ALASKA DEPARTMENT OF FISH AND GAME

JUNEAU, ALASKA

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CARIBOU REPORT

by

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: James E. Hemming

Project No.: W-17-1 and W-17-2 Project Title: Big Game Investigations

Job No.: 1 & 2 (W-17-1) and 3.1R & 3.2R (W-17-2) Job Title: Caribou Investigations

Period Covered: January 1, 1969 to December 31, 1969

SUMMARY

The calving areas, post-calving concentration areas, and rutting areas were defined for the Arctic caribou herd to complete precensus delineation procedures. Everything is now ready for the test of the "Aerial photo-direct count-extrapolation technique" in July 1970.

The calving areas of the Porcupine and Beaver herds were delineated. Seasonal movement patterns were recorded for the Arctic, Beaver and Porcupine herds. The Job Completion Report is in preparation and will be completed by June 30, 1970.

BACKGROUND

At present, the annual harvest in nearly all Alaska caribou herds falls below the annual increment and populations are apparently increasing. However, as Alaska's industries and human populations expand there will be increasingly greater pressures exerted upon caribou in the form of increased hunting and encroachment upon their range. Considerable effort has been expended in the past (Hemming and Glenn, 1968 and Hemming, 1969) to assess the distribution, migration paths, and magnitude of Alaska's caribou herds, but additional research is necessary to properly delineate contemporary caribou populations

OBJECTIVES

To provide basic life history information required for management of Alaska's caribou populations and to test techniques for measuring the status, trend, and utilization of caribou and their associated habitat.

To determine the seasonal distribution patterns of caribou, including summer ranges, winter ranges, calving areas, and migratory pathways, throughout Alaska.

To review, compile, analyze, and prepare for publication the biological data obtained from studies of caribou in Alaska.

PROCEDURES

Techniques for Aerial Photo Census of Caribou

The following census technique is being tested: (1) Aerial reconnaissance in May and June to delineate calving grounds; (2) aerial photo counts of total animals, cows, yearlings and calves in areas of post-calving concentration; (3) ground composition counts during the rut to obtain bull-cow, yearling-cow, and calf-cow ratios; (4) ground composition counts just prior to calving to obtain calf (short-yearling)-cow ratios; (5) extrapolation of data by use of population statistics to determine herd size, calf crop, and annual increment of yearlings.

Distribution and Movements of Caribou in Alaska

Most information was obtained from aerial reconnaissance. Alaska Department of Fish and Game personnel recorded miscellaneous distribution data for all herds on special forms throughout the year. U. S. Fish and Wildlife Service personnel, bush pilots and guides cooperated. Additional information was obtained from local residents and hunters. All observation records include the date, specific area involved, relative caribou numbers, presence or absence of calves, direction of movement, and length of time in the area.

ACKNOWLEDGEMENTS

I should like to express my appreciation to the skilled technical help of the field biologists and the laboratory technicians for their loyalty and dedication this past year. The U. S. Bureau of Land Management, U. S. Fish and Wildlife Service, and U. S. Navy played a key role during various portions of my research. To members of the staff and others not individually named, I express my sincere thanks.

FINDINGS

ARCTIC HERD

Precensus Activities

Final testing of the direct count-extrapolation census technique is scheduled for June 25 - July 6, 1970. The details of this census method

were described by Hemming and Glenn (1968) and an attempt to modify this technique in 1968 was reported by Hemming and Glenn (1969). The Arctic caribou herd was chosen for the test census because of its large size, and because it offers the greatest number of variables which may affect the estimate of population size.

In preparation for the census it was necessary in 1969 to recheck the location of the calving area, to measure calf production levels, and to delineate the approximate area occupied by the cow-calf segment during the period of post-calving concentration. The latter was especially critical because the success of the photo mission during the census will depend upon the degree of clumping of the cow-calf group. In 1969 the greatest degree of clumping occurred on 30 June as the animals headed south near Ipewik Lake, west of Cape Lisburne, and occupied an area approximately 15 miles long and 5 miles wide. An area of this size will require approximately 2,000, 9x9 inch black and white photographs, 1:3000 scale. Flight line spacing requirements are 20% sidelap and 60% endlap. Earlier studies revealed that the size of the area occupied by the post-calving group on a given day is extremely variable. Therefore, it is important to know the range in size of this area in order to establish maximum film requirements.

The terrain in and around the calving area of the Arctic herd consists of low rolling hills and ridges. The general lack of sharp relief simplifies the problem of maintaining a constant elevation above ground during the photo mission.

The manpower and equipment requirements for Phase I of the census will be:

	Aircraft	Special Equipment		Crew
1	Aerocommander 500 U or DeHavilland Beaver	RC-8 Wield Camera	4	(pilot, navigator, 2 photographers)
2	Hiller-Fairchild jet helicopters (3 place)	-	6	(2 pilots, 4 observers)
1	Supercub	-	2	(pilot, 1 observer)
1	Cessna 180	-	3	(pilot, 2 observers)

Precensus reconnaissance will be conducted via Cessna 180 aircraft. When census conditions are optimum, the DeHavilland Beaver will fly the photo mission and photograph all major groups of caribou. Simultaneous direct counts of small peripheral groups of caribou will be done from two Hiller-Fairchild jet helicopters. A Supercub will fly continuous reconnaissance during the census to locate scattered groups of caribou for the helicopter crews to count.

In October, during the rut period, one helicopter and one Cessna 180 will be used during composition counts. Past studies have revealed that no one area is occupied consistently during the rut period. Therefore, extensive reconnaissance via Cessna 180 will be required to locate suitable groups for counting.

All census data will be summarized by February 1971 and the Job Completion Report and publication will be completed by June 1971.

Distribution and Movements

The distribution of the Arctic caribou herd during 1969 was recorded during aerial surveys at various times of the year and with a survey of Eskimo and Indian villages in November. Additional information was obtained from other investigators, bush pilots, hunters, etc.

Specific geographic locations and place names mentioned in this report will be supported by detailed maps in the subsequent Job Completion Report.

Winter 1969

The main caribou wintering areas (January - April) were south of the Brooks Range between Selawik and Allakaket, including the Waring Mountains, Purcell Mountain, Lockwood Hills, upper Pah River valley and the lower Alatna River valley. Smaller groups were present on Kanuti Flats, Indian Mountain near Hughes, Mulgrave Hills, and the upper Eli River near Noatak. North of the Brooks Range small scattered groups of caribou spent the winter between Wainwright and Point Hope. Occasional small bands were reported as far east as the Sagavanirktok River.

Spring 1969

By 9 April the spring migration to the calving area was in progress. Caribou that wintered on the southern and western ranges moved across the Brooks Range from Hunt River to Cutler River and then through the area between Howard Pass and Nimiuktuk River. Animals from winter ranges near Noatak followed the Kugururok and Nimiuktuk Rivers northward. Caribou from southeastern winter ranges moved north across the lower Alatna River valley and then up the John River valley to Chandler Lake and Anaktuvuk Pass. This group then turned west on the north side of the Brooks Range and moved across the upper Killik River, Nigu River, and Howard Pass to Feniak Lake. The few animals that wintered on the Arctic coast used various routes across the North Slope to reach the calving area.

Calving occurred along the upper Utukok, Meade, and Ketik Rivers.

Summer 1969

As usual, bulls and yearlings lagged behind females during the spring migration and began to disperse. Scattered bands occurred from the hills along the Chukchi Sea through the Brooks Range to the drainages of the Sagavanirktok River on the east and north through the foothills of the North Slope.

The female segment of the population moved west immediately after the calving period. On 30 June almost the entire female-calf group was observed near Ipewik Lake. This group was concentrated in an area approximately

15 miles long and 5 miles wide. During the next three days the animals swung south to the Kivalina River and then moved east through the Brooks Range. Females with calves dispersed widely along the Arctic coastal plain from Cape Sabine to the Canning River in July and August. However, a majority of the animals spent the summer west of the Colville River.

Fall 1969

In late August the fall migration began. Several thousand caribou moved west through the Prudhoe Bay area from 16-18 August (Gavin, 1969). These animals, plus another group of approximately 40,000 that summered north of Umiat, moved west along the Colville River. Apparently movement over the Brooks Range was quite leisurely; e.g., caribou arrived at Anaktuvuk Pass on 5 October which is about two weeks later than usual. Sage (1969) reported movement of caribou up the Sagavanirktok River and down the North Fork of the Chandalar River in August. Several thousand of these (presumably the same group) were observed in the Dietrich River valley on 26 August. By late October, caribou moving through the central Brooks Range had reached winter ranges near Bettles and Allakaket.

In the western Brooks Range approximately 5,000 caribou moved into the Mulgrave Hills west of Noatak in early August. In mid-August these animals moved north again to the Cape Beaufort area. By early September large numbers of caribou that had moved west through the mountains from the Colville River and south from the Arctic coast were observed in the Nimiuktuk-Cutler River area. In mid-September these animals moved north of the Brooks Range again. In October the animals moved south again toward winter ranges south of the Kobuk River. The reversed fall movements reported above may be the result of a late dry fall which allowed the animals to utilize northern summer ranges for a longer period than usual. By November caribou had moved south again to winter ranges in the Mulgrave Hills and those south of the Kobuk River.

As reported last winter, some caribou remained between Prudhoe Bay and Barrow and from Wainwright to Cape Beaufort through the winter.

PORCUPINE HERD

Distribution and Movements

The Porcupine caribou herd occupies a remote area of northeastern Alaska and northern Yukon Territory. The human population of the area is sparse and annual caribou harvests are almost insignificant. As a result, only limited information about the population and its pattern of movement has been recorded in the past.

In June 1969, extensive aerial surveys were conducted in order to delineate the calving area. Repeated aerial surveys by Department biologists, oil industry ecologists, and U. S. Fish and Wildlife Service biologists, plus interviews with Indian and Eskimo residents of the area resulted in good information about caribou movements.

Spring 1969

In April and May, caribou moved from winter ranges in Yukon Territory and the south slope of the Brooks Range to the Arctic coast. After moving down the Kongakut, Egaksrak and Aichilik Rivers, they turned west toward the calving area. Calving occurred in late May and early June on the rolling coastal plain between the Aichilik River on the east and the Canning River on the west. At the same time bulls and yearlings were scattered along the foothills of the Arctic slope from the Aichilik River to the Kuparuk River with a few small bands on the coastal plain.

Summer 1969

Shortly after calving, the herd drifted eastward. On 21 June many caribou were observed moving east through the Kavik River area. By 3 July most of the cows, calves and bulls were well into the foothills near the Kongakut River. The region between the Kongakut River and the Peters-Schrader Lake area was essentially void of caribou. Some bulls and yearlings were scattered from the Sagavanirktok River east to the Richardson Mountains, on both the north and south sides of the Brooks Range, all summer. Some caribou of both sexes spent the summer on the Arctic coast of Yukon Territory between Herschel Island and Blow River.

Fall 1969

In September, movement increased. Adult bulls from various portions of the eastern Brooks Range began to move east and north to intercept the female-calf group. No specific routes were used at that time. By October, movement to winter ranges was well in progress as caribou moved south along the headwaters of the Sheenjek and Coleen Rivers in Alaska and the Old Crow River and Fish River-Cache Creek areas of Yukon Territory.

Winter 1969-1970

Four major winter ranges have been used in recent years. In 1969 a portion of the animals that moved down the Sheenjek and Coleen Rivers turned west to winter in the area between Big Lake on the west, Koness Creek on the east, Arctic Village on the north and Venetie on the south. Another group wintered between Chalkyitsik and the headwaters of Black River and from Old Rampart on the north to the extreme headwaters of the Kandik River on the south. The third group wintered from Bell River south throughout the upper drainages of the Porcupine River. The fourth group wintered on the east side of the Richardson Mountains in the Caribou River-Caribou Mountain area.

BEAVER HERD

Distribution and Movements

Winter 1969

In general, caribou were scattered between McGrath on the east, Dishna

River on the west, Cloudy Mountain on the north and upper George River on the south. Areas of fairly intensive use were: Nixon Fork-Takotna River flats, Dishna-Innoko River flats, and the upper George River. A few animals utilized the area between the Kuskokwim River and the Takotna River.

Spring-Summer 1969

Calving occurred in the Beaver Mountain area. By mid-June, cow-calf groups were scattered between Beaver Mountain and Cloudy Mountain. Snow patches were frequented until they melted in late June. Alpine regions are scarce within the range of this herd and the area surrounding them is heavily timbered. Therefore, post-calving dispersal resulted in few observations during the summer.

OTHER HERDS

Distribution and Movements

It has been concluded that caribou found in fall and winter from Rainy Pass northwest to the lower portion of the South and Windy Forks of the Kuskokwim River are part of the Mulchatna herd. Pre-calving surveys found these animals moving south toward the Twin Lakes calving area. The peak of calving occurred on about 16 May, as reported in 1969 by Hemming and Glenn.

The Mentasta herd calved on the west slopes of Mt. Sanford between Boulder Creek and Sanford River. The peak of calving occurred in the last few days of May.

According to local guides, the Chisana herd calved on the bench land along Sheep Creek which flows north from Mt. Sulzer to the White River.

Distribution data from all caribou herds are being summarized for the Job Completion Report that will be finished by 30 June 1970. The inventory of calving areas was completed in June 1969.

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RECOMMENDATIONS

Existing seasons and bag limits should remain the same. However, particular attention should be given to monitoring caribou harvest levels in the Adak and Nelchina caribou herds.

We need a better system of public education to gain increased hunter response and cooperation in our harvest ticket program. Particular attention must be given to improving the efficiency of the harvest ticket data processing program.

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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Robert E. Pegau

Project No.: W-17-1 and W-17-2 Project Title: Big Game Investigations

Job No.: 6 (W-17-1) and 3.3R (W-17-2) Job Title: Caribou Investigations - analysis of range

Period Covered: January 1, 1969 to December 31, 1969

SUMMARY

Several dwarf shrubs that had been grazed at various intensities by reindeer or caribou were re-examined. After one year's growing season, no recovery had occurred on any of the shrubs. Grazing of up to 50% of the plant did not appear to inhibit growth of the remainder of the plant. Grazing intensities of 75 to 100% appear to be fatal to the plants.

The condition and trend score card was field tested by several area biologists. The score card has been modified and is now recommended for use on caribou winter ranges in Alaska.

Two one-acre exclosures were built on the Arctic caribou herd's winter range. Vegetation transects have been established, read and photographed both inside and outside the exclosure.

Some of the more important lichen species were collected at four sites at bi-monthly intervals and analyzed for nutrient content. The Cetraria group had less crude fiber and a higher fat and carbohydrate content than the Cladonia species analyzed. Cetraria cucullata, because of its high palatability, high fat and carbohydrate and low crude fiber content, and ability to withstand heavy grazing pressure, should be one of the lichens given major consideration when evaluating caribou ranges. No differences in nutrient quality from different habitats were detected. Apparently lichens do not exhibit seasonal variation in their nutrient quality as is common for vascular plants.

CONTENTS

BACKGROUND

There are several caribou populations in Alaska. Numerous remote villages are almost totally dependent on wild animals for food, and caribou are often the most heavily utilized animal. A knowledge of the caribou-range relationships will aid in formulating management decisions to maintain healthy populations of caribou in Alaska. Previous range work had been primarily conducted on the Nelchina range on which a review is scheduled for next year. Most of the information included in this report covers a two-year period. The first year was devoted primarily to the development of the score card method which was modified and recommended for use by management biologists on caribou ranges.

OBJECTIVES

To provide basic life history information required for management of Alaska's caribou populations and to test techniques needed in measuring the status, trend, and utilization of caribou and their associated habitat. To determine the caribou-range relationships of the Arctic ranges.

PROCEDURES

Grazed plants were tagged with copper tags and an estimate of the amount of the shrubs grazed was made. After one year's growing season, the plants were reexamined and the effects of grazing recorded. All vegetation sample plots were examined according to the modified Hult-Sernander scale of Hanson (1958). The readings were then tabulated in association tables to allow comparisons between the various sites and with other phytosociological studies in similar Arctic regions. Black-and-white and color photographs were taken of all plots at the two exclosures. Stereo pairs were taken of most plots so that three dimensional records are available for future comparisons.

Four study areas were designated and several species of lichens were collected at each site at bi-monthly intervals and then submitted to a commercial laboratory for analysis of protein, fat, ash, crude fiber, NFE, Ca, and P.

FINDINGS

RECOVERY OF SHRUBS FOLLOWING GRAZING

Several shrub species are utilized by caribou and reindeer during the summer

and winter. Leaves are stripped from their branches from the onset of emergence until mid-August. During the winter, buds and terminal twigs are browsed and some are accidentally broken off by the animals when they are pawing through the snow to obtain forage.

The effects of this use on shrubs have not been extensively studied, but in the Soviet Union, Vakhtina (1964) investigated the recovery of some shrubs following stripping of leaves to simulate browsing.

Several shrub stems that had been grazed by reindeer near Nome, during the winter of 1969, were tagged to enable a reexamination at periodic intervals to determine the effects of grazing on the vigor of the shrubs.

Some shrubs were grazed and then tagged on the 21st of February 1969. These plants were located in a Dryas fell field near the saddle at the head of Wheel Creek, a tributary of the Penny River near Nome. Dryas octopetala forms almost complete mats. Other common subshrubs are crowberry (Empetrum nigrum), narrow-leaved Labrador tea (Ledum decumbens), alpine azalea (Loiseleuria procumbens) and willow(Salix phlebophylla). The important lichens include Alectoria nigricans, Cornicularia divergens, Cetraria nivalis, and Cladonia rangiferina.

At the time of grazing, the snow cover varied from 1" to 15" in depth with the majority being under 3" of snow and ice. Eight narrow-leaved Labrador tea plants that had been grazed from 25-75% were marked. Eight bog blueberry (Vaccinium uliginosum) plants that varied from 10-100% use were also marked.

One of the few instances of grazing of Cassiope tetrangona was noticed at this site. Reexamination of the plants was made in late July 1969. After one season's growth, the bog blueberry plants grazed at the 100% level appeared dead. Those plants grazed at the 75% level had some morbid stems. There was no recovery or resprouting noted on any of the other stems that had been marked.

During April 1969, several shrubs were tagged at two sites near Sunset Creek, seven miles northwest of Nome. The snow cover was complete and most of the feeding craters were from 10-24" deep. The shrubs are in a dwarf shrub-lichen stand with the dwarf shrubs dominating. Bog blueberry, dwarf birch (Betula nana), narrow-leaved Labrador tea, crowberry and alpine azalea are the most abundant subshrubs. Lichens (Cladonia rangiferina, C. arbuscula, C. uncialis, C. gracilis, and Cetraria islandica) occur throughout the stand. There are a few sedges, grasses and forbs interspersed as well. This is the most common and preferred winter range utilized by reindeer on the western Seward Peninsula.

Eleven Salix glauca shrubs were tagged as well as 50 dwarf birch, 12 narrow-leaved Labrador tea and 42 bog blueberry shrubs. These were all reexamined during August 1969, and the only detrimental effects that were noted were on those individual plants that were grazed at 75% or more. There was no indication of recovery on the grazed portions of any of these shrubs following one season of growth. It is likely that the effects of grazing on the shrubs will not become apparent until a few more years of growth has occurred.

One interesting observation in April was that of pregnant reindeer cows which habitually thrashed the taller shrubs, primarily Salix alaxensis and S. pulchra with their antlers. Because the stems were still frozen and very brittle, they were easily broken by the thrashing of the reindeer. I am not certain what function was being carried out by a cow when she was threshing the willows. One group of 32 willows has been marked and was reexamined last year. There was no resprouting noted from any of the broken stems. Several branches of greater than 1/2" in diameter had been broken and these branches appeared to be morbid.

CONDITION AND TREND

The score card for measuring range condition on caribou wintering ranges was tested by several different Department employees on varied ranges. Their suggestions have been incorporated into the new score card. The principal characteristics that are used for determining condition and trend are the composition and cover of the area. The principal forage plants are stressed.

Methods of Using the Score Card

Key wintering areas should be selected during the winter when caribou are on the range. Sites that receive heavy use and sites that appear to be typical of the entire area should be selected for establishment of permanent transects and the use of the condition and trend score card.

Snow and animal-use conditions should be determined during the winter. Special emphasis should be placed on recording of the snow conditions in areas where caribou are grazing the heaviest. Depth of snow and ice crusting are the principal climatic characteristics to be noted.

Permanent transects 1/2 to 1 mile in length should then be established during the summer. These should be on key wintering areas that were located the previous winter. Photographs and notes should be taken of anything that might be of useful reference. The area should be extensively walked over and then the various attributes scored considering the site in its entirety. When scoring any one attribute, the main characteristic should be kept in mind, such as vigor, when trying to determine which of the four choices under lichens, most closely describes the vigor of the lichens on the particular site being scored.

The same area should be reexamined on a 3-5 year cycle, and after a series of condition determinations have been made, a trend will be noted for the vegetation.

Caribou Winter Range Condition and Trend Score Card

	Score
I. Plant Indicators	
A. Vigor	___
1. Lichens	
a. Reindeer lichens (Cladonia alpestris, C. rangiferina, C. arbuscula) robust, living portion over 3 inches long, in dense mats	0

Score

1. Lichens (Continued)
   - b. Reindeer lichens robust, living portion over 2 inches long, mats somewhat interrupted, other fruticose lichens robust. 1
   - c. All lichens scattered, few mats in open areas 4
   - d. Reindeer lichens found only in protected sites, other lichens scattered 6
2. Sedges and Grasses
   - a. Robust, green, numerous seed heads, normally 3-5 plants arising from rhizomes of parent plant 0
   - b. Robust, some yellowing of leaves, seed heads plentiful, at least 2 plants arising from parent plant 1
   - c. Dead leaves about as numerous as green leaves, few seed heads, few rhizomes 3
   - d. Dead tussocks noticeable, rhizomes exposed. 5
3. Shrubs
   - a. All shrubs with numerous leaves, no evidence of morbid stems, young plants plentiful 0
   - b. Shrubs leafy, few morbid stems apparent 1
   - c. Shrubs with several dead branches 3
   - d. Numerous dead shrubs, living shrubs with several dead branches. 5

B. Composition . . . . . ___

1. Lichens
   - a. At least 40% cover by reindeer lichens, other fruticose lichens in small aggregates 0
   - b. At least 20% cover by reindeer lichens, other fruticose lichens abundant. 1
   - c. Lichens mostly the secondary types such as Cladonia gracilis, C. amaurocraea, Cetraria islandica and C. cucullata or similar types. 4
   - d. Lichens, mostly small cup lichens or Thamnolia vermicularis. 6
2. Sedges and Grasses
   - a. Mostly plants with some green shoots in winter, such as Eriophorum vaginatum and Hierochloe alpina. 0
   - b. Mostly single plants with rhizomes. 1
   - c. Mostly coarse plants with little or no green culms in in winter, such as Calamagrostis canadensis, Arctagrostis latifolia 4
3. Shrubs
   - a. Bog blueberry, dwarf birch and green leaf willows (Salix pulchra) abundant and well distributed. 0
   - b. About equal amounts of Labrador tea and crowberry to bog blueberry and dwarf birch; and/or willows in very dense stands. 2
   - c. Labrador tea or crowberry very abundant and/or willows mostly Salix alaxensis. 4
   - d. Shrubs scarce, mostly very low prostrate forms such as crowberry and alpine azalea 5

Score

4. Forbs
   a. Few and scattered 0
   b. Some aggregates 2
   c. Abundant 4

C. Density and Cover . . . . . ___
1. 95% ground cover by lichens and vascular plants, moss mat complete and uniform 0
2. 80% ground cover by lichens and vascular plants, bare ground only on frost boils, etc. 1
3. 60% ground cover by lichens and vascular plants, moss mat broken, some moss pedestals present, numerous patches of bare ground 4
4. Less than 60% ground cover by lichens and vascular plants, most mat thin and spotty, bare ground common 7

D. Use . . . . . ___
1. No use 0
2. Light use of lichens and shrubs 1
3. Moderate use of lichens and sedges, some trampled fragmented lichens 4
4. Rodent burrows and pathways numerous, lichens mostly trampled, heavy use of sedges and shrubs 7

II. Snow and Soil Indicators

A. Snow Cover . . . . . ___
1. Normally less than 3" covering most of the area 0
2. Snow depth normally less than 18" and ice not over 1 1/2" thick 1
3. Snow over 18" deep, usually over 24" deep or ice crust often 1 1/2 - 2 1/2" thick 4
4. Snow always deep during winter, or ice crust over 2 1/2" thick . . . . . Automatic poor rating

B. Soil . . . . . ___
1. Plant litter
   a. No bare ground apparent 0
   b. Common 1
   c. Scarce and patches of bare ground common 3
   d. None, mostly bare ground 5
2. Soil erosion
   a. All soil layers well covered with living material or plant debris, no apparent sheet erosion 0
   b. Some frost boils and active solifluction lobes 2
   c. Numerous frost scars, some shallow gullies 4
   d. Occasional deep gullies, some wind-blown dunes 7

III. Animal Indicators

A. Caribou and Reindeer Condition . . . . . ___
1. Animals in very good condition 0
2. Animals sustaining themselves over winter, but not very fat at end of winter 1
3. Animals continually lose weight on this range, in poor condition at end of winter 4
4. Animals continually dying during winter . . . . . Panic button

		Score
B.	Other Herbivores (usually rodents and hares)	___
	1. Scarce	0
	2. Common	2
	3. Abundant	4
IV.	Interpretation of Total Score	___
	Excellent	Less than 9
	Good	9-15
	Fair	16-25
	Poor	26+

EXCLOSURES IN NORTHWEST ALASKA

In Arctic regions exclosures have been used on a limited basis to determine some of the effects of caribou on the vegetation. The most extensive use of exclosures was by L. J. Palmer on reindeer ranges in the 1920's and '30's. His findings were reported in 1945 (Palmer and Rouse 1945). The Department of Fish and Game has used exclosures on the Nelchina range in southcentral Alaska. Most of these were constructed in the mid '50's and early '60's. Some concern has been expressed about the possibilities of misinterpreting any changes in the vegetation that may occur within these exclosures due to their small size.

Exclosures can be very useful tools to study the influence of caribou grazing and use on vegetation, to determine recovery rates, and to study the successional stages in vegetation which then can be used to more accurately determine range condition and trend on similar ranges.

Exclosures built in 1969

One-acre exclosures were built on two sites where part of the Arctic caribou herd habitually winters. One exclosure is on a small, sandy knoll about 12 miles SSW of Ambler in the Kobuk River valley. The other is near a group of lakes about 10 miles NW of Purcell Mountain near the headwaters of the Selawik River. These were built in late August and early September 1969. Eight-foot steel fence posts were driven into the ground 1 1/4 feet about 15 feet apart. Wooden posts obtained from trees in the vicinity were used for the corners and as strengtheners about every 80 feet along each side of the exclosure.

Five strands of barbed wire, 1 1/4 feet apart for a total height of 6 1/4 feet, were used as the fencing material. The east and west sides are 433 feet long and the north and south sides are 100 feet long.

Vegetation and snow conditions

Ambler

The exclosure near Ambler is located near the edge of an open forest with spruce and birch trees occurring in small scattered stands alternating with small knolls that are covered with dwarf shrub-lichen stands. The vegetation on the knoll on which the exclosure is located is typical of most of the area,

although Cornicularia divergens may be a little more prevalent than on most sites. The lichen mat is extensive and shows evidence of moderate past grazing use. The vegetation mat is thin and bare ground is exposed in several places.

There is a thin layer of organic material on the surface extending from 0 to 4". The rest of the soil was sand to a depth of over 4 1/2 feet and likely much deeper than that. No frozen ground was encountered at this depth in late August. A more complete description of the vegetation is presented with the association tables.

During visits to the area in the winter of 1968 and 1969, snow cover near the exclosure did not exceed 14 inches in depth. Most of the area had a snow covering of only about 2 to 3 inches as the site is completely exposed to the winds.

Selawik

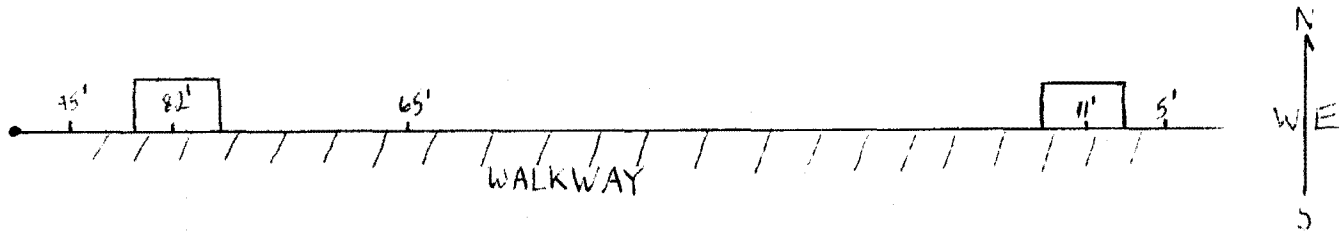
The exclosure in the Upper Selawik drainage is located on a large Eriophorum tussock stand. It is in a relatively low-lying area near the edge of some small foothills. The tussocks are moderately developed with a layer of moss, mostly Sphagnum sp., that fills most of the interspaces. There are some shrubby heaths and lichens as well. The more moist sites are covered almost exclusively with Carex rotundata. Lichens have apparently been heavily grazed in the past as small regrown segments are common, as are the decaying basal portions of several lichens.

The entire area is underlain by permafrost. When the holes were dug in early September, thawed ground only extended to 6-12 inches below the surface.

Snow cover is often from 18-24" deep and is relatively hard because it is compacted by the winds.

Vegetation analysis

Six permanent transects were established inside the exclosure and 10 were established outside. All transects run in an east-west direction with wooden angle stakes placed at the 5, 65, and 95 foot markers of a steel tape. Along each transect, 3.6-square-foot quadrats are centered on the 11, 30, 61, and 82 foot markers as in the diagram below.



All walking was done on the south side of the transects on the opposite side from the quadrats. Each quadrat was read using the modified Hult-Sernander scale as used by Hanson on the Nelchina Basin. The vegetative cover in the plot was recorded according to the following breakdown:

Cover from 3/4 to 4/4 of quadrat = 6
Cover from 1/2 to 3/4 of quadrat = 5
Cover from 1/4 to 1/2 of quadrat = 4
Cover from 1/8 to 1/4 of quadrat = 3
Cover from 1/16 to 1/8 of quadrat = 2
Cover less than 1/16 = 1

Each quadrat was also photographed in both black-and-white and color. Stereo photos were taken of each plot by using a large tripod with a rotating arm.

The black-and-white photos were enlarged to 5 x 7" and the color prints are the standard 3 1/2 x 5". It appears that the color prints are superior both for identifying species and for reading the stereo photos. The cost of enlarging color prints that would be required for greater clarity is comparable to the cost of enlarging all of the black-and-white photos.

Association tables (Tables 1 through 6) were tabulated for each group of transects as an aid in further describing the vegetation. The readings from the four quadrats on each transect were combined to facilitate presentation of the data. Total cover, cover by species, and frequency are presented in each table.

The degree of difference of the vegetation at the two exclosure sites can be readily noted from the association tables. The Ambler exclosure is on a luxuriant stand of lichens with a wide diversity of species whereas the Selawik exclosure has a restricted number of species and they are not nearly so luxuriant.

It was interesting to note the dominance of Cladonia alpestris and Cetraria nivalis at the Ambler site although it has been regularly grazed in the winter. These species are normally the most susceptible to grazing pressure on reindeer ranges of the Seward Peninsula.

Cetraria cucullata seems to be the species most able to withstand continual use as exemplified by the Selawik exclosure.

Plans for the future

These exclosures are two of the largest on tundra ranges in Alaska and they are the only ones in which barbed wire has been used. They will be periodically examined to ensure that they are functioning properly.

The quadrats should be reexamined and photographed at 3-year intervals. The photographs can then be closely examined and any changes of the individual plants should be detectable.

Table 1. Inside of Ambler exclosure. Six transects, 24 quadrats. August 28, 1969.

Species	1	2	3	4	5	6	Ave. Species Comp.	Freq. %	Found in number of quadrats
Total cover	80	95	85	90	87	86			
Hierochloe alpina	1.5	1.7	0.7	1.2	0.2	1.0	1.1	58	14
Carex lugens	0.2	-	-	0.2	-	0.2	t	13	3
Betula nana	1.7	2.0	0.5	0.7	1.2	0.5	1.1	54	13
Empetrum nigrum	0.7	-	2.0	2.2	1.5	2.0	1.4	67	16
Ledum decumbens	1.0	1.0	1.7	2.0	1.5	1.2	1.4	83	20
Loiseleuria procumbens	1.2	1.2	2.7	2.2	1.0	2.7	1.8	83	20
Vaccinium vitis-idaea	0.2	1.0	0.2	0.2	-	-	.3	25	6
Vaccinium uliginosum	-	-	0.5	0.5	-	0.2	t	17	4
Arctostaphylos alpina	0.2	0.2	-	0.7	-	0.2	t	31	5
Salix phlebophylla	-	-	-	0.5	-	0.2	t	13	3
Pedicularis Kanei	0.5	0.2	0.7	1.0	0.2	0.2	.5	42	10
Unidentified forb	0.2	-	-	-	0.5	-	t	13	3
Lobaria linita	-	-	0.2	-	-	-	t	4	1
Stereocaulon	2.2	2.5	1.7	0.7	1.2	0.5	1.5	79	19
Asahinea chrysantha	-	-	-	0.2	-	-	t	4	1
Cornicularia divergens	1.7	2.5	2.5	1.5	3.2	3.7	2.5	96	23
Sphaerophorus globosus	-	-	-	-	0.7	0.2	t	13	3
Peltigera	-	0.7	0.2	-	-	-	t	8	2
Thamnolia vermicularis	-	-	-	0.2	0.5	0.5	t	21	5
Dactylina arctica	-	-	0.2	-	-	-	t	4	1
Cetraria nivalis	1.7	2.2	1.7	2.0	2.0	2.5	2.0	88	21
C. cucullata	1.5	2.0	0.5	2.0	1.5	0.7	1.3	79	19
C. nigricans	0.5	-	-	0.2	0.5	-	t	21	5
C. islandica	0.5	-	-	-	-	-	t	8	2
C. kamczatica	0.5	-	0.2	0.5	-	-	t	21	5
C. laevigata	0.2	1.0	0.7	0.5	0.5	0.2	.5	50	12
C. new species	-	-	-	0.2	-	-	t	4	1

Table 1 (Con't.). Inside of Ambler exclosure. Six transects, 24 quadrats. August 28, 1969.

Species	1	2	3	4	5	6	Ave. Species Comp.	Freq. %	Found in number of quadrats
Cladonia rangiferina	1.7	1.7	1.5	1.5	1.0	1.2	1.4	92	22
C. arbuscula	1.5	1.7	1.2	2.0	1.5	1.7	1.6	92	22
C. alpestris	1.5	1.5	1.2	1.0	0.2	0.7	1.0	71	17
C. uncialis	0.2	0.5	1.5	1.5	1.7	0.7	1.0	67	16
C. cup	0.5	0.2	0.2	-	0.5	-	t	21	5
C. amaurocraea	0.5	0.2	-	0.2	-	-	t	17	4
C. coccifera	0.5	0.2	-	-	-	-	t	13	3
C. gonecha	0.2	-	-	-	-	-	t	4	1
C. malchea	0.2	-	-	-	-	-	t	4	1
C. boryi	0.5	0.2	1.2	1.2	0.2	1.0	.7	50	12
C. gracilis	-	0.2	-	-	-	0.2	t	8	2
C. crispata	-	0.2	-	-	-	-	t	4	1
C. verticillata	-	0.2	-	-	-	-	t	4	1
C. pyxidata	-	-	0.2	-	0.2	-	t	8	2
Alectoria ochroleuca	0.2	0.5	-	0.5	0.2	1.0	.4	40	10
A. chalybeiformis	-	-	-	0.7	0.2	-	t	17	4
A. nigricans	0.7	1.2	1.0	1.5	-	-	.7	54	13

Table 2. Outside, adjacent to Ambler exclosure. Six transects, 24 quadrats. August 29, 1969.

Species	1	2	3	4	5	6	Ave. Species Comp.	Freq. %	Found in number of quadrats
Total cover	100	100	97	88	92	96	-	-	-
Hierochloe alpina	0.2	0.5	-	0.5	0.7	0.2	.4	38	9
Carex lugens	0.2	1.0	0.5	0.2	-	0.5	.4	29	7
Festuca altaica	0.2	-	0.2	-	-	-	t	8	2
Betula nana	0.2	0.2	1.5	1.2	1.0	1.0	.9	54	13
Empetrum nigrum	1.0	-	0.5	0.7	1.7	1.2	.9	46	11
Ledum decumbens	2.5	2.7	2.5	1.7	2.0	1.2	2.1	96	23
Loiseleuria procumbens	3.2	0.7	1.5	0.7	2.2	2.0	1.7	79	19
Vaccinium vitis-idaea	1.0	1.4	1.0	0.5	0.2	0.5	.8	63	15
Vaccinium uliginosum	-	2.2	0.7	-	0.5	0.7	.7	38	9
Arctostaphylos alpina	-	0.7	1.0	0.2	0.7	0.7	.6	33	8
Salix arctica	-	-	0.5	0.2	-	-	t	13	3
Pedicularis Kanei	-	-	-	0.2	0.5	0.2	t	17	4
Unidentified forb	-	-	-	0.5	0.2	-	t	13	3
Stereocaulon	1.7	0.5	1.7	1.7	1.7	1.2	1.4	79	19
Cornicularia divergens	0.7	0.5	0.5	1.7	1.7	2.2	1.2	67	16
Sphaerophorus globosus	-	-	-	-	0.2	0.5	t	13	3
Thamnolia vermicularis	0.2	-	-	-	-	0.2	t	8	2
Nephroma arctica	-	-	-	-	-	0.7	t	4	1
Cetraria nivalis	1.7	1.0	1.0	1.5	2.0	1.0	1.4	92	22
C. cucullata	2.5	2.5	2.5	2.0	1.2	2.0	2.1	92	22
C. nigricans	-	-	0.5	-	1.0	-	t	17	4
C. islandica	0.2	-	0.2	0.5	0.2	-	t	21	5
C. kamczatica	-	-	-	-	-	-	-	-	-
C. laevigata	1.0	1.5	1.0	0.5	0.5	0.2	.8	67	16

Table 2 (Con't.). Outside, adjacent to Ambler exclosure. Six transects, 24 quadrats. August 29, 1969.

Species	1	2	3	4	5	6	Ave. Species Comp.	Freq. %	Found in number of quadrats
Cladonia rangiferina	2.5	3.0	2.0	1.5	0.7	1.2	1.8	92	22
C. arbuscula	2.0	2.7	2.0	2.0	1.7	2.0	1.9	100	24
C. alpestris	3.0	3.5	1.5	1.0	1.5	2.0	2.1	88	21
C. uncialis	0.7	1.0	1.2	1.5	1.5	1.2	1.2	92	22
C. cup	0.2	-	-	0.5	0.2	-	t	17	4
C. amaurocraea	0.2	-	-	-	-	-	t	4	1
C. coccifera	-	-	-	0.2	-	-	t	4	1
C. boryi	1.2	1.5	0.5	1.7	0.7	0.5	1.0	54	13
C. crispata	0.2	0.2	-	-	-	-	t	8	2
Alectoria ochroleuca	1.0	-	-	0.7	0.5	0.7	.5	46	11
A. chalybeiformis	-	0.2	1.0	1.7	2.0	1.2	1.0	46	11
A. nigricans	0.2	0.5	0.7	0.5	0.2	0.5	.4	33	8

Table 3. About 1/4 mile south of Ambler exclosure. Four transects, 16 quadrats. August 29, 1969.

Species	7	8	9	10	Ave. Species Comp.	Freq. %	Found in number of quadrats
Total cover	98	92	88	95	-	-	-
Hierochloe alpina	0.2	-	0.7	0.5	.3	31	5
Carex lugens	1.0	0.7	0.5	0.7	.7	69	11
Betula nana	-	0.7	-	-	t	13	2
Empetrum nigrum	1.7	0.7	2.0	1.0	1.4	69	11
Ledum decumbens	2.0	1.2	1.5	1.5	1.6	94	15
Loiseleuria procumbens	2.5	0.7	2.2	0.7	1.4	75	12
Vaccinium vitis-idaea	0.7	1.2	1.0	1.2	1.0	75	12
Vaccinium uliginosum	-	1.2	0.5	1.2	.7	50	8
Arctostaphylos alpina	-	0.7	-	-	t	13	2
Pedicularis Kanei	0.2	-	0.5	0.5	.3	31	5
Unidentified forb	-	-	0.2	-	t	6	1
Stereocaulon	0.5	0.2	0.5	1.5	.5	50	8
Cornicularia divergens	2.2	1.7	1.7	1.5	1.2	81	13
Thamnolia vermicularis	-	-	0.2	-	t	6	1
Cetraria nivalis	2.0	0.7	1.2	0.7	1.2	75	12
C. cucullata	1.2	1.5	0.5	1.2	1.1	81	13
C. nigricans	0.2	0.2	0.2	0.2	.2	25	4
C. islandica	0.2	0.5	0.2	-	.2	25	4
C. kamczatica	-	-	0.2	0.2	t	13	2
C. laevigata	0.5	1.0	0.7	0.7	.7	75	12

Table 3 (Con't.). About 1/4 mile south of Ambler exclosure. Four transects, 16 quadrats. August 29, 1969.

Species	7	8	9	10	Ave. Species Comp.	Freq. %	Found in number of quadrats
Cladonia rangiferina	2.2	2.7	2.0	2.0	2.2	100	16
C. arbuscula	1.5	2.2	1.5	0.7	1.5	88	14
C. alpestris	2.0	1.5	1.7	1.2	1.6	88	14
C. uncialis	1.0	1.5	1.5	1.2	1.3	88	14
C. cup	0.2	0.2	-	-	t	13	2
C. coccifera	-	0.2	-	-	t	13	2
C. boryi	1.7	2.0	1.2	0.7	1.4	94	15
C. crispata	0.2	0.2	-	0.5	t	25	4
Alectoria ochroleuca	0.7	0.2	0.7	-	t	25	4
A. chalybeiformis	-	-	-	0.7	t	13	2
A. nigricans	-	-	0.2	0.2	t	13	2

Table 4. Inside of Selawik exclosure. Six transects, 24 quadrats. September 4, 1969.

Species	1	2	3	4	5	6	Ave. Species Comp.	Freq. %	Found in number of quadrats
Total cover	100	100	99	98	96	100	-	-	-
Eriophorum vaginatum	3.5	3.5	3.2	3.2	1.7	1.5	2.8	88	21
Carex rotundata	-	-	-	1.2	1.7	3.0	1.0	29	7
Betula nana	1.7	2.0	1.2	1.5	1.2	0.7	1.4	75	18
Ledum decumbens	3.2	3.7	4.0	2.7	2.7	1.2	2.9	83	20
Vaccinium vitis-idaea	2.5	2.0	2.2	1.2	0.2	0.7	1.5	75	18
Vaccinium uliginosum	0.7	0.7	1.2	1.5	1.2	0.5	1.0	58	14
Arctostaphylos alpina	-	-	-	1.0	-	-	t	4	1
Andromeda polifolia	-	-	-	0.5	1.0	0.7	t	-	5
Rubus chamaemorus	1.0	1.0	0.7	0.7	0.5	0.2	.7	21	17
Cetraria cucullata	2.0	2.7	2.0	1.5	1.7	1.0	1.8	83	20
C. islandica	0.7	1.0	1.0	0.5	1.2	0.7	.9	79	19
C. nivalis	-	0.2	-	0.2	0.7	0.2	t	21	5
C. nigricans	-	-	-	-	0.2	-	t	4	1
Cladonia rangiferina	1.5	2.2	2.2	1.2	3.2	1.2	1.9	79	19
C. arbuscula	1.0	1.7	1.5	0.5	1.5	0.7	1.2	79	19
C. uncialis	0.5	-	0.2	-	0.7	0.2	t	25	6
C. alpestris	-	0.2	-	0.2	0.2	-	t	13	3
C. crispata	-	-	-	0.2	-	-	t	4	1
C. amaurocraea	-	-	-	-	-	0.5	t	8	2
C. coccifera	-	-	-	-	-	0.2	t	4	1
C. cornuta	-	-	-	-	-	0.2	t	4	1
C. gracilis	-	-	-	-	-	0.2	t	4	1
C. small cup	-	-	-	-	-	0.2	t	4	1

Table 5. Outside, adjacent to Selawik exclosure. Six transects, 24 quadrats. September 5, 1969.

Species	7	8	9	10	Ave. Species Comp.	Freq. %	Found in number of quadrats
Total cover	100	100	100	100	-	-	-
Eriophorum vaginatum	3.5	2.5	3.0	3.2	3.1	94	15
Carex rotundata	0.2	-	-	-	t	6	1
Carex lugens	1.0	1.5	2.0	1.0	1.4	63	10
Betula nana	-	2.0	0.2	1.0	.8	38	6
Ledum decumbens	1.7	4.0	4.2	4.0	3.5	100	16
Vaccinium vitis-idaea	1.5	1.5	3.0	2.7	2.2	100	16
Vaccinium uliginosum	2.2	0.5	1.2	1.0	1.2	44	7
Empetrum nigrum	0.2	-	-	-	t	6	1
Andromeda polifolia	0.7	-	-	-	t	13	2
Arctostaphylos alpina	-	-	-	0.5	t	6	1
Rubus chamaemorus	1.0	0.7	1.5	1.2	1.1	94	15
Cetraria cucullata	2.0	2.7	2.7	3.0	2.6	100	16
C. islandica	1.0	1.5	1.0	1.5	1.3	94	15
C. nivalis	-	-	-	0.2	t	6	1
C. laevigata	-	0.2	-	-	t	6	1
Cladonia rangiferina	2.7	1.7	1.7	2.2	2.1	100	16
C. arbuscula	1.2	1.7	1.5	1.5	1.5	100	16
C. uncialis	-	-	-	0.5	t	13	2
C. alpestris	-	0.2	0.2	-	t	13	2
C. amaurocraea	0.2	0.2	-	-	t	13	2
C. gracilis	-	-	0.2	-	t	6	1
Peltigera aphthosa	-	0.2	-	-	t	6	1

Table 6. About 100 yards north of Selawik exclosure. Four transects, 16 quadrats. September 5, 1969.

Species	1	2	3	4	5	6	Ave Species Comp.	Freq. %	Found in number of quadrats
Total cover	95	100	99	98	96	99	98	-	-
Eriophorum vaginatum	3.0	3.2	4.0	3.5	3.0	2.7	3.2	92	22
Carex rotundata	-	-	-	-	1.2	-	t	8	2
Carex lugens	-	0.2	-	0.5	0.2	-	t	13	3
Betula nana	1.0	0.5	2.2	1.0	1.0	2.0	1.3	71	17
Ledum decumbens	4.0	3.0	3.7	4.2	2.7	3.2	3.5	100	24
Vaccinium vitis-idaea	1.7	2.2	2.2	1.5	1.2	1.5	1.7	92	22
Vaccinium uliginosum	1.0	2.5	1.0	0.7	1.0	0.7	1.6	58	14
Empetrum nigrum	1.0	1.5	0.5	0.2	-	-	.5	25	6
Oxycoccus microcarpus	-	0.2	-	-	-	-	t	4	1
Andromeda polifolia	-	-	-	-	0.7	-	t	8	2
Arctostaphylos alpina	-	-	-	-	-	0.2	t	4	1
Rubus chamaemorus	0.2	1.0	0.5	1.2	1.2	0.2	.7	54	13
Cetraria cucullata	2.7	2.5	2.7	2.5	1.7	2.7	2.5	100	24
C. islandica	1.2	1.2	0.7	1.0	0.7	1.0	1.0	83	20
C. nivalis	0.2	-	-	0.5	-	0.2	t	17	4
Cladonia rangiferina	2.5	1.7	1.7	2.7	1.2	2.2	2.0	96	23
C. arbuscula	2.0	1.5	1.5	2.2	0.7	1.5	1.6	96	23
C. uncialis	-	0.2	-	-	0.2	1.0	t	25	6
C. alpestris	-	0.2	0.2	0.7	-	-	t	25	6
C. amaurocraea	-	-	0.2	-	0.2	-	t	8	2
C. cup	-	-	0.5	-	0.2	-	t	-	3
C. cornuta	-	-	-	0.2	-	-	t	-	-
C. verticillata	-	-	-	-	0.2	-	t	4	1
C. gracilis	-	-	-	-	0.2	-	t	4	1
C. boryi	-	-	-	-	-	0.2	t	4	1

CHEMICAL COMPOSITION OF LICHENS IN RELATION TO SITE AND TIME OF YEAR

The physiology of lichens is not entirely understood. There has been little effort exerted in trying to determine if the quality of lichens change throughout the year or in relation to the environment. Vascular plants show a marked seasonal variation in their nutrient quality. Normally the peak of quality is reached during rapid growth when the plants are young and the leafy material is succulent. To try to determine if lichens also varied throughout the year, collections were made of some of the important forage species at bimonthly intervals from four locations.

Location of the Four Collecting Sites

Beltz

The Beltz site is located approximately four miles northwest of Nome. It is on a large Eriophorum-Carex dwarf-shrub meadow near Anvil Creek. The area is level with an elevation of 50 to 75 ft. and is typical of the large coastal plain that extends for almost 17 square miles between Nome and Cripple River.

Snake River

The Snake River site is on a large sandy hummock typical of those occurring adjacent to some rivers. It is about 7 miles northwest from Nome and its elevation is between 10 and 25 feet. The low-lying ground around the hummocks is often flooded during freeze-up and ice from 6 inches to 1 1/2 feet deep often covers the area. The hummocks stand 10 to 15 feet higher than the surrounding flood plain and are never flooded. Vegetation on the hummocks is very luxuriant.

Cabin Rock No. 1

Cabin Rock No. 1 site is in the foothills west of the Penny River, about 14 miles west of Nome. It is located on the top of a level, rounded ridge at an elevation of 750 feet. This site is covered by Dryas fell fields and is exposed to the winds with some accumulation of snow on the southwest facing slopes.

Cabin Rock No. 2

Cabin Rock No. 2 site is located about 1/2 mile southwest of Cabin Rock No. 1 on the southwest facing slope of the foothill. It is covered by a typical dwarf-shrub lichen type. The elevation of this site is about 350 feet.

CLIMATE

Unfortunately, the only available meteorological instrumentation is located at the airport in Nome. The airport is in the southeastern end of the coastal plain on which the Beltz site is located. Weather conditions at the Beltz site are probably similar to those recorded at Nome, but microclimatic differences are not known as instrumentation for the sites was not available.

It is certain that weather conditions on the two sites west of Penny River are somewhat different because this area is in the foothills. A general description

of the climate in Nome is included for comparative purposes to other areas (Tables 7 and 8).

Nome has a maritime climate when the Bering Sea is free of ice; usually early June to about the middle of November. During these months there are extended periods of cloudiness, fog, and rain due to storms moving up through the Bering Sea. During summer the temperature range is very narrow and precipitation is highest with prevailing winds from the southwest coming in from the Bering Sea so that cloudy, moist days are common (Table 7).

Andreev (1954) indicates that lichens grow best during periods when they are moist. Lichen growth rates at coastal stations on the Seward Peninsula (Pegau 1968a) tend to be greater than for similar continental areas (Scotter 1963, 1964; Andreev, 1954).

The freezing of the Bering Sea in November causes a change from a maritime to a more continental climate as there is no longer any moderating influence from the Bering Sea. Temperatures generally remain below freezing from mid-November to the latter part of April. Snow normally starts to accumulate on the ground in the first part of November with increasing depths up through early March. Then, with the longer daylight and more moderate temperatures, snow is sublimated and decreases rapidly during April and May. Snow cover is generally gone by early June except for the area on the sides of hills or solifluction lobes, stream beds, etc., in which accumulation occurred through the winter. On some of these sites, there will be snow through September and occasionally a particular site will not become snow-free throughout the year.

At Nome, latitude 64° 30', approximately 62% of the year is a combination of sunlight and twilight with almost continual sunlight, twilight during the summer (Johnson and Hartman, 1969). Direct sunlight occurs approximately 51% of the year. The one disadvantage of northern latitudes is that the sun is never directly overhead so that the sunshine strikes the earth at an oblique angle. At Nome the highest angle that the sun can reach is approximately 48°. Therefore, the energy received on the ground surface is less than if the sun were directly overhead. Consequently, radiation intensity is lower than at lower latitudes.

SNOW AND WEATHER

Since there was no remote meterological instrumentation available at each collecting site, some general observations were made and are presented here.

Beltz

The weather at the Beltz collecting site is probably almost identical to that recorded for the Nome station. It lies on the same flat coastal plain as the Nome station and it is probably safe to compare the data directly. Some observations were made on accumulation of snow at various times. The first snowfall that accumulated to any amount occurred in October. Most of it was blown between the tussocks. The tops of all the hummocks and tussocks

were still exposed. In November, the snow depth was about 1" with very little ice on the vegetation. There were still several exposed hummocks and tussocks throughout. In January, there was between 1 to 3" of snow over the entire area and there were just a few exposed hummocks and tussocks. The snow was hard and formed ice crust over the vegetation. In March, the snow was 6-8" in depth with very few exposed sites. The snow was very dense, as it was constantly blown by the wind, and there was an ice layer about 1 1/2" deep about 2" from the bottom. The density of the ice and snow was measured with a snow hardness gauge. The surface measured 4,000 grams per cm^2 to break through the surface layer. The ice layer was harder than the 10,000 grams per cm^2 which the gauge could register. This ice layer generally had a layer of granular snow underneath which would be sufficient to create an air pocket so that when the ice was struck with some force it would break. It did not present any problems to reindeer grazing as they were observed feeding in these areas and pawing through an ice layer of 1" to 1 1/2" thick. In April, the snow was melting rapidly in some spots and patches of exposed ground became apparent. By mid May almost all of the snow was gone except between the tussocks.

Snake River

In November, the snow was 8" deep at the Snake River collecting site with no ice. In January, it was 24" deep, very soft, and there was a small amount of ice on the vegetative mat. In March, due to the constant winds, the snow had accumulated to some depth because of the willows and other shrubs in the area that tended to break the wind and cause the snow to accumulate. The snow just below the surface was very granular and the surface hardness was 80 grams per cm^2. The granular portion below the surface varied between 30 and 50 grams per cm^2. Snow accumulation in March ranged from 24-52". There was a small amount of ice less than 1/2" thick on some of the vegetative mat, but it was not extensive nor difficult to break.

Cabin Rock No. 1

This site is exposed and wind-blown. The snow is compact, but does not accumulate to too great a depth. In November it was 4" deep. In January, 11" which was very hard-packed with about 1" of ice on top of the vegetation. In March the accumulation was 8" with the average hardness being 7,000 grams per cm^2. There was ice 1 1/2-2" in depth which the pressure gauge could not measure. Where this occurred on flat surfaces, it was extremely difficult to break and very likely reindeer and caribou would be unable to paw through it. But, as in all the sites, there was an accumulation of granular snow which had compacted leaving an air space between the snow and the bottom of the ice which allowed the ice to be broken fairly easily when struck with the heel of a boot. In some instances where reindeer were observed feeding, they would break through this ice layer. In observations of similar situations as this site, reindeer have been able to paw through or break ice layers up to 2" in depth.

Table 7. Average annual meteorological data at Nome, Alaska.

Month	Precipitation		Wind		Relative Humidity	Mean Number of Days			
						Sunrise to Sunset			
	Normal Total	Snow, Sleet Mean Total	Mean Speed	Prevailing Direction	Mean	Clear	Partly Cloudy	Cloudy	Precipitation .01 inch or more
Jan	1.02	9.8	12.1	E	78	8	6	17	11
Feb	0.94	6.1	11.6	NE	74	11	3	14	9
Mar	0.88	8.2	10.7	E	77	10	5	16	11
Apr	0.80	7.1	11.0	N	75	8	6	16	10
May	0.69	1.8	10.5	N	70	7	7	17	8
Jun	0.93	0.1	10.1	WSW	65	5	9	16	8
Jul	2.29	0.0	10.1	WSW	72	3	6	22	13
Aug	3.80	T	11.0	SW	77	2	6	23	16
Sep	2.67	0.5	11.6	N	62	4	6	20	13
Oct	1.71	4.5	11.5	N	68	6	6	19	10
Nov	1.16	8.8	12.2	N	63	6	5	19	12
Dec	0.99	7.7	10.2	E	68	10	4	17	9
Yr	17.88	54.6	11.0	N	70	80	69	216	130

Table 8. Meteorological data from July 1968 - June 1969, Nome, Alaska.

Month	Precipitation		Wind	Relative Humidity	Number of Days			
		Snow, Sleet			Sunrise to Sunset			
	Total	Total	Mean Speed	Mean	Clear	Partly Cloudy	Cloudy	Precipitation .01 inch or more
Jul	1.65	0.0	9.1	65	5	8	18	13
Aug	2.59	0.0	8.6	67	3	6	22	14
Sep	0.39	0.4	9.2	60	6	10	14	8
Oct	1.68	8.5	11.9	71	5	5	21	22
Nov	0.61	7.9	10.5	61	7	4	19	9
Dec	0.40	4.0	7.7	71	12	2	17	9
Jan	0.55	5.5	14.3	83	2	4	25	18
Feb	0.32	4.2	12.9	78	10	4	14	12
Mar	0.24	5.0	10.0	78	9	3	19	9
Apr	0.02	0.2	7.6	73	6	9	15	1
May	0.44	0.4	11.2	57	7	13	11	5
Jun	0.87	0.0	10.6	71	2	4	24	10

Cabin Rock No. 2

This site is on a southwest facing slope and the snow tends to accumulate throughout the winter on the site because the prevailing winds are from the northeast. In November the snow was 12" in depth with no icing. In January it had increased to 26" and was soft with a somewhat harder surface from the constant wind action and there was some ice on the vegetation. In March the snow was very deep, ranging from 32 to 64" in depth, with an average overall depth of 53". The surface hardness was 400 grams per cm^2. Then, from one foot and lower, the snow was again very granular and seldom exceeded 500 grams per cm^2. There were no signs of reindeer use in this area as the snow was much deeper than they characteristically paw through on the Seward Peninsula. In May, there was still an average depth of 33" of snow and it was not completely gone until July 7. An interesting aspect of the vegetation was noted during the March collection of the lichen samples. At the Cabin Rock No. 2 site, which had the deepest accumulation of snow, there were several of the evergreen plants that were once again becoming very green after being the typical light reddish color that they become during the winter. Alpine azalea was very striking in the bright green color of its leaves. Crowberry still had some reddish color, but most had turned green. Cranberry was mostly reddish color. Festuca altaica and Carex bigellowii had green shoots of 1 1/2-2" in length. In contrast, at the Cabin Rock No. 1 site where the snow was much less deep, there was very little indication of the plants turning green. Almost all still had the reddish color. The Snake River site, which was also under very deep snow, was very similar to Cabin Rock No. 2 with several green plants. The Beltz site, with small amounts of snow, had just a few of the plants turning green. One possible explanation for this might be in the amount of solar radiation reaching the different sites. The snow at Snake and Cabin Rock No. 2 is very granular and possibly radiation could penetrate to these depths. Solar radiation is higher during February and March for vertical surfaces facing south than for horizontal surfaces. Both Cabin Rock No. 2 and the Snake River collecting sites face south as compared to the horizontal Cabin Rock No. 1 and Beltz sites. For a horizontal surface at about 64° latitude during February, the solar radiation would be approximately 170 BTU/ft^2. In March it would be approximately 1,050 BTU/ft^2. On the other hand the sites at Cabin Rock No. 2 and south facing sites of the Snake River hummocks, would receive approximately 1,000 BTU/ft^2 in February and 2,200 BTU/ft^2 in March (Johnson and Hartman, 1969). It will require further investigation and instrumentation to determine if radiation can, in fact, penetrate up to 64" of snow, when the snow is granular such as at both the Snake River and Cabin Rock No. 2 sites.

SOILS

A soil survey was conducted in Nome during 1966 (Hinton and Girdner, 1966) that included two of the sites and also areas typical of the two Cabin Rock sites. Most of the following information on soils is taken from this soil survey by Hinton and Girdner (1966).

Beltz

The large coastal plain on which the Beltz site is located slopes gently seaward from the adjacent hills to the north. It is underlain by deposits laid

down in part by ocean currents and in part by streams. These consist of silt, interstratified fine sand and well-rounded gravels. This plain is also mantled with silty loessial deposits ranging from a few inches to several feet in depth. Most of the area is underlain by permafrost up to several hundred feet deep. The soil is a Kuskokwim silt loam. The Kuskokwim series of soils consists of poorly drained silty soils with thick surface mats of organic materials. The soils are perennially frozen near the base of the organic mat. This is the principal soil of the Nome coastal plain. Frost phenomena, including frost boils, frost mound, and peat ridges, are common. The soil above the permafrost is always saturated.

Snake River

The Snake River collection site is located on a hummock in the flood plain of the Snake River and is classified as being in the Sinuk-Ba Association. The collecting site is probably on a Ba soil, but since they were of slight extent, these soils were not separated from the Sinuk type in the soil survey. This area is very level with moderately well-drained soils in stratified silty and sandy alluvium. Large sandy hummocks occur on which characteristically the Ba soil is more than 40 inches deep to a gravelly substratum. During the summer the frozen ground thaws to a depth in excess of 5 feet.

Cabin Rock No. 1

The soil survey did not extend as far west as these two sites, but they are quite typical of the foothills west of the Snake River. Soils are of the Aniak-Pe Association. These soils are excessively drained, very flaggy and gravelly, and are on steep slopes and high ridges. The Aniak soils overlay a micaceous schist and are very acid. The Pe soils are calcareous. Grayish colored limestone on the surface helps distinguish the Pe from the Aniak soils. Fifty to seventy-five percent of the surface of these soils is covered by flagstones and gravel. These soils have thick dark brown surface layers grading to olive at depths of about 12". Shattered bedrock occurs at depths of less than 20". The soils are highly frost scarred with frost boils, stone nets, and active solifluction lobes.

Cabin Rock No. 2

This site is similar to the side slopes of the hills west of Nome, and the soil is typically the Nome-Fd association. The Nome series consists of slightly drained gravelly soils with perennially frozen substrata. A typical profile has a thin surface mat of decomposing plant litter overlaying mottled darker gray and olive gravelly silt loan C horizons. The perennially frozen substratum ranges 15 to 30" from the surface. The Fd series consists of well to excessively drained, very flaggy, shallow soils on moderately steep to steep slopes on the hills north of Nome. Flagstones and gravels are quite common, and frost scars occur throughout the area. The steep slopes are especially affected by solifluction. The typical profile has a thin surface plant litter overlay, very flaggy silt loam which grades to shattered schist bedrock at depths of about 20". The Nome Fd association is a mixture of these two soils which cannot be conveniently mapped separately.

VEGETATION

Beltz

The Beltz site is covered primarily by an Eriophorum-Carex dwarf-shrub meadow with some stands of Eriophorum tussocks. It is wide-spread and covers almost the entire coastal plain near Nome. The collecting site is on the dry subtype which occurs away from the edges of ponds and streams, and the plants are not as green and robust as in the wet subtype. This site is underlain with a dense moss (Sphagnum) layer. The principal plants are Carex aquatilis, C. rotundata, Eriophorum angustifolium, E. vaginatum, and E. scheuchzeri. The shrubs include bog blueberry, crowberry, narrow-leaved Labrador tea, dwarf birch, and cranberry. There are a few forbs on the site, but they are uncommon. Lichens occur throughout, especially on small moss hummocks and in between some of the tussocks. The principal lichens include Cladonia rangiferina, C. arbuscula, C. mitis, Cetraria islandica, and C. cucullata. Cladonia amaurocraea often occurs in the most wind-blown exposed sites on the tops of tussocks. Table 9 more fully describes the vegetation located on the Beltz site. Reindeer utilize this area primarily during the summer; feeding on the sedges and willows.

Snake River

The vegetation on the Snake River site is a very heterogeneous type as there are several microenvironments. Primarily, on the large hummock where collection of the lichens was done, a mixture of forbs, dwarf shrubs and lichens dominate. The Snake River runs adjacent to this site and extensive stands of willow occur throughout, primarily Salix alaxensis with S. pulchra, and S. glauca occurring on the outer fringes with S. hastata. Lichens on these mounds are some of the most robust lichens encountered anywhere in the area as can be seen from the production figures, Table 10. The primary use of this site is in the summer and in the early winter before the snow accumulates to too great of a depth. The lichens are grazed in the summer when they are moist.

Cabin Rock No. 1

This site is a typical Dryas fell field in which Dryas octopetala dominates. In some sites D. integrifolia also occurs. The Dryas mats are interrupted by large rocky strips. Salix phlebophylla, crowberry, narrow-leaved Labrador tea, alpine azalea, and Diapensia lapponica are other common subshrubs. The forbs, Luzula confusa, Tofieldia pusilla, Campanula lasiocarpa, Oxytropis nigrescens, Pedicularis lanata, Antennaria alaskana, and grasses, (Agrostis borealis and Hierochloe alpina) occur scattered throughout. The most common lichens are Alectoria nigricans, A. ochroleuca, Cornicularia divergens Cetraria nivalis, Cladonia rangiferina, and Thamnolia vermicularis. Table 11 presents a more complete description of the vegetation. These sites are commonly used in the winter because snow accumulation is slight.

Cabin Rock No. 2

This site is covered with typical dwarf shrub-lichen type that occurs on the slopes of the foothills in the vicinity. The Cabin Rock No. 2 site has a deeper accumulation of snow than several of the other similar areas since it lies on the leeward side of the prevailing winds. The dwarf shrubs are abundant

Table 9. Cover in 10 quadrats and estimated weight at the Beltz site.

Species	1	2	3	4	5	6	7	8	9	10	Ave. Spec. Comp.	Freq. %	Average Estimated Weight lb/acre
TOTAL COVER	85	90	100	65	85	75	90	95	95	80	-	-	1,980
Eriophorum vaginatum	4	-	-	-	-	-	-	-	-	-	.4	10	26
E. angustifolium			2		1	1	1			2	.7	50	58
E. scheuchzeri	-	-	1	-	1	1	-	-	-	1	.4	40	18
Carex rotundata	1	-	-	-	-	-	2	1	-	-	.4	40	14
C. aquatilis	2	1	1	-	1	3	2	2	2	4	1.8	90	236
Ledum decumbens	3	1	4	3	1	2	1	3	3	1	2.2	100	312
Betula nana	3	1	3	2	1	1	2	5	2	2	2.2	100	332
Vaccinium uliginosum	2	4	3	2	5	1	2	2	4	3	2.8	100	366
V. vitis-idaea	1	1	1	1	1	1	1	1	1	1	1.0	100	62
Empetrum nigrum	2	2	1	1	2	-	-	-	-	-	.8	50	71
Andromeda polifolia	-	-	-	-	-	-	1	1	-	-	.2	20	11
Oxycoccus microcarpus	-	-	-	-	-	-	-	-	-	1	.1	10	7
Cetraria laevigata	3	-	-	-	-	-	-	-	-	-	.3	10	12
C. islandica	1	-	-	-	-	-	2	1	1	1	.6	60	41
C. cucullata	-	1	-	-	1	-	2	-	-	-	.4	30	37
Cladonia rangiferina	2	2	1	-	1	3	-	1	1	1	1.2	80	144
C. arbuscula	2	-	2	1	-	3	-	-	2	2	1.2	60	126
C. gracilis	1	-	-	-	-	1	-	2	1	1	.6	50	49
C. bellidiflora	-	-	-	-	-	-	-	-	1	1	.2	20	11
C. amaurocraea	1	-	-	-	1	-	-	-	-	-	.2	20	18
C. gonecha	-	-	1	1	-	-	-	-	-	-	.2	20	9
C. furcata	1	-	-	-	-	-	-	-	-	-	.1	10	5
C. uncialis	-	-	-	-	-	1	-	-	-	-	.1	10	5
C. crispata	-	1	-	-	-	1	-	-	-	-	.2	20	10

Table 10. Cover in 10 quadrats and estimated weights at the Snake River site.

Species	1	2	3	4	5	6	7	8	9	10	Ave. Spec. Comp.	Freq. %	Average Estimated Weight lb/acre
TOTAL COVER	60	75	100	95	90	80	95	65	70	85			2,872
Arctagrostis latifolia	1	2	-	1	2	-	-	1	-	2	.9	60	82
Festuca altaica	1	-	2	1	-	-	1	-	1	-	.6	50	57
Poa alpina	-	1	-	-	-	-	-	-	-	-	.1	10	16
Carex aquatilis	-	-	-	-	-	-	1	-	-	-	.1	10	10
C. misandra	-	-	-	1	-	-	1	-	-	-	.2	20	13
C. rariflora	-	-	-	-	1	1	-	-	-	-	.2	20	8
C. rotundata	-	-	-	-	-	-	-	-	-	1	.1	10	5
C. membranacea	-	-	-	-	-	1	2	-	1	-	.4	30	22
Eriophorum angustifolium	-	-	-	-	-	-	-	1	-	-	.1	10	6
E. scheuchzeri	-	-	-	-	-	-	-	-	-	1	.1	10	5
Luzula multiflora	-	1	1	-	-	-	1	-	1	1	.5	50	31
Spiraea beauverdiana	4	-	2	1	-	2	1	3	-	2	1.5	70	187
Betula nana	-	-	-	-	1	-	2	2	1	2	.8	50	104
Vaccinium uliginosum	1	2	1	-	1	-	-	1	-	-	.6	50	75
V. vitis-idaea	1	-	-	-	-	-	1	-	1	-	.3	30	24
Empetrum nigrum	2	-	1	-	-	-	1	1	2	-	.7	50	87
Ledum decumbens	1	-	-	-	-	1	-	2	-	1	.5	40	60
Salix pulchra	-	-	1	-	-	-	3	-	1	-	.5	30	71
S. ovalifolia	-	-	-	3	-	-	-	-	-	-	.3	10	26
Artemisia arctica	-	-	3	1	3	-	-	2	-	1	1.0	50	134
Cetraria cucullata	-	-	-	-	-	1	-	2	-	2	.5	30	38
C. islandica	3	-	3	2	2	2	1	-	3	1	1.7	80	306
C. andrejevii	-	-	-	-	-	-	1	1	-	-	.2	20	12
C. laevigata	-	-	-	-	-	1	-	2	-	-	.3	20	18
C. delisei	-	-	-	-	-	-	-	2	1	-	.3	20	21

Table 10 (Con't.). Cover in 10 quadrats and estimated weights at the Snake River site.

Species	1	2	3	4	5	6	7	8	9	10	Ave. Spec. Comp.	Freq. %	Average Estimated Weight lb/acre
Cladonia rangiferina	1	2	2	2	3	2	2	3	-	2	1.9	90	317
C. arbuscula	3	4	4	3	4	2	3	1	2	2	2.8	100	489
C. uncialis	1	2	2	1	-	-	1	-	2	1	1.0	70	124
C. amaurocraea	-	-	-	-	-	-	1	1	-	-	.2	20	14
C. gracilis	1	-	-	2	3	1	1	2	1	1	1.2	80	144
C. gonecha	-	1	1	-	-	-	1	-	1	-	.4	40	36
C. cornuta	-	1	1	-	-	1	1	-	-	-	.4	40	41
C. crispata	-	-	2	2	1	-	-	-	1	1	.7	50	86
C. bellidiflora	-	-	-	-	-	-	-	1	-	1	.2	20	14
C. lepidota	-	-	-	-	-	-	-	-	1	-	.1	10	5
C. degenerans	-	-	-	1	-	-	-	-	-	-	.1	10	5
C. mitis	-	-	-	-	1	-	-	-	-	-	.1	10	7
Cornicularia divergens	-	-	1	-	-	-	1	-	2	-	.4	30	33
Lobaria linita	-	1	-	-	-	1	-	2	-	-	.4	30	38
Nephroma arcticum	-	-	-	-	-	-	2	-	2	-	.4	20	27
Stereocaulon spp.	-	2	1	-	-	-	1	2	-	2	.8	50	74

Table 11. Cover in 10 quadrats and estimated weights at the Cabin Rock #1 site.

Species	1	2	3	4	5	6	7	8	9	10	Ave. Spec. Comp.	Freq. %	Average Estimated Weight lb/acre
TOTAL COVER	95	90	100	75	100	85	65	100	80	80			3,344
Hierochloe alpina	1	-	2	1	-	-	1	-	-	1	.6	50	37
Argrostis borealis	-	-	1	-	-	1	-	-	-	-	.2	20	8
Poa glauca	-	-	-	-	1	-	-	-	1	-	.2	20	10
Festuca rubra	-	1	-	1	-	-	1	1	-	-	.4	40	21
Carex bigelowii	3	1	-	1	2	-	1	1	1	-	1.0	70	39
C. scirpoidea	-	1	-	-	-	-	1	-	-	1	.3	30	16
C. misandra	-	-	1	-	1	-	-	-	-	-	.2	20	9
Luzula confusa	-	-	1	-	-	-	-	1	-	-	.2	20	6
L. wahlenbergii	1	-	-	-	-	1	-	-	1	-	.3	30	12
Dryas octopetala	-	2	1	-	4	-	3	2	2	1	1.5	70	220
Empetrum nigrum	-	3	4	-	1	2	3	3	2	2	2.0	80	263
Loiseleuria procumbens	3	2	-	1	4	4	3	2	4	1	2.4	90	312
Betula nana	2	1	-	-	2	-	1	1	3	-	1.0	60	124
Ledum decumbens	1	1	2	-	-	3	1	1	-	2	1.1	70	98
Vaccinium uliginosum	-	-	1	-	2	-	-	2	-	-	.5	30	61
V. vitis-idaea	1	1	-	1	-	1	-	-	1	1	.6	60	40
Salix phlebophylla	-	1	-	2	2	1	-	2	1	1	1.0	70	113
Arctostaphylos alpina	-	1	-	-	1	-	1	1	-	-	.4	40	34
Oxytropis nigrescens	-	-	1	-	-	1	-	-	-	-	.2	20	15
Saxifraga oppositifolia	-	1	-	-	1	-	-	-	-	1	.3	30	12
Stereocaulon spp.	2	2	3	-	2	2	2	4	1	-	1.8	80	244
Alectoria nigricans	-	-	1	-	-	-	1	-	2	-	.4	30	34
A. ochroleuca	-	1	-	-	1	-	-	1	-	-	.3	30	26

Table 11 (Con't.). Cover in 10 quadrats and estimated weights at the Cabin Rock # 1 site.

Species	1	2	3	4	5	6	7	8	9	10	Ave. Spec. Comp.	Freq. %	Average Estimated Weight lb/acre
Asahinea chrysantha	-	-	-	1	-	-	-	-	1	-	.2	20	13
Cornicularia divergens	-	2	-	-	2	3	-	2	1	1	1.1	60	129
Sphaerophorus globosus	-	-	1	-	-	-	1	-	-	-	.2	20	16
Thamnolia vermicularis	-	1	-	-	1	-	-	-	1	-	.3	30	23
Lobaria linita	1	-	-	-	1	-	2	-	-	-	.4	30	35
Cetraria islandica	1	3	-	2	2	1	1	-	2	-	1.2	70	204
C. andrejevii	-	-	1	-	-	-	2	-	-	1	.4	30	38
C. kamczatica	1	-	-	-	1	-	-	1	-	-	.3	30	21
C. nivalis	-	2	-	2	-	-	1	-	3	-	.8	40	46
C. cucullata	-	1	2	1	1	-	-	1	1	-	.7	60	76
Cladonia arbuscula	3	2	2	3	1	1	-	3	3	2	2.0	90	400
C. rangiferina	2	1	2	1	-	1	1	2	1	-	1.1	80	243
C. uncialis	2	-	-	2	-	-	2	-	1	2	.9	50	117
C. crispata	1	-	-	-	1	-	1	-	1	-	.4	40	22
C. boryi	1	-	3	1	1	1	2	-	1	-	1.0	70	92
C. gracilis	2	-	1	-	-	-	1	-	-	1	.5	40	41
C. amaurocraea	-	1	-	2	-	-	-	1	-	-	.4	30	29
C. coccifera	-	-	1	-	-	-	1	-	-	-	.2	20	14
C. pseudorangiformis	-	-	-	3	-	-	1	2	-	-	.6	30	31

Table 12. Cover in 10 quadrats and estimated weight at the Cabin Rock #2 site.

Species	1	2	3	4	5	6	7	8	9	10	Ave. Spec. Comp.	Freq. %	Average Estimated Weight lb/acre
TOTAL COVER	95	90	100	90	100	95	100	100	95	95			4,792
Carex bigelowii	2	1	-	1	1	2	-	2	2	1	1.2	80	55
C. misandra	-	-	-	-	1	-	-	1	-	-	.2	20	21
C. podocarpa	-	2	2	-	2	-	1	1	-	2	1.0	60	46
Hierochloe alpina	1	-	-	1	-	-	-	2	-	-	.4	30	28
Festuca altaica	-	1	-	1	-	1	-	-	-	1	.4	40	22
Alopecurus alpinus	-	-	-	1	-	-	-	-	1	-	.2	20	11
Poa alpina	-	1	-	-	-	1	-	-	-	-	.2	20	10
Luzula multiflora	1	-	-	-	2	-	-	1	-	1	.5	40	17
Betula nana	5	1	3	2	4	-	1	3	3	2	2.4	90	484
Ledum decumbens	1	1	1	3	1	2	1	1	2	3	1.6	100	263
Vaccinium uliginosum	2	1	-	1	-	2	3	1	-	2	1.2	70	222
V. vitis-idaea	1	1	1	1	-	-	1	1	1	1	.8	80	161
Empetrum nigrum	3	4	4	3	5	2	2	3	4	3	3.3	100	510
Loiseleuria procumbens	3	3	2	2	1	2	-	3	2	3	2.1	90	412
Salix pulchra	-	-	-	1	-	-	4	-	2	-	.7	30	96
S. glauca	-	-	-	-	2	-	1	-	1	-	.4	30	63
S. ovalifolia	-	-	-	-	-	1	-	1	-	-	.2	20	20
Tofieldia coccinea	1	-	-	-	-	-	1	-	-	-	.2	20	8
Pedicularis labradorica	-	-	-	1	-	-	-	-	1	-	.2	20	11
Polygonum bistorta	-	-	-	-	-	1	-	-	1	-	.2	20	14
Nephroma arcticum	-	1	-	-	-	-	1	-	-	1	.3	30	26
Stereocaulon spp.	1	2	3	4	1	2	-	3	3	2	2.1	90	287
Peltigera aphthosa	-	1	-	-	-	1	-	2	-	1	.5	40	34
Lobaria linita	-	-	-	1	-	1	-	-	2	-	.4	30	38

Table 12 (Con't.). Cover in 10 quadrats and estimated weight at the Cabin Rock #2 site.

Species	1	2	3	4	5	6	7	8	9	10	Ave. Spec. Comp.	Freq. %	Average Estimated Weight lb/acre
Cetraria islandica	3	2	2	1	3	-	2	2	2	3	2.0	90	338
C. laevigata	2	1	-	1	-	2	-	3	1	1	1.1	80	116
C. cucullata	2	-	-	-	2	-	2	2	-	-	.8	40	61
Cladonia arbuscula	4	3	3	1	2	4	4	2	2	3	2.8	100	426
C. rangiferina	3	3	2	1	1	2	2	3	2	2	2.1	100	382
C. uncialis	2	3	2	1	1	1	2	3	2	2	1.9	100	317
C. alpestris	-	-	-	1	-	2	-	2	1	-	.6	40	32
C. amaurocraea	1	1	-	1	2	-	1	1	-	-	.7	60	28
C. gracilis	-	2	2	-	1	2	1	1	1	2	1.2	80	111
C. bellidiflora	-	1	-	-	1	-	-	1	-	-	.3	30	21
C. pseudorangiformis	1	-	-	2	-	1	-	-	-	-	.4	30	33
C. boryi	-	-	-	-	-	2	-	1	2	-	.5	30	38
C. cornuta	-	-	-	-	1	-	1	-	-	1	.3	30	17
C. gonecha	-	-	-	-	-	-	-	1	-	1	.2	20	8
C. squamosa	-	-	-	-	-	-	-	-	1	-	.1	.0	5

and include bog blueberry, dwarf birch, narrow-leaved Labrador tea, crowberry, alpine azalea, cranberry, Salix glauca, and S. pulchra. Extensive stands of lichens, primarily Cladonia rangiferina, C. arbuscula, C. amaurocraea, C. uncialis, Cetraria cucullata, C. islandica occur as well. There are sedges, grasses, and forbs throughout, the principal species being Carex bigelowii, Arctagrostis latifolia, Festuca altaica, Hierochloe alpina, Pedicularis labradorica, Polygonum bistorta, and Pestasites frigidus. The entire area is usually underlain with a large moss mat, primarily Sphagnum which retains moisture throughout the year. Table 12 further describes the vegetation at this site.

LICHENS

As the principal objective of this study was to determine some of the effects of grazing on the quality of lichens, a more extensive discussion of lichens is presented. Lichens generally have much lower rates of photosynthesis per unit surface area than leaves of vascular plants, although respiration rates of the two types of tissue are similar (Hale 1967). Net assimilation in lichens will therefore be very much lower than in leaves. Hale (1967) also reports that the rate of photosynthesis is closely correlated with the water content of the thallus.

The optimal rate of respiration usually occurs between 50 and 70° F., although measurable respiration has been recorded at 11°F (Hale 1967). During the summer in Nome, temperatures average between 46 and 49°F (Environmental Science Services Administration 1969) and, with relatively moist days predominating (Table 7), growth conditions should be nearly optimal.

Lichens are unusually well adapted to cold temperatures. Several species have revived and resumed normal respiration after exposure for several hours to temperatures as low as -183°C and -268°C (Llano 1944). The lower temperatures and reduced light during the winter probably allow lichens to grow very little if at all during the winter. In contrast, studies of West European lichens indicate that growth was much higher in winter than summer because of drought conditions in the summer and more moderate temperatures in the winter (Hale 1967).

We were most fortunate in the summer of 1969 to have Dr. Hildur Krog, a noted lichenologist from Norway, visit the Nome area and make a checklist of all the lichens that she found on each of the sites (Tables 13, 14, 15 & 16). Dr. Krog was favorably impressed with the abundance and diversity of the lichens and stated that the area was one of the better lichen sites she had encountered. Productivity of the lichens is shown in Tables 9 through 12. As can be seen, the Cabin Rock No. 2 site and the Snake River site have some of the most abundant supplies of lichens. Lichens at the Snake River site are some of the largest ones encountered.

Chemical Analysis of Lichens

The chemical analysis of lichens can be of value in determining their relative quality as forage for herbivores, primarily caribou. In Alaska, there have been few analyses of lichens reported, these include Spencer and Krumboltz (1929) and Pegau (1968a).

Table 13. A partial list of the lichens located on Snake River.

ASAHINEA	CLADONIA (Cont'd)	CORNICULARIA	PELTIGERA
chrysantha	cenotea	divergens	aphthosa
	coccifera		canina
CETRARIA	coniocraea	LOBARIA	scabrosa
cucullata	crispata	linita	
delisei	cyanipes		STEREOCAULON
islandica	deformis	NEPHROMA	alpinum
laevigata	degenerans	arcticum	paschale
nivalis	elongata		tomentosum
pinastri	gonecha	PARMELIA	
sepincola	gracilis	sulcata	XANTHORIA
	lepidota		candelaria
CLADONIA	macrophylla	PARMELIOPSIS	
alpestris	pleurota	ambigua	
amaurocraea	pyzidata	hyperopta	
arbuscula	rangiferina		
bellidiflora	uncialis		
carneola			

Table 14. A partial list of the lichens located on Beltz.

CETRARIA	PARMELIOPSIS	
cucullata	hyperopta	
laevigata		
nivalis	PELTIGERA	
pinastri	aphthosa	
sepincola	scabrosa	
CLADONIA	STEREOCAULON	
amaurocraea	tomentosum	
arbuscula		
bellidiflora		
cenotea		
cornuta		
crispata		
cyanipes		
deformis		
elongata		
furcata		
rangiferina		
squamosa		
uncialis		

Table 15. A partial list of the lichens located on Cabin Rock #1.

ALECTORIA
- chalybeiformis
- minuscula
- nigricans
- ochroleuca
- pubescens

ASAHINEA
- chrysantha
- scholanderi

CETRARIA
- andrejevii
- cucullata
- delisei
- hepatizon
- islandica
- kamczatica
- laevigata
- nigricans
- nivalis
- richardsonii
- tilesii

CLADONIA
- alpestris
- amaurocraea
- arbuscula
- bellidiflora
- boryi
- coccifera
- cornuta
- crispata
- elongata
- furcata
- gonecha
- gracilis
- pseudorangiformis
- pyxidata
- rangiferina
- squamosa
- uncialis
- verticillata

CORNICULARIA
- divergens

DACTYLINA
- arctica
- ramulosa

DERMATOCARPON
- miniatum

HYPOGYMNIA
- subobscura
- vittata

LOBARIA
- linita

NEPHROMA
- arcticum

PARMELIA
- almquistii
- alpicola
- centrifuga
- disjuncta
- omphalodes
- saxatilis
- stygia
- sulcata

PELTIGERA
- scabrosa

PHYSCIA
- caesia
- dubia

PILOPHORUS
- robustus

RAMALINA
- almquistii
- scoparia

SOLARIA
- bispora
- crocea

SPHAEROPHORUS
- fragilis
- globosus

STEREOCAULON
- botryosum
- glareosum
- subcoralloides
- tomentosum
- vesuvianum

THAMNOLIA

UMBILICARIA
- caroliniana
- cinereorufescens
- polyphylla
- proboscidea
- torrefacta
- vellea

XANTHORIA
- candelaria
- elegans

Table 16. A partial list of the lichens located on Cabin Rock #2.

ALECTORIA
- chalybeiformis
- lanea
- nigricans
- ochroleuca

ASAHINEA
- chrysantha

CETRARIA
- andrejevii
- cucullata
- delisei
- hepatizon
- islandica
- kamczatica
- laevigata
- nigricans
- nivalis
- pinastri
- richardsonii
- sepincola
- "new species"

CLADONIA
- alpestris
- amaurocraea
- arbuscula
- bellidiflora
- boryi
- cenotea
- coccifera
- cornuta
- crispata
- cyanipes
- elongata
- furcata
- gonecha
- gracilis
- lepidota
- macrophylla
- pocillum
- pseudorangiformis
- pyxidata
- rangiferina
- squamosa
- uncialis
- verticillata

CORNICULARIA
- divergens

DACTYLINA
- arctica

EVERNIA
- esorediosa

LEPTOGIUM
- lichenoides

LOBARIA
- linita

NEPHROMA
- arcticum
- expallidum
- parile

PARMELIA
- omphalodes
- saxatilis
- sulcata

PARMELIOPSIS
- hyperopta

PELTIGERA
- aphthosa
- leucophlebia
- scabrosa
- spuria

SOLORINA
- crocea

SPHAEROPHORUS
- globosus

STEREOCAULON
- paschale
- tomentosum

THAMNOLIA

UMBILICARIA
- torrefacta

Table 17. Chemical composition of lichens collected at four sites.

Month	Site	Species	Percent composition on dry-weight basis: Protein (N x 6.25)	Fat	Crude Fiber	Ash	NFE	Ca	P
Jul	B	Cladonia arb.-rang.							
"	S	"	2.2	1.2	21.2	1.1	74.3	.05	.042
"	C1	"	1.8	1.3	16.2	1.6	79.1	.02	.034
"	C2	"	1.9	0.9	32.7	1.1	63.4	.05	.046
Sep	B	"	1.9	0.7	26.1	5.0	66.3	.17	.038
"	S	"	2.1	0.3	41.3	1.0	55.3	.06	.042
"	C1	"	2.1	0.9	35.0	3.7	58.3	.05	.064
"	C2	"	1.9	0.8	30.6	1.1	65.6	.05	.038
Nov	B	"	2.2	1.0	21.7	5.4	69.7	.25	.040
"	S	"	2.7	0.7	36.7	0.9	59.0	.04	.044
"	C1	"	1.7	0.8	28.5	1.9	67.1	.02	.032
"	C2	"	2.0	1.2	24.4	1.5	70.9	.06	.038
Jan	B	"	2.0	0.6	39.0	3.9	54.5	.14	.046
"	S	"	3.1	0.7	43.3	1.1	51.8	.05	.040
"	C1	"	2.5	1.2	24.5	2.4	69.4	.10	.084
"	C2	"	2.4	2.3	25.3	2.4	67.6	.06	.040
Mar	B	"	2.9	1.1	25.6	2.9	67.5	.15	.060
"	S	"	2.1	0.9	32.8	0.9	63.3	.07	.064
"	C1	"	2.0	1.1	16.9	2.7	77.3	.03	.040
"	C2	"	2.0	0.8	31.0	1.3	64.9	.05	.048
May	B	"	1.9	1.0	26.7	3.3	67.1	.08	.032
"	S	"	2.6	1.0	32.5	1.0	62.9	.02	.042
"	C1	"	2.4	1.2	21.7	2.2	72.5	.05	.058
"	C2	"	2.4	1.4	36.8	1.6	57.8	.07	.058
Jul	B	Cladonia uncialis							
"	S	"	1.8	1.6	23.5	0.8	72.3	.04	.032
"	C1	"	1.7	1.4	14.0	1.8	81.1	.02	.034
"	C2	"							
Sep	B	"							
"	S	"	1.9	1.0	14.5	0.9	81.7	.04	.030
"	C1	"	1.8	1.5	14.5	2.1	80.1	.02	.036
"	C2	"	2.0	1.1	23.3	0.7	72.9	.04	.044
Nov	B	"							
"	S	"	2.8	0.9	25.6	0.8	69.9	.04	.040
"	C1	"	1.6	1.2	18.7	2.0	76.5	.02	.034
"	C2	"	1.8	1.5	18.2	1.0	77.5	.05	.032
Jan	B	"	1.8	0.8	27.6	2.4	67.4	.11	.038
"	S	"	2.3	1.1	18.4	0.9	77.3	.04	.030
"	C1	"	2.0	1.4	13.4	3.2	80.0	.04	.034
"	C2	"	2.2	2.0	19.0	2.3	74.5	.07	.034
Mar	B	"	2.0	1.3	16.0	2.0	78.7	.12	.036
"	S	"	2.2	1.8	11.7	1.1	83.2	.06	.068
"	C1	"	2.1	1.4	11.7	2.1	82.7	.04	.048
"	C2	"	1.6	0.8	20.0	0.9	76.7	.04	.040
May	B	"	1.6	1.6	9.4	2.5	84.9	.08	.032
"	S	"	2.5	1.1	19.7	0.9	75.8	.07	.038
"	C1	"	2.1	1.5	23.6	2.0	70.8	.03	.046
"	C2	"	2.2	1.6	19.5	1.2	75.5	.05	.044

Table 17 (Con't.). Chemical composition of lichens collected at four sites.

Month	Site	Species	Percent composition on dry-weight basis: Protein (N x 6.25)	Fat	Crude Fiber	Ash	NFE	Ca	P
Jul	B	Cetraria islandica							
"	S	"	2.4	0.5	5.6	1.1	90.4	.08	.048
"	C1	"							
"	C2	"	2.4	0.4	4.5	1.3	91.4	.11	.062
Sep	B	"	1.9	0.5	5.6	3.2	88.8	.30	.034
"	S	"	3.1	0.5	4.6	1.1	90.7	.08	.060
"	C1	"	2.2	0.9	18.1	1.6	77.2	.08	.044
"	C2	"	2.6	0.8	4.0	1.3	91.3	.16	.070
Nov	B								
"	S	"	3.6	0.7	5.5	1.0	89.2	.05	.050
"	C1	"	2.0	0.6	10.8	1.6	85.0	.06	.032
"	C2	"	2.4	0.8	5.7	1.1	90.0	.12	.038
Jan	B	"	1.9	0.6	10.3	2.0	85.2	.20	.038
"	S	"	2.9	0.5	3.3	0.8	92.5	.05	.036
"	C1	"							
"	C2	"	2.5	1.0	6.9	1.8	87.8	.14	.042
Mar	B	"	2.1	0.5	7.0	2.0	88.4	.18	.040
"	S	"	2.6	0.4	3.7	0.9	92.4	.05	.126
"	C1	"							
"	C2	"	2.3	0.5	5.3	1.3	90.6	.08	.070
May	B	"	2.2	1.1	12.6	2.3	81.8	.21	.036
"	S	"	3.6	0.4	23.3	1.0	71.7	.03	.056
"	C1	"	2.7	0.8	4.8	1.7	90.0	.06	.044
"	C2	"	3.2	0.9	9.1	1.5	85.3	.08	.074
Jul	B	Cetraria cucullata							
Sep	B	"	2.0	2.6	5.4	2.5	87.5	.28	.040
Nov	B	"	2.4	3.0	4.4	3.8	86.4	.53	.040
Jan	B	"	1.8	1.6	5.2	2.3	89.1	.26	.048
Mar	B	"	2.0	2.0	5.9	2.4	87.7	.21	.042
May	B	"	2.1	3.0	4.3	2.2	88.4	.14	.034
Jul	S	Cladonia gracilis							
Sep	S	"							
Nov	S	"	3.1	1.0	22.9	0.8	72.2	.06	.042
Jan	S	"	2.3	0.6	19.3	0.8	77.0	.04	.030
Mar	S	"	2.7	0.5	24.5	1.1	71.2	.06	.046
May	S	"	2.6	0.4	31.0	1.0	65.0	.04	.038
Jul	C1	Stereocaulon spp.	6.9	1.0	28.4	1.9	61.8	.03	.072
Sep	C1	"	5.4	0.8	25.7	1.0	67.1	.03	.040
Mar	B	Cladonia rangiferina-live	2.7	0.6	33.8	1.7	61.2	.14	.048
Mar	B	" - dead	1.9	0.4	38.9	4.0	54.8	.20	.044
Mar	S	" - live	3.4	0.4	30.5	1.0	64.7	.04	.070
Mar	S	" - Dead	2.1	0.3	52.0	1.3	44.3	.10	.048

Analyses of some lichens on Canadian ranges have been reported by Scotter (1965) and Tener (1965). Courtright (1959) summarized the analyses reported in several countries. Unfortunately, not all of these studies have included the dates on parts of the plants collected.

To better evaluate the importance of lichens to caribou, it is desirable to see if there is a seasonal or habitat variation in the nutrient quality of lichens. Various species of lichens from the four different locations were collected at bimonthly intervals from July 1968 until June 1969. Analyses were performed by Laucks Testing Laboratories and the results are presented in Table 17. Results are expressed on a dry weight basis. There were a few species for which insufficient material was collected and the analysis could not be conducted. A collection has been made to replace these and it is currently being analyzed. Because of the difficulty of positively identifying some similar species, especially during the winter when they were collected from under the snow, some species were grouped. These include the Cladonia arbuscula group which is primarily C. arbuscula and C. rangiferina. In previous studies (Pegau 1968a, Courtright 1959), where Cladonia rangiferina and C. arbuscula were separated, there appeared to be only slight differences. It is felt that in most management studies it would be wisest to group Cladonia mitis, C. arbuscula, and C. rangiferina as there are some difficulties in distinguishing every plant of this group and there is even some question by authorities as to what constitutes one species or the other (Thomson et al. 1969). The Cetraria islandica group contains some C. laevigata. The other species are strictly the species indicated.

The Cladonia arbuscula - C. rangiferina group and C. uncialis were chosen because of their widespread distribution and high palatability. Cetraria islandica was chosen because of its ubiquitous distribution and because, like C. cucullata, it tends to recover from disturbance. C. cucullata is not abundant, especially in the Cabin Rock sites, so collecting was restricted to the Beltz site. Cladonia gracilis was collected only at the Snake River site. Only the living portion of the lichens was analyzed, since this is the portion normally grazed by caribou or reindeer.

Two samples of pure Cladonia rangiferina were collected. The living and dead portions of the podetia were separated and both portions were analyzed to determine if there was a difference. The protein and NFE (primarily carbohydrates) content was higher in the living portion in both samples. Crude fiber was higher in the dead portion in both samples. Fat, mineral, Ca and P showed no general trend. Caribou and reindeer, by selecting the living portions of the lichens, are obtaining the most nutritious portion. Detailed statistical analysis of the data will have to wait until the analysis of the missing samples is completed. Preliminary analyses indicate that the protein content of all the lichens analyzed except Stereocaulon spp. are below the apparent minimum requirements for most livestock (Stoddard and Smith 1955). Stereocaulon spp. (primarily S. tomentosum and S. alpina) is an important lichen on some ranges, especially overused or disturbed areas. Fortunately, ruminants do not require as complex protein diets as most single stomach animals because microorganisms of the rumen are able to convert simple nitrogenous compounds into amino acids in making the cells of which they are composed (Morrison 1959). Further on in the digestive tract, the rumen microorganisms' cells are digested and the protein that has been produced by the microorganisms is then available to the caribou.

The crude fiber content is markedly less in the Cetraria group and their fat and carbohydrate contents are higher than the Cladonia species analyzed. Fats provide approximately 2.25 times the energy than that of protein or carbohydrates (Morrison 1959). Cetraria cucullata is highly palatable, has a high fat and carbohydrate content, and is able to withstand grazing the best (as noted at the Selawik exclosure), so it should be one of the lichens given major consideration when evaluating caribou ranges.

The mineral, Ca and P content was similar in all species. The calcium and phosphorus ratio is normally within the 6:1 to 0.6:1 suggested by Morrison (1959) for cattle and sheep.

There is no apparent difference in nutrient content between any of the four sites. Lichens are probably less related to soil and habitat conditions than vascular plants as they obtain their nutrients and moisture from the atmosphere. The principal effect of habitat location on lichens is in their growth and production as noted in Tables 9 through 12.

No noticeable seasonal variation in the quality of lichens was demonstrated. This contrasts markedly with vascular plants, where the protein content tends to rise during the growing season and the crude fiber content is lowest during that period when the plants are growing the most (Pegau 1968b, Scotter 1965, Tener 1965 and Courtright 1959).

Klein (1970) suggests that northern ungulates undergo seasonal physiological changes which adapt them to the quality of their forage supply. The highest metabolic requirements of the animals occur during the spring and summer when the vascular plant growth is the most nutritious. McEwan and Wood (1966) showed that caribou voluntarily reduced their food intake in late fall and during the winter so that the winter dietary requirements for protein were reduced over those of the summer.

Carbohydrates become an important source of energy during the winter. These changes in requirements coincide with the protein rich diet in the summer and high carbohydrate diet during the winter (Klein 1970).

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RECOMMENDATIONS

Grazed plants should be examined for several years so that the full impact of different intensities of grazing can be determined. Once it has been established what levels of grazing is optimal for shrubs, a more refined evaluation of condition and trend can be made of a particular range.

The condition and trend score card should be used by area biologists on key caribou wintering areas to help them formulate what levels of caribou populations are optimal for each range.

Transects inside and outside of the exclosures should be reexamined in 1972. More frequent examinations and any maintenance of the exclosures required should be conducted to ensure that the exclosures are in good condition.

Lichen diets should be considered as only providing maintenance requirements at best. Special emphasis should be placed on Cetraria cucullata when making management decisions on lichen ranges.

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