per 600 square miles. Using Clarke's total range figure of 600,000 square miles, the total wolf population as calculated by Banfield was only 1,000. If Clarke's estimate was too high, Banfield's estimate was too low. More than 1,000 wolves (585 adults) were killed in northern Manitoba and southern Keewatin alone during the year 1953-54. Kelsall (1968) estimates one wolf per 60 square miles of land surface for a total population within the range of the mainland Canadian barren-ground caribou of 8,000 wolves.

There is no doubt that certain areas of northern Canada continuously support higher wolf densities than other areas. The area most favoured for denning appears to be near the tree-line. This is the one area where wolves will be without caribou for the shortest period of the year. Caribou move out onto the tundra in late May, the bulls continuing throughout June, and the mid-summer migration brings the caribou back towards the tree-line by early August. Those wolves denning near the tree-line are without substantial numbers of caribou only 6 to 8 weeks, and scattered caribou can always be found near the tree-line throughout the year.

Murie (1944) estimated one wolf per 50 ± square miles in Mt. McKinley National Park, Alaska, while Cowan (1947) estimated one wolf per 87 to 111 square miles in Jasper National Park, Alberta. Stenlund (1955) estimated one wolf per 16 square miles in Superior National Forest, Minnesota; Mech (1966) estimated one wolf every 10 ± square miles on Isle Royale, Michigan; and Pimlott (1969) estimated one wolf per

tundra throughout the winter. During such years, the loss to native hunting undoubtedly does adversely affect the population.

The annual kill documented for 1967-68 must be considered minimal, as very few caribou wintered on the tundra and the Eskimo kill was low. The Indian and Eskimo caribou kill fluctuates annually, depending on the winter distribution of the caribou population.

Only one instance of deliberate wastage of caribou was observed during the present study. In March 1968, 10 caribou were shot on Charcoal Lake, Saskatchewan, and only the heads were taken by the Indian hunter. The hunter was not identified but was a resident of Wollaston Lake, using a ski-doo as means of travel. In all other instances where native kills were examined, all usable parts of the caribou had been taken by the hunter.

The practice of feeding caribou meat to dogs is still prevalent among both Indians and Eskimos. This usually occurs when the native is travelling on the land by dog team, and with the increasing use of ski-does, especially by the Eskimo, I do not feel this is a significant problem. The number of dog teams in the communities of Baker Lake, Chesterfield Inlet, Rankin Inlet, and Eskimo Point dropped from 190 in 1957 to 62 in 1967 (R.C.M. Police, pers. comm.).

There is no reason to believe the native kill will continue at its present level. In the near future the caribou population may well change its present wintering distribution and once again cross the Churchill River and penetrate as far south as it did 15 to 20 years ago. Such a shift in winter distribution would create a substantial increase in the annual kill. It is doubtful, however, if such a shift will occur with the population at its present level.

Wolf predation

Distribution and abundance

Perhaps the first estimate of wolf numbers within the range of barren-ground caribou

10 ± miles in Algonquin Provincial Park, Ontario.

Since wolves within barren-ground caribou range in northern Canada depend on this species for much of their diet, the density of wolves must necessarily vary between areas according to the season. During the winter months, when most caribou are within the taiga, wolf densities there appear to be higher than on the tundra. During the summer months, wolf densities might be expected to increase near the tree-line and on the tundra.

Wolf populations also appear to fluctuate periodically in the Canadian North, possibly with changes in numbers of barren-ground caribou. Reports indicate wolves are fewer now in northern Manitoba than in the early and mid-1950's. An intensive poisoning program during this period undoubtedly contributed to their decline, but this program terminated in the early 1960's and the population is still considered low. Total caribou within the Kaminuriak Population declined during the 1950's and has remained low through the 1960's. This decline in abundance of the major prey species is probably largely responsible for the present low wolf population. A total of 465 wolves in 169 packs were observed during aerial surveys over the Kaminuriak Population from 1966 to 1968. Wherever caribou were concentrated, wolves were most likely to be observed. During the summer months most flying was done north of the tree-line where caribou densities were generally low and consequently wolves much more scattered. The proportion of wolves unobserved on surveys is unknown. More wolves were recorded during the winter months within the taiga, although wolves are seldom seen in winter except on frozen lake surfaces.

There is strong evidence to suggest that wolves, particularly of the tundra races, move great distances annually to remain within the area of caribou distribution. Instances of wolves moving south from north of the tree-line into the area of caribou distribution were observed. Whereas tundra

wolves typically den near or north of the tree-line and many move south into the taiga during the winter, it is doubtful whether the timber wolves move north of the tree-line in the summer. Both "races" may be found together during the winter months, but in the spring the tundra wolves move north, usually ahead of the spring caribou migration, to their denning areas north of the taiga.

Kuyt (1962) has tag recoveries from three wolf cubs which moved 185 miles from the denning area near Beverly Lake, N.W.T., southwest towards the tree-line following the fall caribou migration. Kuyt (1969) believes most wolves observed on the caribou calving ground and in the area of July post-calving distribution are non-breeding wolves, possibly yearlings and 2-year-old animals. The main denning area is farther south near the tree-line.

He recorded a winter density of one wolf per 6.9 square miles near Abitau Lake, N.W.T., in March 1968. This was within an area of high caribou density, and, 20 miles from the centre of caribou concentration, both caribou and wolves were absent. Kuyt considers that such a high density as that at Abitau Lake could occur only at times of maximum compression of prey population.

It is very difficult to obtain a reliable estimate of total wolf numbers within the range of the Kaminuriak barren-ground caribou population. Wolf densities vary between areas and with the season, making estimates based on limited aerial surveys questionable. Wolves are easily observed on the tundra during the summer and on frozen lakes in the winter. The number which were undetected off the lakes in the winter is unknown. All wolf densities and total numbers based on results from aerial surveys during this study must be considered minimal. The number of wolves which remain north of the tree-line in the winter depends on the number of caribou which winter on the tundra.

Kelsall (1957) estimated approximately one wolf per 60 square miles of land surface

over the entire barren-ground caribou range in mainland northern Canada. Assuming land surface comprises 75 per cent of the total study area of 109,000 square miles, the total number within the range of the Kaminuriak Population would be 1,350.

From May 1966 to October 1968, an average of 463 miles was flown per wolf observed north of the tree-line. Wolves can be observed approximately 1 mile on either side of a plane flying over the tundra. A calculation based on a 2-mile-wide strip transect results in an estimate of one wolf per 231 square miles. The tundra area measures 62,000 square miles, for an estimated summer wolf population on the tundra within the study area of 268 animals.

This is much lower than Kelsall's figure of one wolf per 60 square miles. During the late 1950's an intensive wolf control program was conducted which undoubtedly reduced total numbers over the last decade. Although this program was terminated by the early 1960's, except for small-scale, local control programs, it appears the population has remained at a much lower level than in the 1950's. This can possibly be explained by the lowered availability of prey. There was a sharp increase in total numbers of barren-ground caribou within the present study area in the 1940's. This increase possibly was a result of an easterly shift of animals from one or more of the westerly populations. The caribou population numbered twice its present size in the early and mid-1950's (Banfield, 1954; Loughrey, 1956). With the increase in the prey population, an increase in the number of wolves was inevitable. Although caribou numbers continued to decline through the 1950's, the wolf population appears to have remained high.

Although the wolf control program undoubtedly assisted in terminating the decrease in caribou numbers, the wolf population would inevitably have decreased naturally without the extensive poisoning program. Before this occurred, however, caribou numbers might have been reduced to a greater extent than they actually were.

Summer aerial surveys over the tundra part of the study area yielded an average density of one wolf per 231 square miles, and a total estimate of 268. During the winter of 1967-68, the number of wolves estimated within the area of caribou distribution in the taiga was 258. This figure resulted from extrapolating wolf densities calculated from observations during monthly barren-ground caribou surveys. Combining the two estimates gives a total wolf population for the study area of only 526. This has to be considered a minimum figure. The number of wolves unobserved on transect, especially during the winter, is unknown. Conversely, the number of tundra wolves included in the winter estimate within the taiga is also unknown. The average density throughout the study area is estimated at approximately one wolf per 200 square miles.

This figure is low compared to results of the predator control program in the 1950's. J. D. Robertson, formerly in charge of the wolf control operation in northern Manitoba, added the following to his report for the year 1954-55 (Manitoba Dept. of Mines and Natural Resources, Annual Report, 1954-55).

The trappers took 323 pups in the Brochet Section after a total of 286 positive adult wolves had been accounted for by the program and trappers. This is an alarming figure if all the pups originated in the Brochet Section. It indicates a heavy wolf population still exists. Our data this year show, of 136 wolves aged, 34 under one year old or one-quarter of the population was yearlings. In 1954, of 11 pregnant females examined, the average litter size was 6.3. This sample being small, I shall use the figure of five pups for each pregnant female in the following argument.

It would take 60 breeding females to produce 300 pups. There would be an equal number of breeding males, making a total of 120 breeding adult wolves. There would also be 40 non-breeding wolves one year old. As the trappers could not possibly account for more than 50% of the dens, we could duplicate the adult figure

and add another 300 pups, giving us a wolf population of approximately 600 wolves for the Brochet Section These figures could possibly be duplicated for the Duck Lake Section, not to mention the area north of our boundary in the Keewatin District east to the coast, west to the Dubawnt River and north of the tree-line.

The above figure of 600 wolves for the Brochet Section is misleading for it includes 300 pups. From the poisoning program it was concluded that by winter only one quarter of the population was under 1 year of age. Robertson's calculations allow for 320 adults by the following winter, resulting in an additional 106 wolves (one quarter of total) under 1 year of age for a total of 426 wolves. This is still considerably higher than the figure of 258 resulting from winter aerial surveys in 1968.

Predation

It is now necessary to determine the effect the estimated 500-600 wolves have upon the Kaminuriak barren-ground caribou population.

Banfield (1954) estimated a 5 per cent loss annually from mainland barren-ground caribou populations due to wolf predation. Clarke (1940) estimated a requirement of 11 caribou per wolf annually, and Kelsall (1960) estimated 14 per wolf annually. Kuyt (1969) raised captive wolves and calculated 3.5 pounds of meat daily would be the minimum requirement of wolves in the wild.

Barren-ground caribou of the Kaminuriak Population are north of the tree-line from June to October, a period of 5 months. I found approximately 250 wolves on the tundra during this period. By examining 595 wolf scats during spring and summer near the Thelon River, Kuyt (1969) found caribou comprised 47 per cent of the food items. It seems reasonable, then, that approximately one half of the diet of wolves on the tundra during the summer consists of caribou.

A total of 250 wolves, requiring 3.5 pounds of food per day for 5 months (150

days) would consume 131,250 pounds over the summer period, of which one half, or 65,000 pounds, would consist of caribou. Kuyt (1969) found one third (33.8 per cent) of caribou carcasses ($n = 151$) on the tundra during the summer, a large percentage of which he attributed to wolf predation, were less than 1 year of age. Miller (pers. comm.) determined that during the winter of 1967-68 the proportion of calves in the caribou killed by wolves was double the ratio found in the population (20 per cent compared to 10 per cent). Kuyt's figure is also nearly double the actual calf percentage in the population during the summer months. The proportion of calves in the Kaminuriak Population from July to October was found to approach 15 per cent.

These data suggest that wolf predation rates on calves are consistently greater than on other age classes, and that the proportion of calves to other caribou killed is approximately double their proportion in the population.

For 65,000 pounds of meat, 300 calves of an average consumable weight of 20 pounds and 590 adults of an average consumable weight of 100 pounds would be required, and these figures would give 33 per cent calves in the total kill.

During the winter months (November to May) caribou comprise the staple diet of wolves (Kuyt, 1969). If we assume the total wolf population is 550, and each wolf requires 3.5 pounds of meat per day for this winter period of 210 days, the total requirement is 735 pounds of meat per wolf or 404,250 pounds for the total population. Aerial segregation data indicated a loss of approximately 4,000 calves from October to June of 1967-68 and 1968-69. Bergerud (1969) has found calf mortality during the winter months to be insignificant, to the extent that he is able to use fall calf ratios for his annual recruitment figure. In Newfoundland there are no wolves, and lynx, although important predators on young calves shortly after birth, do not affect woodland caribou populations in the winter. I believe the high winter loss (40 per

cent) of calves from the Kaminuriak Population is due to wolf predation.

If we assume wolves are responsible for the loss of these 4,000 calves, and allow 40 pounds of meat per calf, this calf loss provides 160,000 pounds of the estimated 404,250 pounds of meat required for the wolf population during the winter. The remaining 244,250 pounds of meat required would be provided by caribou over 12 months, at 100 pounds per carcass, for a total of 2,442 animals.

The annual loss of caribou from the population of approximately 63,000 animals prior to calving, to a population of about 550 wolves, is estimated at 3,032 caribou over 12 months and 4,300 calves. The annual loss of caribou 12 months of age or older is estimated at 4.8 per cent. The number of caribou over 12 months killed per wolf annually is calculated at 5.5, and the total number, including calves, is 13 caribou per wolf annually. This last figure is similar to the 11 (Clarke, 1940) and the 14 (Kelsall, 1960) calculated by earlier authors.

Wolf control

To assist in terminating a drastic decline in barren-ground caribou numbers, the federal and provincial governments began an extensive wolf control program which continued throughout the 1950's. Only limited wolf control in small areas has continued since the early 1960's.

It is difficult to assess the value of the wolf control program for we do not know the consequences if the program had not been initiated. When wolf control was introduced, the caribou decline was alarming. The native caribou kill alone exceeded the annual recruitment rate during this period, but these people depended upon the caribou and conservation measures would be slow to instill and enforce. The only other major drain on caribou was by wolves. Where men and wolves competed for a diminishing resource, it was the loss to wolves which had to be controlled. The program consisted of government-set poison baits, government-paid predator control officers, bounty

Table 22
Results of a wolf control program in northern Manitoba and southern District of Keewatin from 1952 to 1960 (from Manitoba Game Branch annual reports, 1952-60).

Year	No. of poison sets	Positive kills	Likely kills	Total poisoned	Wolves killed per bait	Killed by paid hunters		Killed by trappers		Total kill	
						Ad.	Pups	Ad.	Pups	Ad.	+pups
1952-53	63	325	46	371	5.8			148	298	519	817
1953-54	96	309	57	366	3.8			219	478	585	1,063
1954-55	120	306	77	383	3.2			166	412	549	961
1955-56	132	287	15	302	2.2	327*		12		641	641
1956-57	139	309	38	347	2.5	131*				478	478
1957-58	61	242	40	282	4.6	132*		12		426	426
1958-59	70	184	66	250	3.5	33	161			283	444
1959-60	74	152	38	190	2.5	17	134			207	341
Total	755	2,114	377	2,491	3.3	640	295	557	1,188	3,688	5,171

*Possibly includes some wolf pups.

Table 23
Results of a wolf control program from 1952 to 1960 in the Brochet Section of northern Manitoba and southern District of Keewatin (from Manitoba Game Branch annual reports, 1952-60).

Year	No. of poison sets	Positive kills	Likely kills	Total poisoned	Wolves killed per bait	Killed by paid hunters		Killed by trappers		Total kill	
						Ad.	Pups	Ad.	Pups	Ad.	+pups
1952-53	20	95	10	105	5.2			24	163	129	292
1953-54	46	133	20	153	3.3			47	356	200	556
1954-55	80	254	71	325	4.0			32	323	357	680
1955-56	68	188		188	2.7	31	236			219	455
1956-57	56	87	21	108	1.9	118				226	226
1957-58	28	129	9	138	4.9	17	114			155	269
1958-59	35	113	43	156	4.4	33	161			189	350
1959-60	48	113	24	137	2.8	17	134			154	288
Total	381	1,112	198	1,310	3.4	216	645	103	842	1,629	3,116

systems, and a native spring pup capture program.

Table 22 presents the results of the program in northern Manitoba and southern Keewatin from 1952 to 1960. A total of 3,688 adults and 1,483 pups were killed during this 8-year period. Although the total kill of wolves declined from 1953-54 to 1959-60, a more accurate index to wolf abundance is perhaps the number of wolves killed per poison bait. In 1953-54, 3.8 wolves were killed per bait and 5 years later in 1958-59, after more than 3,500 wolves had been removed, 3.5 wolves were still killed per bait.

Table 23 presents the wolf kill data for the Brochet Section of northern Manitoba and southern Keewatin from 1952 to 1960 (extracted from Table 22). The Brochet Section is a traditional wintering area for caribou of the Kaminuriak Population. The largest number of wolves killed per bait was in 1952-53; the second and third largest numbers were in 1957-58 and 1958-59, after over 2,000 wolves had been killed from this particular section alone. More adult wolves were poisoned from this section in 1959-60 than in 1956-57 with fewer poison baits (48 versus 56). More adult wolves were killed in 1959-60 than in

1952-53. These figures suggest the wolf control program within the study area was not effective in diminishing wolf numbers during the early and mid-1950's.

When wolf control operations began in the Great Slave Lake area, N.W.T., in 1955-56, wolves under 1 year of age comprised only 13 per cent of those killed; in 1960-61, after a continued wolf control program, wolves under 1 year comprised 73 per cent of those killed (Kelsall, 1968). This may explain what happened in northern Manitoba and southern Keewatin. As the population was harvested, survival of the young steadily increased. Wolf numbers appear to have declined in spite of reduced control programs beginning in the late 1950's and early 1960's. Whether this was a natural decline following the decrease in caribou numbers or a direct effect of the wolf control program is unknown. The wolf control program is discussed in more detail by Fuller and Novakowski (1955), Loughrey (1958), and Kelsall (1968).

The present status of the wolf within the range of the Kaminuriak Population does not appear critical. Predation during the summer months on caribou over 1 year of age is low. Those wolves in the northern portion of the range during June and July undoubtedly prey mainly on calves, but wolf numbers near the calving ground and area of post-calving distribution appear very low.

The winter months, especially from February to May, appear to be the period of highest wolf predation on adult caribou. The extent of winter predation appears to increase greatly when snows are deep and caribou become concentrated and stationary, as in 1967-68. In areas where caribou densities reach 65 per square mile and wolf densities approach one per 6 to 8 square miles, there are bound to be substantial numbers of caribou killed. In late winter and spring, as crusts form and travelling becomes easier for wolves but difficult for caribou, considerable numbers of caribou may be lost to predation. The estimated loss of adult caribou (over 1 year) to wolf pre-

dation was very similar to the loss to human predation (3,032 compared to 3,318) in 1967-68.

It has been suggested that an extensive and costly wolf control program, such as that of the 1950's, was not sufficient to reduce wolf numbers in many areas. The cost of such a program today would be much higher than it was 10 to 15 years ago. The 1957-58 predator control program in the Northwest Territories alone cost over \$45,000 (Loughrey, 1958).

There is also the question whether the poisoning program is justified in view of the fact many animals other than wolves are killed.

I believe wolves are necessary to maintain a healthy population of barren-ground caribou. The argument that humans can continue to harvest the population and take the place of the wolf is not valid. In many cases humans have a detrimental effect upon a cervid population by killing the strongest and best adapted individuals while leaving the poorer breeding stock to continue adding inferior animals to the population. Wolves, which admittedly kill many healthy and prime animals, also harvest those which are not benefitting the population, in contrast to man's selective harvest. Too little is presently known of the wolf-caribou relationship. Native-kill statistics, annual recruitment rates, and other aspects of caribou population dynamics can be determined, but the remaining unknown is the effect of wolves upon the population.

Discussion

Annual mortality from predation is estimated at approximately 10 per cent of the Kaminuriak Population over 12 months of age from 1966 to 1969. Native kill in 1967-68 accounted for 5.3 per cent and wolf predation was estimated at 4.8 per cent of the population over 12 months in age.

If there are 63,000 caribou over 12 months and 550 wolves, there are about 114 caribou per wolf. In 1962, an estimated 145 to 160 wolves were within the range of the Nelchina caribou herd, Alaska, which at

that time numbered 71,000 animals (Skoog, 1968). This is a ratio of approximately one wolf per 473 caribou. Wolf predation upon caribou of the Nelchina Herd must be much less than that on the Kaminuriak Population. This may be a factor in the higher rate of calf survival for Alaskan populations.

Pimlott *et al.* (1969) suggest wolves may be capable of controlling deer populations when the ratio of wolves to deer does not exceed 1:100. If this ratio holds for white-tailed deer, then a much higher ratio would presumably fit a similar statement on the barren-ground caribou, with its much lower reproductive rate. In view of the calculated ratio of one wolf per 114 caribou for the Kaminuriak Population in the spring, it seems quite possible that wolves may control this population.

A 10 per cent total mortality of caribou over 12 months of age within the Kaminuriak Population is not considered excessive. It is lower than the annual mortality for Alaskan caribou populations (Skoog, 1968) and Newfoundland caribou (Bergeud, 1969). It is much lower than the calculated mortality for the same population 15 to 20 years earlier when native hunting alone accounted for an estimated 29 per cent of the population annually (Banfield, 1954).

The adult male to female ratio of 55:100 suggests hunting pressure on adult males could be increased with no detrimental effect on the status of the population. In September 1968, the caribou concentration on the central and western portions of the late summer range contained a very high proportion of adult males. The only caribou which are affected by native hunting from May to November are those animals distributed along the coastal tundra near the Eskimo communities of Rankin Inlet, Whale Cove, and Eskimo Point. During the winter months the kill of caribou may become excessive when large numbers of caribou remain on the tundra and others move south into the taiga near the Indian communities of Brochet and Wollaston Lake.

Total numbers and composition

When kill statistics were collected in 1967-68, few caribou remained on the tundra and these statistics must be considered minimal.

Over the past 10 or 12 years, government policy has discouraged natives from remaining on the land in favour of centralizing them in accessible communities for convenient administration. Efforts are now being made to assist many Eskimos to exploit the surrounding natural resources to boost the local economy. The fishing and trapping industries are being revitalized and a number of houses have been moved out on the land as temporary centres for hunting, trapping, and fishing.

These are progressive and properly oriented programs, but it must be emphasized that with this "reoccupation" of the land, an increase in the annual caribou kill should be expected. The present seasonal distribution and low number of the Kaminuriak Population will prevent the kill from approaching that of 15 to 20 years earlier. Alternative activities within the communities prevent many of the men participating in the hunting of caribou. Although 3,560 caribou were estimated killed in 1967-68, this figure could easily increase to 5,000 any year. The native people should be the first to benefit from the wildlife resources of their particular area. Many of the Indians and Eskimos still rely heavily on caribou to provide their only source of fresh meat. Assuming an average of 75 pounds of consumable meat per carcass and a minimum value of 50 cents per pound, the 1967-68 kill of 3,560 caribou provided 267,000 pounds of fresh meat valued at \$113,500 to the natives. The cost of supplementing or replacing this with meat from the south would be much greater.

Females

The basis for calculating the number of adult females in the population was the June 1968 calving ground survey. The number of caribou 1 year of age and older on the calving ground was calculated to be 33,962 animals. From ground and air segregation between June 15 and 18, it was determined that 80 per cent of the caribou on the calving ground aged 12 months or more were breeding females. These figures, combined with spring calf ratios (1967 to 1969), autumn adult sex ratios, and results from the 3-year caribou collection program are drawn upon to derive the following calculations.

Breeding

The 1968 early June calving ground survey gave an estimate of 33,962 caribou 12 months or older on the calving ground. Segregation data indicated that 80 per cent, or 27,169, were breeding females.

Twelve months

The collection program found no instances of females breeding in their first year.

Twenty-four months

One of 46, or 2.2 per cent, of rising 2-year-old females collected in the month of April and June from 1966 to 1968 was pregnant. Prior to calving in 1968, the rising 2-year-old class equalled the annual recruitment in 1967 (estimated 6,000) less mortality from June 1967 to June 1968. Mortality on caribou over 1 year of age has been estimated at 5.3 per cent by human predation and 4.8 per cent by wolf predation, for a total loss from predation of 10.1 per cent. This loss to predation (6,000 - 10.1 per cent = 5,394) leaves 5,394 caribou 24 months of age by June 1968. Assuming one half are females (2,697) of which 2.2 per cent are breeders, only 59 (2,697 x 2.2 per cent) females of this age class gave birth in June 1968.

Thirty-six months

There are no recruitment figures for the spring of 1966. Age composition of samples collected in April and June 1968 suggests

that a large class of 34- and 36-month-old animals was present. The June 1968 sample showed that 13.6 per cent (9 of 66) of caribou 1 year of age or older on the calving ground were 3-year-old females, or 4,618 animals (33,962 x 13.6 per cent). Of this 55.6 per cent (5 of 9) were pregnant, or 2,567.

Forty-eight months and older

The total number of breeding females on the calving ground in 1968 has been calculated at 27,169. Of this total, 59 were 24 months of age and 2,567 were 36 months of age. The remaining 24,543 caribou (27,169 - (2,567 + 59)) giving birth in 1968 must have been females 48 months of age or older.

Non-breeding

Twelve months

The spring recruitment in 1968 was estimated at 6,000 caribou of which one half should have been females. No females were found to breed in their first year so the number of non-breeding caribou 12 months of age in June 1968 is calculated at 3,000 animals.

Twenty-four months

It is estimated that there were 5,394 caribou 24 months of age in the population in June 1968 of which half, or 2,697, were females. Only 59 of these were believed pregnant, leaving 2,638 (2,697 - 59) non-breeding 24-month-old females in June 1968.

Thirty-six months

It has been estimated that 4,618 (13.6 per cent of the caribou 12 months and older) female caribou 36 months of age were on the calving ground in June 1968. Of this total, 2,567 were breeding females. Not all non-breeding 3-year-old females would have been on the calving ground and I therefore estimate the number of females in this class at 5,000 animals. Thus, the number of non-breeding 36-month-old females is estimated at 2,433 (5,000 - 2,567).

Forty-eight months and over

From samples collected in April and June

from 1966 to 1968 it was found that 86.4 per cent of females 46 and 48 months and older were pregnant. The number of breeding females 48 months and older was estimated at 24,543 animals, leaving 3,863 non-breeding females 48 months and older in June 1968.

Males

Twelve months

The recruitment in the spring of 1968 has been estimated at 6,000 caribou, of which one half, or 3,000 animals, were presumably males 12 months of age.

Twenty-four months

It has been calculated that there were 5,394 caribou 24 months of age in the population by June 1968, of which one half, or 2,697, were presumably males.

Thirty-six months and over

In the fall of 1968, the adult male (39 months and older) to adult female (39 months and older) ratio was calculated to have been 55:100. The number of females 3 years of age and older in June 1968 has been estimated at 33,406. Utilizing the ratio of 55:100, the number of males 3 years of age and older in the population by June 1968 is estimated at 18,373. Mortality of adults between June and September 1968 should not have significantly influenced the composition or total numbers of the population over this 3-month period.

Discussion

The calculated sex and age composition of the Kaminuriak barren-ground caribou population in June 1968 is presented in Table 24.

The total population prior to calving in June 1968 was estimated to be 63,173. Of the entire population, it was estimated that 61.8 per cent was female and 38.2 per cent male. The adult male to female ratio (36 months and older) was estimated at 55:100. Adult males and females comprised 29.3 and 52.8 per cent of the population respectively. Of the females, 69.4 per cent were

Table 24

The estimated sex and age composition of the Kaminuriak Population of barren-ground caribou prior to calving in June 1968.

Females

Age (in months)	No. breeding	% breeding	No. not breeding	% not breeding	Total	% of total females
12	0	.0	3,000	25.1	3,000	7.6
24	59	.2	2,638	22.1	2,697	6.8
36	2,567	9.4	2,433	20.3	5,000	12.7
48+	24,543	90.4	3,863	32.5	28,406	72.9
Total	27,169		11,934		39,103	
% of total females		69.4		30.6		100.0

Males

Age (in months)	Total	% of total males
12	3,000	12.4
24	2,697	11.2
36+	18,373	76.4
Total	24,070	100.0
Total males		
24,070	% of population 38.2	Total females 39,103
		% of population 61.8
		Total population 63,173

Class representation in population

Class (in months)	No. in class	% of population
12	6,000	9.4
24	5,394	8.5
36+ females	33,406	52.8
36+ males	18,373	29.3
Total	63,173	100.0

pregnant at the beginning of the calving season in June 1968. Breeding females comprised an estimated 43 per cent of the total population in the spring of 1968.

Males 1 year of age and older comprised 38.2 per cent of the population prior to calving in 1968 and those 36 months or older 35.4 per cent. Skoog (1968) records males comprising 44 per cent, 43 per cent, and 39 per cent of the caribou 1 year of age or older in the Arctic, Fortymile, and Nelchina herds respectively in Alaska. He also found males comprised 40 per cent and 30 per cent of caribou 3 years of age and older in the Fortymile and Nelchina herds respectively. His estimates were obtained from autumn segregation counts whereas my figures are mainly based on data obtain-

ed before the calving season, with the exception of the fall adult sex ratios.

That the proportions of males 1 year of age and older in Alaskan caribou herds are higher than determined for the Kaminuriak Population is probably due to the consistently greater first-year calf survival for Alaskan caribou. The number of calves in the Nelchina Herd from 1956 to 1962 was estimated to be 20.6 per cent of the total, or twice the percentage of calves in the Kaminuriak Population in 1967 and 1968 prior to the next calving season. The sex ratios of caribou in the first 2 years of life are relatively even and taking large components of young animals into account this tends to influence sex ratios in favour of males. A lower calf survival in the Kaminuriak Popu-

lation is thus responsible for the difference between its sex ratios and those of Alaskan caribou. In fact, when only caribou 36 months of age and older are considered, the percentage of males in the Kaminuriak Population is comparable to those reported for Alaskan populations.

The Alaskan Nelchina Herd is heavily exploited by sport hunting which decreases the adult male representation. The Forty-mile Herd, although subject to sport hunting, does not receive as much pressure as does the Nelchina Herd. Males 36 months of age and older are relatively fewer in the Nelchina Herd (30 per cent) than in the Fortymile Herd (40 per cent). The Kaminuriak Population is not subject to selective sport hunting. Adult males 36 months and older comprise 35.4 per cent of the total population, or about midway between the proportion in the Nelchina and Forty-mile herds.

In 1968, 43 per cent of the population before calving were estimated to have been pregnant females. A high mortality of caribou during the first year of life (78 per cent) is the factor which more than any other inhibits population increase. The annual recruitment is approximately one half that reported for Alaskan populations.

In 1967 and 1968, calves comprised 14 to 15 per cent of the Kaminuriak Population before the rut. By spring, calves comprised only 9 or 10 per cent of the population, a loss of approximately 41 per cent over the winter months. Winter calf mortality in Newfoundland is no greater than adult mortality (Bergerud, 1969), and annual recruitment is estimated directly from the proportion of 6-month-old animals in the population. Winter calf mortality (October to April) within the Nelchina Herd, Alaska, averaged 16 per cent from 1955-56 to 1960-61 (Skoog, 1968). This figure is much lower than the corresponding rate (41 per cent) for the Kaminuriak Population. Miller (pers. comm.) reported the proportion of calves in a sample of caribou killed by wolves during the winter of 1967-68, within the main wintering concentration of the

Kaminuriak Population, as twice as high as the calf proportion obtained from air and ground segregation. I believe winter predation on caribou by wolves was possibly the main contributing factor in the high loss of calves during the three winters 1966-69.

The size of the Kaminuriak Population before calving in 1968 was estimated at approximately 63,000 animals. Although all the aerial surveys support it, this estimate is considered minimal.

In 1955, when the population was steadily declining from the peak in numbers reached in the late 1940's, Loughrey estimated it to number 149,000 caribou. The present estimate is only 42 per cent of the number estimated 13 years earlier. It is believed the decline terminated around 1960 when a low of approximately 50,000 caribou was reached. A gradual increase to the present level of 63,000 animals occurred throughout the 1960's.

The exact size of the population depends on the time of year the estimate is made. During the peak in calving, 1968, the population numbered approximately 90,000 caribou. One month later it had decreased to slightly less than 74,000 animals and by the following spring reached its lowest level, before the new calving season, of approximately 63,000 caribou.

With the sharp increase in caribou numbers during the 1940's an expansion of the normal range occurred, in particular, an extreme southward extension into the taiga during the winter months. The decline in total numbers resulted in a reduction in range utilization and in extent of seasonal migrations.

Historical records (Hearne, 1795; Richardson, 1829) suggest the present extent of range utilized by the Kaminuriak Population is similar to that used in the past. This also suggests the present size of the population is similar to that which periodically existed in primitive times. There is reason to suspect that extreme periodic population fluctuations and range extensions have occurred in the past, similar to those documented during the 1940's. Barren-ground caribou populations appear to fluctuate continually in total numbers. This has also been shown for Alaskan caribou populations by Skoog (1968) and for woodland caribou populations in Newfoundland by Bergerud (1969).

The overall density of the population (63,000) in relation to total range (109,000 square miles) is one caribou per 1.7 square miles. This is much lower than densities recorded for other reindeer and caribou populations. Kelsall (1968) uses the figure of approximately five caribou per square mile of productive land for Canadian mainland populations in the late 1950's. During most seasons of the year, only a small proportion of the range supports the majority of caribou, and densities may reach extreme proportions. From January to April 1968, an estimated 51,214 caribou wintered in an area which varied from 3,954 square miles in January to 682 square miles in April, and densities reached as high as 68.5 caribou per square mile. For 2 months the density remained over 65 caribou per square mile. Densities on the calving ground in June 1968 averaged 14.7 animals 12 months or older per square mile.

The adult male to female ratio of 55:100 is in close agreement with those in other populations of barren-ground and woodland caribou in North America. This ratio appears typical for a caribou population unexploited by selective sport hunting.

Although the number of calves produced annually is relatively high, first-year calf survival is low. The estimated first-year mortality for calves of 78 per cent in 1966-68 is higher than most recorded first-year mortality rates for other caribou populations. In Alaska, Skoog (1968) reports a 40 per cent loss in the Nelchina Herd, and Bergerud (1969) records a loss of 68 per cent for woodland caribou calves in Newfoundland.

At birth in 1968, calves constituted 30 per cent of the population. The proportion of calves to total animals by the spring of 1967, 1968, and 1969 was 9 to 10 per cent.

The population cannot increase with an annual recruitment of 9 to 10 per cent and the present rates of mortality. The total native kill of caribou over 12 months was estimated at 3,318 animals in 1967-68. This is 5.3 per cent of the population over 1 year of age, and approximately 55 per cent of the annual recruitment.

In Newfoundland, where the only major predator of adult woodland caribou is man, Bergerud (1969) documents an annual loss of adults from natural mortality factors of 6 per cent. There is reason to expect this loss to natural causes, in areas supporting wolf populations, would be included in the loss of animals to wolf predation. My calculations suggest a loss of caribou over 12 months of age in the Kaminuriak Population from wolf predation of 4.8 per cent. It is possible that wolves are harvesting only that proportion of the population which would normally be lost to natural mortality factors. The one serious effect wolves may have on the population is through winter predation on calves.

If the annual recruitment were to increase to 15 per cent and adult mortality were to remain constant, the population would increase. To judge from the large representation of 36-month-old females in the June 1968 caribou collection, the spring recruitment in 1966 did approach 15 per cent.

With the present level of mortality and recruitment, the population may increase or decrease slightly in any year. The population possesses the potential for a rapid increase, but this potential is presently not being attained.

Barren-ground caribou have traditionally been relied upon to provide food, clothing, and shelter by many of the Indians and Eskimos inhabiting the forest and tundra inland from the western shore of Hudson Bay. The extent of dependence upon this natural resource by the native people has steadily declined over the past two decades and today caribou are considered mainly a dietary supplement rather than a means of survival. Most caribou are now killed within a short distance from the communities, and the scattered campsites of 20 years ago, most situated along traditional caribou migration routes, are now abandoned.

The Kaminuriak Population, ranging over northeastern Saskatchewan, northern Manitoba, and the southeastern District of Keewatin, was estimated to number 149,000 animals in 1955 (Loughrey, 1955). An extension of range limits from 1936 to 1947 subjected the population to excessive hunting pressure, far exceeding the annual recruitment, and the population declined rapidly. The Kaminuriak Population was estimated to number 63,173 animals before calving in 1968. Annual mortality from human predation has decreased from 30,000 in 1955 (Loughrey, 1955) to 3,500-4,000 in 1968. This results from a decrease in population size and a decrease in hunting pressure. From August 1967 to July 1968, an estimated 5.3 per cent of the caribou population over 1 year of age was killed by Indian and Eskimo hunters. It was estimated also that 4.8 per cent of the population over 1 year of age was lost to wolf predation annually from 1966 to 1968. Annual recruitment for the same period was estimated at 9 to 10 per cent or close to the estimated total loss to predation and hunting of 10.1 per cent. This similarity between annual recruitment and mortality resulted in a relatively stable population during the 3-year study period. A population fluctuation of less than several thousand caribou over the 3-year study period could not have been detected with the confidence levels accepted for aerial population surveys during this study.

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Prior to calving in 1968 there were an estimated 33,406 females and 18,373 males 3 years of age or older in the Kaminuriak Population for an adult male to female ratio of 55:100. At the same time an estimated 43 per cent of the population consisted of breeding females. The potential productivity of the population is high, but an estimated 78 per cent annual mortality rate for calves from 1966 to 1968 prevented the population from increasing. The factors responsible for this high rate of calf mortality are unknown.

The normal range of the Kaminuriak Population is approximately 109,000 square miles. At most times of the year, however, most of the caribou are distributed within a small portion of the total range. From June to October, caribou are distributed on the tundra and at times penetrate the extreme northern edge of the transition zone. From November to May, most of the population moves south into the taiga of northern Manitoba and Saskatchewan. A varying proportion of the population, however, may remain during the winter months on the tundra, particularly along the Hudson Bay coast near Eskimo Point. The factors determining the proportion of caribou wintering on the tundra are poorly understood, but it may possibly relate to climatic conditions, in particular the timing of freeze-up and early winter snowfall, encountered in late October and early November when the migration south into the taiga usually occurs.

Those caribou which migrated south into northern Manitoba in early November of 1966 and 1967 followed a very similar movement pattern from November to January. A rapid movement south into northeastern Manitoba was followed by a western penetration to the Saskatchewan border just north of Reindeer Lake. The late winter (February to April) distribution and movement varied considerably between the 2 years. In 1966-67, caribou continued moving west and northwest upon reaching the Saskatchewan border in January and crossed the Territorial border near Selwyn Lake

in March. From January to April 1968, the taiga-wintering caribou remained concentrated and relatively stationary in a restricted area near the Saskatchewan-Manitoba border north of Reindeer Lake.

Caribou distribution and movement from February to April appear to depend on snow conditions encountered when the animals reach the Saskatchewan border. I believe an extremely deep snow cover motivates them to continue moving, usually in a northerly direction, to seek out more optimal conditions. A shallow snow cover during late winter allows the animals to be relatively unrestricted in their movements and they usually disperse over a wide area. A near-normal late winter snow cover (25-30 inches) usually results in the animals becoming concentrated and their movements restricted. Many combinations of these three general late winter movement patterns may occur, depending upon the continuously changing nival characteristics.

The spring migration routes to the calving ground varied considerably from 1966 to 1968, depending on the location of the late wintering distribution of the pregnant females. The same general area was utilized for calving during the 3-year study period. The peak in calving occurred June 10 to 15 with the earliest calf observation on June 3, 1966. Observations in 1967 suggested that those pregnant females which wintered on the tundra reached a peak in calving several days before those females which wintered in the taiga. I suggest this variation in peak calving may result from pregnant females which winter on the tundra remaining in better physiological condition during pregnancy than those wintering in the taiga.

Post-calving herds form during the latter part of June and remain distributed south of Baker Lake until late July. The mid-summer migration south begins during the last 10 days of July and continues through the first 2 weeks of August. Caribou disperse into three general areas of distribution from mid-August to early October. The proportion of calves and adult females in each area varied considerably in late September of

1968. Caribou within these three late summering areas move towards a common area of rut during late September. The rut is believed to reach a peak during the third week of October.

Historical records suggest that the Kaminuriak Population has extended its winter range south in northern Manitoba several times since the turn of this century. The last such winter range extension reached a peak around 1946-48, receding in extent until approximately 1960. Winter range limits appear to have remained stable from 1960 to 1968. I believe extension of range is a direct result of an increase in population size, suggesting extreme fluctuations in total caribou numbers within the Kaminuriak Population occur periodically. Such increases in population size are possibly due to immigration of animals from other populations or from intrinsic factors such as successive years of unusually high calf survival.

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