RANGE, MOVEMENTS, POPULATION, AND FOOD HABITS OF THE STEESE-FORTYMILE CARIBOU HERD

By

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May, 1956

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RANGE, MOVEMENTS, POPULATION, AND FOOD HABITS OF THE STEESE-FORTYMILE CARIBOU HERD

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Presented to the Faculty of the University

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PREFACE

The economic and recreational importance of the caribou has become increasingly evident in recent years. Intensive studies have been inaugurated in both Canada and Alaska in an attempt to erase the many unknowns concerning this complicated game animal. In this paper the author presents the results of one such study, made in interior Alaska, 1952 to 1955.

Management studies on Alaskan caribou began in July, 1949, under the direction of the Federal Aid in Wildlife Restoration branch of the United States Fish and Wildlife Service, Project W3R. At first these studies dealt mainly with movements, distribution, and numbers of caribou, with the principal emphasis being on the Nelchina herd. During fiscal year 1952, however, the work expanded and became more intensive, and the emphasis shifted to include the Steese-Fortymile herd. The author began his study of the latter herd in September, 1952, as a research project sponsored by the Alaska Cooperative Wildlife Research Unit at the University of Alaska and by Federal Aid in Wildlife Restoration. Upon the cessation of college work in May, 1954, he continued the study through 1955 while employed by Federal Aid, under the direction of Robert F. Scott and Sigurd T. Olson. The author greatly appreciates this financial assistance, and thanks the U. S. Fish and Wildlife Service for permission to use both the data gathered by him while an employee and also some gathered by other personnel.

During the study the author also received much valuable and necessary help from many persons. He would like to extend his appreciation to--

At the University of Alaska--Dr. John L. Buckley, Leader of the Alaska Cooperative Wildlife Research Unit, for financial aid and use of equipment, for guidance in planning, and for exhibiting great patience in dealing with a stubborn Swede. Dr. Brina Kessel, Associate Professor of Biological Sciences, for many helpful suggestions and much assistance, and for her most critical reading of this thesis. Dr. Neil W. Hosley, Dean; Dr. Richard H. Byrns, Professor of English; and Frederick C. Dean, Head of Wildlife Management Department, for critical comments on the thesis.

U. S. Fish and Wildlife employees--Robert F. Scott, Supervisor of Wildlife Restoration branch, David R. Klein, and Sigurd T. Olson, Wildlife Management Biologists, for the many philosophical discussions concerning caribou that often revealed interesting "things". Raymond Woolford, Assistant Supervisor of Game Management branch, Harry Pinkham and Raymond Tremblay, Game Management Agents, for many smooth and rough hours of air transportation, and for much help in the operation of hunter checking stations.

Field comrades--Eugene J. Rueter for pleasant companionship during many hours of weary hiking and dreary checking-station duty. Robert A. Rausch for uncomplainingly struggling through melting snows and across cold streams with the author. Wilbur L. Libby for cheerful hours of "Maine-iac" philosophy. James G. King for suffering starvation on dehydrated food, beyond the call of duty.

Others--Frank S. Glaser for sharing some of his vast store of caribou knowledge with the author. The many other residents of interior Alaska who related valuable observations on caribou and extended much hospitality. Mrs. Janet F. Dean for the long hours spent

typing and re-typing. Mrs. Patricia O. Skoog for the impatient pushes--gentle, but firm--that finally led to the completion of this thesis.

To all these people, the author gratefully acknowledges his thanks.

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ABSTRACT

RANGE, MOVEMENTS, POPULATION, AND FOOD HABITS OF THE STEESE-FORTYMILE CARIBOU HERD

The Steese-Fortymile caribou (Rangifer arcticus stonei Allen) form one of the most economically important herds in Alaska. This study of the herd took place from September, 1952, to December, 1955, under the auspices of the Alaska Cooperative Wildlife Research Unit at the University of Alaska and of the Federal Aid in Wildlife Restoration branch of the United States Fish and Wildlife Service, Project W3R.

The Steese-Fortymile range occupies about 35,000 square miles of east-central Alaska and the Yukon Territory, lying mainly between the Tanana and Yukon Rivers. The terrain is mountainous, but not rugged; roads and towns are scarce, and a maximum of 60,000 people live on the fringes. Seven major plant communities comprise the range vegetation, three of them covering 60 to 70 per cent of the area and furnishing the bulk of the food for caribou. The carrying capacity is computed to be 70,000 to 90,000 caribou.

The erratic and continual movements of caribou characterize this game species. Their movements vary from day to day and season to season. Most of the traveling takes place during the early morning and late afternoon; major seasonal movements take place in the spring and fall. Past and present data provide a general picture of the movement pattern of this herd throughout the year.

The Steese-Fortymile herd dwindled from a peak of about 500,000 animals in the late 1920's to a low of 10,000 to 20,000 in

the early 1940's. The decline is attributed to a population shift. The present population contains at least 50,000 animals and is increasing steadily. Reproduction was high during the years 1950 to 1955. The rut takes place during the first two weeks of October; most of the calves are born during the latter half of May, following a gestation period of about 33 weeks. Valuable information on caribou behavior during the calving period is presented. Counts taken in May show that at least 50 per cent of the calves survive the first year. Wolf and man are the most important mortality factors affecting this herd. The total annual mortality, excluding calves, is estimated at eight per cent. Sex and age data from composition counts and hunter-checking-station operations indicate that this herd is young and that the sex ratio approaches 100:100. The annual increment for the herd is computed to be 10 to 15 per cent.

Caribou are cursory feeders and eat a wide variety of plants. The main periods for resting and feeding occur during the middle portions of the day and night. The caribou's diet hinges upon the available food supply, and thus varies with the seasons. In winter, the diet consists mostly of lichens, grasses, and sedges, with browse plants of some importance; data from 23 stomach-samples are presented. In spring, the new shoots of willow, dwarf birch, grass, and sedge are most important; information is based only on field observations. In summer, a wide variety of plants are eaten; willow and dwarf-birch foliage are of greatest importance, followed closely by grasses and sedges; data from 27 stomach-samples are presented. In fall, the diet shifts from a predominance of woody plants and fungi in late August to one of lichens, grasses, and sedges in late September; data

from 70 stomach-samples are presented.

The problems of data-gathering are discussed, as related to management practices. The contributions made by this report are outlined, and the important information still needed for proper caribou management is listed.

INTRODUCTION

Caribou range over a large portion of Canada and Alaska. They occupy an area of some four million square miles, extending northward from continental United States to the Arctic Ocean and westward from the Atlantic Ocean to the Bering Sea. The present taxonomic status of these caribou remains indefinite, but Olaus Murie (1939) classified them into seven species. Of these the barren-ground group (Rangifer arcticus Allen) is by far the most abundant. Murie (op. cit.) divided this group into six subspecies, two of which constitute the present herds of Alaska: the Grant caribou (Rangifer arcticus granti Allen), composing a small herd of a few thousand on the Alaska Peninsula, and the Stone's caribou (R. a. stonei Allen), composing the remaining herds and totaling in excess of 200,000 animals. The Steese-Fortymile herd belongs to the latter subspecies and contins at least 50,000 animals (see POPULATION). Figure 1 shows the present location of the caribou herds in Alaska.

The caribou's value to society remains largely economic. In the past, natives depended greatly upon the caribou for food and clothing, as did later the white trappers and prospectors. Today in Canada, "The caribou is still a vital factor in the economy of more than 25,000 residents of northern Canada, including Eskimos, Indians, and European settlers...." (Banfield, 1954:1). In Alaska, although certain groups still rely mainly on the caribou for subsistence, most of the natives exist on a fish and fur economy or have adopted the white man's way of life. The caribou continues as an important food item, however, for the high cost of living causes many people to hunt this animal for meat alone. In addition, there is a growing number of sportsmen who hunt mainly for recreation or for trophies. Recreational hunters should

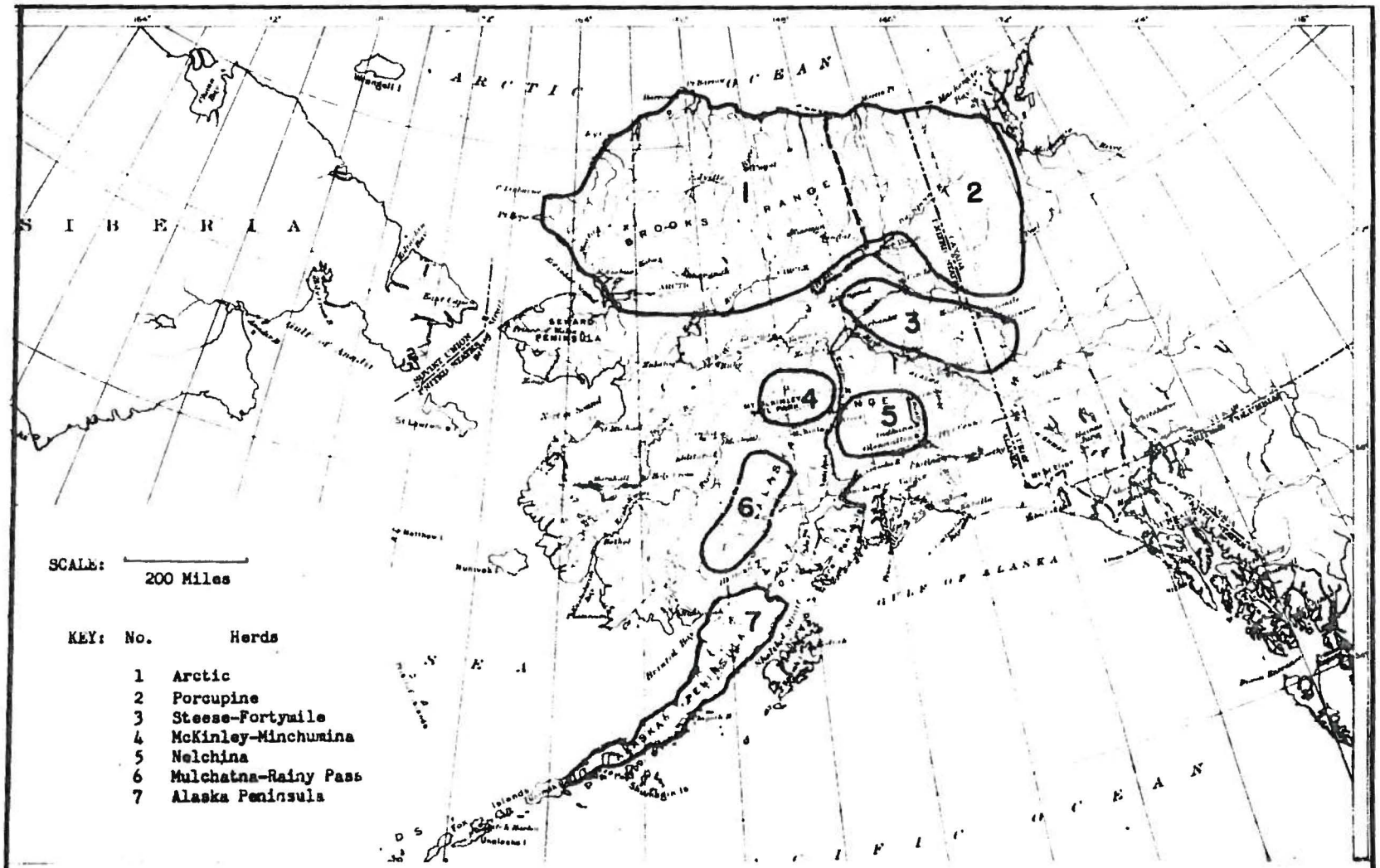

Figure 1. Approximate locations of principal caribou herds of Alaska and adjacent parts of Yukon Territory.

become more and more numerous in the future; such hunters add materially to the economy of an area through their purchases of equipment and services. The Alaskan caribou herds of greatest economic value at present are the Nelchina herd, near Anchorage, and the Steese-Fortymile herd, near Fairbanks. Both lie near the population centers of Alaska and receive the greatest hunting pressure.

In spite of the caribou's great economic importance, an eventual conflict is evident between this animal and man. Caribou are wilderness animals; they are both gregarious and nomadic, and therefore require an extensive range. It is doubtful whether or not they can, or will, exist alongside of populated areas. Although most ranges of the barren-ground caribou remain isolated and of little use to man, civilization continues to encroach upon them. During the past 15 years the development of the arctic and sub-arctic regions has progressed rapidly, and current world affairs indicate continued development. The ranges of both the Nelchina and the Steese-Fortymile caribou herds lie adjacent to the most rapidly developing areas in Alaska. The continued existence of these herds depends upon their proper management in future years.

Such management requires a thorough knowledge of the caribou's life-history, especially that concerning annual reproduction and mortality. Range investigations also are necessary to determine the carrying capacities of the regions utilized by the animals. Until recently, few studies of caribou had been made, and even now the data available are largely incomplete. Much of the initial work was done during the 1920's and 1930's by Olaus J. Murie (1935) and Lawrence J. Palmer (see LITERATURE CITED), both while working for the U. S. Biological Survey (now the U. S. Fish and Wildlife Service). Later, Adolph Murie (1944)

collected caribou data while studying the wolf-Dall sheep relationships in Mt. McKinley National Park, 1939 to 1941. Finally, about 1947, the Canadian Wildlife Service began extensive caribou work (Banfield, 1954), followed by the U. S. Fish and Wildlife Service about 1949.

In September, 1952, the author began the project here reported. It was designed initially to supplement the intensive Pittman-Robertson program then in effect, using Federal Aid in Wildlife Restoration funds. The principal aim was to obtain data vital to the management of caribou, notably that concerning range requirements, movement patterns, reproduction, mortality, herd composition, annual increment, and food habits. The Steese-Fortymile herd was chosen for study because of its economic importance and its accessibility.

The airplane played an important role in this study, being especially necessary for locating the caribou and tracing their movements. Most of the information gathered, however, was gained through ground operations. Extensive field work during the calving season helped to fill a gap in the hitherto obscure knowledge of this phase of the caribou's life. Back-pack trips into areas of caribou concentrations supplied the means for obtaining herd-composition data. Body weights and measurements were obtained through the operation of hunter checking stations, as were stomach samples for the food-habits study. Talks with long-time Alaskans and a perusal of the literature produced a knowledge of the past history of this herd.

Admittedly, for the time allotted, the scope of this project was too great to allow complete information to be gathered on all phases of the study. Much of the data obtained, however, adds to the basic knowledge concerning caribou. Continued research gradually

will eliminate the many gaps remaining.

RANGE

The Steese-Fortymile caribou herd occupies a large portion of the extensive, mountainous region of east-central Alaska and the Yukon Territory. A subarctic, continental climate characterizes this region--long, cold winters with minimum temperatures to -75° F.; short, warm summers with maximum temperatures to 100° F.; and yearly average temperatures of about 25° F. Precipitation generally remains light, averaging about 11 inches per year. Topography and climate combine to produce a vegetation typical of the Hudsonian biotic province, of which this region forms a part (Dice, 1943). Figure 1 shows the location of the range.

Extent.

The range occupied by this herd lies predominantly between the Yukon and Tanana Rivers. In former years the herd utilized a much more extensive area than it does now, probably because of the large population then present. During the 1920's, for instance, the extreme boundaries of the range extended northwest to Rampart, on the Yukon River; north to the edge of the Yukon Flats; northeast to the headwaters of the Little Black and Porcupine Rivers; east to the Ogilvie Mountains; southeast to the White, Stewart, and Lewes Rivers; south and southwest to the Alaska Range; and west to the Tanana Flats and the Nenana River (see Table 2). These boundaries enclose an area of about 85,000 square miles. Also, in the fall of 1920 a large number of these caribou passed through Mentasta Pass to winter on the south slope of the Alaska Range; and in the fall of 1924 large numbers reached the vicinity of Whitehorse, for the first time in 20 to 30 years according to local residents

(O. Murie, 1935).

Essentially, these extreme limits of the range remain true today. The present herd stays principally within the region bounded by the White Mountains on the northwest, the Yukon River on the east, the Ladue River on the southeast, and the Tanana River on the west. More specifically, the continuous highland embracing the headwaters and the upper and middle reaches of the Chatanika, Chena, Salcha, Charley, Goodpaster, Fortymile, Sixtymile, and Ladue Rivers, and of Beaver, Preacher, and Birch Creeks, represents the most important area utilized by the herd--an area of some 35,000 square miles. Generally, the caribou stay east of the Alaska and Elliott Highways; occasionally the animals cross the Yukon River, somewhere above the town of Circle, to enter the adjacent mountains to the east. Figure 2 shows the past and present boundaries of the range.

Topography.

A moderate, rather constant elevation characterizes the mountainous relief of the region. Measurements from U. S. Geological Survey quadrangle maps reveal that approximately 90 per cent of the area lies above 1,800 feet--20 per cent lying above 3,000. The remaining 10 per cent encompasses the river bottoms at elevations ranging approximately from 400 to 1,800 feet.

The mountains are not rugged, although in a few places they are enough so, apparently, to provide ample escape facilities for the Dall sheep present there. The mountain slopes are rather gentle or moderately steep, meadows occurring commonly; the rounded ridges and mountain tops are readily accessible by man or beast. The areas shown in Figures 3 and 4 are typical of this caribou range.

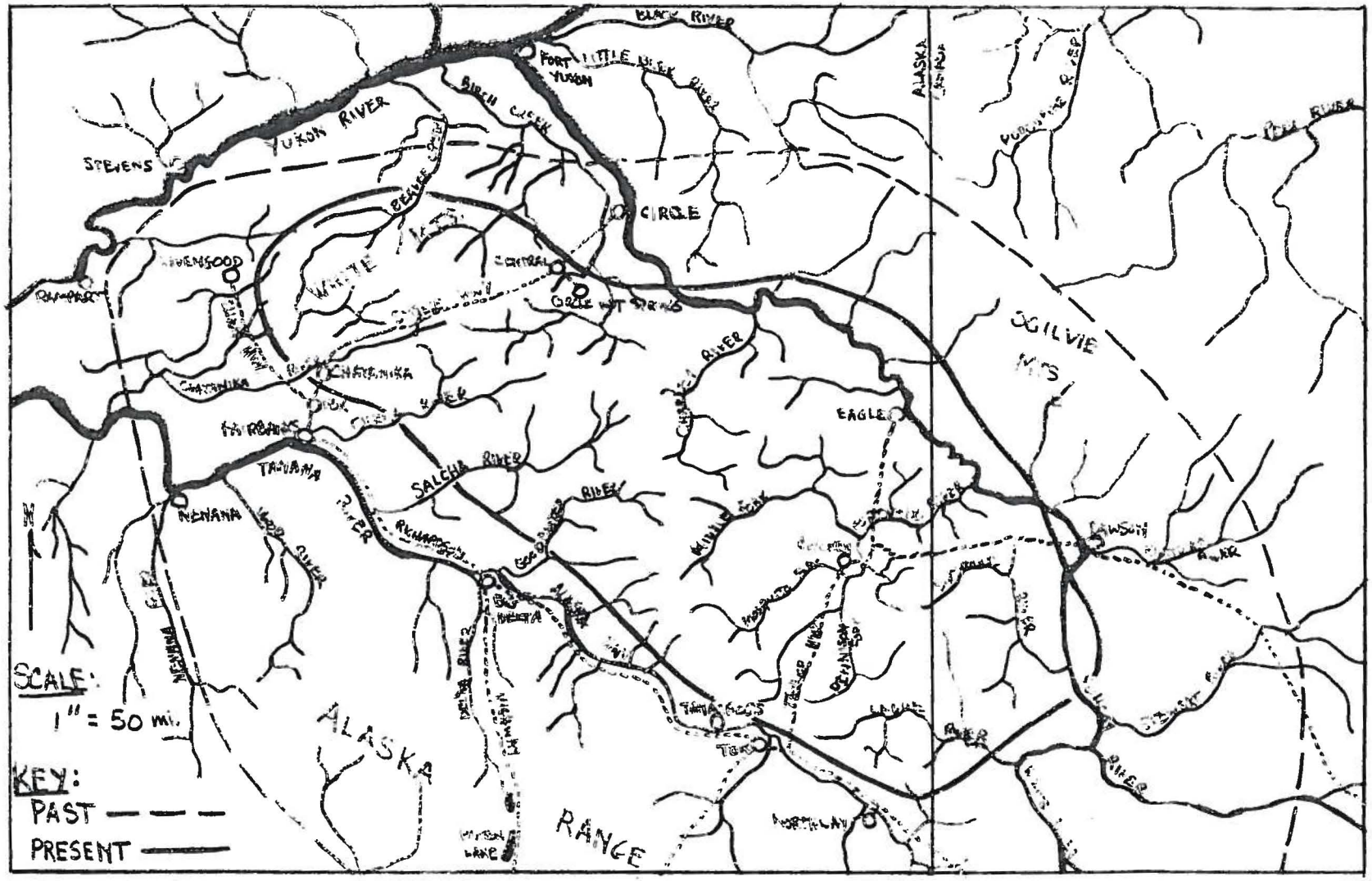

Figure 2. Approximate boundaries of the Steese-Fortymile caribou ranges past and present.

This type of relief serves to keep the land comparatively well-drained, lakes and marshes occurring but rarely. Those lakes present are mostly 50 acres or less in surface area. Small bogs and sections of muskeg, however, appear throughout the range and occur commonly where gentle slopes prevail. The many streams that interlace the region carry the run-off to either the Tanana or the Yukon Rivers. The larger streams provide means of access to some sections.

Roads are few, so the caribou range is largely inaccessible for most people. Two roads traverse portions of the range. In the north the Steese Highway extends northeast from Fairbanks to Circle Hot Springs and Circle; and in the south the Taylor Highway extends from the Alaska Highway northeast through the Fortymile country to Eagle and Dawson. It is mainly by means of these two highways that hunters can reach the caribou. From these highways numerous mining roads extend for short distances. Old, unused roads and trails are common throughout the region, but are passable only by foot, by horse, or by tracked vehicles. The Alaska and Elliott Highways pass along the western portion of the range.

Towns are scarce also. The largest, Fairbanks, a city of some 30,000 people, lies at the junction of the Alaska and the Steese Highways. Dawson, with about 500 residents, is situated on the Yukon River in the Yukon Territory. The remaining towns occur along the major roadways and have resident populations of less than 200: Livengood, Fox, Chatanika, Central, Circle, Circle Hot Springs, Big Delta, Tanacross, Tok, Northway, Chicken, and Eagle. Three military bases are in existence along the Alaska Highway between Fairbanks and Tok. The total population of the area, including military personnel, probably does not

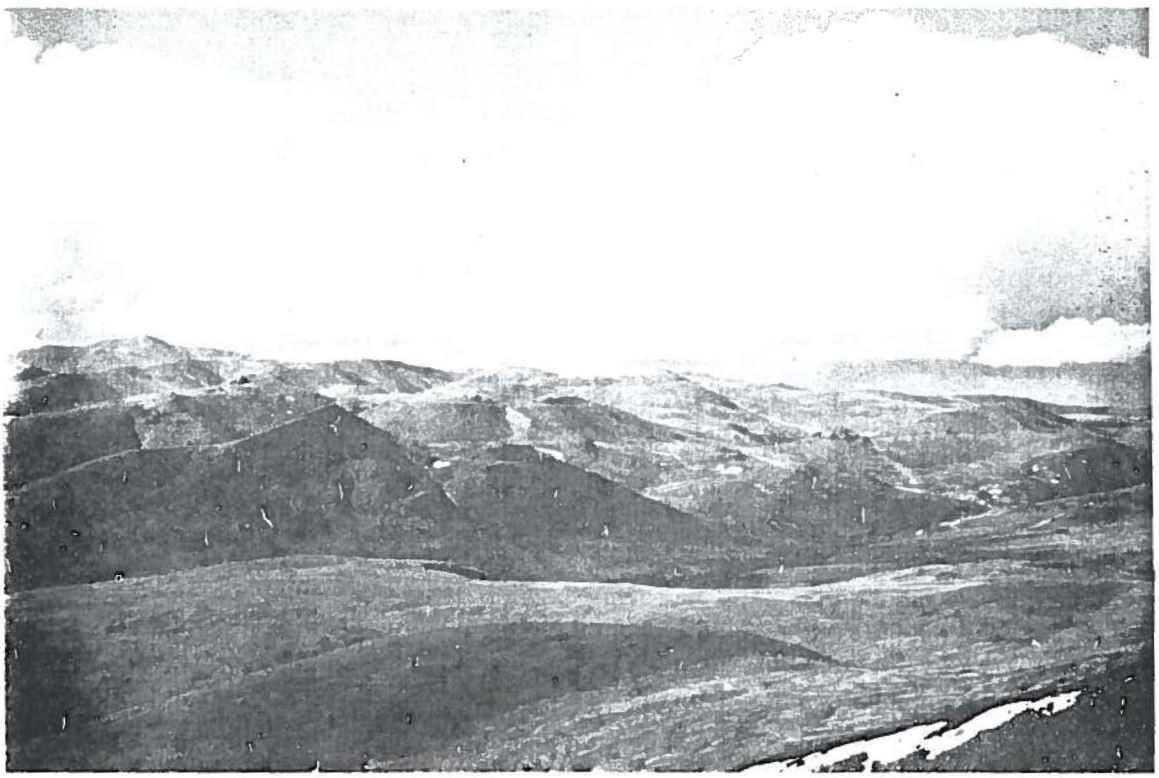

Figure 3. Highlands lying between Salcha and Charley Rivers.

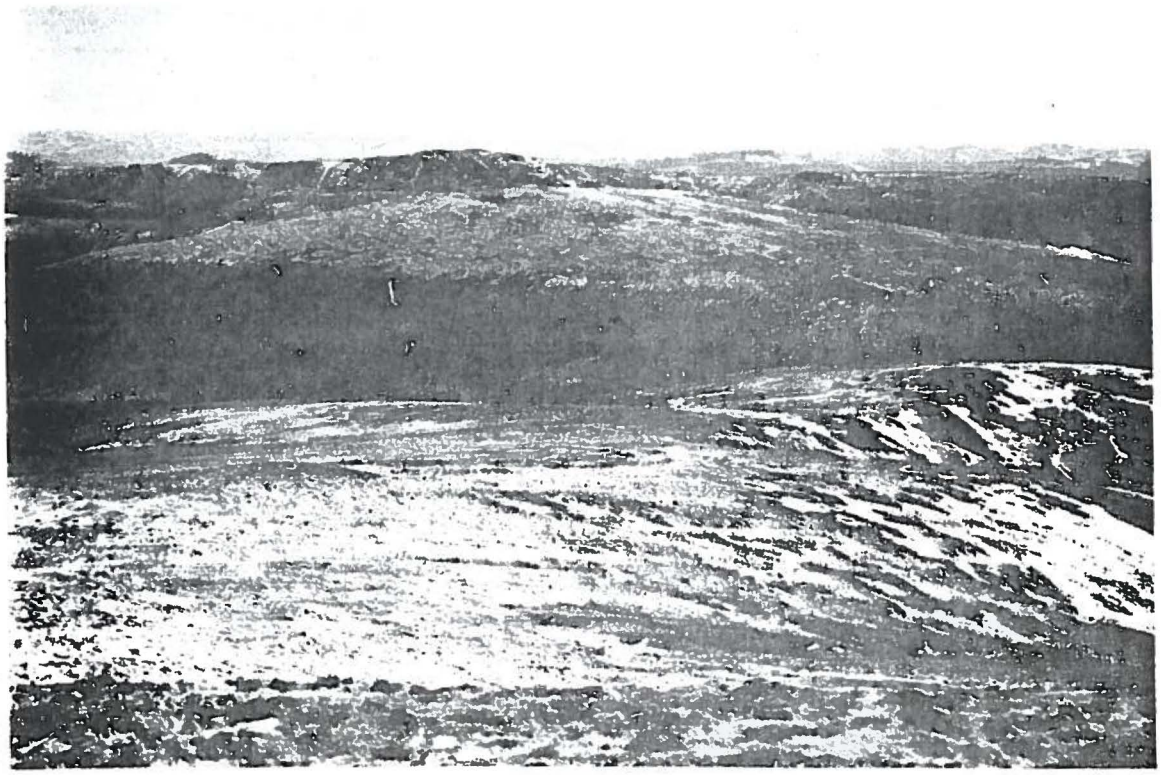

Figure 4. View looking south from Twelve mile Summit, Steese Highway.

exceed 60,000 people, and the vast majority of these live on the outskirts of the caribou range. Figure 2 shows the major streams, roads, and towns.

Vegetation.

The region as a whole lies within the western portion of the Hudsonian biotic province (Dice, 1943). Within this region the White Spruce-White Birch community predominates as the climax vegetation. Relief, drainage, fire, and man, however, are factors that can prevent or retard the complete establishment of the climax community. High altitude, for example, produces an alpine flora; poor drainage favors the existence of moisture-tolerant plants, such as black spruce or sedges; fire and man, working separately or together, can set back the plant succession several stages.

The action of these four factors results in the existence of various types of plant communities within the caribou range. Some of these are more important to the caribou than are others. A knowledge of the distribution of these communities provides an index to the abundance of food material and, thus, to the carrying capacity of the range.

The method used by the investigator to analyze the range vegetation consisted of two parts: first, determining the plant communities present, their habitats, and their composition; and, second, finding the relative abundance of these communities within the range. The actual techniques finally used resulted largely from the advice of Dr. John L. Buckley.

The first part of the range analysis was accomplished during the summer. Originally the investigator had intended to analyze the

various plant communities by a transect sampling-method. A misjudgement of the time available, however, prevented a complete analysis by this method. As a result, the occurrence of the various plants within each community was determined by their relative frequency, instead of by their actual per cent of ground coverage.

Major Plant Communities.--The major plant communities found within the range are resolved here into seven groups: White Spruce-White Birch, Dwarf Birch-White Spruce, Dwarf Birch-Willow, Dryas, Sedge-Black Spruce, Sedge-Grass, and Aspen-Poplar-White Birch. The order of the first four follows the altitudinal sequence of their occurrence from low elevation to high. The Sedge-Black Spruce and the Sedge-Grass groups grow on poorly drained sites at various altitudes. The Aspen-Poplar-White Birch community occurs mainly on burned-over areas. A description of each community follows below. The elevations stated refer to the southern part of the range; corresponding elevations in the northern part of the range are about 500 feet lower. The lichens mentioned refer principally to the fruticose type and, more specifically, to those belonging to the genera Cladonia, Cetraria, and Stereocaulon--the lichens of most importance to caribou as forage (Palmer, 1926; O. Murie, 1935; stomach analyses). The scientific names used for the various plant species are taken from Eric Hultén's Flora of Alaska and Yukon, 1941 to 1950.

The White Spruce-White Birch community grows on well-drained soils at elevations ranging to a maximum of about 2,500 feet. White spruce (Picea glauca /Moench/ Voss), white birch (Betula resinifera Britton), and moss form the dominant vegetation, with the birch tending to drop out in mature stands. Sphagnum moss (Sphagnum spp.),

low-bush cranberry (Vaccinium Vitis-idaea L.), Labrador tea (Ledum palustre L.), crowberry (Empetrum nigrum L.), bearberry (Arctostaphylos Uva-ursi [L.] Spreng), and lichens occur commonly in the more open sections of the forest. Some of the less common, or less important, plants of this community include alder (Alnus crispa [Ait.] Pursh), willow (Salix spp.), dwarf birch (Betula nana L. and B. glandulosa Michx.), high-bush cranberry (Viburnum edule [Michx.] Raf.), bunchberry (Cornus canadensis L.), blueberry (Vaccinium uliginosum L.), club moss (Lycopodium spp.), horsetail (Equisetum spp.), and several others. At the upper elevation limits, dwarf birch replaces the white birch in abundance. Figure 5 illustrates this plant community.

The Dwarf Birch-White Spruce group exists on well-drained soils immediately above the previous community, and extends to about 3,500 feet elevation. The dominant plants are dwarf birch, blueberry, low-bush cranberry, and moss. Slightly less abundant are white spruce, Labrador tea, sphagnum moss, and lichens. Black spruce (Picea Mariana [Mill.] B.S.P.) often temporarily replaces the white spruce after fires. Willow, crowberry, fireweed (Epilobium angustifolium L. and E. latifolium L.), alpine bearberry (Arctostaphylos alpina [L.] Spreng.), horsetail, alder, and lupine (Lupinus arcticus S. Wats.) occur commonly throughout this community. With increasing elevation the willow gradually replaces the white spruce, and the next community becomes dominant. This plant group is illustrated in Figure 6.

The Dwarf Birch-Willow community grows on well-drained soils extending to a maximum elevation of about 4,000 feet. The dominant plants are dwarf birch, willow, and sphagnum moss. Blueberry, low-bush cranberry, sedge (Carex spp.), dryas (Dryas spp.), crowberry, and

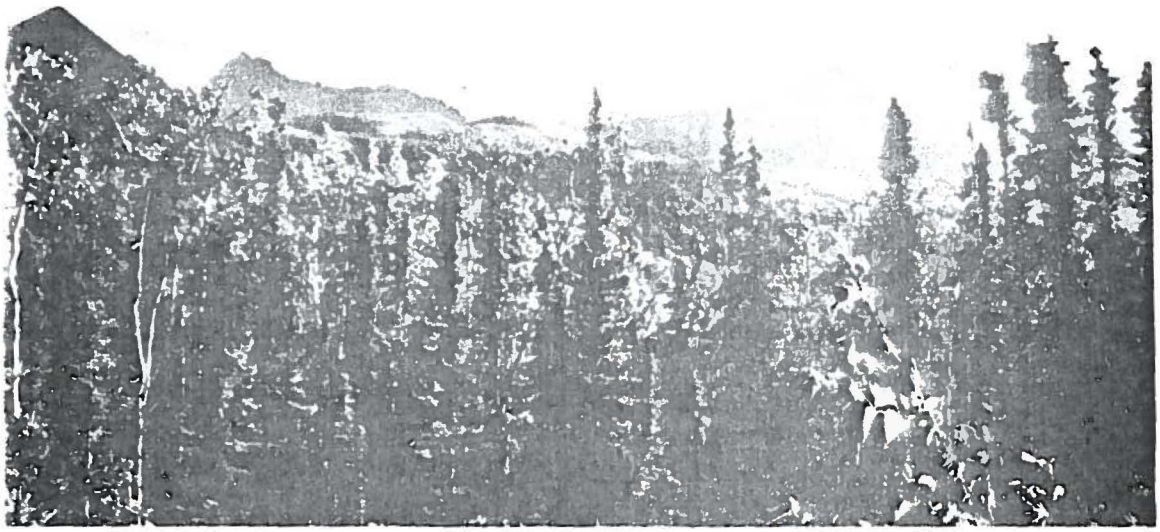

Figure 5. White Spruce-White Birch community.

Figure 6. Dwarf Birch-White Spruce community.

lichens are quite common. Milkvetch (Astragalus sp.), smartweed (Polygonum spp.), coltsfoot (Petasites sp.), alpine bearberry, false heath (Cassiope sp.), Labrador tea, and stunted white birch are also present. At the upper limits of elevation dwarf birch and willow become more and more prostrate in form, and dryas becomes more and more abundant. Figure 7 shows this plant community.

Dryas forms the dominant vegetation of the next group, termed Dryas, illustrated in Figure 8. At elevations up to about 4,500 feet sedge, false heath, or crowberry often is present in sufficient quantity to form a minor community. Blueberry, low-bush cranberry, willow, milkvetch, alpine bearberry, moss, and lichens occur sporadically. Above 4,500 feet the vegetation consists largely of dryas and crustose lichens, and above the 5,600 feet level, largely of lichens.

The above communities exist on moderately to well-drained soils. On poorly drained land there exists a sub-climax type of vegetation; the following two types occur within the range.

The Sedge-Black Spruce community, shown in Figure 9, grows mostly on gently sloping or level land extending from the lowest range elevation, 400 feet, to about 3,200 feet. The dominant plants include sedge (Carex spp. and Eriophorum spp.), black spruce, blueberry, Labrador tea, and sphagnum moss. Somewhat less abundant are low-bush cranberry, dwarf birch, moss, and crowberry. Willow, tamarack (Larix laricina [Du Roi] K. Koch), horse tail, leatherleaf (Chamaedaphne calyculata [L.] Moench), and lichens occur irregularly.

The Sedge-Grass community occurs most commonly on gentle slopes at the higher elevations, reaching to a maximum of about 3,800 feet. It often replaces the preceding group after a severe fire. The

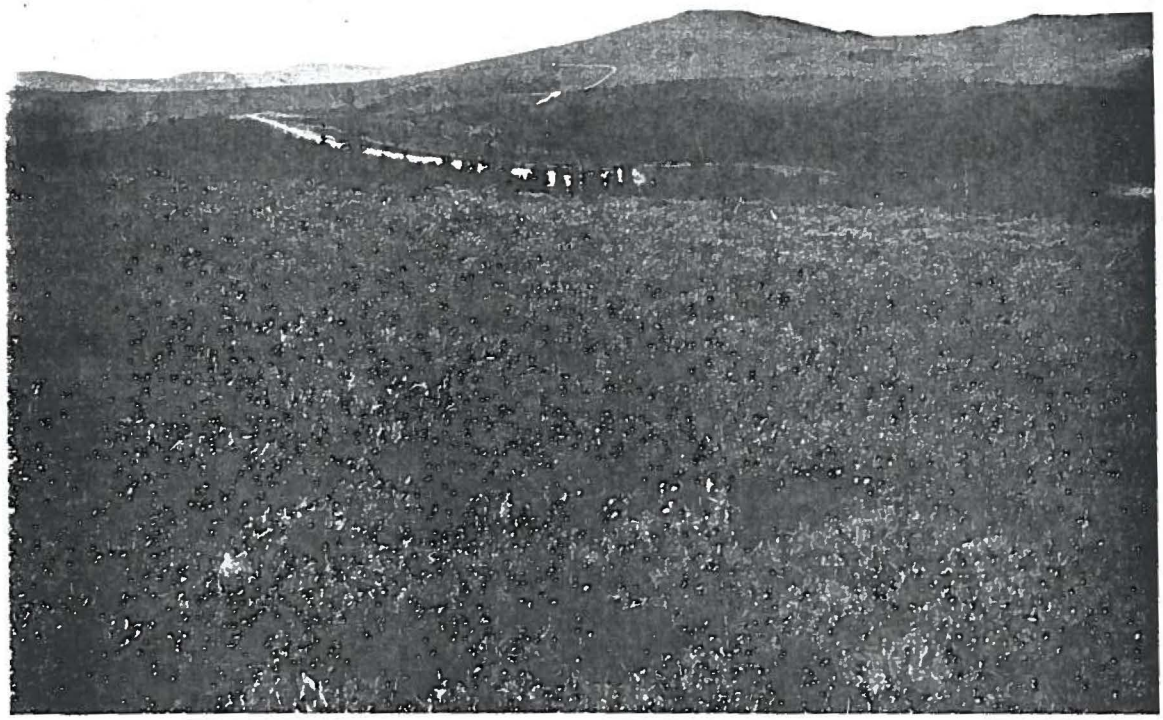

Figure 7. Dwarf Birch-Willow community.

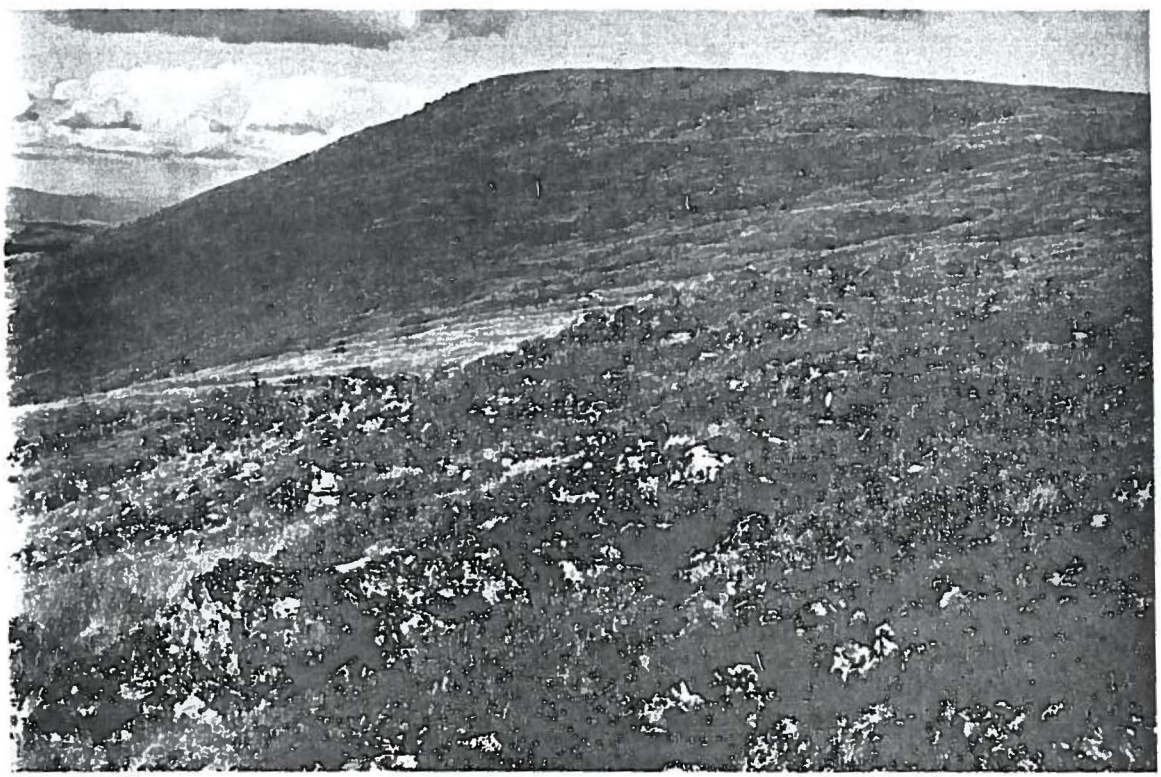

Figure 8. Dryas community.

dominant plants within this community are sedges (Carex spp. and Eriophorum spp.). Grasses (Poa spp., Agrostis spp., Calamagrostis spp., etc.) are abundant; sphagnum moss is abundant at some places. Willows are found frequently on the tussocks or humps of vegetation. At the upper elevation limits, dryas often becomes fairly common. Figure 10 illustrates this plant community.

The last major plant community, Aspen-Poplar-White Birch, exists on well-drained soils, establishing itself mainly as a result of fires. It replaces predominantly the White Spruce-White Birch community, but also the lower limits of the Dwarf Birch-White Spruce. This final group, shown in Figure 11, extends to a maximum of 3,000 feet; the white birch, however, tends to drop out at an elevation of about 2,500 feet. Aspen (Populus tremuloides Michx.) and white birch are the dominant plants. Poplar (Populus tacamahacca Mill.) is somewhat less abundant. Some stands consist almost entirely of aspen, and others mostly of white birch. Fireweed, wild rose (Rosa acicularis Lindl.), low- and high-bush cranberry, and Labrador tea are common constituents of this community. A multitude of other plants occur sporadically, including bearberry, bunchberry, crowberry, twinflower (Linnaea borealis L.), horsetail, club moss, grasses, alder, willow, moss, and lichens.

Range Distribution.--The second part of the range analysis took place during the fall. The prime requisite for this part was the ability to recognize from the air the previously mentioned plant communities. The procedure consisted of flying over sections of the range and recording the time required to traverse each plant community along the flight line.

Fall proved to be the best time of year to perform this task,

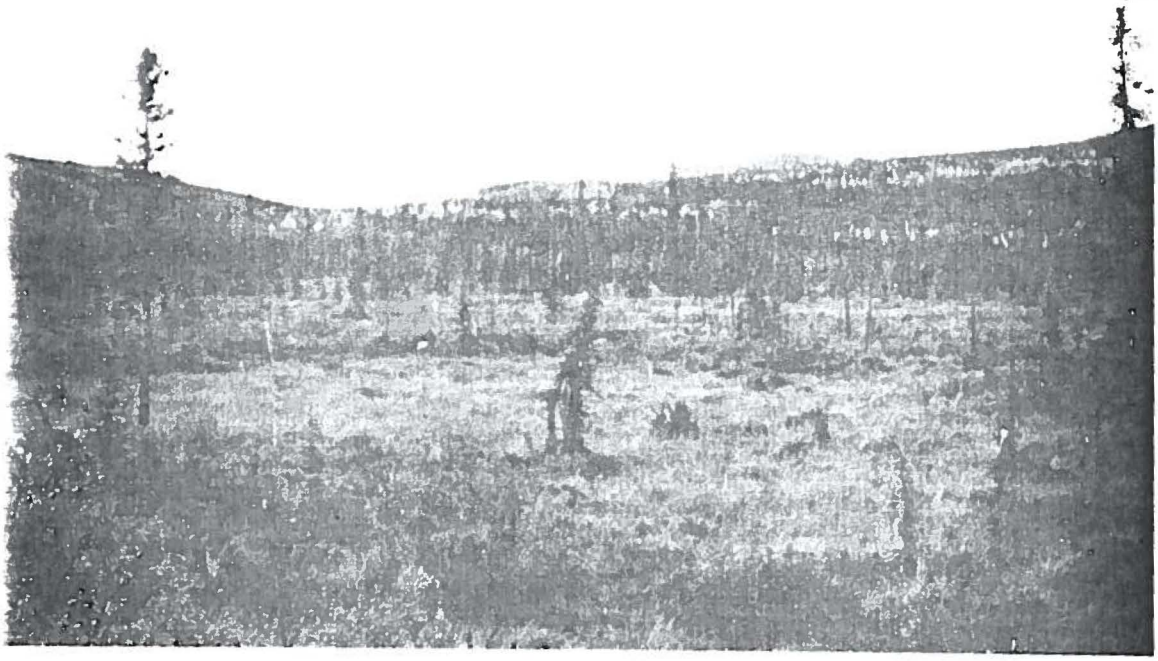

Figure 9. Sedge-Black Spruce community.

Figure 10. Sedge-Grass community.

Figure 11. Aspen-Poplar-White Birch community.

because then the differences in appearances of some plants stand out noticeably. In mid-September the aspens and poplars appear rather naked, having lost the majority of their yellowed leaves; the white birches, however, retain many of their leaves, now yellow or light-orange in color. On the upper mountain slopes the yellowed leaves of the willows contrast sharply with the reddened foliage of the dwarf birches and the blueberry bushes. The dried grasses and sedges provide a light-brown tone to the landscape. The spruces, of course, still retain their dark-green hue. Such contrasting characteristics simplified the task of identifying the various pland communities from the air.

An accurate range analysis of the plant distribution would require the use of random flight-lines over the range. A lack of time and money, however, prevented the flying of such lines. Instead, a flight made to locate the caribou herd provided the only means for accomplishing the task. During such a flight a tendency exists to traverse mainly the areas above timberline, where one can see the animals more easily. As a result, the data obtained do not provide a true picture of the actual plant distribution.

The flight took place on September 21, 1953. Each plant community was given a number. One observer chose a point along one of the wing struts for a line-guide; then, as each community passed into view he called out its number to a second person, who recorded it and the time. As the plane passed certain landmarks, the time of passing was recorded on the map. These map-notations permitted the computation of the plane's average ground-speed between the designated landmarks.

The total data collected during this flight included the route traveled by the airplane, time-notations as to the plane's passing of certain landmarks and as to the start and finish of observations, and a chronological record of the various plant communities along the flight-line. Collectively, these data establish a basis for computing the relative abundance of the aforementioned plant communities.

The computation consists of determining 1) the total distance flown during the periods of observation, 2) the total distances traversed for each of the plant communities, and thus 3) their relative abundance. Direct measurements from U. S. Geological Survey quadrangle maps provided the total distance flown. The average ground-speed between each pair of landmarks noted on the maps was calculated from the measured map-distance and the computed elapsed-time for that distance. The flight-time over each plant community, when correlated with the average ground-speed, provided the means for computing the miles of each community along the flight-line. The plant community distances indicate the relative abundance of the different plant communities. The results of these computations appear in Table 1.

The table shows that the Dwarf Birch-White Spruce, the Dwarf Birch-Willow, and the Dryas community make up 80.3 per cent of the flight-line. All three of these communities, as well as certain portions of the others, lie above 1,800 feet elevation. Altogether, then, the total percentage of all plant communities occurring above this elevation approaches 90 per cent--the figure one would assume from the statement made on page 7 that about 90 per cent of the range lies above 1,800 feet.

Further comparison of the plant community frequencies with the

TABLE 1. DISTRIBUTION OF PLANT COMMUNITIES ALONG A FLIGHT-LINE TRAVERSING PART OF THE STEESE-FORTYMILE RANGE.

Plant Community	Coverage (in miles) Along Flight-line	Per cent Frequency
White Spruce-White Birch	27.97	7.9
Dwarf Birch-White Spruce	117.29	33.2
Dwarf Birch-Willow	101.41	28.8
Dryas	64.35	18.3
Sedge-Black Spruce	25.19	7.2
Sedge-Grass	5.24	1.5
Aspen-Poplar-White Birch	10.79	3.1
TOTAL	352.24	100.0

figures relating to the distribution of land elevations (see Topography) reveals a discrepancy. The Dryas community lies above 3,000 feet and has a percentage of 28.8; portions of the Sedge-Black Spruce and the Sedge-Grass communities also occur above 3,000 feet. The combined percentages of the communities above that elevation, then, equal about 45; the percentage of range occurring above 3,000 feet totals only about 20. The difference results from the non-random flight-line flown; the flight traversed mainly an area lying above timberline and a section of the range that is higher than average. The excess percentage must pertain to that vegetation occurring between 1,800 and 3,000 feet, because, as noted previously, the total percentage of all plant communities above 1,800 feet does approach the correct figure.

In a redistribution of the excess 25 per cent, the Dwarf Birch-White Spruce would receive the largest amount, because it is the most common plant group between 1,800 and 3,000 feet; the White Spruce-White Birch community, next in abundance, would receive the next largest amount; and so on. The final adjustment of the frequency percentages might well result in the following figures: White Spruce-White Birch, 10 to 15 per cent; Dwarf Birch-White Spruce, 50 to 55 per cent; Dwarf Birch-Willow, 10 to 15 per cent; Dryas, 7 to 12 per cent; Sedge-Black Spruce, 7 to 12 per cent; Sedge-Grass, 3 to 8 per cent; and Aspen-Poplar-White Birch, 4 to 9 per cent. This so-called adjustment, of course, represents purely an effort by the author to correct the noticeable errors in light of what he knows regarding the land distributions at various elevations and the altitudinal limits of the plant communities.

Despite the various discrepancies noted, the frequency-percentage figures do establish a general picture of the range and so provide

an index to the vegetation distribution. The numerical order of the adjusted figures seems to correspond with that observed from the ground. As such, the figures also provide an index to the relative abundance of caribou food.

Carrying Capacity.

The Steese-Fortymile caribou frequent mainly those areas close to timberline. This choice is influenced by such factors as food palatability, climatic conditions, insect abundance, and so on. As a result, those plant communities appearing most commonly at low elevations (White Spruce-White Birch, Sedge-Black Spruce, and Aspen-Poplar-White Birch) can not provide caribou with much of their food. At the opposite elevation extreme, the Dryas communities are also rather unimportant as food providers. The three remaining plant groups (Dwarf Birch-White Spruce, Dwarf Birch-Willow, Sedge-Grass) furnish the bulk of the caribou's food. The adjusted frequency-percentages expressed previously reveal that these three associations occupy 60 to 70 per cent of the range, whose total area equals about 35,000 square miles (see Topography). Thus, the caribou obtain most of their food from a land-surface of approximately 21,000 to 26,000 square miles, or 13,400,000 to 16,700,000 acres.

Palmer (1926) estimated that each head of reindeer on the tundra of western Alaska required 40 to 60 acres of land each year for its food supply. Later, the range deteriorated through overgrazing and fires; therefore, in 1945 he revised his estimate to 100 acres (Hanson, 1952)--85 being necessary for winter forage. His feeding experiments with penned reindeer and caribou showed that the two animals eat approximately the same type and amount of food per day (Palmer, 1944).

On ranges similar to those of western Alaska in 1945, then, a caribou would also require about 100 acres a year for food.

The tundra of western Alaska contains extensive stands of browse, sedges, and lichens. There the winter diet of the reindeer reaches nearly 100 per cent lichens. The Steese-Fortymile range grows an abundance of the browse and sedges, but frequent fires during the past half-century have destroyed much of the lush lichen growths once prevalent. Palmer (1941) believes that caribou require at least 50 per cent lichens in their diet for maintenance of condition during the winter months. Because lichens apparently play such an important role during the winter, a caribou on this depleted range needs much more land for forage than does a reindeer in western Alaska.

Palmer (1941) indicated that fair lichen growth formerly occurred on about two-thirds of the Steese-Fortymile range, but that fires since 1900 had burned over, once or twice, about 75 per cent of the lichen forage. This former lichen growth might have been similar to that of western Alaska in 1945. On a range having such a growth, which is considered a lichen index of 1, a caribou requires a maximum of about 85 acres during the winter when on a diet of almost 100 per cent lichens. Fires, however, have reduced the lichen index on the Interior range to .25. Solving the proportion $\frac{1}{.25} = \frac{x}{85}$ results in the value of 340 acres as the winter requirement for each caribou of the Steese-Fortymile herd. But a caribou supposedly needs only a 50 per cent diet of lichens, so the winter requirement might then be lowered to 170 acres. The addition of Palmer's estimated summer requirement of 15 acres brings the yearly range requirement of each caribou to 185 acres. The three plant communities which furnish the

bulk of the caribou's food cover an area of from 13,400,000 to 16,700,000 acres. Therefore, the range should be able to support in the vicinity of from 70,000 to 90,000 caribou.

This estimate for range capacity arises primarily from Palmer's belief that caribou require at least a 50 per cent lichen diet during the winter. Information from Nunivak Island, however, tends to contradict that belief. There, the reindeer long ago used up the available lichens and now exist largely on a sedge diet during the winter; yet they manage to maintain their vigor. If caribou can live satisfactorily on a winter diet of sedges, the range could conceivably support a denser population than that indicated above. But caribou seem to prefer lichens at that time of year (Palmer, 1941) and, not being herded or confined as are the reindeer, may well move to find the plant-type they desire, even if it means finding a new range. Supposedly, a lack of lichens forced the caribou from the Kenai Peninsula during the last decade of the nineteenth century, after extensive fires had destroyed most of the lichen growth. Exact information, however, is lacking, and so the problem of the influence of food supply upon the caribou remains for future investigation.

Detrimental Factors.

Caribou depend for their existence directly upon the range, the deterioration of which can cause dire changes in the population. This deterioration expresses itself in the decrease of both food supply and total range area; both result in a lower carrying capacity. Essentially, three factors bring about this loss: man, fire, and the caribou themselves.

Man can act both as the worst enemy and the best friend to the

caribou's range. He destroys, but he also has the power to build. As yet, however, he has not seen fit to assume the second role beyond primordial preparations.

The gold rush at the turn of the century marked the beginning of detrimental changes to the Steese-Fortymile range. The center of the gold miming operations lay between the Tanana and Yukon Rivers. Transitory towns sprang up throughout the region; the hills swarmed with miners and prospectors, who investigated every corner of the area. To facilitate their operations, many cleared land by burning off the vegetation--an act frequently resulting in excessive clearance. "Cheechakos" ignorant of woods-lore filled the ranks, and their untended camp-fires often spread to the forests. The vegetation suffered greatly during those early years.

Mining operations declined after World War I, but the range has continued to deteriorate. Fire still causes the major loss, but "modernization" also contributes. Modern mining-methods concentrate the mining to certain areas, and thus reduce the total area of land being damaged; the intensive use of the land, however, makes the damage to vegetation complete. Specifically, this statement refers to the use of hydraulic apparatus, the dredge, and the bulldozer. Forest fires, road construction, and an increased human population all tend to accompany this industry. At the present time mining is experiencing a depression, but an ample rise in the price of gold and other minerals, however, would extend this factor of range deterioration to many areas.

Another result of modernization expresses itself in the opening of the land to settlers and to industry. Roads provide access to isolated caribou range, and "civilization" soon follows along them.

Plans exist for the construction of roads that will seriously threaten the caribou someday. Dam sites have been selected at several spots within the caribou's domain. The potential dams offer another threat, both by flooding land and by attracting industry and settlers.

Progress can not, and should not, be stopped. Wildlife managers, however, must be aware of the possible effects of modernization and be constantly ready to change their policies accordingly. The trend indicates a continued decline in the total area available to caribou.

The prevalence of fires seems to indicate a similar decline in the food supply. Lutz (1953) has estimated that from 1898 to 1940 an average of at least one million acres burned each year in interior Alaska. Before 1940 forest fires were allowed to burn unmolested, except where they threatened man. Since then fire-fighting crews of the Bureau of Land Management have attempted to curb the destruction, but a lack of money has limited their operations to accessible areas. Because most of the caribou range remains inaccessible, the fires continue to take their toll.

Fire records of the Division of Forestry of the Bureau of Land Management show that 3,450 square miles of that district which includes the major portion of the Steese-Fortymile caribou range had burned during the years 1920 to 1945. Since 1945, within the caribou range alone, about 4,000 square miles have burned--3,000 encompassing plant communities normally containing fair lichen growths. The records are reasonably complete only since 1950, however, because previously many fires were not recorded or even reported. The period from 1950 through 1955 reveals that man caused 83 per cent of the fires reported.

Fire influences the carrying capacity of the range by reducing

the total food supply of the caribou. The summer supply maintains itself fairly well. Sedge, grass, and browse species return swiftly to production after being burned, and can increase their abundance by reseeding other burned areas. Also, fires often do not affect the area above timberline, for they frequently die somewhere in the Dwarf Birch-White Spruce plant community. Caribou derive a large portion of their summer forage from the treeless area. Fire, then, affects mainly the winter forage, and specifically the lichens. Because lichens are dry and inflammable throughout the summer and fall, a fire often results in their complete destruction. Palmer (1941) found on burned areas of the Interior range that the time required for a 100 per cent recovery of lichen varied greatly according to the site and the degree of burn. Thus the importance of fire as a detrimental factor to caribou hinges principally on the belief that the animal requires lichens in its winter diet. As indicated previously, the success of reindeer on Nunival Island tends to contradict that belief. Fires admittedly do destroy a part of the caribou's food supply, but the complete significance of this destruction remains unknown.

The third factor affecting the range is the caribou itself. An excessive population can cause a drastic reduction of the food supply. Although no instance exists where caribou are known to have overgrazed their range, the reindeer of the Pribilof Islands offer an alternative example. On St. Paul Island the reindeer population rose from 25 in 1911 to 2,046 in 1938; 12 years later the herd numbered 8. At the population peak the density reached one reindeer per 13 acres of land--at least three times the estimated carrying capacity of the land (Scheffer, 1951). This example serves to illustrate the

importance of controlling the size of a reindeer herd confined to a limited range. Caribou need a similar control, but not so much to prevent their dying off, perhaps, as to prevent their exodus from a depleted range (see POPULATION).

MOVEMENTS

The Steese-Fortymile caribou utilize a large region. Their irregular movements, both daily and seasonal, over this extensive range cause definite problems in management. Sometimes the animals seemingly disappear; sometimes they disperse so thinly that aerial and ground observations are practically useless; at other times they concentrate into compact herds of hundreds. Stragglers occur throughout the range at almost any time of the year. The wildlife manager seldom can predict the hunters' kill, for he seldom knows where the caribou will be at any given time.

Influential Factors.

The caribou's nomadic habit long has puzzled man and has resulted in many explanatory hypotheses. Olaus Murie (1935) reviews some of these hypotheses and presents his belief that the search for suitable food is the prime cause of migration, and that the continual searching has resulted in "restlessness" becoming inherent to the race. He believes further that the stimulus for the migrations results from "local failure or seasonal changes of the vegetation" which cause the caribou to search for better food; and these "Local wanderings then take on the nature of a migration...and the animals retrace their ancestral routes." (op. cit.:50).

Banfield (1954:30) in discussing causes for migrations states

> ...it seems probable that the barren-ground caribou is fundamentally both gregarious and nomadic in behaviour....As a gregarious species, the herds are continually in random movement, seeking an adequate supply of food. Superimposed upon these local random movements are annual travel requirements....Local weather and physiography affect routes and periods of movement....Seasonal changes in meteorological factors, food preferences, food production, and

> reproductive requirements cause a superposition of annual cyclic spatial movements over the territories occupied by the herds.

Banfield's concept elaborates on Murie's idea, and seems able to account for more of the anomalies of caribou movements. That the nomadic habit, or restlessness, is inherent to the race seems evident. This "drive" causes the caribou to rove continually, and it expresses itself in their daily and seasonal movements. The cursory feeding habit of the animal illustrates well this restlessness.

At certain times of the year an apparent intensification of the nomadic drive causes large-scale migrations to take place. The exact stimuli for such movements are difficult to determine. Seasonal changes in vegetation alone cannot account for the migrations, especially in view of recent activities of the Steese-Fortymile herd. During April to December, 1954, the herd moved steadily, making two and a half round trips from the Sixtymile area in Canada to the Steese Highway--a total of about 1,500 miles. Such a movement has not occurred within the past 20 years at least, according to long-time residents. The factors causing this "abnormal" behavior remain unknown.

Stimuli for large-scale movements could result from an external phenomenon, such as the amount or intensity of light, or from an internal event, such as periodic changes in hormone secretion. Possibly a type of learning similar to that acquired by maze-running animals enables the caribou to follow definite routes during migration. Fires, weather, insects, man, food supply, and other factors can alter these patterns.

Daily Movements.

The greatest fluctuations in movements occur day by day. A

band may feed peacefully in one area for several days and then travel 50 miles or so to another area, remaining there for a day, a week, or a month. Within a given locality the band constantly moves from place to place. Individuals within the group exhibit even more erratic behavior.

A multitude of external factors influence the daily behavior. The availability of food and water can regulate movements. Wolves might keep a herd moving by continual harassment, and hunters can elicit a similar response. An abundance of flies or mosquitoes sometimes forces caribou to seek relief on windy ridge-tops. A fire will exclude them from an area, both by the flames themselves and by the destruction of food. Deep or hard-crusted snows can prevent the animals from finding food in certain localities. Thick fog seems to make them uneasy, but less likely to travel long distances; dark nights produce a similar effect. Salt licks and mineral springs provide a strong attraction.

Internal factors exert a powerful, but often obscure, effect upon behavior. During the rutting season mature bulls move about constantly in the performance of their breeding functions. Their actions in turn influence the movements of the cows. During the calving period the cows tend to stay above timberline, and they often move off by themselves at the time of parturition. The shedding of velvet may cause the caribou to seek objects on which they can rub their antlers. Their well-known curiosity for strange objects often causes them to alter their movements temporarily.

These various behaviorisms often take place during certain portions of the 24-hour period. Field observations reveal that most

of the resting and feeding occurs during the middle portions of the day and night. In winter, however, the caribou probably rest and feed all night long; Frank Glaser (viva voce) believes the animals do not move much at that time of day. Caribou generally do their traveling during the early morning and late afternoon—mainly during the three to four hours preceding or following night. The seasonal changes in daylight alter the behavior patterns somewhat. Also, individual and group variation is common, and some animals are traveling while others are resting.

Caribou can traverse great distances swiftly. During migrations they frequently travel throughout the day, snatching up food occasionally as they move along. In the spring migration of 1953 a large portion of the Steese-Fortymile herd moved north from the Sixtymile River to the White Mountains, a distance of at least 300 miles. They traversed this mountainous route in approximately three weeks—an average of 15 miles per day. Three subsequent journeys over the same route in 1954 each required approximately the same amount of time. Individuals or small groups sometimes move much greater distances per day. The author watched one small band travel about six miles in 20 minutes, with no visible slackening of the pace as it passed from view. Banfield (1954) reports the vanguard of a large herd moving 40 miles in one day.

A gallop similar to that of a horse provides the caribou with its fastest means of travel. Banfield (1951) reported caribou galloping across a frozen lake at 45 to 50 miles per hour. The animal tires quickly at such a pace, however, and therefore uses it mainly for emergencies.

The gait used for long-distance running is the trot. The caribou using this gait resembles a high-stepping trotter, holding its head high, arching its forelegs, and thrusting them out with precision movements. One animal was clocked at 25 miles per hour while trotting over tussocky muskeg. Every initiated person knows the great labor involved in walking, let alone running, over muskeg country. The caribou's feat seems amazing considering that the animal holds its head in a position which makes ground observation difficult or impossible. The trot is used both for escape and for ordinary travel, although the speed is much less during the latter.

The principal gait for long-distance traveling is the fast walk. Caribou use this manner of locomotion quite frequently, especially during the seasonal migrations. Judging from the difficulty a human has in keeping abreast of walking caribou, the writer believes their speed must reach six to seven miles an hour. Such a swift walk allows the animals to cover distances quickly. Indeed, it is almost unbelievable how fast a "strolling" band of caribou can disappear from view.

These various gaits are well suited for the nomadic life of the caribou. Most mammals have a definite, rather small home range, and rarely leave it; their travels usually are circular or winding, but remain within the home boundaries. The Steese-Fortymile caribou claim an extensive region for their range, but its limits are vague and unbinding to these animals. Their travels often take them in a certain direction for long distances, sometimes even beyond their normal range.

Seasonal Movements.

The annual migrations of caribou are directional, long-distance treks. Normally one occurs in the spring and another in the fall, with

other large-scale movements apt to take place at any time. In the past these irregularities often disgruntled and inconvenienced the natives and miners who depended upon the caribou for food. Today the erratic movements often produce a similar effect in both the hunter and the wildlife manager. The time, extent, and direction of the migrations remain doubtful and require a certain amount of guesswork to predict.

Records of the movements before 1950 of the Steese-Fortymile herd are difficult to find. Of the many people in contact with the caribou since the goldrush days, few have bothered to record their observations. Thus the records are scanty—the available information being scattered thinly among many old Alaskans and in an array of printed matter. Table 2 at the end of this section contains a compilation of historical information regarding the movements of this herd, as gathered by the writer.

The assembled data disclose definite gaps in the knowledge of the annual movements, the principal one occurring in the latter half of the 1930's. Two periods seem evident, however, in which the migration patterns are fairly well defined; the first being approximately 1905-1935, and the second, 1942-1955. The patterns described below represent the author's opinions as inferred from the data presented in Table 2.

1905-1935.—During this period the range and population of the herd reached their greatest size. The main wintering grounds (those used November to March) extended east from Paxson Lake along the north slope of the Alaska Range through the Fortymile and Eagle districts to the Dawson and Whitehorse areas in Yukon Territory. Sometimes caribou

wintered on the south slope of the Alaska Range. The White Mountains-Circle region was utilized as a wintering area also. The main summer range (that used June to August) occupied the area through which flow the Chena, Charley, Salcha, Goodpaster, and Fortymile Rivers. Figure 12 shows the approximate boundaries of these seasonal ranges. Groups of caribou occurred throughout the range at almost any time of the year, the large population at that time probably necessitating a greater range dispersion of the animals than is now necessary. During the spring and fall migrations the scattered bands and small herds funneled into the summer or winter ranges, commonly along certain routes.

The main portion of the spring migration took place in April and May. Those caribou wintering on the north and south slopes of the Alaska Range generally passed northerly along the Delta River and through Big Delta to the summer range. The animals wintering in the Fortymile country and the adjacent parts of Canada moved northwest along the Middle and North Forks of the Fortymile River. Those in the Ogilvie Mountains usually traveled westerly through the Eagle area. Caribou in the White Mountains-Circle region reached the summer range via the highlands at the head of the Chena River. Frequently, the southern groups continued their migration to the White Mountains before turning about and moving back to the summer range. On one spring day in 1920, Murie (1935) witnessed portions of the same huge herd passing northwest over Twelvemile and Eagle Summits and southeast over Cleary Summit, 50 miles to the southwest, across the trail now called the Steese Highway.

The fall migration usually commenced in August and reached a peak during September and October. The bands assembled and, generally

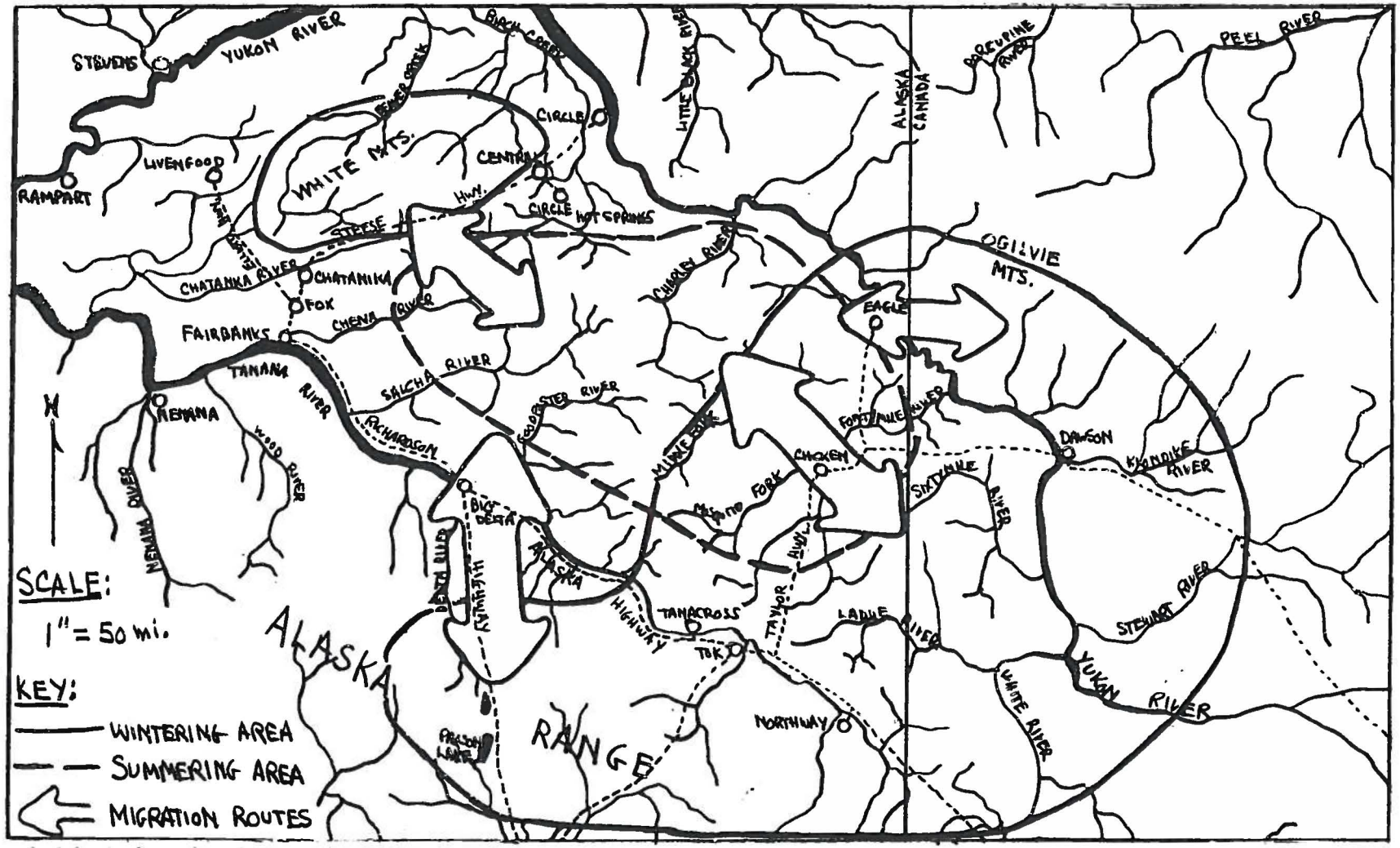

Figure 12. Main wintering and summering areas and major migration routes used by Steese-Fortymile caribou, 1905-1935.

speaking, returned along the same routes used in the spring.

The peaks of these migrations varied from year to year, as did the number of caribou using any given route. Some caribou used other routes entirely and moved in different directions from those indicated above. In the early 1920's, for instance, large numbers of caribou began to move through the Nenana area. Each year for the next 10 years or so they passed north in October and south in April and May. About 1936 these movements ceased as suddenly as they had begun (Linder, 1954).

The records disclose little information regarding whether or not age or sex segregation occurred during the movements. Thus, the discussion indicates merely the general pattern of past migrations. Figure 12 shows the principal routes traveled during the migrations.

1942-1955.--By the second period an apparent reduction in both range and population had taken place. The main wintering grounds now encompass the area surrounding the South, Dennison, and Mosquito Forks of the Fortymile River, the North Fork of the Ladue River, and the Sixtymile River. The White Mountains region has become less important as a wintering area. The data covering this period indicate that small numbers of caribou have wintered in the latter region occasionally, but not to the extent reached in the 1920's. The winter of 1954-55 provides the only exception; large numbers wintered from the upper reaches of Birch Creek southward to the Charley River. The once-favored flats near Circle and Circle Hot Springs have not supported caribou since the mid-1930's. The summer range remains essentially the same, although the southern limits probably do not extend as far south as they once did.

The winter and summer ranges indicated in Figure 13 are approximate, and caribou frequently occur outside those boundaries. The

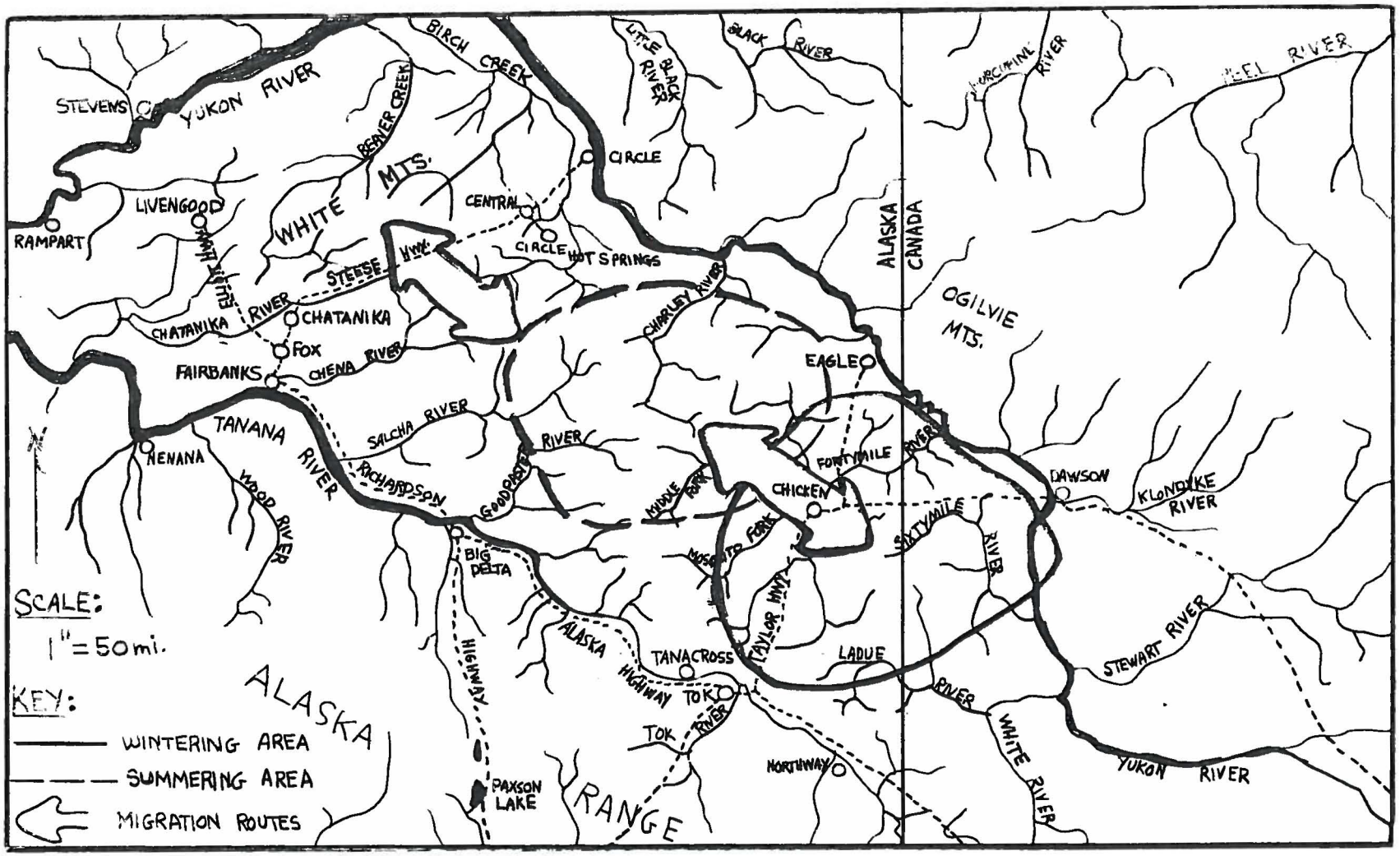

Figure 13. Main wintering and summering areas and major migration routes used by Steese-Fortymile caribou, 1942-55.

decreased population has resulted in the herd's reacting more as an entity than previously. The more limited dispersion of the animals now allows them to assemble and move together along one route during the migrations.

The spring migration begins in late March and reaches a peak during April, May, and June. The herd generally moves northerly along the Middle and North Forks of the Fortymile River. Usually this movement continues to the White Mountains, where the animals turn about and then return. Sometimes the movement occurs late and the return does not take place until late summer or fall. Those caribou wintering in the White Mountains move southeast along Twelvemile and Eagle Summits to reach the summer range. The major part of the spring movement consists of mature cows and of calves, yearlings, and two-year-olds of both sexes. Most of the mature bulls lag behind, dispersed thinly. Adolph Murie (1944) observed a similar segregation occurring in Mt. McKinley National Park. The movement slows and halts temporarily during the calving period in mid-May, and the herd tends to split up into smaller groups. After calving the caribou regroup and move to their summer range, where they again disperse. Some of the bulls remain to the south during the summer and do not rejoin the others until fall.

About mid-August the animals begin to assemble for the fall migration, which reaches a peak in September and October. Caribou on the main summer range proceed either southward or northward, while those summering to the north move southward. A northerly movement sometimes results in part of the herd wintering in the White Mountains region, but most of the animals generally return to the south again before November. The herd usually crosses the Taylor Highway in October or

November. The adult bulls join the rest of the herd during September, sometimes producing a distinct northern movement from the Fortymile region at that time; throughout October both sexes remain together. The breeding season in late September and early October seems to slow the migration somewhat. By December the caribou have established themselves on their winter range, and once again break into small groups and disperse. A segregation of the sexes may take place again, with many of the adult bulls utilizing an area separate from the rest of the herd. Figure 13 shows the generalized spring and fall movements.

The 1954 movements of this herd varied somewhat from the generalized patterns described above. The herd made the spring migration from Canada to the White Mountains as expected, and returned toward the summer range. Then, instead of dispersing, the animals continued southward and in late July reached Canada again. In mid-August the herd returned northward, reaching the Steese Highway in the first part of September. In late September the caribou retraced their steps and arrived in Canada in mid-October. In November most of the cows and young animals moved north again, reaching Birch Creek in late December; many of the adult bulls remained in the Fortymile region. Such movements have not occurred for 20 years at least, and no explanation for this phenomenon is available at present.

The foregoing discussion implies that caribou migrate in large, rather compact herds. Actually they usually cover a wide area, and a migration becomes an intermittent stream of animals moving in one direction. Occasionally they do gather into a huge herd of thousands, but this phenomenon seldom lasts long. In summer and winter their dispersion reaches a maximum.

TABLE 2. MOVEMENTS AND OCCURRENCES OF STEESE-FORTYMILE CARIBOU DURING THE PERIOD 1903 to 1955

Year	Observation	Source
1903	August: a herd of 3,000 near Goodpaster River; it seemed to be moving north. That summer, small bands were scattered over a large area at the head of the Goodpaster. Large herd seen almost every year at Eagle.	Osgood, 1909.
1905	Caribou numerous near Eagle Summit in July; they left in the fall.	Miller, viva voce.
1906	Five large, fall runs of caribou occurred in the Fairbanks-Circle region between 1906 and 1913--the last in 1913.	Palmer, 1941.
1909	October: about 100,000 crossed Mosquito Fork and Kechumstuk Flats.	Stuck, 1914.
1911	Main band of caribou, 15,000-20,000, assembles in north and passes south through Ogilvie Mts. in November and December. In March the migrants return. Formerly, large herds crossed Yukon River near Eagle.	Sheldon, 1911.
1912 1913	Large numbers of caribou crossed Fortymile River near Steel Creek in falls of 1912 and 1913.	Hart, viva voce.
1915 1916 1917	Large herds in the Fortymile region during the winters of 1915-16, 1916-17, and 1917-18.	Brooks, viva voce.
	While on a cross-country trip from the Tanana River "a few years ago", Stuck observed that the bed of Charley River from bank to bank for 50 miles "was trodden hard and solid by hooves of caribou...while every here and there lay a dead one, killed by a band of wolves...we chopped off frozen hind quarters and cooked them for our dogs."	Stuck, 1917.
1918 1919 1920	Many caribou at head of Delta River in the fall and winter of 1918, 1919, and 1920. "The season (fall) of 1920 was typical." The caribou moved northwest past the head of the Chena River during late August and early September. Upon reaching the White Mountains they turned about and returned, moving southeast during late September. An estimated 568,000 passed. In mid-October caribou appeared at Paxson; 10,000-12,000 animals passed south through	O. Murie, 1935.

TABLE 2 (Continued)

Year	Observation	Source
	Mentasta Pass.	
1921	Few or no caribou in the vicinity of Rampart to this date; frequent crossings of Yukon River just below Stevens Village.	Gasser, viva voce.
	Large herds in the Fortymile region during the early 1920's.	Brooks, viva voce.
	Large run on Eagle Summit, 1921.	Miller, viva voce.
	Many caribou passed through Tanacross, starting on April 28; about 6,500 crossed from south side of Alaska Range, all making for the upper Fortymile or Goodpaster Rivers. "Animals were nearly all does." April 11: many passed Tetlin Lake. In July, 30,000 on Mosquito Flats and 15,000 at head of Healy River.	O. Murie, 1935.
1923	April 24: a large number of caribou were seen on Twelvemile Summit moving east toward Eagle Summit.	O. Murie, 1935.
	In early 1920's large numbers of caribou began to migrate through Nenana; never came through before that time. They came every fall in October and every spring in April and May for probably 8-10 years, and then suddenly stopped.	Linder, 1954.
	Caribou reached Rampart in the early 1920's.	Gasser, viva voce.
1924	Large number near Whitehorse in late fall.	O. Murie, 1935.
1925	Large fall runs in Fairbanks-Circle district during 1924 and 1925.	Alaska Game Commission, 1932a.
	Last big run of caribou in the Fortymile region occurred in 1925.	Palmer, 1940.
1927	Large fall run through the Salcha River-Harding Lake-Goodpaster River section.	Palmer, 1940.
	No decimation of caribou numbers; some think the herds are increasing. In fall, 500,000-700,000 passed south through Big Delta. May 26: 1,019 near Little Gerstle River. August 2 - October 30: 1,000 near head of White River.	Alaska Game Commission, 1928.

TABLE 2 (Continued)

Year	Observation	Source
	August 20 - September 1: 50 near Little Gerstle River. September 14-27: 1,500 near Medicine Lake. October 27: 2,500 on west side of Delta River.	
1928	May 1: 200 near Big Delta.	
	Many caribou along Steese Highway in fall of 1928; remained that winter in Fairbanks area.	Alaska Game Commission, 1929a.
	No material change in caribou numbers. August 19 - October 3: 4,000 in Big Delta area.	Alaska Game Commission, 1929b.
1929	Abundant on Eagle Summit in spring.	Miller, viva voce.
	Large summer crossing of Birch Creek; consisted mostly of cows, of which not 1/3 had calves. Fall run across Steese did not reach former peaks. Scarcest in 4 or 5 years at Circle Hot Springs. September 14 - October 15: 10,000 crossed Yukon River 20 miles north of Circle.	Alaska Game Commission, 1930a.
	Annual migrations shifting in the past few years. August 22 - October 8: 3,000 seen along Richardson Highway.	Alaska Game Commission, 1930b.
1930	Caribou seen throughout the Fort Yukon district. Belief exists that caribou are decreasing.	Alaska Game Commission, 1931a.
	Weak, diseased animals killed in Circle district. September 30 - October 14: 3,000 seen near Central. August 24 - October 7: 2,000 near Little Gerstle River.	Alaska Game Commission 1931b.
	Caribou abundant each fall at Eagle until about 1930.	Beiderman, viva voce.
1931	Caribou plentiful at headwaters of the Susitna River and to southeast of Paxson; many seen near Mt. Sanford and Chistochena this spring; have been seen as far south as Copper Center. No huge migrations since 1924-25; caribou have either changed routes or are decreasing.	Alaska Game Commission, 1932a.
	September 25-29: 2,000 seen along Steese Highway. August 14 - September 23: 1,150 near Mt. Hayes.	Alaska Game Commission, 1932b.

TABLE 2 (Continued)

Year	Observation	Source
1931	Migration from Tanana Valley to south slope of the Alaska Range stopped about 1931.	Scott, et al., 1950.
1932	December 16: many caribou along lower Birch Creek.	White, 1932.
1933	Many caribou in the Nenana area during fall.	Linder, 1954.
	Abundant along Steese Highway in fall.	White, 1933.
	August 21-31: 147 near Healy River. September 26-30: 300 along Steese Highway.	Alaska Game Commission,
1934	May 21-31: 20 along Healy River.	1934b.
	Abundant on Cleary Summit in spring. Increased runs in the Eagle and Circle districts; cows and calves particularly abundant. General decline in numbers.	Alaska Game Commission, 1934a.
	May 1: many crossing Steese at Cleary Summit. July 25: large northwest movement of cows and calves on Twelvemile Summit.	White, 1934.
	Late fall run in Circle area; wintered in the Circle, Black River, Eagle sections. Decline in past 5 years; more noticeable each year; fall runs much reduced in Chisana area.	Alaska Game Commission, 1935a.
	Third consecutive year that migration across Richardson Highway has failed to occur. August 20-27: 50 seen near Big Delta. August 24 - September 10: 500 near Goodpaster River. September 27 - October 7: 2,000 near Big Delta.	Alaska Game Commission, 1935b.
	Good fall and spring run on Eagle Summit in 1934; caribou crossed Steese Highway twice each year, 1905-1934, sometimes only once; last large crossing in 1934.	Miller, viva voce.
1935	Many caribou in Nenana area in October.	Linder, 1954.
	Thousands of caribou near Eagle in June, 1935; left during first part of July. Herds now cross Yukon River above Eagle and Fortymile instead of above Circle as formerly.	Alaska Game Commission, 1936a.
	Caribou decreasing in numbers throughout Alaska. August 18 - October 10: any number seen along Steese Highway.	Alaska Game Commission, 1936b.

TABLE 2 (Continued)

Year	Observation	Source
1935	September 1: caribou moving southeast across Birch Creek.	White, 1935.
	Last time large numbers of caribou were seen near Eagle was in mid-1930's.	Residents of Eagle, viva voce.
	"At the headwaters of the Chena River, northeast of Fairbanks, a northwestward movement is noticeable, generally late in July....Various crossings of the Yukon are well known, the chief of which are in the vicinity of Woodchopper Creek and Nation River. Others are near Eagle and Fortymile, as well as at points above Dawson....The main migration passes within a few miles of Eagle, and goes thence on into Yukon Territory, across the Sixtymile River, parallel with the Yukon River and principally on the south side....Above Dawson many local crossings, where caribou habitually swim the Yukon, are known....Occasionally a few animals cross the Tanana River southeast of Fairbanks, traveling more and more southward until at the Delta River a considerable number may cross the lowlands of Tanana Valley into the Alaska Range. Others cross the valley near the mouth of the Healy River and other points up the Tanana, over to the slopes of the Alaska Range. Having arrived at this mountain chain, a great many move eastward along its north slopes in a direction parallel with the range, but others cross the mountains by way of the Delta River, by Mentasta Pass, or by less-traveled routes over the range....It was reported that many caribou had wintered in the hills near the mouth of the White River, in the Kluane Lake region, and elsewhere southeast of Dawson....It is known that caribou winter to some extent on Ladue Creek, along the upper White River, in the Chisana River region, and in Fortymile River....Limited numbers spend the winter on upper Goodpaster River and in other parts of the Yukon-Tanana highland.... The writer has found caribou on the upper waters of the Chatanika River in February...."	O. Murie, 1935.
1936	Spectacular migrations not seen for years; drastic decline in numbers. August 15 - September 18: 3,000 seen in Circle Hot Springs area. August 21-24: numerous along the Steese Highway.	Alaska Game Commission, 1937.

TABLE 2 (Continued)

Year	Observation	Source
1936	October 31: many caribou crossing Shaw Creek.	White, 1936.
	9,000-10,000 caribou at Harrison Creek.	Miller, viva voce.
1937	Large numbers of caribou were last seen near Dawson about 1937; they came each fall before that time.	Residents of Dawson, viva voce.
	July 4: 8,000 on Eagle Summit. September 17: small number along Steese Highway.	White, 1937.
1938	Caribou abundant in Fortymile region during the winter.	Robinson, viva voce.
	Not seen in usual numbers along Steese Highway since 1928; gradual decrease in numbers. Caribou abundant along Steese all fall. September 22: large herd crossed the Yukon near Woodchopper, going south; light crossings in 1936 and 1937; huge crossing 4 or 5 years ago. Big herd moved north past Circle in late October and south again in late November, caribou definitely declining.	Alaska Game Commission, 1938; 1939.
	Spring: many caribou headed north about 100 miles northwest of Whitehorse.	Cole, viva voce.
1939	Good run through Salcha River-Lake Harding-Goodpaster River section during fall.	Palmer, 1940.
	Many caribou in vicinity of Indian River, 50-100 miles south of Dawson, during winter.	Cole, viva voce.
1940	No fall migration across Steese Highway; only stragglers seen between Fairbanks, Circle, and Big Delta.	Palmer, 1940.
	August 21: northwest movement of cows and calves across Steese Highway.	Rhode, 1940.
1941	Fall migration across Steese a scattering infiltration of animals beginning in early August and continuing through September. In fall, usually in September, animals pass in migration through the Fairbanks-Livengood-Circle section in an easterly direction toward the head of Yukon River into Canada. Caribou formerly wintered on the flats in vicinity of Medicine	Palmer, 1941.

TABLE 2 (Continued)

Year	Observation	Source
	Lake and Circle Hot Springs.	
1942	Good fall run across the Steese Highway.	Scott, et al., 1950.
	Caribou in the Fortymile region near the border in the winters of 1940-41, 1941-42, and 1942-43.	McCombe, viva voce.
1943	Small migration across the Steese in fall.	Scott, et al., 1950.
	Indication that caribou are moving into arctic ranges in northwest drift from the Interior.	Alaska Game Commission, 1943.
	Migrations are at an all-time low.	Alaska Game Commission, 1944.
1944	Abundant near Dawson in late fall.	Milan, viva voce.
	A few bulls remained on Beaver Creek in winter of 1944-45.	Bucholtz, viva voce.
1945	No fall migration across Steese Highway.	Scott, et al., 1950.
1946	Late fall run across Steese.	Scott, et al., 1950.
	Caribou in the Fortymile region during winter.	McCombe, viva voce.
1947	Good fall run across Steese	Alaska Game Commission, 1948.
	May: run of cows and young animals moved east across Beaver Creek to calving grounds.	Bucholtz, viva voce.
1948	Fall migration across Steese Highway during the end of September.	Scott, et al., 1950.
	Large number moved southward across Yukon River near Woodchopper, during fall.	Glaser, viva voce.
	Many caribou in Fortymile region during winter.	Barr, viva voce.

TABLE 2 (Continued)

Year	Observation	Source
1949	Numerous in the Fortymile during the winters of 1948-49 and 1949-50.	Wilkey, viva voce.
	July 22: "Caribou were crossing at Eagle Summit last week in large numbers."	Jessen's Weekly, July 22, 1949.
	No fall run across the Steese.	Scott, et al., 1950
1950	Crossed Steese in June and July; good calf crop; crossed again in fall; present in the Fortymile region in December.	Woolford, 1950.
	Fall movement westward across Beaver Creek.	Bucholtz, viva voce.
	June 30: "17,000 caribou are estimated to have crossed the Steese Highway the last 10 days... moving westward with a large per cent calves ...."	Jessen's Weekly, June 30, 1950.
	"Hundreds" of caribou in the Sixtymile country in December.	Dawson Weekly News, December 14, 1950.
1951	Caribou wintered on Nome Creek, 1951-52.	Cox, viva voce.
	Present along Steese Highway in June and July; good calf crop. Fairly large fall run.	Woolford, 1951.
1952	Caribou in Canada during early spring; began moving into Alaska again in mid-April; crossed the Steese Highway in June and July, but there was no fall crossing; reached Fortymile region in October.	Woolford, 1952.
	October 7: 800 caribou seen on Jack Wade flats.	Robinson, viva voce.
	Caribou wintered on Sixtymile and Ladue Rivers and on Dennison Fork. Cows usually migrate first.	Gerhart, viva voce.
	Caribou begin to move out of Fortymile region, and head up the Middle Fork of the Fortymile River, as soon as the weather warms up in the spring.	Robinson, viva voce.
	General spring movement out of Fortymile region at breakup to the headwaters of the Goodpaster	A. Purdy, viva voce.

TABLE 2 (Continued)

Year	Observation	Source
	River; they calve each year on the upper Middle Fork of the Fortymile River; cows and young animals move first.	
1953	March 29: 2,000 near Dawson moving slowly west.	Glaser, viva voce.
	April 30: herd strung out from Steese to Taylor Highways moving northwest; mostly cows and young animals. Return movement southeast in June. Caribou then broke into small groups and summered at headwaters of Charley and Goodpaster Rivers. August 1 - September 14: animals present in Fortymile region; mostly bulls moving northwest. October 10 - November 30: caribou moving southeast across Taylor Highway.	Personal observation.
	November: many near Dawson and in Sixtymile area; followed the Yukon River southward.	Milan, viva voce.
	Caribou used to winter commonly on the flats near Circle and Circle Hot Springs.	Jewell, viva voce.
1954	About April 1 caribou began moving northwest through the Fortymile region.	McCombe, viva voce.
	May 1: cows and young animals already were crossing Steese Highway; northwest movement continued throughout May. June 8-13: 27,000 animals, mostly cows and young animals, crossed Steese heading southeast. July 12-20: caribou moving southeast across Taylor Highway. August 15 - September 9: caribou moving northwest across Taylor Highway; adult bulls common. September 3: animals beginning to appear along Steese. September 20-25: caribou turning about and returning to the southeast. October 11-20: caribou crossing Taylor Highway headed southeast.	Personal observation.
	October 17: many caribou in Sixtymile area.	McCombe, viva voce.
	Many caribou near Dawson in early November; some on Bonanza Creek.	Milan, viva voce.
	November 11-14: caribou crossed Taylor in large numbers headed northwest; mostly cows and young animals. December 7: main herd nearing Steese;	Personal Observation.

TABLE 2 (Continued)

Year	Observation	Source
	advance group across Birch Creek. December: large number of adult bulls present near Taylor in vicinity of Mt. Fairplay; they seemed to be moving slowly northwest. Many caribou, mostly cows and young animals, spent the winter of 1954-55 in the upper Birch Creek region.	
1955	February 26: caribou no longer present along the Taylor.	Blank, viva voce.
	March 24: large numbers present in area bounded by the heads of Chena and Salcha Rivers, the Charley and Yukon Rivers, and Birch Creek. No directional movement noticed.	Scott, 1955.
	May 15-20: large portion of herd moved northward from wintering area; about 10,000 crossed Steese and calved at head of Preacher Creek. Most of the herd remained to south of highway. June 8-20: herd north of Steese crossed the highway headed south. July - September: most of herd remained in area at heads of Salcha, Charley, Goodpaster, and Fortymile Rivers. Stragglers along both Taylor and Steese Highways. October 14-31: most of herd crossed Taylor between mileposts 6 and 112 headed southeast into Canada. December: herd settled in Fortymile and Sixtymile regions for the winter.	Personal observation.

POPULATION

The erratic, continual movement of caribou; their extensive, irregular distribution; and the difficulties of sex and age identification provide definite obstacles to the securement of population data. Accurate total-population counts hinge upon the occasional convergence of the animals into large herds or into areas where aerial transects can be used. Reproduction figures require the tallying of many animals on a cow:calf:yearling basis. Mortality information stems mainly from direct observations and periodic censuses. Valid herd-composition data depend on counts made during the infrequent periods when the sex and age groups are together. To secure these statistics requires both a constant vigilance in order to locate current caribou concentrations, and a constant preparedness in order to reach the concentrations swiftly.

Size.

A knowledge of the size of a caribou herd provides the basic information needed for regulating its harvest. Total-population estimates depend almost entirely upon censuses involving direct counts, which can be made from either the ground or the air, depending upon the circumstances.

The singular habits of caribou make indirect censusing methods impractical. Tracks, an excellent index to the populations of some animals, indicate merely the direction and magnitude of caribou movements. The tendency to travel in files usually prevents an accurate estimate of the number of animals using a route. The hodgepodge of tracks in beaten-down trails, as illustrated in Figures 14 and 15, can

Figure 14. Caribou trail formed during spring migration.

Figure 15. Caribou trail formed during fall migration.

elicit estimates of 50, 100, 500, or more, depending upon the observer.

Caribou scattered over a wide area also can elicit a variety of estimates. An excellent example exists in the Nelchina count of February 1 to 3, 1955 (Watson and Scott, 1956). A large portion of the Nelchina herd stretched over a sparsely wooded plateau of some 5,000 square miles south of Paxson Lake. Thirteen members of the U. S. Fish and Wildlife Service and five airplanes were used for the count. The area was divided into transect lines one mile apart; each line was traversed by a plane with two observers, each tallying the caribou within a quarter-mile strip on either side of the plane. This 50 per cent coverage resulted in a tally of over 18,000 animals, indicating an actual total of about 36,000. Yet, everyone believed he had missed counting many others. Before the results of the transects were known, individual estimates for total numbers ranged from 6,000 to 20,000. This variability illustrates the difficulty of estimating caribou numbers by sight alone, without the use of a systematic censusing method.

The transect technique described above provides one of the most accurate censusing methods available for caribou, but requires a flat, fairly open terrain. The most common method used to date has been the aerial reconnaissance, which provides but a general idea of caribou abundance. Large numbers of animals often are missed entirely; compact herds of several thousands are difficult to estimate accurately without the use of photographs, and again the animals must be in open country. Complete ground tallies have proved feasible when an occasional migration moved along a narrow route past a good vantage point. All these methods, however, result in a minimum figure, for it is practically

impossible to determine the number of animals occurring in the parts of the range not observed.

Past.--Speculation as to the size of the Steese-Fortymile herd has interested many types of people, yet few ever have attempted to census the large herds seen. Conversations with long-time Alaskans and a perusal of the literature indicate that the hills once swarmed with caribou, that the herds required weeks to pass, and that they numbered thousands or millions. Although such statements suggest a large population, they provide no basis for an accurate evaluation. As a result, most early estimates of total population persist merely as speculations.

One estimate stands out as being reasonably sound. In the fall of 1920, Olaus J. Murie observed a large migration at the head of the Chena River. Using data obtained from direct observations and from reports of other observers, he arrived at a figure of 568,000 for the size of the Steese-Fortymile herd (O. Murie, 1935). He states further, "In light of subsequent experience this figure seems conservative and it is safe to say that the herd numbered well over half a million, possibly much nearer a million." (Ibid:6). The fact that the herd required 20 days to pass one point tends to substantiate this estimate, as does also the reputation of Dr. Murie.

A large migration through Big Delta in the fall of 1927 lends further support to Murie's estimate. An enforcement agent estimated that 500,000 to 700,000 animals moved southward past one point in two to three weeks (Alaska Game Commission, 1928). No basis for this estimate was indicated.

During the 1920's the herd apparently was increasing. Caribou began to move through the Nenana (Linder, 1954) and the Rampart

(Gasser, viva voce) areas, where formerly the animals had not occurred. In the fall of 1924 a large number reached Whitehorse for the first time in 20 to 30 years (O. Murie, 1935). Huge migrations were observed in 1920, 1921, 1925, and 1927 (see Table 2). A report in 1928 states that the herd was increasing (Alaska Game Commission, 1928).

Later reports began to indicate a decline. In 1929 residents of the Circle region reported the smallest run in several years through that district (Alaska Game Commission, 1930a). Another report stated that the migration routes seemed to be shifting in the past few years (Alaska Game Commission, 1930b). In 1931 the belief existed that the caribou were decreasing in numbers (Alaska Game Commission, 1931a). Migrations from the Tanana Valley to the south slope of the Alaska Range stopped about 1931 (Scott, et al., 1950). Another report said that the caribou had either changed their migration routes or were decreasing (Alaska Game Commission, 1932a). The last "big" migration across the Steese Highway occurred in 1934 (Miller, viva voce). Conversations with Eagle residents revealed that few caribou have been seen there since the mid-1930's. The migrations through Nenana stopped about this time, also (Linder, 1954). A report in 1936 disclosed that caribou were decreasing throughout Alaska (Alaska Game Commission, 1936b). Another stated that spectacular migrations had not been seen for years, and that there had been a drastic decline in numbers (Alaska Game Commission, 1937). Large numbers were last seen in the Dawson area about 1937 according to local residents. The last known large crossing of the Yukon River was observed near the mouth of the Charley River in 1938; and along the Steese Highway caribou had not been seen in "usual" numbers since 1928 (Alaska Game Commission, 1938; 1939).

Observations through the 1940's continued to lament the decline of caribou. A report in 1943 stated the belief that caribou were moving into the arctic ranges in a northwest drift from the Interior (Alaska Game Commission, 1943). Another said that migrations were at an all-time low (Alaska Game Commission, 1944).

Through the 1920's, then, the population remained high. The herd numbered perhaps half a million or more, and apparently reached a peak in the latter portion of that decade. The decline in numbers seemed to begin after 1928 and to reach its maximum rate in the mid-1930's. The population low probably occurred sometime in the early 1940's.

Information regarding the present size and reproduction of the herd indicates that the population low possibly was between 10,000 and 20,000 animals, depending upon the rate of increase since then and assuming that emigration and immigration were at a minimum. Table 3 shows the possible total populations, 1944 to 1956, based on 10, 15, and 20 per cent yearly increases in reference to the 1953 population estimate (see Table 4). The herd's present rate of increase seems to be at least 10 per cent, judging from recent calf crops (see Table 7). Data on the growth of reindeer populations reveal average yearly increases of 15 to 27 per cent (Hadwen, 1922; Scheffer, 1951; Hanson, 1952).

A population low of 10,000 to 20,000 animals means that the herd decreased by over 500,000 animals in a period of 15 years. This drop represents an average loss of at least 35,000 each year plus a number corresponding to the annual increment from reproduction. Although the exact reason for such a swift decline remains unknown, a plausible explanation does exist.

TABLE 3. POSSIBLE TOTAL POPULATIONS OF THE STEESE-FORTYMILE HERD IN SPRING, 1944 to 1956, BASED ON 10, 15, AND 20 PER CENT YEARLY INCREASES IN REFERENCE TO THE MINIMUM POPULATION ESTIMATE OF APRIL, 1953.

Year	Yearly Increase		
	10 Per Cent	15 Per Cent	20 Per Cent
1944	17,000	11,300	7,700
1945	18,700	13,000	9,300
1946	20,500	15,000	11,100
1947	22,600	17,200	13,400
1948	24,800	19,800	16,000
1949	27,300	22,800	19,300
1950	30,100	26,200	23,100
1951	33,100	30,200	27,800
1952	36,400	34,800	33,300
1953	40,000	40,000	40,000
1954	44,000	46,000	48,000
1955	48,400	52,900	57,600
1956	53,200	60,800	69,100

The sparse data available indicate that the maximum carrying capacity of the range might have been reached in the mid-1920's. At that time a herd of more than 500,000 inhabited a range of about 85,000 square miles (see RANGE)--a minimum density of one animal to 100 acres. Some of that land, of course, could not supply food; fires were destroying vegetation continually; and the herd was increasing. In 1930 a report disclosed that several weak, diseased caribou had been killed in the Circle district that fall (Alaska Game Commission, 1931b). This occurrence might indicate that over-population was beginning to affect the health of the herd. Yet no record exists of any extensive die-off, and such a catastrophe could hardly take place unnoticed.

Excessive hunting cannot account entirely for the decrease. In 1935 an enforcement agent at Fort Yukon stated that at least 10,000 caribou were killed each year in his district, which extended to south of Chicken, and that each trapper killed 30 to 60 animals a year for dog feed (Alaska Game Commission, 1934a; 1935a). Yet a herd of 500,000 should easily withstand an annual harvest of more than 50,000 animals. Once the population had been reduced, however, hunting could have become a serious factor provided the kill continued as large as implied.

An average loss of 35,000 animals a year can hardly be attributed to a die-off or to hunting. The largest number probably moved to other regions. Either range deterioration or over-crowding, or both, might be influential factors for such an emigration. The effect of either on caribou movements remains obscure, however, for as yet no one has studied caribou behavior intensively.

Kelsall (1955) describes what he terms a "population shift" as occurring in one area of northwestern Canada. There the wintering

caribou population dwindled from over 200,000 animals in 1949 to less than 40,000 in 1954, a phenomenon accountable only by the caribou moving to new areas. He states, "The mingling of major caribou herds on certain boundary areas has been observed frequently..." with, in one case, "...animals from one herd moving off winter ranges in an entirely new direction with animals from a second herd." Such behavior likely caused the great decline in the size of the Steese-Fortymile herd. A population shift easily could escape human detection in the vast, thinly-populated regions involved--even today with the great number of airplanes in the area.

The animals could have used a number of routes in leaving the Steese-Fortymile range. Adjacent herds existed on nearly every side, permitting free interchange of animals. Some observations show that caribou frequently moved northwest and southeast across the Yukon River near Stevens Village (Gasser, viva voce). Others reveal that bands often reached the Fort Yukon area, and perhaps extended farther (Alaska Game Commission reports; see Table 2). At times these caribou mingled with the herds in the Ogilvie Mountains and at the head of the Peel River (Sheldon, 1911). Olaus Murie (1935:69) indicates there were "...rather definite points of contact between the caribou of the Yukon-Tanana herd and those of British Columbia..." and that large numbers often moved south across the Alaska Range. The present Nelchina herd may have resulted from remnants of the Interior herd (Scott, et al., 1950). The herd ranging in the Mt. McKinley area was easily accessible via the Alaska Range. A northwest drift of caribou from the Interior to the arctic was thought to have taken place during the late 1930's and early 1940's (Alaska Game Commission, 1943). Figure 1 shows the

locations of the present herds, some of which may have been formed or supplemented by emigrants from the Steese-Fortymile herd.

Present.--Reports through the early and middle 1940's all indicate a low population. In the latter years of that decade various observations point to a gradual increase in numbers. A conversation with a miner of the Fortymile area (Wilkey, viva voce) discloses that the animals were numerous there during the winters of 1948-49 and 1949-50. Barr (viva voce) also remarked on the abundance of caribou at those times. In mid-July of 1949 large numbers crossed the Steese Highway (Jessen's Weekly, 1949). In the latter part of June, 1950, Frank Glaser (viva voce) of the U. S. Fish and Wildlife Service estimated that at least 20,000 caribou crossed the Steese Highway headed southeast. Woolford (1950, 1951) reports that during both 1950 and 1951 large numbers crossed the Steese in summer and fall, and that there were good calf crops. During June, 1952, many caribou moved across the Steese at Eagle Summit; at least 5,000 animals were counted and again the number of calves was high (Alaska Cooperative Wildlife Research Unit, 1952). Caribou were numerous in the Fortymile region during the winter of 1952-53 (Gerhart, viva voce).

The total population during this period remained unknown. The consensus seemed to be that the herd contained not over 10,000 animals. As late as 1950 its size was estimated at 6,500 (Scott, et al., 1950). Frank Glaser alone maintained that the herd numbered over 20,000 animals. No concerted effort had been made to census these caribou since Olaus Murie's attempt in 1920.

On April 30, 1953, an aerial flight revealed the herd (mostly cows and young animals) to be strung out along a line 10 to 20 miles

in width and stretching between the Steese and Taylor Highways. The animals were moving northwest and keeping mostly to the timbered areas. The wide dispersal of the caribou and the concealing effect of the timber prevented any accurate estimate from the air.

Ground contact was made with the herd during May along and to the north of the Steese Highway. Calf, yearling, and sex-ratio counts were obtained at this time. From June 10 to 15 they streamed southeast across the Steese in large groups, crossing along three miles of road above timberline. A crew of five from the U. S. Fish and Wildlife Service and the Alaska Cooperative Wildlife Research Unit worked day and night obtaining a total count. That count, in combination with the composition counts made earlier, provided the basis for making a minimum estimate of the total-herd size at that time.

Counts including calves totaled 19,900 animals, and those excluding calves, 10,500--a total of 30,400. The number of calves excluded from the latter counts was computed to be 6,200, based upon calf-counts taken on 9,923 animals, 3,694, or 37.2 per cent, of which were calves. The total number of animals crossing the highway then reached 36,600. Composition counts indicated this portion of the herd to contain 18,660 adult cows, but only 1,440 adult bulls. Assuming a 1:1 sex ratio (see Composition), the 17,220 missing bulls would bring the total population figure to 53,820 as of June 16, 1953. This figure represents a minimum one, for undoubtedly some cows, as well as calves and yearlings, were missing from the tally also.

To be most useful the total population figure should apply to the herd just previous to calving, for by then annual calf mortality is evident. Thus, the elimination of 13,600 calves (37.2 per cent of

36,600) from the above total figure leaves a minimum population before calving of about 40,000 animals. Table 4 illustrates the procedure used to compute the herd size and composition. These data provide the most complete herd statistics known to date.

Reproduction.

The most important data needed to assess the growth of a caribou herd concern the annual production and survival of calves. Calf production itself, of course, depends basically upon the success of mating the previous October and upon a normal development of the foetus to parturition. The apparent stamina of new-born calves and the attentiveness shown by cows toward their offspring are important factors aiding the survival of calves after birth.

Breeding.--The inaccessibility of the herd during the mating season the past few years has limited the gathering of breeding data. Observations made by the author both immediately before and after the main period of the rut, however, serve to illustrate caribou behavior during the breeding period.

The shedding of velvet provides the first indication of the approach of the rut. Many of the largest bulls, probably the most vigorous of those over five years old, begin shedding during the third week in August--their antlers being cleaned and hardened by the first week of September. The less vigorous and the younger males lose their velvet later, but all except the yearlings and some of the two-year olds have bare antlers by mid-September. The cows begin shedding velvet during the second week of September, but most do not have hardened antlers until late September or early October. Calves of both sexes often carry velveted antlers through November.

TABLE 4. COMPOSITION AND MINIMUM SIZE OF THE STEESE-FORTYMILE HERD, COMPUTED BY UTILIZING POPULATION DATA OBTAINED DURING MAY AND JUNE, 1953.

Classes	Caribou Crossing Steese Highway		
	Computed From Total Counts Including Calves	Computed From Total Counts Excluding Calves	Computed Total
	19,900[a]	10,500[a]	30,400
Calves	7,400[b]	6,200[b]	13,600
Yearlings	1,600[c]	1,300[c]	2,900
Adults	10,900	9,200	20,100
Cows	10,120	8,540	18,660
Bulls	780[d]	660[d]	1,440
Adults and Yearlings	12,500	10,500[a]	23,000
Total	19,900[a]	16,700	36,600

Total number caribou crossing Steese Highway, June 10-15. 36,600

Estimated number of bulls missing (assuming 1:1 sex ratio). . . . 17,220

Total population size, June 16, 1953. 53,820

Total population size, April, 1953 (excluding calves) 40,220

a/ Direct counts.

b/ 37.2% of total; based on counts of 9,923 animals, of which 3,694 were calves.

c/ 12.4% of adult-yearling total; based on counts of 1,336 animals (excluding calves), of which 166 were yearlings.

d/ 2-3 year bulls: 6.6% of adult total; based on counts of 228 adults, of which 15 were young bulls.
Bulls over 3 years: .3% of total animals; based on counts of 12,774 animals, of which 36 were older bulls.

Soon after losing their velvet the bulls begin their "fighting", which might be described more accurately as merely shoving matches. On September 12, 1953, two large bulls of a mixed band of 30 animals were observed in such a match. They placed their heads together and pushed each other about firmly, but not violently, for about 10 minutes; after that the one which seemed to have been shoved the most left the band and soon disappeared over a ridge a mile or so away. In the meanwhile several pairs of younger bulls engaged in similar matches, although none resulted in the banishment of the "loser".

Since that time the author has observed carefully during September a total of 12 bands, ranging in size from 20 to 50 animals. Each band contained what seemed to be a dominant bull--generally large and with massive antlers. The other males in the band retreated when approached by this one. There were many shoving matches between the younger bulls, and even between cows, but the dominant male did not "fight" until approached by bulls from outside the band. All males within the band from two years old and up were observed to try to mount the cows, with no interference from him. No herding of any kind was attempted by any of the dominant bulls, and animals moved in and out of the bands freely, with the exception of incoming "challengers". It is the author's opinion that in the fall adult bulls simply join existing bands of cows and younger animals (rather than "rounding up" the cows), and that one bull becomes dominant in each group, probably after chasing off all possible contenders. More observations are needed to verify this opinion, however.

A bull was first observed to attempt the mounting of a cow on September 5, 1954. The male in this instance was large and had

hardened antlers. After that date the observed frequency of attempted mountings increased steadily. On September 27, 1954, however, the latest observation before the main period of mating, most cows were still not receptive to the bulls. The next observations began on October 16 of both 1954 and 1955; by then attempted mountings seemed limited to the younger bulls and the cows again did not seem too receptive.

Most of the actual mating, then, occurs sometime between September 27 and October 16--a period of two weeks or so. Such a short mating season is verified in part by the occurrence in spring of a correspondingly short period during which the vast majority of the calves are born.

Potentially the production of calves should remain high provided that a sufficient number of bulls exist and that the sexes are together during the rut. The tendency for many of the adult bulls to lag behind during migrations and for cows and bulls to be in widely separated areas at certain times of the year suggests that sometimes the bulls possibly are not present in sufficient numbers during the rut to serve the cows adequately. This idea is pure conjecture, however, and no observations exist to support it. For the past six years, fall movements must have brought the sexes together for the rut, because calf production has been high each year.

Two of nine cows examined in late November, 1953, contained no embryos; both were in the 7 to 9 year age-class. One of the remaining seven was a yearling, showing that at least some cows are sexually mature at 16 to 17 months. Field observations at the time of calving, however, revealed that relatively few cows classified as two-year-olds

were accompanied by calves. Among reindeer, females are known to breed at five months of age (Palmer, 1927). No similar occurrence among caribou has been recorded.

Calving.--During May and June of 1953, 1954, and 1955 the author was present on the calving grounds to observe caribou behavior before, during, and after parturition. The principal calving area, outlined in Figure 16, is located some 15 to 25 miles north of the Steese Highway, and has been used fairly regularly by this herd during the past 30 years or so. In 1955, however, only about 10,000 animals calved there; most of the herd remained to the south. The following discussion, then, results mainly from observations made during the first two springs.

Calves begin to appear during the second week of May, following a gestation period of some 33 weeks. The first new-born calf was sighted on May 9, 1953, and in 1954 and 1955 many new calves were present when the author arrived on the calving grounds in mid-May. Calving continues at least till mid-June, for on June 16, 1955, four two- to three-day-old calves were seen. Similar observations were recorded for the Mt. McKinley herd by Adolph Murie (1944), who reported seeing the earliest calf on May 12, and a one- to two-day-old calf as late as June 22. Thus, the extremes of calving are the second week of May and the third week of June. The vast majority of calves, however, are born during the latter half of May.

The forward portion of the spring migration begins to arrive at the calving area shortly after May 1. As parturition nears, the animals slow down and disperse, but a drifting movement continues northward, swinging to the south again after reaching the White

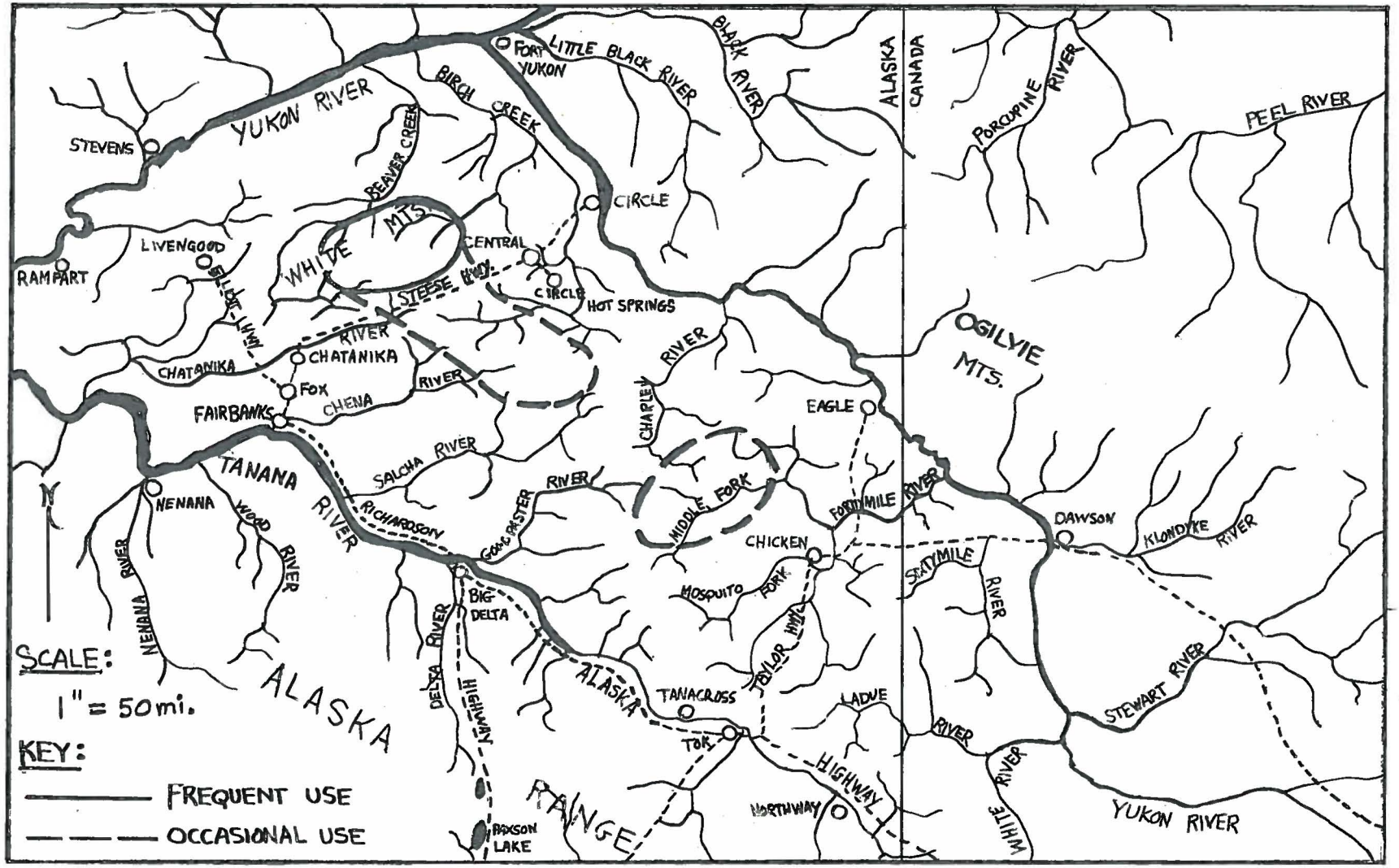

Figure 16. Main calving area used by Steese-Fortymile caribou.

Mountains, or after calving. The caribou frequent the ridges above timberline, especially those supporting extensive growths of grass and sedge, as illustrated in Figures 17 and 18, and remain in small bands. Of 494 bands recorded May 8 to 23, 1953 to 1955, 94 per cent contained less than 50 animals, 82 per cent less than 25, and 72 per cent less than 15, with the largest band numbering 172. Cows and yearlings dominate the spring migration; bulls composed only 7.1 per cent in 1953, 1.0 in 1954, and 0.2 in 1955 of the total animals (excluding calves and yearlings) north of the Steese Highway.

In 1954 the author reached the front of the spring movement on May 18 along Nome Creek. Counts obtained that day showed that 54.0 per cent of the cows had calves (47 calves:87 cows). The next day's tally, taken about 10 miles farther toward the rear of the movement, revealed that only 15.3 per cent of the cows had calves (43 calves:281 cows). Counts taken May 26 to 27 of the few animals still moving northward across the Steese Highway showed that only 2.8 per cent of those cows had calves (1 calf:36 cows). These few data tend to indicate that cows nearest to parturition are most numerous toward the front of the spring migration.

Most yearlings leave or are cast-off by their mothers sometime before parturition. Many assemble in small bands on the calving grounds; some actually remain with their mothers until calving, and a few even later; and there is evidence that a number lag behind during the spring movement. Counts taken in 1954 on the calving grounds showed 21 yearlings to 100 cows (234:1,128), while those taken at the rear of the migration indicated 197 to 100 (71:36). Similar counts in 1955 revealed 16 yearlings to 100 cows (93:591) on the calving grounds

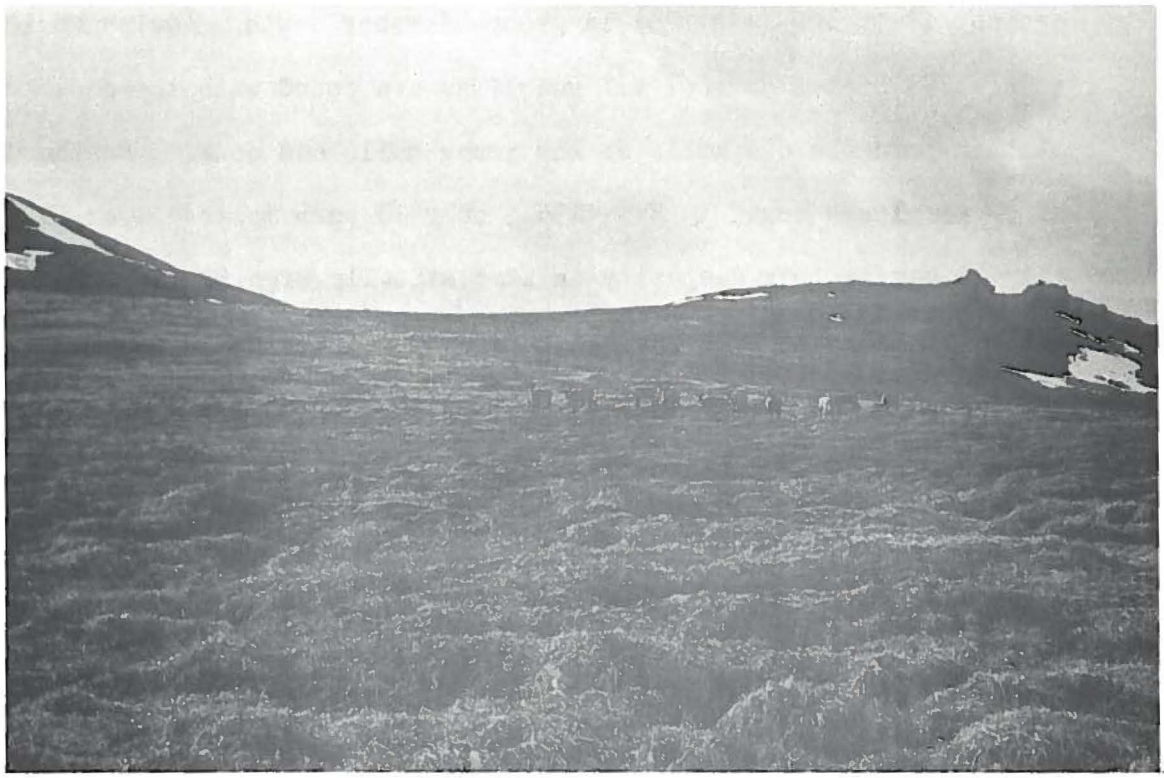

Figure 17. Caribou band on grassy ridge above timberline, in May.

Figure 18. Caribou moving through brush near timberline, in June.

against 47 to 100 (176:373) in groups farther south. Adolph Murie (1944:179) states "...not all yearlings are found with the cows. Many of them join the old bulls or the young bulls and cows." Furthermore, of 37 yearlings sexed in May, 1954, only 10 were males. Even with such a small sample this disparity is statistically significant. The implication is that the male yearlings tend to lag behind more than do the females. As yet the non-calving portion of the herd has never been observed for composition data.

Some pregnant cows remain with the bands until the calves are born, after which they may leave or stay behind if the band continues to move. Some of the small bands of less than 15 animals seem to consist wholly of cows which drop their calves about the same time. Twenty-eight such groups were sighted during 1953 and 1954, each cow having a calf of less than five days. Unless disturbed, these cows likely remain together throughout the calving period. Many an expectant mother, however, moves off alone shortly before parturition and remains by herself until the new-born calf is strong enough to travel. Lone cows, with and without calves, are a common sight during the calving season; 98 such animals were recorded.

Most of the calves are born on grassy plots amidst dwarf birch and willow underbrush; many others are dropped on the long grassy slopes frequented at that time; and some, on rocky ridges above timberline. Figures 19 and 20 illustrate the areas where many calves are born. No cow was observed while giving birth, although one had the legs of a calf extending partly out of the vagina. This cow disappeared from view shortly after being alarmed, and did not appear again.

During the 1953 and 1954 calving seasons, 18 lone cows with

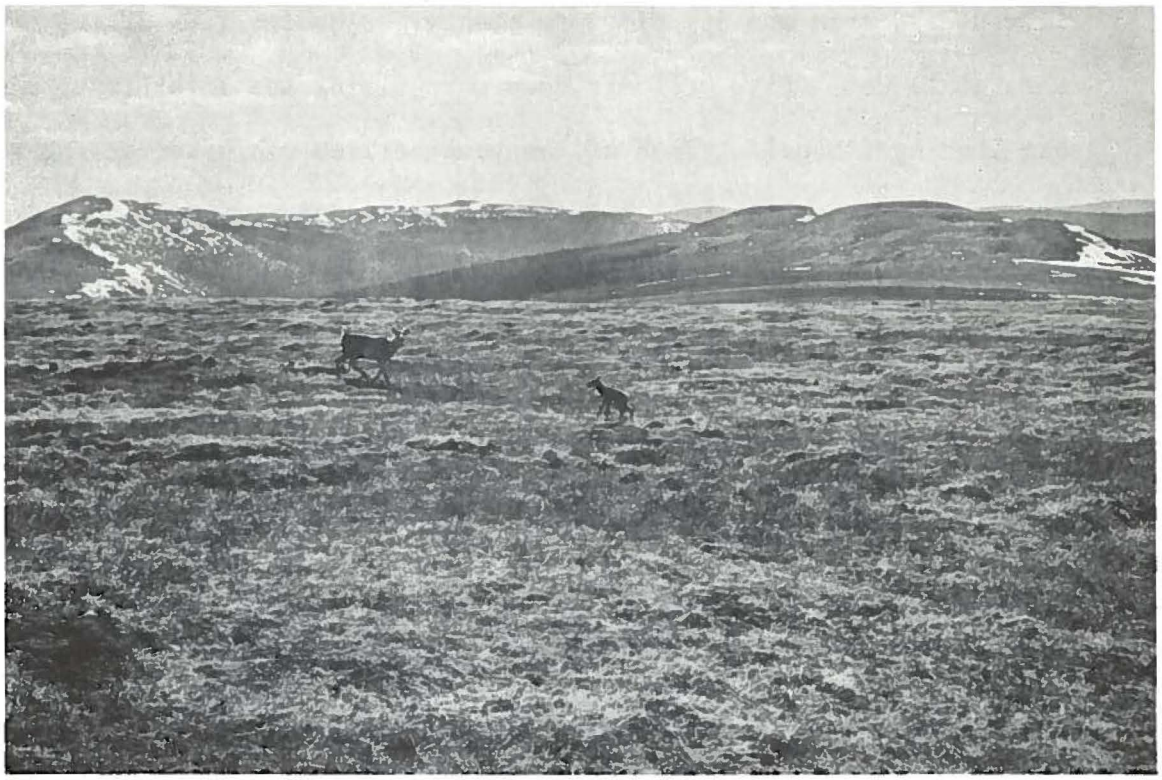

Figure 19. Cow with new-born calf on grassy ridge-top.

Figure 20. Cow with young calf on grassy plot amidst brush.

calves less than one day old were observed closely; four of the calves were still wet. Five of these cows were eating the afterbirth; one was licking its calf. Each of the young calves was lying on a grassy area above timberline, all but three amongst underbrush, with the mother lying beside it or feeding close by. Four of the pairs were observed for periods of 30 to 45 minutes without disturbing them, during which time the calves remained down and the cows never wandered more than 10 yards away. The cows acted nervously--first standing, then feeding, then lying down, next nosing the calf, then feeding again, and so on--and were extremely alert and watchful. At the first sight of the author each of the 18 cows ran excitedly to its calf. Each lowered its head to the calf and then ran off a short way. Usually the calf struggled to its feet and began to follow. If not, the cow returned and repeated the head-lowering and movement-away behavior again and again until the calf followed, and in two instances finally pushed the calf to its feet. As the two moved away, the cow would stop occasionally to wait for the calf to catch up; if it were moving too slowly, the cow would return and again lower its head to the calf, as if to urge it on.

The cow and new-born calf, unless disturbed, remain at the birth site at least until the calf has dried, and probably spend most of the first day in the near vicinity. During the first week of the calf's life, the mother cares for it most attentively. Cows with calves less than about four days old are the most alert animals in a band and usually run off at the first sight or smell of danger; the others usually remain for further confirmation. Most cows do not regroup nor join large or mobile bands until their calves are older

than two days. In 1953 and 1954 only two calves less than two days old were noticed among bands numbering over 20, and none in the moving groups--calves of that age being easily identified by their stumbling gait. In 1955, however, the presence of much snow caused the caribou to congregate at snow-free areas.

At birth the calves are very weak, but while still wet can stumble quite a distance. One such calf was seen to stagger after its mother for half a mile before they both disappeared from view, the cow waiting every so often for the little one to catch up. Figure 21 illustrates the awkwardness of these young calves. During the first two days of life the calves remain rather rubber-legged, but can travel slowly for moderate distances. As this age they do not yet recognize a human as an enemy. Rather, such a calf actually seems to adopt the human as a proper guardian after its mother has left. Their strength develops swiftly, for the cows constantly lead them over extensive muskeg and steep, rocky slopes. By the third day they can outrun a human for moderate distances, but soon tire. Calves three to four days old act more aloof and seem to sense humans as something foreign. After a week they can keep up fairly well with a caribou band moving swiftly. By then, a calf still does not sense danger from the sight of a human, but apparently does recognize his odor as something to run from. The one calf of that age observed closely by the author approached cautiously, and ran off only after scenting his outstretched hand.

The ages indicated above for calves are purely the author's opinion. New-born calves have about four inches of umbilical cord remaining, and after three days this cord is entirely dry except for a

Figure 21. New-born caribou calf, one to two hours old.

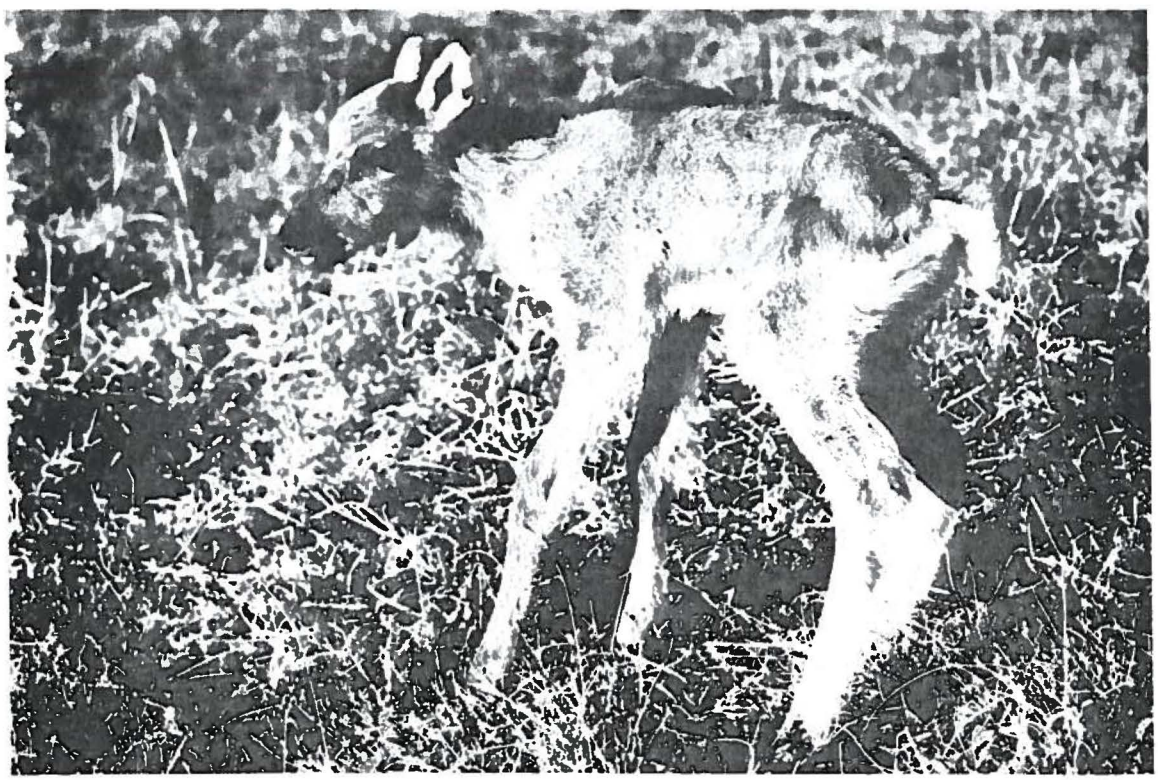

Figure 22. Ear-tagged caribou calf, two days old.

small area next to the belly. (This information was gained from the recapture of a tagged calf.) Ages after that are judged from the relative body size, the elapsed time from the main calving period, the gait, and the calves' general behavior.

An attempt was made to tag the young calves, when convenient and not interfering with other observations. No special effort was made to catch calves unless they happened to run in the same direction the observers were traveling. The success of tagging hinged greatly on the terrain, the age of the calf, and the stamina of the tagger. During the three years, 44 calves were ear-tagged, one of which is shown in Figure 22.

The reaction of the cow to the prospective tagger was similar in each instance. As the observer approached to within 50 yards the cow began to snort frequently, and usually left its calf if the observer came closer, although two stayed next to their calves until he was about 10 yards distant. After leaving the calf, the cow circled nervously about 40 to 60 yards away, snorting often, and sometimes running up to within 20 yards. Gradually, the cow moved farther and farther away, and often passed from sight within 15 minutes. In only 8 of 26 such observations by the author did the cows remain in sight longer than that. After the author left the calf, the cow, if in sight, still continued to circle--at a distance of over 100 yards and sometimes over half a mile. Occasionally it approached the calf to within 50 yards, but then moved away again. Usually this erratic movement continued for at least 45 minutes. Six cows were observed definitely to return to their calves. Of these, two returned within 30 minutes, one within two hours, and three after two hours. The

returning cows accepted the tagged calves after identifying them by smell, and gave no visible reaction to the human odor. In addition, 11 tagging sites were checked later and the calves were gone. One cow apparently did abandon its tagged calf, for the calf was found dead at the tagging site two days later. In another instance, a cow returned to a tagging site twice but failed to find the calf, which was lying down making no noise. After several hours the calf joined a passing band--a cow without a calf seemingly accepting the lost one.

After the calves are three days or more old, the cows begin to regroup and to join other existing bands. By the time most of the calves are one to two weeks old the bands number 100 to 1,000 animals. By then the cows stampede with the rest of the band when frightened, often seemingly forgetting about their offspring. Frequently calves become mixed within or left behind a stampeding band, and so become separated from their mothers. Such separations also occur at times due to the calves' scampering and playing while the band is resting or feeding. It is a common sight to see young calves running swiftly back and forth through a resting group with the mothers trotting behind trying to keep track of them.

Cows soon realize when their calves are missing, and immediately begin to search for them. A cow searching for her calf is easily identified by her distinctive movements. She reacts much like a person would after losing something: looking first one way, then another; trotting this way and that; seemingly greatly perturbed. At first the cow restricts her movements to the band itself, but if the calf is not located she retraces the path of the band. She is persistent in her search and will continue for several hours, crisscrossing a wide area,

stopping every so often to snort. Bawling calves cause the searching cows to investigate, and often excite cows in nearby bands even though their own calves are beside them. Both the snorts of the cow and the bawls of the calf aid in bringing the two animals together.

Cows seem to have a fair idea of what their calves look like. In searching they frequently pass some calves with hardly a glance, yet move directly to others. One sighted its calf about 200 yards away with another cow and calf and immediately ran to it; the calf had not made any audible sound. Another cow moved back and forth through a band of some 200 animals, smelling calves and every so often running directly to certain ones 30 to 50 yards away. She never did locate her calf during the hour the band was under observation, and every calf in the band seemed accounted for. Possibly she had lost her calf some time ago and was still reacting to the "absent-calf" stimulus. Positive identification of calves seems to hinge directly upon scent, for every cow will smell a calf before accepting it.

A searching cow smelling a strange calf simply leaves it and continues the search. But if a strange calf should wander near a cow, the cow often strikes viciously at it with the head or forelegs. If the cow still retains hard antlers, this action can result in a dead or wounded calf (see Mortality).

Some cows ignore strange calves and even allow them to follow. At first glance one might think that the cow had twin calves, but in 15 such instances observed the extra calf belonged to another cow. No evidence of twinning was observed. It is doubtful if the extra calves are allowed to suckle, although a cow having lost its calf might adopt a stray one. One observation showed two cows vying for the possession

of a calf. The three were in a band moving slowly across a ridge, and each cow would try to exclude the other by moving between it and the calf. This behavior continued until the band passed from view 10 minutes later. It was never ascertained whether or not the calf actually belonged to one of them.

The bands continue to grow in size after calving as more cows and calves and other bands join together. By the first week of June during all three years, the animals had assembled in herds of 1,000 to 2,000. In mid-June they moved en masse southward across the Steese Highway.

During these crossings, close tallies were made to obtain total-count figures and final reproduction data. The post-calving calf:cow ratios (after "infant" mortality) were 72.9 per cent in 1953 (see Table 4), 72.5 in 1954 (1,694:2,335), and 64.9 in 1955 (200:308). The drop indicated by the last figure probably resulted from the severe weather conditions existing that spring on the calving grounds. Adolph Murie (1944) reports calf:cow ratios in the Mt. McKinley herd of about 50 per cent during June of 1939, 1940, and 1941. The Steese-Fortymile herd seems to have a high production of calves, but the figures stated above apply strictly to the calving groups. It is possible that some of the cows not bearing calves do not reach the calving ground, and hence do not enter the tally. Composition counts from the non-calving groups are needed to gain complete knowledge of caribou reproduction.

Mortality.

Annual mortality provides basic information for establishing the rate of increase for a herd. Initial calf-production itself remains rather stable, barring unusual circumstances, such as malnutrition

or an abnormal sex ratio; mortality, however, varies from one year to the next, depending upon weather, disease, hunting, or the prevalence of predators. The various mortality factors are classified here as indirect, such as certain behaviorisms and physical characteristics of the caribou that predispose the animals to certain losses; or as direct, such as predators and disease. Complete knowledge of the total losses sustained each year is difficult to obtain, and present data are insufficient. Periodic censuses and direct observations provide the principal means of evaluating annual mortality.

Indirect Factors.--Certain physical attributes of caribou influence survival. Perhaps the most obvious are the senses of sight, hearing, and smell. All three seem well-developed, but the last is by far the most important for detecting danger. Caribou often see or hear the approach of a predator, but do not run off until they have caught its scent, and sometimes not even then. Wolves occasionally can approach quite close and pull down caribou by simply exerting a sudden burst of speed (Glaser, viva voce). Whether feeding, resting, or traveling caribou seldom seem alert, but a certain scent can stampede an entire herd within a brief instant. This apparent reliance upon the one sense certainly limits their ability to avoid predators.

The main defense of caribou against a predator lies in their great running speed (see Daily Movements). After one month of age they can quickly outdistance most of the land predators, although wolves actually can capture almost any caribou in a long-distance chase (Glaser, viva voce)--especially the handicapped ones, such as pregnant cows, fat bulls, and calves.

Grank Glaser (viva voce) recalls seeing an adult bull defy two

wolves with its antlers. The incident occurred in September when the bull had newly polished antlers. It shook its head threateningly at the wolves, which retreated and then departed.

Eagles can reach any caribou easily, of course, but their predation applys mostly to the young calves. Cows protect their offspring from these birds by rearing up and striking out at them with the forelegs, or by simply standing over the calves. The writer has witnessed such behavior many times during the calving season. The calves are not defended from the larger predators.

Certain behaviorisms of caribou also contribute to mortality. The great curiosity exhibited by caribou, especially yearlings and two-year olds, is well-known. This trait often causes them to approach closely to strange objects again and again before finally becoming alarmed and running off. It acts as a detrimental factor by bringing the animals to within easy rifle range for hunters and, perhaps, to within striking range for wolves. Figure 23 and 24 illustrate the curiosity displayed by caribou upon the approach of man.

Another detrimental characteristic is the lack of alertness exhibited by most caribou. Sometimes individuals sleep so soundly that a person can approach quite close. The writer walked to within 10 feet of a dozing cow, which did not awake until the snap of the camera shutter. Glaser (viva voce) relates how he once walked up to a sleeping cow and grabbed it by its antlers. Olaus Murie (1935) tells of similar incidents. An apparent "safety-in-numbers" feeling seems to exist, for individuals within large groups of 1,000 or so animals are much less alert than are those in smaller groups. Banfield (1954) reports being able to approach within 25 yards of large herds. Cows

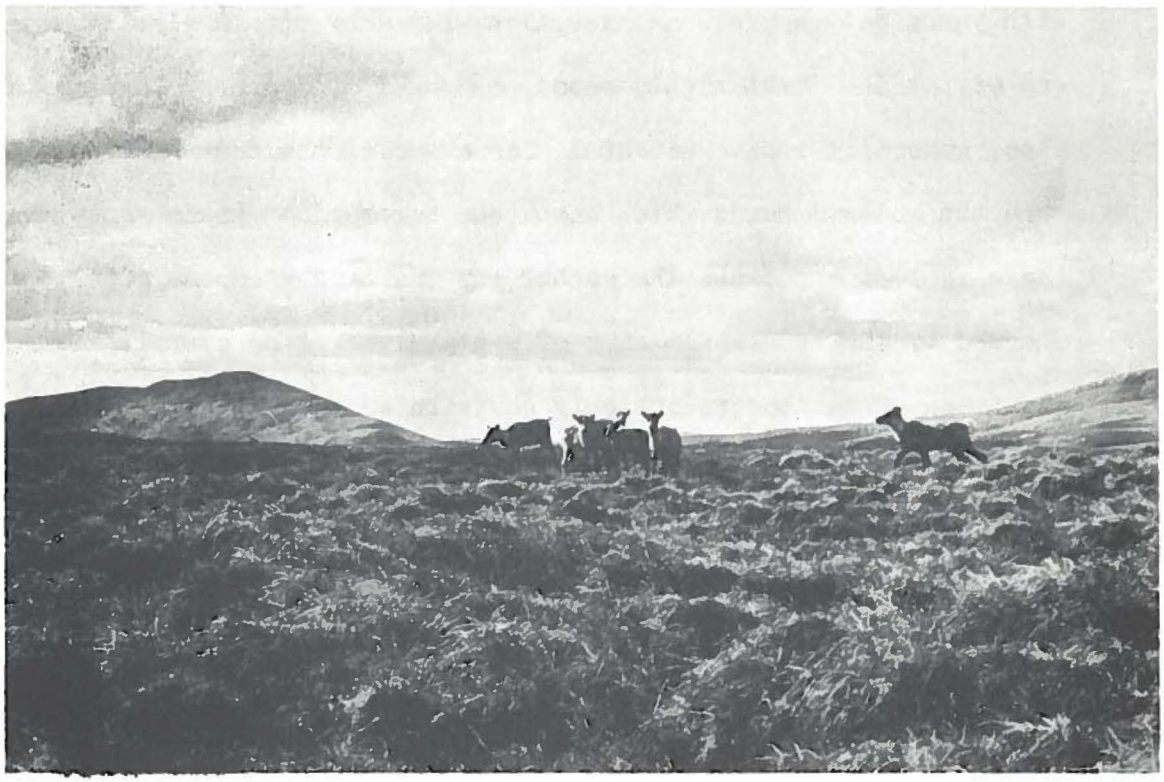

Figure 23. Band of yearlings displaying curiosity trait.

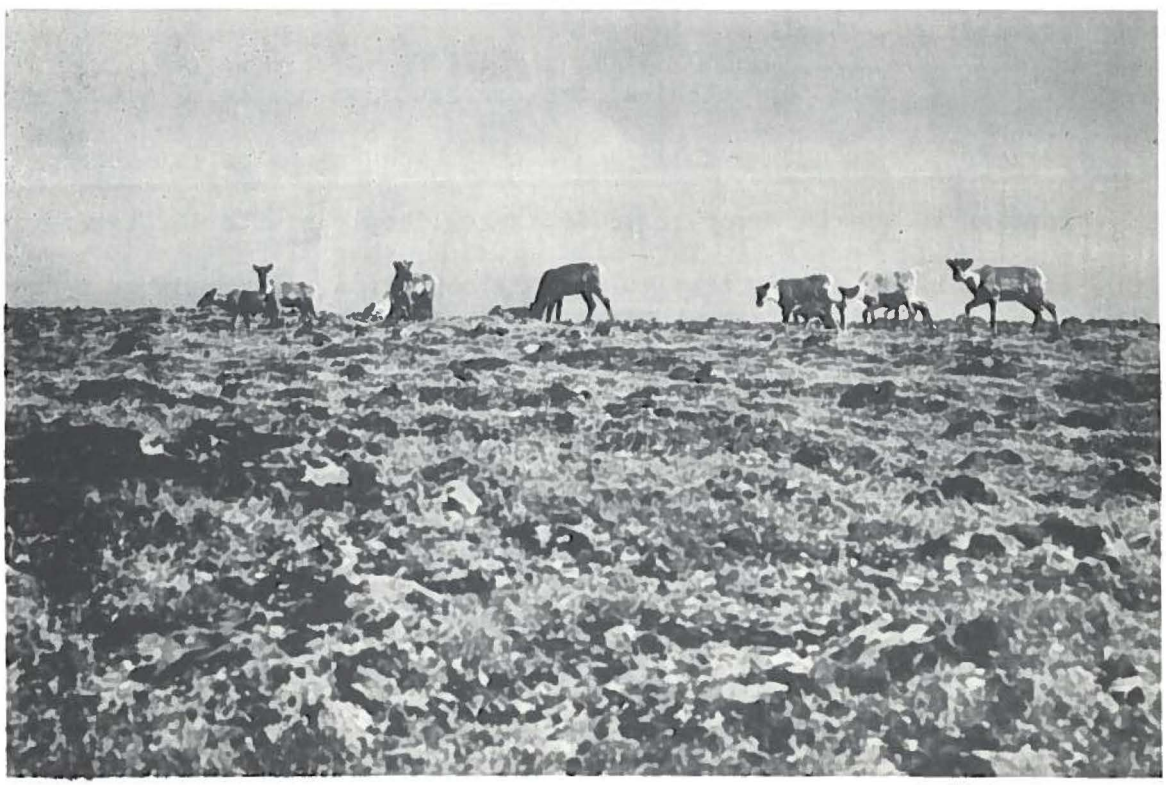

Figure 24. Group of caribou reacting to human's approach.

with young calves prove an exception, for they remain alert and usually run off at the first sight, sound, or smell of danger. Lone animals, also, generally remain watchful. As a whole, the cows seem more alert than the bulls. Bands which have been harassed stampede sometimes at the slightest incident; the author saw one band stampede after being alarmed by the sudden flushing of a ptarmigan. The overall lack of alertness of caribou undoubtedly contributes to mortality losses.

The apparent disregard of the animals for dangerous places increases the possibility of death from accidents. Caribou sometimes are swept to their death over rapids or waterfalls while crossing a swift stream (Banfield, 1954). They unhesitatingly climb steep, rocky slopes and ledges, where a fall or an avalanche could disable them. Some break through thin ice on lakes and streams, and die (Banfield, 1954). The writer has frequently seen cows travel over rough terrain where strong young calves can follow only with difficulty, and the weak ones, probably not at all.

Certain physiological factors handicap the animals at certain periods. Most mature bulls build up thick layers of fat before the rutting season in October; in September they run with difficulty and tire quickly, making them vulverable to wolves. Pregnant cows are impeded in much the same manner during the spring. Innate physical weaknesses prevent some calves from surviving the rigors of constant travel.

Certain weather conditions serve to aid the action of the direct mortality factors. Deep snows make the caribou more vulnerable to wolf predation. Crusted snow might prevent the animals in certain regions from obtaining enough food. A fast break-up in the spring

could increase losses from caribou attempting to cross the swollen streams. A late break-up or severe weather could cause a high mortality among young calves.

Direct Factors.--The above factors set the stage for those causing direct mortality. These can be classified as five types: disease, accidents, intraspecific strife, weather, and predation.

Disease does not seem an important factor among the Steese-Fortymile caribou. Of the many animals observed in the field and examined at hunter checking stations during 1953, 1954, and 1955, only three exhibited any sign of disease. One, a cow observed in late May before the advent of many flies, had an ear covered with large warts or boils. The other two animals, both bulls, were examined at a checking station in late October. One, three or four years old, had a severe mange condition along the flanks, brisket, legs, and muzzle; its antlers were well-developed, but still in velvet. The animal was thin and obviously in poor health, although the hunters said it showed no signs of weakness before they shot it. The other bull, a two-year-old, had a similar but less severe case of mange; its antlers, however, were free of velvet and its physical condition compared closely with that of other bulls being taken. Observations from the past reveal that a few diseased caribou were taken in the early 1930's (Alaska Game Commission, 1931b; Jewell, viva voce), but such an occurrence has not been recorded since.

Adolph Murie (1944) found that necrosis of the jaws occurred commonly in the Mt. McKinley herd. Banfield (1954) reported that malady and similar ones as being widespread among the barren-ground caribou of northwestern Canada. Watson (1954) found that 4.2 per cent

of the lower jaws collected from the Nelchina herd near Anchorage, Alaska, "...had indications of slight to advanced actinomycosis." About five per cent of the jaws collected from the Steese-Fortymile region showed evidence of necrosis. This form of infection, however, does not seem particularly detrimental, for all the infected animals from the last mentioned region appeared in excellent health. As a whole, the Steese-Fortymile herd seems to be in good health.

Accidents undoubtedly take a toll of animals each year. Banfield (1954) believes that the loss is quite high, but that drowning at rapids and waterfalls causes most accidental deaths. Adolph Murie (1944:175) implies a high loss, also, and states, "One encounters enough carcasses on the range to indicate that quite a number of caribou die from natural causes other than wolf predation." The range of the Steese-Fortymile herd, however, has so few lakes, large or swift streams, and rugged mountains that deaths resulting from drowning and from falls must be at a minimum. During three years of field work few carcasses were found other than hunters' kills, and only seven animals were noted to limp. Calves are the ones most likely to succumb to accidents, because of their unsteady gait while young and their general physical weaknesses as compared with older animals. A few calves probably drown while crossing streams in the spring, when the water is high and often swift. In the writer's opinion, few adult caribou in this herd die from accidents.

A certain amount of strife occurs among caribou, but not to the extent of causing a large mortality. Most damaging conflict is avoided entirely by the existence of a "peck-order". Dominant animals bear an authority which seems inviolate, and those lower on the scale stay a

respectable distance from their superiors. Occasional clashes occur between individuals, but are seldom more than brief shoving matches. Even rutting bulls usually do not fight vigorously enough to injure one another seriously. Banfield (1954), however, states that some trappers in northwestern Canada have reported finding bulls with antler punctures.

The young calves, apparently the lowest on the peck-order scale, receive a good deal of abuse. Those younger than about five days have the most difficult time, for they are still rather awkward and unsteady on their feet. During the sudden flight of an alarmed band, often some are knocked to the ground. Trampling may kill a few, but no examples were found. Some adults react viciously toward any strange calf that wanders near; they strike at it with their forefeet or their head. Cows and yearlings still having hard antlers can kill or wound a calf. Most pregnant cows retain their hard antlers until one to five days after parturition; a few drop them shortly before. Two of eight dead calves found during May, 1954, bore antler punctures that probably caused death. Calves older than a week seem agile enough to avoid physical contact with their elders. Death from intraspecific strife probably is limited to the young calves, and possibly to a few rutting bulls.

Severe weather affects mainly the physically-weak animals. Calves are particularly vulnerable shortly after birth, and inclemency during a calving season could destroy a large portion of that year's crop. Fred Purdy (viva voce) recalls a cold spring in the late 1920's when he found many dead calves on the ridges north of Chicken, presumedly dead from exposure. Banfield (1954) relates an instance where

blizzards in June, 1947, were believed to have caused an 80 per cent loss of calves in one area of the Canadian arctic. In May, 1955, the cold, snowy weather conditions on the calving grounds of the Steese-Fortymile herd apparently caused some mortality, because the calf:cow ratio dropped 7.6 per cent from the 1954 figure. The loss seemed surprisingly low, but, nevertheless, the only dead calf found was still-born, so apparently calves are hardy enough to withstand any but the very worst of weather--whatever that may be. The weather has been mild enough during the past six springs to allow high calf production.

Older animals are little affected by weather, unless previously weakened by disease, etc., for they are well-adapted to their frigid environment. Snowfall is consistently light in interior Alaska, and thereby seldom sufficient to hinder the animals. Thus, death from exposure to severe weather conditions is restricted mainly to the young calves.

Predation represents the greatest mortality factor known. Animals capable of killing caribou include the coyote, wolverine, and bear; the bald and golden eagles; the wolf; and man. Of these, only the last two kill an appreciable number.

The coyote and wolverine could kill many young calves if present on the calving grounds. Both are presently so scarce on the Steese-Fortymile range, however, that their kills are insignificant.

The slow speed of bears restricts much of their predation to the new-born calves. After about three days, most calves probably are fast enough to escape. Fortunately, calving takes place mostly above timberline and also over a restricted area, so that predation is limited mainly to grizzlies and, specifically, to those occupying the

rather confined calving area. Bears undoubtedly kill an occasional adult, but only by waylaying one. The author watched one grizzly vainly trying to catch a caribou from a small band. The animals easily kept ahead of the bear's furious charges. One grizzly was sighted from the air feeding on a caribou carcass, but the meat probably belonged to several wolves that were watching from nearby. As a whole, predation by bears is probably insignificant, especially since "hibernation" limits their activities to a maximum of seven months.

Both the bald and golden eagles can kill young calves, but are limited by size mainly to those less than three weeks old. The attacks are confined mostly to strayed or lost calves, because the cows defend their offspring from the birds. Both the scarcity of eagles on this range and the small area used for calving further restrict the number of kills.

In 1954 the author witnessed the killing of a caribou calf by a golden eagle. The calf, about two weeks old, had been left behind by a stampeding band. A commotion on a nearby ridgetop attracted the writer's attention. The eagle was attempting to grasp the running calf along the back, the calf slowing every so often to ward off the bird. Both passed from view. Ten seconds later the bird flew back and settled on the ground about 300 yards from the observer. About 15 seconds later the calf ran into view directly toward the eagle, bawling and evidently looking for its mother. The eagle rose when the calf was about 10 yards away and settled on its head. Within two minutes the calf was dead and the eagle had flown off. The bird's talons had punctured the skull in two places.

Two of eight dead calves found that spring definitely were

killed by eagles, judging from the talon-like punctures on the body. Eagle predation is limited to about one month in the spring, however, so the total mortality must be small. Murie (1944:162) states, "Eagles are known to prey on caribou calves but the number they kill is insignificant." This statement seems to apply to the Steese-Forty-mile herd, also.

Wolves offer a major threat to a caribou herd. Calves are particularly vulnerable to attack. Those less than two weeks old have little chance of escaping (Glaser, viva voce), but after a month they can run as well as the older animals. In May, 1940, Frank Glaser (1940) estimated that wolves killed at least 10 per cent of the new-born calves in a herd that included about 4,000 cows. At that time the wolf population was high; fortunately the population has remained rather low since then, although Miner (viva voce) says it is increasing now. An abundance of wolves on the calving grounds conceivably could wipe out the calf crop. The short calving period and the restricted calving area again serve to limit extensive predation.

Wolves are able to run down healthy, adult caribou in a long chase (Glaser, viva voce), but such fatiguing measures are seldom necessary. The writer has witnessed two incidents where the wolves gave up the chase within a quarter mile. Glaser (viva voce) tells of many similar incidents. Apparently wolves are content to wait for an easy catch. Often they kill the caribou that are the slowest, supposedly the weakest, of a running band, so that Adolph Murie (1944: 165) states "...the wolf appears to be a factor in maintaining quality in the herds." Such may be the case, but pregnant cows in the spring and fat bulls in the fall also tend to lag behind. Glaser (1940) says

that in February and March, when the wolves band together, caribou suffer great losses, especially the pregnant cows. Banfield (1954: 51) suggests that calves and aged bulls receive the heaviest wolf pressure, but that "...the total amount of wolf predation has been greatly over-estimated." Three years of field work on the Steese-Fortymile range have revealed only six carcasses attributed to wolves. At present, this herd does not seem to suffer appreciable losses from wolf predation.

Man is the greatest threat to the caribou. Not only does he prey upon the animals themselves, but many of his actions also are detrimental to the range (see RANGE). This section, however, discusses only the direct mortality caused by hunting.

Not more than 60,000 humans presently reside on or adjacent to the Steese-Fortymile range (see Topography). The maximum number of caribou hunters in this area in 1955 was estimated at about 6,000, based on the following estimates from license sales, checking station data, and population figures: 1) a maximum of 4,000 hunting licenses sold to local residents; 2) a maximum of 1,000 natives without licenses; 3) a maximum of 500 hunters in the Yukon Territory portion of the range; and 4) a maximum of 500 hunters from other regions. The number has grown swiftly since 1945 with the rapidly increasing civilian and military populations, and this growth probably will continue for some time.

The present limit of one animal for Alaskan hunters keeps the kill from this herd at a minimum. In 1954 about 1,300 animals were taken; in 1955, about 2,000. These years represent the first in the past 15 or more that the kill has exceeded 1,000 animals. The

low number of hunters in the Yukon Territory keeps that kill to less than 1,000, even with the limit of five bulls. The total hunters' take from the Steese-Fortymile herd, therefore, has been rather low in recent years--probably one reason for the rapid increase in the herd.

Evaluation.--The rough topography and inaccessibility of much of the range prevents the evaluation of each mortality factor separately. Checking stations can determine man's effect, but that of the other factors must come largely from periodic tallies. Field observations, however, can provide one with sufficient information for general estimates.

Calf mortality during the first year of life is discussed later under Annual Increment--the maximum loss being about 50 per cent during the years 1952 and 1953. This loss varies from year to year, depending mostly on weather and the prevalence of predators. Total losses from the remaining herd must be estimated entirely from field observations, because total and composition counts so far have been inadequate. The discussion earlier pointed out that disease, accidents, intraspecific strife, weather, and predation from coyotes, wolverine, bears, and eagles probably account for few deaths among animals older than calves. The author believes that these losses total not more than one per cent of the total herd, calves excluded. Banfield (1954:44) estimated that the factors of disease, accidents (including intraspecific strife), and weather "...take an annual toll at least as large as predation...."; he believes predation is not more than five per cent. His mortality figure is larger because 1) he includes calves and 2) the loss from drowning is high in that part of Canada.

Losses from wolf predation seem low, judging from field work.

The author estimates a maximum wolf kill of two per cent of the total herd, calves excluded. Banfield (1954) estimated a maximum loss of five per cent to this predator, but only two and a half from one herd; his estimates include calves.

Man's take from the Steese-Fortymile herd has been highly variable during the past 15 years, ranging from less than 50 animals in 1942 to about 2,000 in 1955. Success depends entirely on the accessibility of the caribou. Under present conditions, the annual kill probably will not exceed 2,500 animals--about five per cent, or probably less, of the herd.

The total annual loss from the herd, excluding calves, then reaches a maximum of eight per cent. Present calf production and survival amply cover this loss (see Annual Increment).

Composition.

Sex and age ratios denote the status of a caribou population--whether it is increasing, decreasing, or stable. The securing of this information depends mainly upon random counts, and these are hampered greatly by certain physical characteristics of caribou that make field identification of live animals as to age and sex extremely difficult. True ratios can be obtained only during the rut, when all the groups are together, and sometimes the information gained from hunters' kills must suffice, even though it is usually biased. Three years of field work still have not produced complete data on the composition of the Steese-Fortymile herd.

Age and Sex Identification.--Accurate age and sex identification of caribou in the field becomes possible only under certain

conditions, and most feasible only at certain times of the year. The difficulty arises from the fact that both sexes bear antlers; although the cows' are rather small, they often grow as large as those carried by three-year-old bulls. The following factors provide, some specifically and others generally, the means for classifying caribou as to age and/or sex: antler size and growth, body size and color, tooth eruption and wear, genital organs, head profile, and behavior. The best times for identification occur during approximately May 1 to 14 and September 1 to 14, when the distinguishing features are most evident. Table 5 lists the identifying characteristics most useful at those times.

Most of the characters in Table 5 remain general, for individual variation among caribou is frustratingly common, and no one character can be used entirely alone. The antler lengths given are necessarily average. Figures 25 and 26 illustrate what is meant by hooked and straight noses. The presence or absence of hard antlers on yearlings and cows during the May 1 to 14 period can be qualified slightly. Between May 18 and 20, 1954, only one of 42 yearlings observed closely had hard antlers and four had lost theirs recently. During the same period, 428 of 512 cows observed still retained their antlers, while 81 of the remaining 84 had lost theirs within the past week. Thus, within the groups tallied, 2 to 15 per cent of the yearlings and 80 to 99 per cent of the cows still would have had their antlers May 1 to 14. By June 7, only 23 cows of 1,837 cows tallied, or 1.3 per cent, still had hard antlers; 9 of that total, or 0.5 per cent, bore 8 to 12 inches of velveted antlers, indicating that these cows must have shed the old antlers in April, or perhaps earlier.

Classifying caribou at periods other than those designated

TABLE 5. CRITERIA FOR FIELD IDENTIFICATION OF CARIBOU AS TO AGE AND SEX DURING MAY 1 to 14 AND SEPTEMBER 1 to 14.

Age Class	Identifying Characters	
	May 1 to 14	September 1 to 14
Calf	No antlers; small, reddish-brown body, about 20" at shoulder; awkward gait.	Velvet spikes 4-10", may have fork; small, dark-brown body, about 36" at shoulder; adult gait.
	Nursing habit; accompanied by cow; sex, only by observation of genital organs or manner of urination.	
Yearling	Most without hard antlers; some with velvet knobs; light-tan body; usually accompanied by cow.	Velveted antlers 10-18", no brow tine; a few males beginning to shed velvet; light- to dark-brown body.
	Rather small body; exceptionally curious; ventral neck-mane very short or non-existent; sex, only by observation of genital organs or manner of urination.	
2 Year	Males: most with velvet knobs to 2". Females: many with hard antlers; may have calf. Often in bands with yearlings; light-tan body.	Males: 20-26" antlers; many still in velvet and poorly formed; brow tine poorly developed. Females: small, velveted, poorly-formed antlers; some with calf.
	Males somewhat darker in color; ventral neck-mane short, poorly developed; great curiosity; males with hooked noses, females usually with straight noses; sex, by genital organs or urination.	
3 Year	Males: 4-6" velveted antlers, some forked. Females: most with hard antlers, a few with velvet knobs or none, may be followed by calf or yearling.	Males: 26-34" antlers, many free of velvet, well developed; brow tine still small. Females: small, velveted, poorly-formed antlers; often with calf.
	Males: dark; large size, hooked nose; fairly well-developed ventral neck mane. Females: light; medium size; straight profile; poorly developed mane.	
4 Year or More	Males: 10-24" velveted antlers, forked, less gregarious. Females: most with hard antlers; some with none; some with velveted knobs to 10"; usually followed by yearling or calf.	Males: over 30" antlers, most free of velvet, well-developed; usually with waddling-type walk. Females: velveted antlers, much variation in development; often with calf.
	Males: dark, with conspicuous white neck-mane; large size, hooked nose. Females: mostly light, with rather small neck-mane; medium size; nose profile usually straight.	

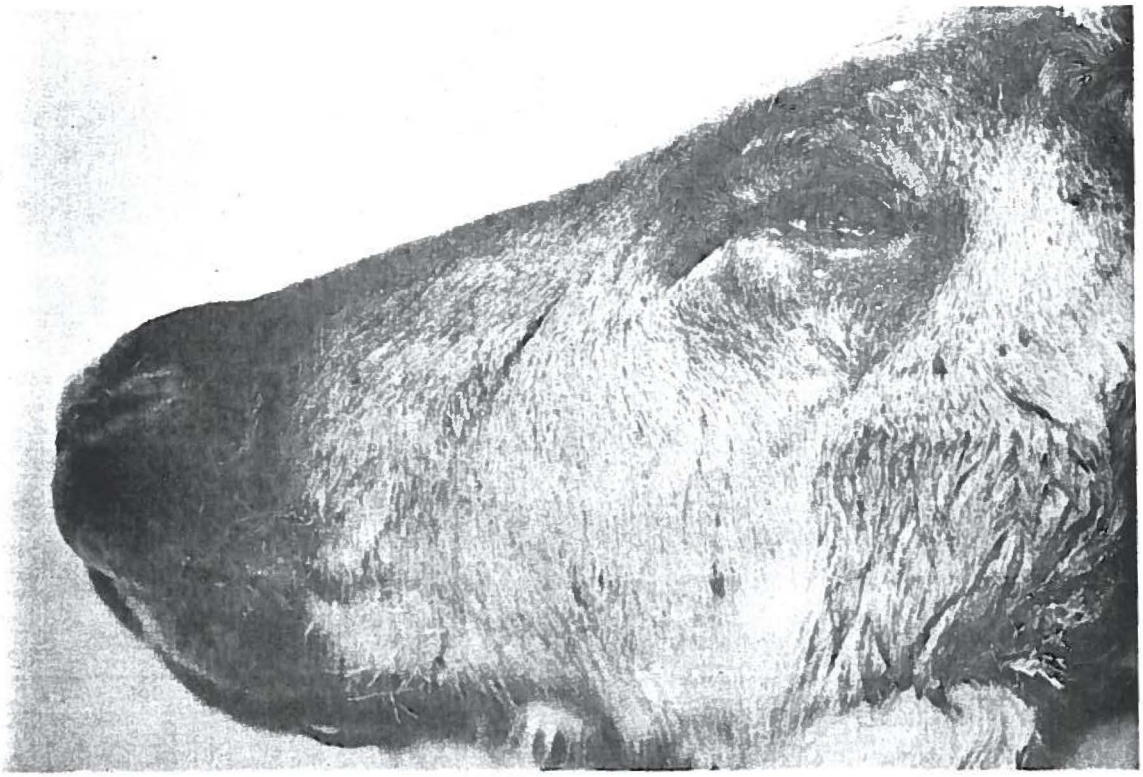

Figure 25. Straight nose-profile, characteristic of most cows.

Figure 26. Hooked nose-profile, characteristic of most bulls.

proves more difficult--except for calf counts or for broad groupings. Actually, the best cross-section of the herd can be obtained only during the rut in the first two weeks of October, when the age and sex groups are together. By then, however, all the animals except calves and a few cows have lost the velvet, and positive separation of one- to three-year-old bulls from the cows depends on seeing the genital organs or manner of urination. Such identification requires close observation, good light, and slowly moving animals--conditions often not present. Other general characters, such as neck mane and nose profile, aid in identification, but their use requires experience in caribou observation.

About mid-October the older bulls begin dropping their antlers. On October 21, 1954, the author sighted two without antlers and three with only one antler--all were large bulls. Until December, antler shedding is limited to the bulls over three years old; relative antler size remains the main criterion for classifying the other animals. Later, the presence or absence of antlers is the main character; and from June to August, relative antler growth. During these periods only bulls over three years old and calves are easily determined, and cows when accompanied by calves; the others often must be lumped together, because the sexes are practically indistinguishable except by the genital organs.

Body weights and measurements show clearly the difference in size existing between adult bulls and cows. Hunter checking stations provide these data; Figures 27 and 28 illustrate the procedure used. Table 6 shows the average weights and measurements taken from hunters' kills September to November, 1952 to 1955, listed by age-class.

Figure 27. Weighing caribou at hunter checking station.

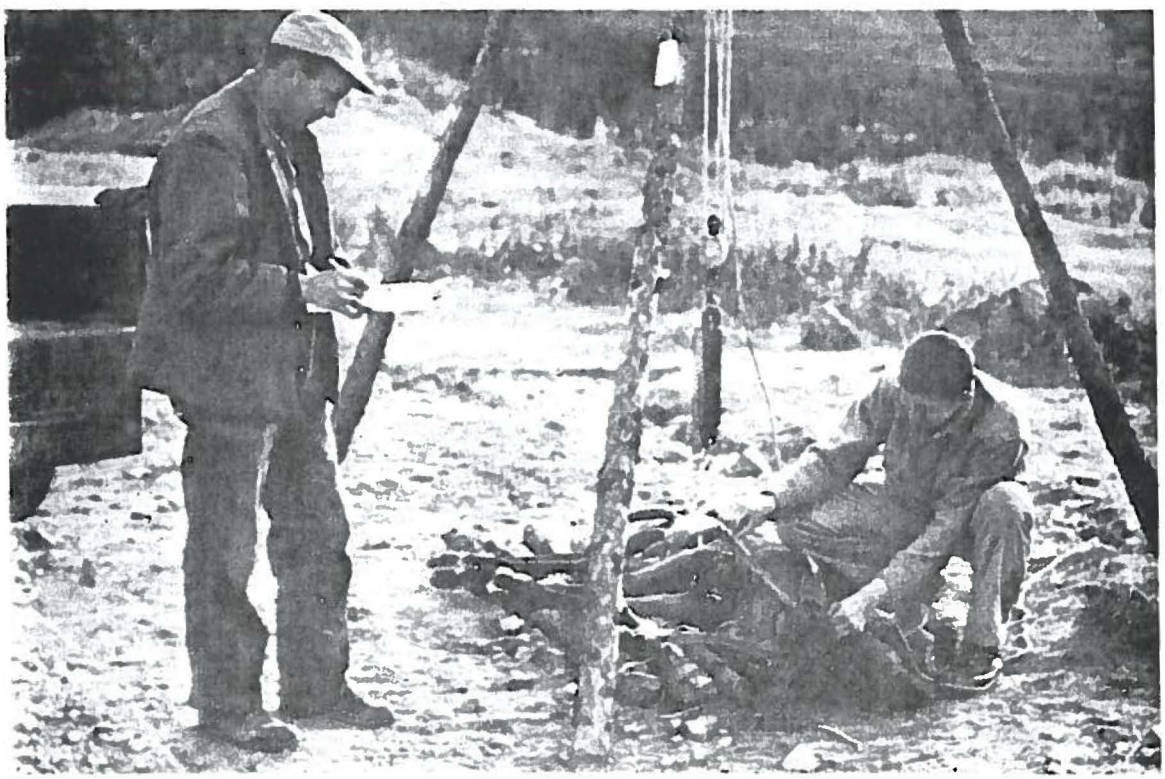

Figure 28. Measuring caribou at hunter checking station.

TABLE 6. BODY WEIGHTS AND MEASUREMENTS OF STEESE-FORTYMILE CARIBOU, TAKEN FROM HUNTERS' KILLS SEPTEMBER to NOVEMBER, 1952 to 1955.

Measurements	Sex	Male					Female			
	Age	Calf	1	2	3	4+	Calf	1	2	3+
Weight[a] (Hog-dressed)	Average	80±10	140±10	185±20	225±20	285±25	75±10	120±10	140±15	150±15
	No. of Specimens	11	19	12	16	20	17	15	11	58
Total[b] Length	Average	57	69	71	80	78	56	66	68	73
	No. of Specimens	7	14	8	14	10	14	8	6	25
Hind[c] Foot	Average	19	22	22-1/2	23	23	18-1/2	21	21-1/2	22
	No. of Specimens	11	16	13	24	21	15	13	10	51
Tail[c]	Average	5-1/2	6	6	6-1/2	6-1/2	5-1/2	5-1/2	6	6
	No. of Specimens	11	21	15	27	19	15	11	10	51
Ear[d]	Average	4-1/2	5	5-1/4	5-1/2	5-1/2	4-1/4	5	5	5-1/4
	No. of Specimens	4	8	7	18	16	3	6	6	29
Height at Shoulder[b]	Average	37	42	44	47	48	36	42	42	43
	No. of Specimens	8	13	10	17	12	14	8	6	29
Girth[b]	Average	36	42	46	50	53	37	42	45	46
	No. of Specimens	4	8	6	17	14	4	5	5	27
Antler[c] Beam Length	Average	6	16-1/2	23	29	45	5-1/2	12-1/2	11-1/2	16-1/2
	No. of Specimens	10	19	21	23	34	12	10	10	53

a/ Measured to nearest 5 pounds.
b/ Measured to nearest inch.
c/ Measured to nearest 1/2 inch.
d/ Measured to nearest 1/4 inch.

The conditions present at checking stations hinder the procurement of measurements more accurate than indicated. Cows over two-years-old are lumped together, because the measurements ceased to vary much between age-classes beyond that point. Among the bulls, all the measurements but weight and antler-beam-length ceased to vary after three years of age, so all animals older than that are lumped together. The data are too few to obtain a further breakdown on the weights and antler sizes of the old bulls. Few hunters bring out these large animals in a condition conducive to measurement. The author believes that the bulls attain top weight and antler growth at six to eight years of age. Three bulls in this age group weighed 325 pounds, hog-dressed; several others that were cut up and could not be weighed looked much heavier. Weights of bulls taken after the rut are not included in Table 6, because of the loss in weight due to mating behavior. The average loss varied as follows: 7 two-year-old bulls averaged 30 pounds less than the pre-rut average for that age-class; 15 three-year-olds averaged 35 pounds less; and 8 four-to-six-year olds, 50 pounds. These figures imply that the two- and three-year-old bulls are rather active during the rut.

The caribou carcasses referred to above were aged by a method based on tooth development and wear, similar to that used by Severinghaus (1949) on the white-tailed deer. The method was evolved in 1953 after an examination of about 350 lower jaws from the Steese-Fortymile and Nelchina caribou herds. The author's attempt to separate the age classes over two years by tooth measurements proved unsuccessful; the variability was too great. U. S. Fish and Wildlife Service personnel at Anchorage, Alaska, continued the study, but have not been able to

produce satisfactory criteria as yet. Therefore, aging has been done by the highly variable inspection method, in which the relative tooth-wear is "measured" by a glance. Table 7 illustrates the criteria, in key form, used by the author for aging caribou during August to November. This period was chosen because most animals to be examined come from hunters' kills at that time.

The calf, yearling, and two-year-old age-classes are easily distinguished by the number of cheek teeth present. At two years the caribou first has a complete set of permanent teeth. Banfield (1954) has worked out the tooth eruption and replacement sequence to that age for the barren-ground caribou of the western Canadian arctic.

The age classes beyond two years were determined by placing the jaws from the original collection into piles according to the amount of wear evident. A comparison then with known-age reindeer jaws established the upper age limit and helped designate the lower ones.

Age and Sex Data.--The discussion above indicates the difficulties of obtaining composition counts. Hunters' kills provide the best data on age ratios beyond the calf and yearling age-classes. Sex ratios of calves and yearlings can be obtained at various times of the year, but those from older animals must be taken during the rut to obtain the true proportions. The procurement of composition data, however, depends initially upon the accessibility of the caribou.

The lack of available caribou during the hunting seasons of 1952 and 1953 resulted in low kills. Hunters' kills the following two years, however, reached new highs for this herd, and provided valid age and sex data. Table 8 shows the figures obtained in those years.

TABLE 7. KEY TO AGES OF CARIBOU DURING AUGUST TO NOVEMBER, AS DETERMINED BY DEVELOPMENT AND WEAR OF CHEEK TEETH.

A. Less than 6 cheek teeth, including 3 deciduous premolars, the 3rd premolar having 3 cusps.

1. 4 cheek teeth, with a fifth possibly protruding; light wear on all teeth..... Calf

2. 5 cheek teeth, with a sixth possibly protruding; heavy wear on premolars..... Yearling

B. 6 cheek teeth, all permanent.

1. Teeth high above gumline, cusps projecting; light to moderate wear; dentine/enamel ratio less than 2:1.

a. Little or no wear on premolars and 3rd molar..... 2 Years

b. Light wear on premolars and 3rd molar..... 3 Years

c. Light wear on 1st premolar; moderate wear on rest of teeth..... 4 to 6 Years

2. Teeth low above, or at, gum-line, cusps flattened; heavy to excessive wear; dentine/enamel ratio more than 2:1.

a. All teeth above gum-line; heavy wear..... 7 to 9 Years

b. Some teeth at or below gum-line; excessive wear..... 10+ Years

TABLE 8. AGE AND SEX CLASSIFICATION OF HUNTERS' KILLS, 1954 AND 1955, FROM THE STEESE-FORTYMILE CARIBOU HERD.

Age Group (Years)	1954						1955					
	Male		Female		Total		Male		Female		Total	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
2-3	44	69.8	39	54.2	83	61.5	147	52.9	116	46.4	263	49.8
4-6	13	20.7	21	29.1	34	25.2	104	37.4	86	34.4	190	36.0
7-9	5	7.9	10	13.9	15	11.1	27	9.7	45	18.0	72	13.6
10+	1	1.6	2	2.8	3	2.2	0	0.0	3	1.2	3	0.6
Total	63	46.7	72	53.3	135		278	52.7	250	47.3	528	
Hunters' Kills Sexed	462	49.7	467	50.3	929		773	52.3	704	47.7	1477	
Calves	22	57.9	16	42.1	38		31	63.3	18	36.7	49	
Yearlings	-	-	-	-	-		31	46.3	36	53.7	67	

The age classification of the two kills compares closely, especially in the 7 to 9 and 10+ age groups. The differences between the two years in the 2 to 3 and 4 to 6 age groups can be explained: in 1954, the 4 to 6 year-old-bulls were noticeably absent from the animals exposed to hunters; in 1955, these bulls were still present, for the main hunt took place just after the rut. The latter year's classification probably is the more valid, because the caribou bands were less segregated then. Those figures show that animals from the 2 to 3 year group comprised 49.8 per cent of the kill, and those from the 4 to 6 class, 36.0 per cent. The results reveal that the population of the Steese-Fortymile herd is a young one--a fact indicative of an increasing population.

Calves and yearlings do not appear in the age classification either year, because their numbers were quite low proportionately. People seem reluctant to kill these animals, especially the calves. Hunters undoubtedly exhibit some preference among the older age classes, also, even though meat hunters seem to predominate in interior Alaska. Most of them get some chance at selecting their kill, because most caribou seen are in bands. Judging from talks with hunters, the author believes that the tendency exists to pick from the group sighted the largest or the one with the largest antlers. Some hunters, however, leave rutting bulls alone to seek "fat" cows, while others look for "tender" young stock. Evaluating hunters' selection remains but a guess, at best.

The kills classified in Table 8 show a sex ratio of 49.7 per cent bulls in 1954 and 52.3 per cent in 1955. If one assumes a bias slanted to the taking of bulls, the actual percentages of cows should be greater than indicated. One series of sex-ratio counts provides

a higher percentage of cows. The counts were taken in 1954, just after the rut, on 189 animals, which included 50 calves, 78 cows, and 61 bulls. These figures give a bull:cow ratio of 78:100. The counts are probably significant, even though few, because the many bands of caribou observed at that time seemed very similar in composition. Other data indicate a close sex-ratio, also. In 1955, 31, or 46.3 per cent, of 67 yearlings sexed at the hunter checking station were males, or a ratio of 86 males:100 females. Calf counts taken in the fall indicate a preponderance of males at that time. Table 8 shows male:female ratios among calves of 138:100 in 1954 and 172:100 in 1955. Of 43 calves sexed in calving-ground operations during May, however, 23 were males--a male:female ratio of 115:100. Banfield (1954) found a ratio of 175 males:100 females among 11 sexed calves less than one month old; among 12,023 adults, he found a ratio of only 35.8 males:100 females. Composition data from the Steese-Fortymile herd are too few as yet for conclusive results, but they point to a sex-ratio approaching 100:100.

Annual Increment.

The percentage of calves surviving to the yearling age-class provides the most important index to the herd's rate of increase. An increasing population, barring immigration, requires a total calf-survival in excess of the total loss of animals in all other age groups. Although the latter loss is difficult to determine, calf survival is readily obtained by correlating calf counts taken just after calving with those taken just before calving the following year.

In recent years, unfortunately, the caribou have remained inaccessible until the time of calving. By then some, or many, of the yearlings have left their mothers, so that all yearling counts

necessarily are a minimum. Table 9 presents the data available concerning the survival of the calf crops of 1952, 1953, and 1954. The percentages are expressed according to two ratios: calves versus total animals and calves versus cows. The latter ratio is the more precise, because the former can vary considerably with the changing composition of the animals tallied. Yearlings, however, are noticeably lacking in the smaller groups, from which most of the complete composition counts are taken, e.g. the calf:cow ratios. The former ratio can be obtained from the large herds as well as the small, and therefore the majority of yearlings present probably are included. Because they include these yearlings and also represent larger samples, the figures expressed in Table 9 under the calf:total-animals ratio are likely the most valid, even though the composition of the calving groups did vary slightly during the three years. Those figures show that about 49.0 per cent of the 1952 calf crop survived the first year, 47.0 per cent of the 1953 crop, but only 28.2 per cent of the 1954. The last figure can be disregarded, however, because 1) only a small portion of the herd reached the calving-ground area north of the Steese Highway; 2) therefore, many yearlings from that group probably remained to the south; and 3) one would expect a high calf-survival, because of the mild 1954-55 winter.

The 1952 and 1953 figures indicate a minimum calf survival of about 50 per cent. Adolph Murie (1944) encountered the same difficulties in obtaining complete yearling counts from the Mt. McKinley herd, but also arrived at the same survival figure--about 50 per cent for the calf crops of 1938 and 1939. Banfield (1954) obtained a calf survival of 64.3 per cent in one arctic herd of northwestern Canada.

TABLE 9. DATA AVAILABLE ON CALF SURVIVAL TO YEARLING AGE-CLASS.

Year of Calf Crop	Ratios Used	Per Cent Calves in June (2-3 weeks old)	Per Cent Calves Surviving to Following May (11-12 months old)	Per Cent Calves Surviving to One Year
1952	Calf:Total Animals	25.3 [a](505:2,000)	12.4 [b](166:1,336)	49.0
	Calf:Cow	----------	----------	----
1953	Calf:Total Animals	37.2 (3,694:9,923)	18.2 (630:3,460)	47.0
	Calf:Cow	72.9 (See Table 4)	21.4 (501:2,335)	29.4
1954	Calf:Total Animals	37.2 (3,551:9,542)	10.5 (82:782)	28.2
	Calf:Cow	72.5 (1,694:2,335)	11.8 (80:681)	16.3

a/ Counts made by Dr. Brina Kessel of the University of Alaska.

b/ Counts made by Frank Glaser of the U. S. Fish and Wildlife Service.

Short-yearling counts made a month before the calving period, or before the spring migration starts, should provide a more accurate set of data. Such counts, however, depend greatly upon the accessibility of the caribou.

Table 10 shows the procedure for computing the annual rate of increase of the Steese-Fortymile herd during the years 1953, 1954, and 1955, assuming a 50 per cent survival of calves. The basic figures for herd size and for the number of cows in the herd are taken from the composition counts of May to June, 1953 (see Table 4). Calf:cow ratios provide the figures for the number of cows producing calves. The two per cent wolf predation is estimated (see Mortality). Hunters' kill data are available for each of the years mentioned. The one per cent miscellaneous loss represents an arbitrary guess of the deaths (calves excluded) resulting from accidents, diseases, etc. (see Mortality).

The rate of increase for the three years averages about 10 per cent. That figure is probably low for this herd, because 1) the herd size of 40,000 for 1953 is a minimum; 2) thus, the calf production figures are low; 3) calf survival likely exceeds 50 per cent; and 4) wolf predation is probably less than indicated, judging from personal field work. The true rate of increase for this herd probably lies between 10 and 15 per cent.

TABLE 10. COMPUTATION OF ANNUAL RATE OF INCREASE FOR STEESE-FORTYMILE CARIBOU HERD, USING DATA OBTAINED IN 1953, 1954, AND 1955.

Year	Herd Size in Spring[a]	Number of Cows[b]	Per Cent Cows Producing Calves[c]	Number of Calves Produced	Annual Losses					Annual Increment	
					Calves[d]	Wolves[e]	Hunters[f]	Misc.[g]	Total	No. of Animals	Per Cent Increase
1953	40,000	18,400	72.9	13,400	6,800	800	600	400	8,600	4,800	12.0
1954	44,800	20,600	72.5	14,900	7,450	900	1,700	450	10,500	4,400	9.8
1955	49,200	22,600	64.9	14,700	7,350	1,000	2,300	500	11,150	3,550	7.2

a/ Initial figure taken from 1953 estimate (see Table 4).
b/ Assumed that 46 per cent of herd are cows (see Table 4).
c/ Obtained from counts taken just after the calving period.
d/ Assumed that 50 per cent of calves succumb (see text above).
e/ Estimated at 2 per cent (see Mortality).
f/ Kill figures obtained from hunter checking stations and other reports.
g/ Estimated at 1 per cent (see Mortality).

FOOD HABITS

The nomadic behavior of caribou takes them over a wide area and brings them in touch with many different plant communities. Understandably, then, caribou are cursory feeders and eat a wide variety of plant food. Their diet varies considerably during the year as seasonal changes in the vegetation occur. Field observations and stomach-sample analyses provide the means for determining the relative importance of certain plants as food. This knowledge aids the game manager in estimating the total food supply available and, thus, the carrying capacity of the range.

Manner of Feeding.

The desultory feeding habits of caribou are well-known. Seldom do grazing caribou remain stationary; usually they are moving steadily in one direction, and some individuals snatch mouthfuls of vegetation while practically on the run. Such action is especially noticeable during the spring and fall migrations. Olaus Murie (1935:41) aptly compared the actions of one young bull to "...a commuter eating breakfast on the run." At certain periods, such as during the calving season or when on the wintering grounds, the animals feed more leisurely, but even then they do not remain long at one place. The writer watched four caribou in December paw out 30 plots in the snow over an area of about 500 square feet in 20 minutes, and yet they seemed to take only one mouthful of food from each. Such cursory feeding tends to prevent overgrazing, and the continual traveling further distributes the caribou's effect upon the range.

The urge or drive for food seems strong among these animals,

often being expressed even in their nervous reactions. Frequently, alarmed caribou snatch at vegetation repeatedly, in a way reminiscent of a nervous person's fidgeting. The writer also has noticed such behavior on several occasions from a cow that was waiting for its lagging calf to catch up. In another instance, one cow in a small feeding band apparently was anxious to move on. She would trot off a short distance, stop, snatch nervously at willow twigs nearby, and then return to the band, repeating this action several times, often not seeming to even obtain a mouthful of food. After about 15 minutes the band finally departed, with the cow in the lead. Seldom is a caribou not nibbling on, or reaching for, some form of food, except when lying down, and then it usually is chewing its cud.

In summer, the main periods for feeding and resting seem to occur during the hours surrounding noon and midnight. From May to July there is some daylight during all 24 hours, and caribou are active throughout the day and night. The writer does not know how active caribou are during the winter night, but they probably spend most of the dark hours feeding and resting; Frank Glaser (viva voce) states that caribou do not move around much after dark. Field observations do indicate that 9 a.m. to 3 p.m. is an important resting and feeding period throughout the year.

Olaus Murie (1935:40) states that "...probably the caribou normally feeds largely by scent." He describes an interesting observation of a blind yearling on Unimak Island, apparently in excellent health, being able to feed normally; a later stomach analysis showed that it ate the available plant species in a proportion similar to other caribou. In winter the animals must rely almost exclusively upon

this sense to find food under the snow. Murie also relates how a captive bull came running up to him when he unveiled a sack of lichens; evidently eye sight also helps the caribou to find food. Feeding experiments with penned animals led Palmer (1944) to conclude that caribou were fastidious eaters; they ate only the finer parts of the food offered. This idea is supported both by field observations and by stomach-sample analyses, for caribou noticeably eat only the leaves and the tips of twigs of the woody plants.

Seasonal Diet.

Caribou exhibit a wide latitude in their choice of food. Their diet corresponds closely with the available supply, which in turn varies largely with the seasons. Some plants, such as lichens, are available throughout the year; others, such as fungi, become available only in summer; and some, such as sedges, are most abundant in summer, but are still available in winter. The greatest diet changes take place in the spring and fall.

The portion of the range being used at any one time also influences plant availability. Weather conditions, such as deep snows, might restrict the animals to those plants readily obtained, such as the browse species. The diets of individual caribou can vary also. The main techniques used for determining the plants utilized are field observations and stomach analysis. The latter gives the most data, but so far the main source of stomach samples has been from hunters' kills in September and October. A recent plan allowing the taking of specimens throughout the year should give quantitative data for the other months.

Winter.--This season extends for approximately six months, roughly from mid-October to mid-April, depending upon weather conditions. It is the longest of the seasons and, as with most big-game animals, the most critical for caribou in regard to mortality and food supply. The types of food plants available are at a minimum, and most are covered with snow.

Field observations indicate that caribou eat a large quantity of lichens during this season. Aerial flights over the wintering grounds reveal "barren" ridgetops pockmarked with pawed-out areas in the snow. On these ridges the main vegetation consists of lichens, dryas, low-bush cranberry, blue berry, mosses, and a few dwarfed willows and birches; ground observations at this season show that mostly the lichens are eaten from the pawed-out areas.

Many references concerning the importance of lichens to caribou appear in the literature. Olaus Murie (1935) thought that lichens were not indispensable if a proper substitute were available, but that caribou showed a distinct "craving" for them. Palmer (1941) states that lichens constitute the chief winter forage of caribou and reindeer; that these animals will eat lichens by preference if readily available; and that they require at least 50 per cent lichens in their diet for maintenance of condition during the winter months. Adolph Murie (1944: 153) states, "One of the requirements of a wintering ground seems to be the presence of lichens, even though they by no means form the exclusive diet." These authors all conclude that the chief lichens utilized are those from the genera Cladonia and Cetraria. Banfield (1954) includes the arboreal lichens, such as Alectoria, as an important food. The writer personally has observed caribou on two occasions diligently

stripping such lichens from spruce trees. Stomach analyses reveal that the Cladonia lichens occur most commonly, followed by the Cetraria and Stereocaulon types.

Other plants providing important forage for caribou during the winter months are sedge, grass, willow, and dwarf birch. Olaus Murie (1935:37) indicates that "...grasses are then eaten in large quantities ...." Adolph Murie (1944:153) states, "Grasses, sedges, and willows are also eaten extensively in winter." Data from the Nelchina caribou near Anchorage, Alaska, disclose that sedges were a main winter food-plant (Alaska Game Commission, 1950). Field observations and stomach analyses show that the Steese-Fortymile caribou eat a large quantity of sedges, grasses, and the leaves and twigs of willow and dwarf birch.

Water and minerals make up a part of the caribou's winter diet, also. The writer assumes that the animals obtain a portion of their water from snow. He has observed caribou on two occasions, however, drinking from overflows on the ice of creeks. In each instance the animals broke through the thin upper crust of ice with their forefeet and drank from the resulting pool. Some kinds of minerals apparently are utilized, for caribou will dig into the banks of streams to eat the dirt. During the winters of 1952, 1953, and 1954 many such places were observed along Jack Wade Creek and Walker's Fork near Chicken, Alaska.

Quantitative data concerning winter food-habits are few. Olaus Murie (1935) presents an analysis of four stomach-samples collected in February. The writer analysed 19 stomach-samples taken from hunters' kills November 20 to 30, 1952. The results of both analyses appear in Table 11, and they represent the only ones available at this writing.

TABLE 11. AVERAGE PLANT-COMPOSITION, BY VOLUME, OF STOMACH SAMPLES COLLECTED DURING WINTER FROM STEESE-FORTYMILE CARIBOU.

Plant Groups	Olaus Murie (1935) 4 Samples - February		This Study - 1952 19 Samples - November	
	Percentage Range	Mean Per Cent	Percentage Range	Mean Per Cent
Lichen	?-30	19	25-80	55
Woody	?-20	14	5-35	15
Grass-Sedge	?-50	35	10-60	25
Fungi	0	0	0-T[a]	T
Moss	?-20	12	0-T	T
Forbs	0	0	0	0

a/ T = Trace

The plants are grouped broadly, because most of the vegetation cannot be identified more closely. Murie does not indicate the method of analysis; the writer, at that date, used estimation alone. The percentages from the latter probably are not accurate, but they do indicate relative abundance.

Table 11 indicates that the lichen and sedge-grass groups are the most important plants utilized in winter, with the woody plants important, also. These results correspond closely with the general data collected from field observations by this author, and others as well. More complete information should be available when the stomach samples collected in October, 1955, are analysed.

Spring.--This season extends from about mid-April to mid-June, again depending upon weather conditions. During this period, when the most rapid vegetative growth of the year occurs, the caribou are quick to change their diet to include the new sprouts that spring up in the snow-free areas. The willow catkin usually is the first growth to appear, followed shortly thereafter by shoots of grass and sedge. Later the buds, leaves, and sprouts of willow, dwarf birch, and alder appear, along with those of horsetail and various forbs. Caribou feed upon all these plants. Lichens, although still eaten, become much less important.

Extensive field observations were made during this season in 1953, 1954, and 1955, while gathering data on calving. These observations indicate that willows and sedges are the food-plants most utilized at that time; they also are the most abundant food in the areas frequented by caribou then. The animals consume great quantities of horsetail when available, but this plant is not abundant. Adolph

Murie (1944:153) found that "...in May and early June willow and dwarf birch seem to make up the bulk of the food." Caribou certainly exhibit a liking for the leaves of willow and dwarf birch, a liking that continues throughout the summer. No quantitative data for this period are available.

Summer.--This season lasts about two months, extending from mid-June to mid-August. During this period food is abundant throughout the range, and the caribou soon fatten. Adult bulls store great quantities of fat, mostly along the back and rump; this fat carries them through the rutting period in October, when they eat little food.

During the summer, caribou feed extensively on willow, dwarf birch, grass, and sedge. Many types of forbs are eaten, including lupine, vetch, fireweed, smartweed, and others, but few of these plants are abundant, especially above timberline. In summer the caribou usually remain above timberline near windy ridges to gain relief from the hordes of flies. Adolph Murie (1944:154) states that in summer, "Equisetum was especially sought on several occasions." Olaus Murie (1935:41) relates, "In July and August, when mushrooms become plentiful, these are promptly placed on the caribou menu." Banfield (1954) found that mushrooms had a high palatability rating among the caribou of northwestern Canada. Stomach samples taken in the fall show that the Steese-Fortymile caribou display a great fondness for these fungi, also.

Water is plentiful and readily accessible throughout the range during the summer. The many field observations made by the author however, have failed to record caribou drinking water during the spring, summer or fall. The only evidence of drinking noted pertained to

visits of caribou to a mineral spring on Walker's Fork near Chicken, Alaska; tracks are abundant there whenever caribou are in that region.

Some quantitative data are available for the summer months. Olaus Murie (1935) presents data from six stomach-samples taken July to August; Adolph Murie (1944), from three taken June to July; Banfield (1954), from fourteen taken in summer; and the author, from four taken in July. The analysis methods for the first three groups were not indicated; the author's method is described in the last section of FOOD HABITS. Table 12 lists the results of these analyses; the plants are grouped to correspond to the author's data. These few samples indicate that the woody and grass-sedge plant groups provide the major portion of the caribou's summer diet.

Fall.--This season extends approximately from mid-August to mid-October. Frosts usually occur in the latter part of August, and vegetation begins to die soon afterwards. The fungi and forbs are the first food plants affected, followed by the leaves of willow, then those of dwarf birch, and last the grasses and sedges. The latter plants, although dead, still are important food items. Lichens, moss, and a number of other species are affected little by the cold.

Olaus Murie (1935:37) describes the fall of 1922 in Mt. McKinley National Park:

> Early in August the vegetation began to turn yellow. A willow limb here and there, a few clumps of Arctous alpina, or blueberry bushes, showed yellow and red. Later in the month, and early in September, pure green vegetation was apparent only in swampy plots, recesses of the hillsides where seepage was working out toward the main stream. Such green "oases" are utilized to the last by the caribou that linger in the higher valleys.

Stomach samples collected from hunters' kills August to

TABLE 12. AVERAGE PLANT-COMPOSITION, BY VOLUME, OF STOMACH SAMPLES COLLECTED DURING SUMMER FROM BARREN-GROUND CARIBOU.

Plant Groups	O. Murie (1935) 6 Samples[a] July to August		A. Murie (1944) 3 Samples[b] June to July		Banfield (1954) 14 Samples[c] June to August		This Study - 1955 4 Samples[a] July	
	Percentage Range	Volume Average Per Cent	Percentage Range	Volume Average Per Cent	Percentage Range	Volume Average Per Cent	Percentage Range	Volume Average Per Cent
Lichen	?-40	15	0-T[d]	T	?	31	1-15	6
Woody	?-80	56	T-59	20	?	39	62-84	75
Grass-Sedge	?-30	11	40-99	80	?	28	7-34	18
Fungi	?-T	T	0	0	?	1	0	0
Moss	?-5	3	0	0	?	T	0-T	T
Forbs	?-1	T	0-T	T	?	T	0-4	1

a/ Steese-Fortymile caribou.
b/ Mt. McKinley caribou.
c/ Western-Canadian-Arctic caribou.
d/ T = Trace.

September, 1954, provided excellent information concerning the fall diet change occurring among the Steese-Fortymile caribou. A total of 70 samples was obtained: 48 from the Taylor Highway area, August 20 to September 7, and 22 from the Steese Highway area, September 12 to 24. Table 13 shows the distribution of these samples by collection date. The data were analysed according to the time periods indicated: I. August 20 to 31, II. September 1 to 7, and III. September 12 to 24. These divisions seem logical from the standpoint of locality, time, frequency, sample size, and weather. Concerning the last, frost occurred frequently after September 1 and the fungi disintegrated rapidly.

The samples were analysed by the method described in the next section. The plants were grouped according to the following types: lichens, woody, grass-sedge, fungi, moss, forbs, and other. This broad grouping seemed the most valid, because the major portion of each sample was difficult to analyse more precisely. Individual plants were identified to species whenever possible or practical.

The results of the analysis indicate the wide variety of plants utilized by caribou during the fall. Seventy-five per cent of the samples examined contained a minimum of 9 to 11 species of plants. Table 14 shows the minimum number of plant species found in the various samples and the frequency of samples containing that number. Table 15 lists those plants appearing in the samples that were identified readily to genus or species. No attempt was made to identify the unknown plants further than the broad groupings previously mentioned.

The Cladonia type lichens dominated that plant group, with Cetraria and Stereocaulon being found only in trace quantities (less

TABLE 13. STOMACH SAMPLES OBTAINED DURING THE FALL, 1954, LISTED BY COLLECTION DATE.

I		II		III	
Date	No. of Samples	Date	No. of Samples	Date	No. of Samples
August 20	1	September 1	2	September 12	1
22	3	2	2	14	1
23	1	3	1	15	4
25	2	4	7	17	4
26	2	6	4	19	11
27	2	7	13	24	1
28	1				
29	6				
31	1				
Total	19	Total	29	Total	22

TABLE 14. MINIMUM NUMBERS OF PLANT SPECIES FOUND IN CARIBOU STOMACH SAMPLES COLLECTED AUGUST 20 TO SEPTEMBER 24, 1954.

Minimum Plant Species Present	Number of Samples
7	2
8	7
9	17
10	18
11	18
12	7
13	1
	Total 70

TABLE 15. PLANTS FOUND IN CARIBOU STOMACH SAMPLES COLLECTED AUGUST 20 TO SEPTEMBER 24, 1954.

Lichens:

- *Cetraria* spp.
- *Cladonia* spp.
- *Stereocaulon* spp.

Woody:

- *Betula* spp.
- *Ledum palustre decumbens*
- *L. p. groenlandicum*
- *Picea* spp.
- *Salix* spp.
- *Vaccinium Vitis-idaea*
- *V. uliginosum*

Grass-Sedge

Fungi

Moss

Forbs:

- *Dryas* sp.
- *Lupinus* sp.
- *Oxytropis* sp.
- *Polygonum* sp.

Other:

- *Equisetum* spp.
- *Lycopodium* sp.

than 0.1 per cent). Lichens were present in every sample.

Woody plants occurred in all the samples, also, with willow and dwarf birch being the most important. Willow appeared in every sample during the first two periods and was by far the most dominant woody plant, but occurred in only 8 of the 22 samples collected September 12 to 24. Dwarf birch appeared in 63 of the 70 samples, and became the dominant woody plant during the last period. Spruce occurred in 34 samples, but only as a trace. The remaining woody plants were present mainly in trace quantities during the first two periods, but increased in abundance during the third. Low-bush cranberry occurred in 61 samples, Labrador tea in 55, and blueberry in 59.

Fungi were a major food item during all three periods, appearing in 69 of the 70 samples. The moss and grass-sedge plant groups occurred in 69 samples, increasing in abundance toward the end of September. Forbs consistently averaged less than one per cent, but appeared in 60 samples. Club moss and horsetail were the only plants to appear in the "other" grouping. The former was present only as a trace in one sample. The latter occurred in 23 samples: in 15 at less than 0.1 per cent and in 8 at percentages ranging from 2.6 to 18.8.

The final results of the analysis appear in Table 16, where the average plant-compositions of the samples are presented according to the collection periods. The total-sample volumes ranged from 9 to 178 cubic centimeters, averaging 78. The per cent of each sample analysed ranged from 6.6 to 55.1, averaging 20.1.

As indicated in Table 16, fungi, lichens, and woody plants were the most important food items encountered, averaging from 12.4

TABLE 16. AVERAGE PLANT-COMPOSITION OF CARIBOU STOMACH SAMPLES COLLECTED AUGUST 20 to SEPTEMBER 24, 1954.

Plant Groups	I. August 20 to 31			II. September 1 to 7			III. September 12 to 24		
	Average Per Cent	Range	Standard Deviation	Average Per Cent	Range	Standard Deviation	Average Per Cent	Range	Standard Deviation
Lichens	15.1	0.5-37.4	±10.8	17.8	0.2-45.2	±11.1	47.8	5.8-71.2	±19.1
Woody	36.0	9.6-75.2	±21.1	43.1	7.7-93.6	±23.6	12.4	2.6-40.0	± 8.4
Grass-Sedge	0.7	0.0-3.4	± 1.1	4.1	T-20.0[a]	± 4.3	10.2	0.5-21.0	± 6.3
Fungi	45.3	11.5-84.0	±22.9	30.3	4.4-66.5	±20.0	19.5	0.0-63.2	±16.8
Moss	2.3	0.0-6.7	± 2.9	4.3	T-10.0	± 2.6	6.0	T-18.7	± 6.3
Forbs	0.7	T-3.4	± 1.2	0.2	0.0-3.2	± 0.5	0.4	0.0-2.7	± 0.6

a/ T = Trace.

to 45.3 per cent of the total-sample volumes. Forbs were relatively unimportant, being present mainly in trace quantities and reaching a maximum of only 3.4 per cent. The grass-sedge group became an important item only during period III, when the average reached 10.2 per cent. The amount of moss present remained low throughout, the average ranging from 2.3 per cent to 6.0, although one sample during period III contained 18.7 per cent.

Table 16 shows, by the range and standard deviation, that the samples varied greatly in the lichen, woody, and fungal plant groups. Statistically (assuming, of course, that the analysis technique is accurate), using the formula $n = \frac{t^2 s^2}{(\bar{x}-m)^2}$ (Snedecor, 1946:457), the average percentages expressed for these three groups are within ±10 of the true means: at the 90 per-cent confidence level for the sample of 19 in period I, and at the 95 per-cent level for the samples of 29 and 22 in periods II and III, respectively. To bring the true means of these groups to within ±5 at the 95 per-cent level requires a sample size of 95 for each of the first two periods, and 65 for the last. These computations, of course, apply only to a normal distribution; a larger number of samples is needed for verification.

The stomach composition percentages expressed provide an index to the fall change in food utilization by the Steese-Fortymile caribou. Fungi and woody plants were dominant during the August 20 to 31 period, averaging 45.3 and 36.0 per cent of the total volume. Lichens composed only 15.1 per cent of the samples. During the September 1 to 7 period the fungi percentages dropped to 30.3 and the woody plants and lichen percentages rose to 43.1 and 17.8, respectively. This change is attributed to the effect of freezing temperatures upon the availability

of fungi. The other plants had not yet been affected greatly by the frost. During the September 12 to 24 period the fungi percentage dropped to 19.5 and the woody plants to 12.4, while the lichen rose to 47.8. Again the change is attributed to frost. By then few fungi remained, although apparently they were still a desired food item. Many woody plants had lost most of their leaves and undoubtedly much of their succulence. It was noted that those which retain their leaves quite late, such as dwarf birch, blueberry, and low-bush cranberry, increased in importance within this group, while the willows, most of which lose their leaves soon after the heavy frosts, became practically insignificant. The grass-sedge group became as important as the woody plants during this period. This group, like the lichens, is not affected greatly by freezing temperatures.

The data indicate that the Steese-Fortymile caribou's diet consists largely of woody plants and fungi during early fall, with a shift toward lichens and grass-sedge in late fall, and probably winter. More stomach samples are needed to give the complete picture of this diet change.

Analysis Technique for Stomach-samples.

Volumetric analyses of caribou stomach-samples prove difficult because of the large amount of finely divided material present. Three classes of plant material are evident in the samples: 1) coarse, which can be identified readily; 2) fine, which can not be identified practicably; and 3) medium, gradating between coarse and fine, which can be identified upon close examination. It was found that these classes average approximately 15, 40, and 45 per cent, respectively, of the total-sample volume. Also, the various plants are not

represented necessarily in the same relative abundance within the three classes mentioned. The percentage of lichens, for example, is uaually much less in the coarse then in the finer material, whereas the reverse seems true for fungi. The analysis method used must consider these factors, be accurate, and yet not be too time-consuming in application.

Seventy caribou stomach-samples collected August 20 to September 24, 1954, were available for analysis. The stomach material had been placed initially in plastic bags, and later preserved in jars containing 10 per cent formaldehyde. A description of the analysis technique used by the author follows below.

Each sample was washed in a large strainer (about 12 meshes per inch) under a steady flow of water to remove the fine material. If the total-sample volume were small, the washing was necessary only to remove the formaldehyde. Cheese cloth (about 50 meshes per inch) placed under the strainer retained the removed portion for measurement. The material remaining in the strainer (coarse and medium) was transferred to a pan for examination.

The coarse material was picked out and grouped in piles according to various plant types. Broad plant groupings were used because the majority of the material could not be separated to genus or species. Then each pile, after draining on absorbant paper, was measured volumetrically by water displacement, and the volume recorded.

Next, a random sample of the remaining portion (the medium material) was analysed. For this step, the material was placed into a nine-inch circular pan on whose bottom were etched eight equal sectors. Water was added to allow free movement of the particles, and the pan agitated to disperse the material. One of the sectors,

chosen by random numbers, was emptied--the vegetation being separated into various piles as before. After draining, the piles were measured and the volumes recorded. These volumes also were expressed as percentages of the total volume from the sector.

The remaining portion of the sample was measured and recorded, as was the volume of the fine material retained from the washing. The total volume of these represented the material not analysed--about 80 per cent. The composition of this material was assumed to be the same as that obtained from the sampling described in the preceding paragraph; the only justification for this assumption as regards the fine material is the author's belief that the breakdown of plant material from medium to fine proceeds equally for all plant types. As such, the volumes of the various plant types were computed from the percentages obtained for the medium material, and recorded accordingly.

Finally, the three recorded volumes--coarse, sector, and unanalysed material--of each plant type were totaled and the final composition percentages computed for the total sample. Figure 29 illustrates the data sheet used in this analysis method.

Figure 29. Sample data-sheet used in stomach-sample analysis.

SAMPLE NO. 9

DATE COLLECTED: 8/31/54 SEX: Female

LOCALITY COLLECTED: Taylor Hwy. - Mile 95

Plants	Coarse Material		Medium Material in Sector		Computed Composition Unanalysed Material	Total	
	cc.	%	cc.	%	cc.	cc.	%
Lichens	2.1	9.6	.7	17.1	17.4	20.2	15.8
Woody:	4.1	18.7	1.9	46.4	47.3	53.3	41.7
Grass-Sedge	.2	.9	T	-	-	.2	.1
Fungi	14.9	68.1	1.1	26.8	27.3	43.3	33.8
Moss	.1	.4	.3	7.3	7.5	7.9	6.2
Forbs:	.5	2.3	.1	2.4	2.5	3.1	2.4
Other:	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	21.9		4.1		102.0	128.0	

Material Remaining: 77

Material Washed Away: 25

Total Material Unseparated: 102.0 cc. Total Sample Volume: 128.0 cc.

Total Material Separated: 26.0 cc.

CONCLUSIONS

The great importance of caribou to the people of Alaska warrants an extensive management program for this game species. Such a program, however, is faced with many problems that hinder the gathering of sufficient biological information. Many of these became evident during the course of the present study, notably when disrupting some of the author's best-laid plans. Nevertheless, some of the data obtained filled notable gaps in the life-history knowledge of the barren-ground caribou, as well as in the knowledge of the Steese-Fortymile herd itself. But many important gaps remain to be filled, and the complete set of data needed for proper caribou management will not be a reality for many years yet.

The Problems.

The most difficult problems affecting caribou management result from the caribou themselves. The underlying causes can be attributed basically to the animals' inherent nomadism and gregariousness. Specifically, the characteristics that most impede management practices are 1) the erratic, unpredictable movements; 2) the extensive range used; 3) the frequent wide dispersal of the animals; and 4) the customary segregation of sex and age classes.

The erratic movements of caribou greatly hinder the plans of the game manager. Seldom can he predict the hunters' kill until shortly before it takes place, and thus the annual harvest is extremely difficult to regulate. The success of data-gathering field trips depends upon the accessibility of the animals, and how long they will remain so. Detailed planning often results in nothing.

The extensive range used by caribou and their frequent wide dispersal prove to be serious obstacles at times. The Steese-Fortymile herd commonly becomes "lost", and hours of flying reveal nothing but a few animals scattered here and there. Yet, a knowledge of the herd's whereabouts at specific times is vital to a successful management program. The airplane is a necessary tool for covering the vast distances of the range, but such flying is costly. Much time and money is expended each year simply in trying to keep track of this herd and to trace its movements.

Finally, when the caribou <u>are</u> accessible, the segregation of sex and age classes often prevents the obtainment of significant data. Except during the rut, most of the adult bulls remain separate from the cows and young animals. The males seldom have been represented fully in the hunters' kills from the Steese-Fortymile herd. During the calving in spring, some of the yearlings and young animals are not present on the calving grounds. The compositions of the various groups fluctuate throughout the year, so that counts taken at any time other than during the rut usually cannot be applied to the entire population.

This discussion serves to point out some of the difficulties encountered in trying to obtain the data necessary for management. When the author first began this study, he frequently became quite discouraged, because the caribou seemed to thwart his every plan. But after three years of experience, he has come to realize that defeat normally occurs quite often in one's dealing with caribou. The continued study of this game animal, however, should eliminate some of the present problems.

The Contributions.

The contributions made by this report to the knowledge concerning caribou fall into two classes: those pertaining strictly to the Steese-Fortymile herd and those applicable to the barren-ground caribou in general. The former includes the following:

1. The delimitation of this herd's range, with an elementary break-down of the vegetation occurring therein, plus an estimate for carrying capacity.
2. A description of the herd's movement patterns during the past and the present.
3. Data expressing the total size, composition, and annual increment of the herd.
4. Data revealing the relative importance of certain food plants in the diet during the various seasons, especially fall.

Contributions to the general knowledge of the barren-ground caribou include these:

1. Important observations of caribou behavior during the breeding and calving periods, notably the latter.
2. Criteria useful for age and sex determination in the field.
3. A series of body weights and measurements of value to taxonomic studies.

The Gaps.

Much information concerning the caribou remains unknown. Most of the gaps pertain to specific items which are necessary to management. The obvious data still needed include the following:

1. The foods actually eaten and those preferred by caribou

throughout the year.

2. The relative amount of each food-plant eaten.

3. The exact importance of lichen as a food.

4. The exact knowledge of the types and relative abundance of the range vegetation.

5. The amount of food-plants available on the range, and their annual rates of production.

6. The effect of caribou upon the range vegetation.

7. The complete knowledge of herd composition and mortality.

8. The development of an accurate aging technique.

9. The thorough understanding of caribou behavior.

The solution to none of the above items is easy to obtain, and many years of effort will be required to solve all of them. Future caribou studies should concentrate on filling these vital gaps in the knowledge so necessary to the proper management of this vital big-game species.

SUMMARY

Caribou range over a large portion of Canada and Alaska. These animals are classified into seven species, of which the barren-ground group (Rangifer arcticus Allen) is by far the most numerous. This group presently consists of six subspecies, two of which constitute the herds in Alaska: the Grant caribou (R. a. granti Allen) and Stone's caribou (R. a. stonei Allen). The Steese-Fortymile herd belongs to the latter group and contains at least 50,000 animals.

The caribou's value to society remains largely economic. Residents of both Canada and Alaska still utilize this animal for food quite extensively, and in the latter region there is a growing number of sportsmen who hunt mainly for recreation or trophies. Alaskan herds of greatest economic importance at present are the Nelchina herd, near Anchorage, and the Steese-Fortymile herd, near Fairbanks.

Much of the initial work on caribou was done by O. J. Murie and L. J. Palmer of the U. S. Biological Survey in the 1920's and 1930's. The Canadian Wildlife Service began intensive caribou work about 1947, and the U. S. Fish and Wildlife Service, about 1949.

The present project commenced in September, 1952, under the auspices of the Alaska Cooperative Wildlife Research Unit at the University of Alaska and of the U. S. Fish and Wildlife Service. The project was designed initially to supplement the intensive Pittman-Robertson program then in effect using Federal Aid in Wildlife Restoration funds. The airplane played an important role in this study, but most of the data were gained through ground operations. Talks with long-time Alaskans and a perusal of the literature

produced a knowledge of the past history of the Steese-Fortymile herd.

This herd once inhabited a vast region encompassing about 85,000 square miles of east-central Alaska and western Yukon Territory. At the present time the herd utilizes an area of some 35,000 square miles lying principally between the Tanana and Yukon Rivers. About 20 per cent of this range lies above 3,000 feet elevation and about 90 per cent above 1,800 feet. Many streams interlace the area and keep it rather well-drained, lakes and marshes occurring rarely. The Steese and Taylor Highways are the only roads traversing the range, but numerous mining roads extend from these for short distances. Towns are scarce and a maximum of 60,000 people inhabit the area, most of them living on the fringes.

Seven major plant communities compose the range vegetation, their limits being influenced by drainage and altitude. An analysis of their distribution reveals that the three communities (Dwarf Birch-White Spruce, Dwarf Birch-Willow, and Sedge-Grass) furnishing the bulk of the caribou's food cover 60 to 70 per cent of the range, or 13,440,000 to 16,640,000 acres. Palmer's experiments and estimates concerning reindeer and caribou provided the basis for estimating that each caribou requires 185 acres of land each year for subsistence. This estimate, together with the acreage expressed above, indicates that the present range can support 70,000 to 90,000 caribou.

Man, fire, and the caribou represent the major factors causing range deterioration. They lower the carrying capacity by destroying food or by decreasing the available land area. Man, by expanding his civilization and by causing 80 per cent of the fires, offers the greatest threat. The trend indicates a continued decline in both food

supply and total range.

The erratic and continual movements of caribou are difficult to predict or to understand. The basic cause for these movements stems from the seemingly inherent restlessness of the animal, but many external and internal factors influence the expression of this drive.

The movements of caribou vary greatly from day to day, but certain activities seem to take place at certain times of the day. Resting and feeding usually occur during the middle portion of the day and night; traveling, during early morning and late afternoon. Various gaits enable caribou to traverse distances quickly, and their nomadism and apparent disregard for a home range results in their traveling great distances each year.

Major seasonal movements take place in the spring and fall. The available records of these movements indicate two periods in which the migration patterns are fairly well defined: 1905-1935 and 1942-1955. The data concerning each period provide a general picture of the herd movements during the past and the present.

The Steese-Fortymile caribou herd has dwindled greatly since its peak of one-half to one-million animals in the late 1920's. Observations indicate that the decline began after 1928, and that the population reached a probable low of 10,000 to 20,000 animals in the early 1940's. The decline is attributed to a population shift to new ranges. During the past 10 years the remnant herd has increased steadily, and in April, 1953, numbered at least 40,000.

In September the adult bulls join existing bands of cows and young animals for the rut, and remain with them through most of October. Most of the mating takes place during the first two weeks of October. Calves are born, after a gestation period of about 33 weeks,

from the second week of May until the third week of June, with the vast majority being dropped the latter half of May. Calf production is known to have been high during the years 1950 to 1955. Calf:cow ratios in 1953, 1954, and 1955, after "infant" mortality, reached 72.9, 72.5, and 64.9 per cent, respectively. Calving-ground studies during the last-mentioned years produced valuable information on caribou behavior during that period; 44 calves were ear-tagged, also.

Certain physical characteristics and behaviorisms of caribou influence mortality indirectly. Direct mortality factors can be classified as five types: disease, accidents, intraspecific strife, weather, and predation. Animals considered predators on caribou include the coyote, wolverine, and bear; the bald and golden eagles; the wolf; and man. The author considers all the factors but wolf and man relatively unimportant as presently concerns the Steese-Fortymile herd. They affect mostly the calves, and probably take a maximum toll of adult animals of one per cent. The wolf is not numerous on this range, although its population seems to be increasing, and probably does not take more than two per cent of the adult caribou. Hunters kill a maximum of five per cent of the adults. The maximum total annual mortality, excluding calves, is estimated at eight per cent. Present calf production and survival amply covers this loss.

Herd-composition data are difficult to obtain, because caribou are difficult to segregate into age and sex classes by sight. A knowledge of certain physical characters and behaviorisms aids greatly in making counts, but accuracy hinges upon field experience. The best periods for classifying caribou occur May 1 to 14 and September 1 to 14, when the distinguishing characteristics between sexes are

most evident. The rutting period provides the best time for obtaining true age and sex ratios, because the bands are most uniform then. Data obtained from hunter checking stations and from composition counts indicate that the population is young and that the sex-ratio approaches 100:100.

Composition counts taken in May indicate that at least 50 per cent of the calves survive the first year. The annual increment for this herd, after total mortality, was computed to be 10 to 15 per cent.

Caribou are cursory feeders and eat a wide variety of plants. The drive for food seems strong, often being expressed even in their nervous reactions, although the animals also are "fastidious" eaters. The main periods for resting and feeding are the hours surrounding noon and midnight. The animals seem to rely greatly on their sense of smell for finding and choosing food. The caribou's diet hinges upon the available food supply, and thus varies greatly with the seasons. The greatest changes take place in spring and fall. Weather conditions and the animals' location, both altitudinal and latitudinal, influence the diet by restricting the number and types of plants available. Field observations and stomach-sample analyses are the main techniques for determining the relative importance of various food plants.

The winter season extends approximately from mid-October to mid-April. Available food plants are at a minimum, and most are covered with snow. Analyses of 23 stomach-samples provided quantitative data for this period; field observations furnished general data. The lichen and grass-sedge plants proved to be the most important food, with woody plants of some importance, also.

Spring lasts approximately from mid-April to mid-June. Rapid

vegetative growth occurs then, and the caribou's diet changes abruptly. Food-habits data for this period came entirely from field observations. Willow leaves, buds, and twigs and the new shoots of grass and sedge form the major part of the diet, but dwarf birch foliage is important. Caribou utilize many other plants, also, but most are not abundant.

The summer season, extending approximately from mid-June to mid-August, produces an abundant supply of plant food. Most caribou tend to stay above timberline then, where relief from flies can be had on windy ridgetops; this behavior limits much of the animals' feeding to alpine vegetation. Quantitative data were available from the analyses of 27 stomach-samples; field observations tend to verify the findings. Willow and dwarf birch foliage are of greatest importance, followed closely by the grasses and sedges. Fungi and forbs are eaten extensively when available, but lichens are a minor food item.

The fall season begins soon after the first frosts in August and lasts until about mid-October, depending upon weather conditions. The caribou's diet changes swiftly as the vegetation falls before the freezing temperatures. Food-habits data result mainly from the analysis of 70 stomach-samples collected August 20 to September 24 from hunters' kills. A complete description is presented of the analysis technique used and of the results. The data indicate that the Steese-Fortymile caribou's diet consists largely of woody plants and fungi during early fall, with a shift toward lichens and grass-sedge in late fall.

The most difficult problems affecting caribou management result from the caribou themselves. The characteristics that most impede management practices are 1) the erratic, unpredictable movements; 2)

the extensive ranges used; 3) the frequent wide dispersal of the animals; and 4) the customary segration of sex and age classes.

Contributions made by this report are placed in two classes: those pertaining strictly to the Steese-Fortymile herd and those applicable to the barren-ground caribou in general. The former class lists four contributions, the latter, three.

Much information concerning the caribou remains unknown. Nine items are listed, a knowledge of which is essential to the proper management of this big-game species. Many years of effort will be required to gain all of them.

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