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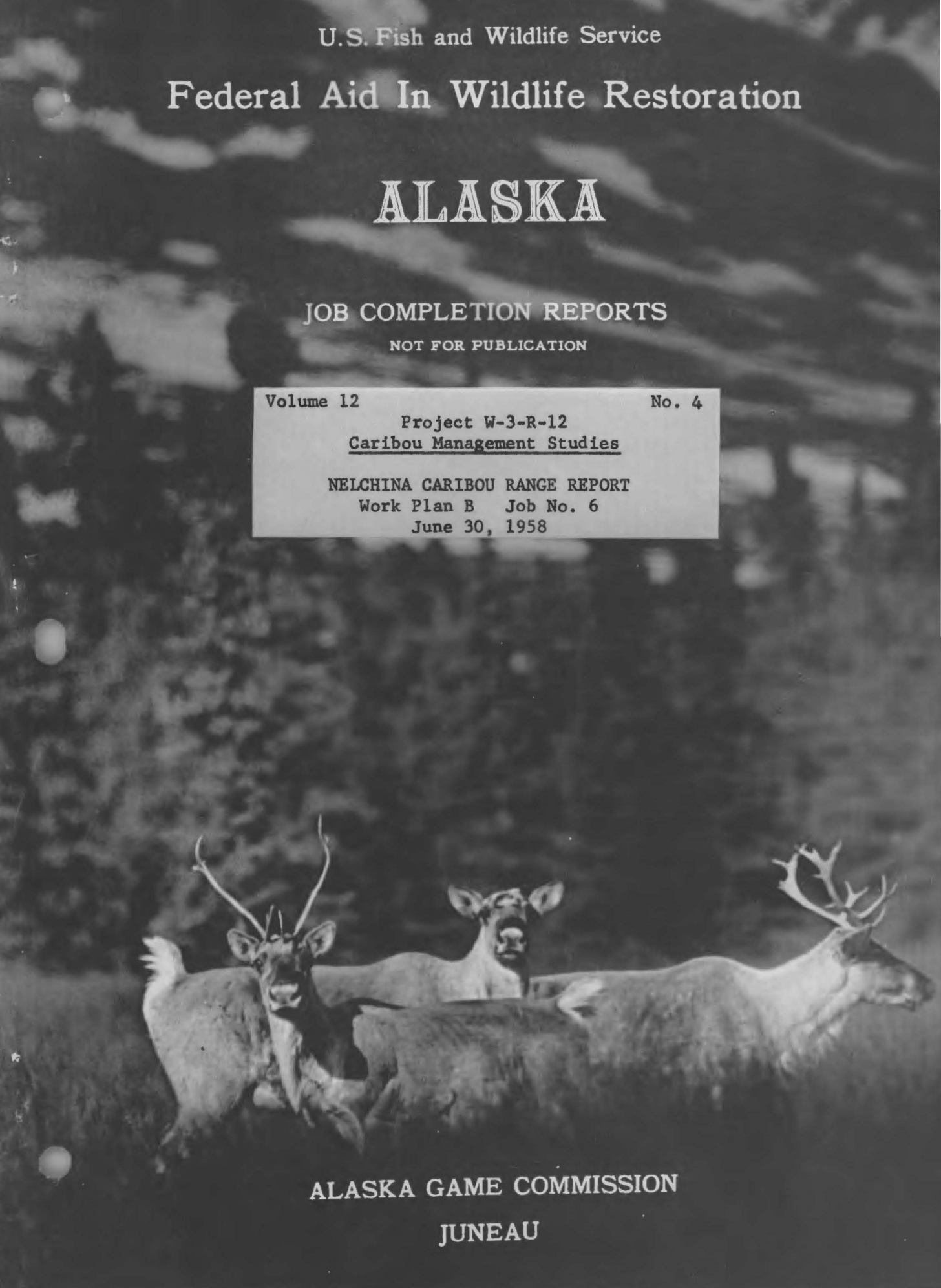
Caribou Management Studies

NELCHINA CARIBOU RANGE REPORT
Work Plan B Job No. 6
June 30, 1958



ALASKA GAME COMMISSION

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JOB COMPLETION REPORTS

Project W-3-R-12 Alaska April 30, 1958

Wildlife Investigations

Work Plan B Job No. 6

Caribou Management Studies

ANALYSIS OF NELCHINA CARIBOU RANGE

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Not for Publication

(The results described in this report are preliminary. Conclusions are subject to change with further investigation and interpretation.)

JOB NO. 6. Analysis of Nelchina Caribou Range.

PERIOD COVERED: June 15 to September 30, 1957.

ABSTRACT

A field crew under the direction of Dr. Herbert C. Hanson made an ecological reconnaissance of the Nelchina Caribou Range during the summer of 1957. This report contains the main results of the project, and the findings are outlined briefly below:

1. The physiography and climatology of the range as a whole are described, and a general description of the vegetation's distribution is presented.

2. The major vegetation types were classified, analyzed, and characterized; each is described and quantitative data are presented from representative stands of each.

3. The environmental factors affecting the various vegetation types are discussed.

4. The chief kinds of plant succession occurring in the Nelchina region are classified and described.

5. The effects of caribou upon the vegetation are noted.

6. A tentative classification system is presented for determining the condition of the vegetation for winter feeding in various parts of the range--based on lichens.

OBJECTIVES

To identify and describe the natural plant communities comprising the Nelchina Caribou Range.

To determine the patterns of plant succession, and the factors affecting succession, maintenance, and occurrence of the plant communities.

To develop a procedure for evaluating the effects of caribou upon the range, and a method of estimating carrying capacity for caribou in the Nelchina area.

TECHNIQUES USED

Various means were employed to gain access into different parts of the Nelchina Caribou Range. Pack and riding horses were used from the mouth of the Chickaloon River to reach the calving area near the headwaters of Tyone Creek. A panel truck was used to cover the range along the Glenn, Lake Louise, Richardson, and Denali Highways. Fortunately, the Denali Highway was completed in August so examinations could be made along the entire length of this road, from Paxson to Cantwell. A river boat was used to investigate the vegetation and stations bordering Lake Louise, Susitna Lake, Tyone Lake, and the Tyone River as far down as the junction with Tyone Creek. Float airplanes were used for transportation to the vegetation and stations near lakes scattered throughout the Nelchina Caribou Range and near a few lakes south and east of this range.

Camps were established in various locations, from which trips to other areas could be readily made. The main camps were near the headwaters of Tyone Creek (altitude about 3600 feet), Mile 27 west of Paxson on the Denali Highway (altitude 3300 feet), Mile 19 east of Cantwell on the Denali Highway (altitude 2300 feet), Susitna Lake (altitude 2400 feet), and the junction of Tyone River and Tyone Creek (altitude 2375 feet). Lodges along the Glenn and Richardson Highways were used for a few short periods. The excellent tent and other camping facilities proved most suitable for the field work.

A preliminary reconnaissance of the Nelchina Caribou Range was made by airplane in order to secure a general perspective of the topography and vegetation. In order to secure the maximum of data to apply upon the objectives, it was decided to make as many quantitative analyses of the various types, and observations of as much of the vegetation, as possible, throughout the most accessible part of the range. Sociological analyses, resulting in association tables, and numerous descriptions of stands and general features of vegetation types were made. Among the characteristics of vegetation studied are: number and kinds of species present, total herbage cover, herbage cover of species according to the modified Hult-Sernander scale, frequency, height, vitality, life-forms, constancy, and dominance (Hanson 1950). Numerous observations were also made on successional features and environmental conditions in all of the stands.

The Hult-Sernander scale as modified by Hanson (1953) was used for estimating the cover of each species in meter-square quadrats. This scale is as follows:

1 - herbage covers	less than	1/16	of the	square	meter		
2 -	"	"	1/16 to 1/8	"	"	"	"
3 -	"	"	1/8 to 1/4	"	"	"	"
4 -	"	"	1/4 to 1/2	"	"	"	"
5 -	"	"	1/2 to 3/4	"	"	"	"
6 -	"	"	3/4 to 4/4	"	"	"	"

Height measurements were taken of several species. Ten one-meter-square quadrats, located systematically, usually along a line in a typical part of the stand, were used for each analysis. Because of the limitation of time and the large area under study, it was decided to analyze as many stands as possible using 10 quadrats in each, instead of 20 quadrats in each of fewer stands. Soil profiles were described according to standard soil survey methods (U. S. Soil Survey 1951). Appreciation and thanks are expressed to Dr. Paul F. Martin of the Alaska Agricultural Experiment Station for making electrometric determinations of the pH of numerous soil samples. Notes were taken for each stand on slope, exposure, altitude, soil moisture and drainage, condition of the vegetation, effects of caribou and other animals, frost action, solifluction, invasion of species, successional status, and other noticeable features. Photographs in color and black and white were taken of nearly all the stands and of many quadrats. About 535 specimens of plants were collected for authentic identification and as part of the records in permanent collections, such as the Langlois Herbarium of The Catholic University of America, the National Herbarium, Fish and Wildlife Service in Anchorage, and others. Appreciation is expressed to the following for identifications: Dr. Mason E. Hale for lichens, Dr. William C. Steere for mosses, Dr. Jason R. Swallen for Poa spp., Rev. M. Duman for Cyperaceae and some flowering plants, and Mr. A. Le Roy Andrews for Sphagnum spp.

All of the raw data obtained is filed at the Anchorage office of the Federal Aid to Wildlife Restoration Branch.

FINDINGS

An ecological reconnaissance of the Nelchina Caribou Range was conducted during the summer of 1957 under the auspices of the Alaska Federal Aid in Wildlife Restoration Research Project W-3-R-12, as a

part of the Territory-wide caribou management studies. The writer is greatly indebted to Robert F. Scott, Supervisor of Game Restoration for numerous suggestions, planning, providing facilities, and other assistance; to R. O. Skoog and R. A. Rausch for assisting in the field work, providing for all camping and travel facilities, and generally for arranging for the smooth operation of the summer's work; to Willie Miller for most helpful assistance on the pack-horse trip; and to several others who assisted in collecting data.

Physiography and Climatology

The Nelchina Caribou Range is located about 150 miles northeast of Anchorage and is bounded roughly on the south by the Glenn Highway, on the east by the Richardson Highway, on the north by the Alaska Range, and on the west it extends into the Talkeetna Mountains. The approximate area is 12,000 square miles. The population of caribou is about 40,000 according to two aerial censuses made in 1955 and 1956 by the U. S. Fish and Wildlife Service. The altitude varies from about 1500 feet near the junction of Tazlina and Copper rivers in the southeastern corner to about 7,000 feet in the Alaska Range and Talkeetna Mountains. A large area of the southern and eastern parts are in the Copper River drainage basin, the western and northern parts in the Susitna River drainage basin, part of the northeastern corner in the Delta River basin, part of the northwestern corner in the Delta River basin, and part of the Talkeetna Mountains in the southwestern corner in the Matanuska River basin. The topography varies from broad plateaus with numerous lakes and occasional low hills which occupy a large portion in the southeast ("Lake Louise Flat", because Lake Louise is nearly in the center), to long gentle slopes of scattered hills and foothills, to rugged mountains. Figure 1 shows the area described.

Much of the southeastern part of the Nelchina Caribou Range, particularly the lower portions, consists of alluvium, beach and terrace deposits of the Quarternary. Bordering this on the west and in the valleys and adjacent land of the Maclaren, Susitna, and Nenana rivers are glacial and glaciofluvial deposits. The range of hills (Alphabet Hills) extending eastward from the junction of the Susitna and Maclaren rivers consists of extrusive rocks with associated greenstones and siliceous rocks of undifferentiated Permian and Carboniferous. A deposit of similar rocks of undifferentiated Triassic and Permian extends from near Paxson to near the Susitna River, mostly north of the Denali Highway; and again west of the Susitna River, southwestward from Valdez Creek. The south slopes of the Alaska Range consist of

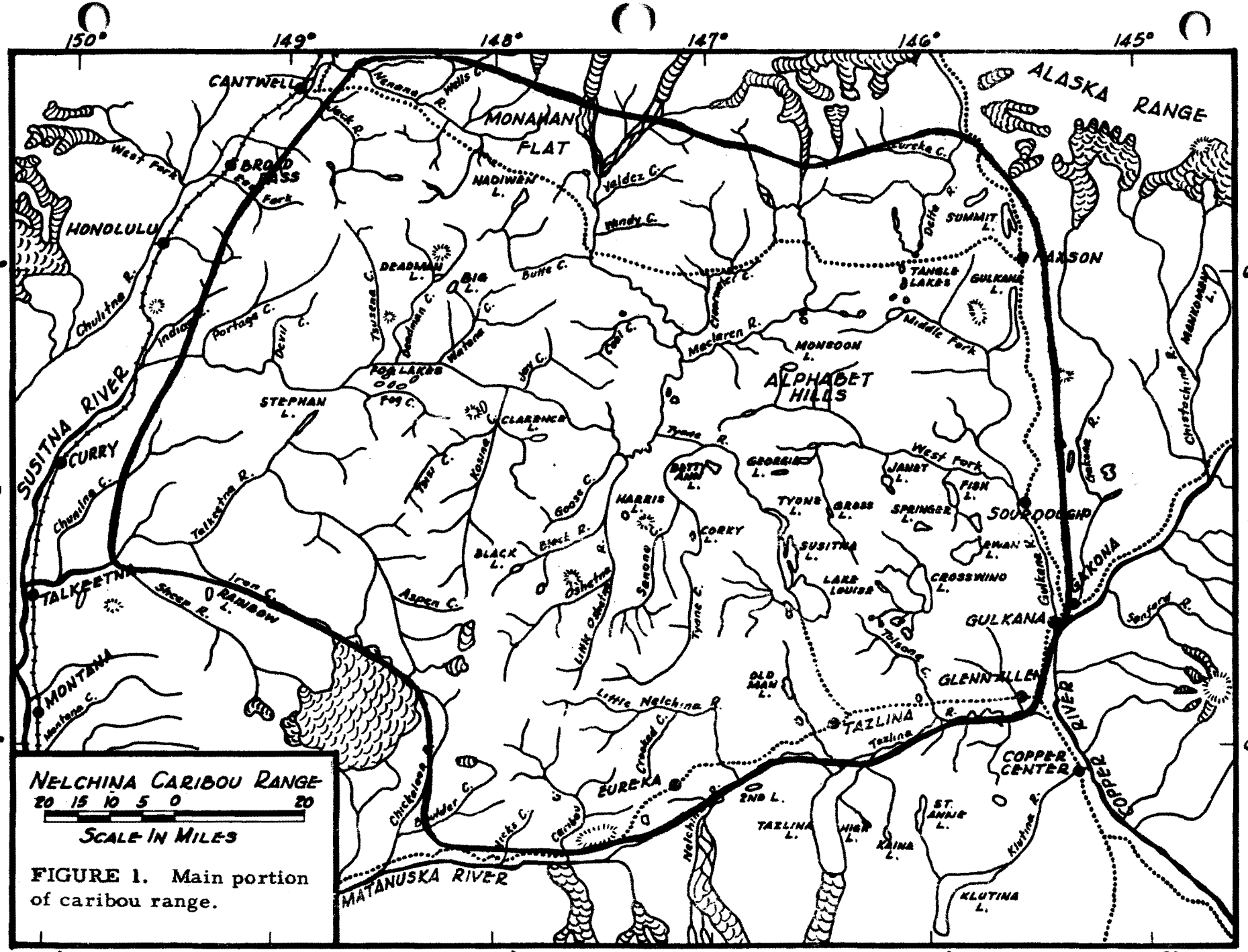

FIGURE 1. Main portion of caribou range.

a variety of marine and nonmarine rocks with volcanic intrusions of Permian to Cretaceous age. From the Glenn Highway in the vicinity of Eureka to about the Oshetna River and westward into the foothills, a block of about 300 square miles consists of clastic rocks, sandstones, limestones, and shale of the Jurassic and Cretaceous, with volcanic intrusions. It is noteworthy that this area appears to be the only part of the Nelchina Caribou Range which contains limestone and similar rocks, and that much of this area is an important part of the calving range. Is it possible that lime-rich soil is an important factor in causing the caribou to return to this area each year for calving? A block of undifferentiated Cretaceous and Jurassic granite and associated intrusives occur in the northwestern part of the Nelchina Caribou Range, between the Susitna and Nenana rivers (Dutro and Payne, 1957).

Climatological data are available for only a few localities in this region (U. S. Weather Bureau). These data are summarized in the following table:

	Gulkana Altitude 1572 feet, Lat. 62°9' Long. 145°27'		Summit Altitude 2400 feet, Lat. 63°20' Long. 149°9'	
Month	Mean temp. °F.	Mean ppt. inches	Mean temp. °F.	Mean ppt. inches
January	-5.9	0.79	2.6	1.01
February	1.7	0.42	7.5	1.23
March	14.9	0.37	11.2	1.32
April	28.8	0.21	23.3	0.54
May	43.7	0.41	37.1	0.98
June	53.7	1.19	48.9	2.13
July	56.9	2.12	53.9	3.38
August	52.6	1.87	48.7	3.37
September	43.6	1.23	40.4	3.35
October	29.0	0.74	25.1	1.89
November	8.5	0.66	11.0	1.43
December	-4.0	0.79	3.2	1.52
Annual	27.0	11.70	25.8	22.25
Range	-49 to 89		-32 to 81	
Years of record	13	13	13	14

Gulkana, near the southeastern corner of the Nelchina Caribou Range, differs strikingly from Summit, a few miles southwest of Cantwell in the northwestern corner, in having about half as much precipitation. The snowfall in 1955 was 72.8 inches at Gulkana, 187.3 at Summit. It is reported that snow accumulates to a depth of 4 feet in spruce forests in the vicinity of Gulkana. The chances of having droughts damaging to vegetation in spring and early summer are considerably greater in the vicinity of Gulkana than at Summit. The precipitation at both stations increases from the low point in April to the high in July, and then declines again. The wettest period at both stations is from June through September; the driest period is April-May. In 1955 the last killing frost occurred at Gulkana on June 3, at Summit on June 12; the first killing frosts in autumn on August 14 and August 26, with frostless seasons of 72 and 75 days, respectively. The frostless season is shorter in much of the region situated above tree-line. At Meier, in the northeastern corner and near tree-line at an elevation of 2717 feet, the frostless season in 1955 was only 61 days. In 1955 the number of days with maximum temperature of 70°F. or above was 26 at Gulkana, and 8 at Summit; maximum temperature 32°F. or below, 251 and 265 days, respectively. So, Gulkana is colder in the winter and warmer in the summer than Summit. On the whole it appears that conditions for plant growth are somewhat better in the vicinity of Summit and eastward in the Nenana River valley into part of the Nelchina Caribou Range than elsewhere in this region.

The Vegetation

Black and white spruce occur generally throughout the Nelchina Caribou Range at elevations below 3,000 feet. Scattered trees may occur as high as about 3,500 feet, or slightly higher, as on hillsides west of the Susitna River, in the vicinity of Paxson, and east of Cantwell. The largest block of spruce and associated vegetation is in the southeastern quarter of the region where the largest area below the 3,000-foot contour is found. Smaller blocks are in the Susitna River-upper Talkeetna drainage basins, the triangle formed by the valleys of the Susitna and lower reaches of the Maclaren River and Clearwater Creek, and westward from the upper Susitna River including Monahan Flat and the upper valley of the Nenana River. As tree-line is approached the trees form a gallery type of open forest along many streams, or form patches of more or less scattered trees on slopes of hills. The tallest trees and densest stands are found at the lowest altitudes. Glandular birch, dwarf heath shrubs, and willows are the most common species in the undergrowth; mosses and lichens in the ground layer.

Few areas have escaped fire during the past 50 to 75 years. Fire occurs frequently because of the highly inflammable nature of the vegetation, especially during periods of drought. The vegetation is exceedingly patchy, in large part because of fires which have occurred at different times in the past. The spruce forest has been replaced by stands of aspen, aspen-balsam poplar, willow-dwarf heath-glandular birch, and glandular birch-dwarf heath shrub. The last one is the most widespread. Burned areas are conspicuous usually because of dead trees lying on the ground and upright snags. Various stages of regeneration can be determined by the height and density of the spruce trees. Causes and effects of these fires have been treated in detail by Lutz (1956). Bogs and sedge marshes are numerous in poorly drained sites.

At an altitude of about 2800 feet the spruce trees are usually more scattered than lower. The glandular birch, which forms the most common understory in the spruce forest, is the chief dominant in the vegetation between 3000 and 4000 feet, on the slopes, hilltops, and plateaus. Willows are mixed with the birch in varying abundance, and are dominant in the moister parts. Dwarf heath shrubs, mosses, and lichens are abundant. Altai fescue is usually present and is the chief dominant in grassland patches between the shrubs, or it may cover extensive areas at about 4000 feet, particularly in the southwestern portion.

Above about 4000 feet various kinds of vegetation occur, depending upon the steepness and exposure of slopes, rockiness, drainage, and the kind of soil. Some of the vegetation types are sedge meadow, alpine meadow, dwarf heath shrub, Dryas-Kobresia, and barren (sparse cover of lichens, mosses, and vascular plants).

In this introductory paper on the vegetation of this region, it appears most feasible to use as few major types as possible. Eleven major types are distinguished, chiefly on the criterion of the dominant vascular species in the uppermost layer of vegetation (cf. Hanson 1953, 1958). The dominance was judged by the degree of cover, frequency, and height. Some stands, especially in the burned spruce areas, are classified according to the tallest, although sparse in places, species; for the soil and other environmental conditions are characteristic of the climax type in which spruce is dominant, rather than of the successional stage following the fire. Stands at the upper limits of the spruce are classified according to the dominant shrub. The spruce, under present conditions cannot apparently become sufficiently numerous to attain dominance except in small localized areas.

The 11 major types are 1) Spruce, 2) Glandular Birch, 3) Dwarf Heath Shrub, 4) Fescue, 5) Willow, 6) Aspen, 7) Alpine Meadow, 8) Dryas-Kobresia, 9) Sedge, 10) Bog, and 11) Mountain Sage.

Spruce Type.

Most of the 22 stands in the spruce type were on fairly level to gently sloping land. The type does occur also on steep slopes along rivers and foothills. The ground surface usually showed a polygonal pattern, with moundlike centers 10-24 inches higher than the bordering depressions. Occasionally the borders were depressed (Stand 34). Most of the centers of stands had a cover of lichens 0.5 to 1.0 inches thick. This mat was usually packed and partly shattered. Low heath shrubs, particularly Vaccinium uliginosum, V. vitis-idaea, and Ledum decumbens were scattered on the mounds. In the climax stage, not disturbed recently by ground fire, as in Stand 68, Cladonia sylvatica and C. rangiferina were 3-4 inches high. Mounds evidently have been formed by the pushing up of silt into hummocks of vegetation by frost action, and often as frost boils. The mounds enlarge by continued frost boil activity and by solifluction of silty material into depressions.

Soil profiles showed an organic layer varying from 0.5 to 4 inches in depth, underlaid by loam and then silt loam or silt. A few profiles had sand or sandy loam below the organic layer. The pH varied from 4.1 to 6.3 near the surface, to pH 6.0 to 8.2 (Stand 43) in the lowest horizon. The unusually high alkalinity in Stand 43 may have been caused in part by ashes from a fire 5-6 years ago. Roots were very numerous in the organic layer in all stands and often numerous for a few inches deeper. The working depth of the roots was usually at about 12 inches (7-18 inches). As a rule the soil showed no effervescence with 20 per cent HCl. Permafrost was encountered in 4 of the 22 stands at depths of 28 to 32 inches. Old surface horizons, covered by solifluction from mounds, were found in several of the stands. Charred material, indicating former fires, were found commonly in surface horizons of the profiles.

The depressions generally were occupied by very dense vegetation, such as mosses, Sphagnum spp., dwarf heath shrubs, and Salix spp. Betula glandulosa and spruce trees were usually more numerous and larger in depressions than on the mounds. Lichens were taller, but much less abundant in the depressions than on the mounds. They did not appear to be utilized under the shrubs and trees, probably because the caribou during winter have more difficulty in pawing down through the taller and denser snow-covered shrubs than in the polygon centers.

Except where fire has occurred recently (Stand 43) the cover of vegetation was very good, usually 97-100 per cent. The spruce (except in the climax stage), Betula glandulosa, and Salix spp. were usually more or less scattered, forming incomplete cover. The dwarf heath shrubs, mosses (average cover 3.5, ranging from 1.8 to 5.5), and lichens usually had a high degree of cover. The total number of vascular species per stand varied from 14 to 28, averaging 20. The total number of vascular species in the 22 stands was 87. There were nine constants (species appearing in 80 per cent or more of the stands), namely Betula glandulosa, Vaccinium uliginosum, V. vitis-idaea, Ledum decumbens, Empetrum nigrum, Salix pulchra, Rubus chamaemorus, Salix alaxensis, and Petasites frigidus. The first four of these had the greatest cover.

The range condition was rated as poor or poor-fair in sixteen of the stands, fair in three, and fair to good in only three, two of the last in climax Stands 68 and 69. The lichen cover averaged 3.1 (omitting cover of 0.1 in Stand 43 because of the recency of fire), and ranged from 1.5 to 5.0. The lichen growth was usually short (0.5-1.0 inch), matted on the polygon centers, partly shattered, and taller but probably not available for winter grazing in the border depressions. The chief kinds were Stereocaulon spp., Cladonia sylvatica, C. rangiferina, crustose-like species of Cladonia spp. such as C. pleurota, Peltigera aphthosa, Nephroma arcticum, and scattered Cetraria cucullata. Broken-off tips of branches of shrubs and exposed roots and basal branches were scattered on many polygon mounds. Trails and broken and dead moss tufts indicated earlier heavy use by caribou. Recovery during the past 2 or 3 seasons was indicated by upright growth of Cladonia sylvatica and C. rangiferina in many of the stands, but the scarcity or absence of C. alpestris indicated that succession has still a long ways to go before the lichen climax is reached. The lichen climax is considered to be a stand with dense growth of lichens, 4-5 inches tall, consisting chiefly of Cladonia alpestris and C. rangiferina.

The analyses of the stands provided information on three kinds of secondary succession following fire, usually influenced by heavy use by caribou; primary succession beginning in sedge marsh; and primary succession on frost boils. Early invaders on burned-over spruce forest were revealed particularly in Stand 43, burned 5-6 years ago. Mosses including Polytrichum strictum, P. juniperinum, Paludella squarrosa, Ceratodon purpureus, Aulocomnium palustre, and Drepanocladus uncinatus, furnished most of the cover. The most abundant vascular species was Vaccinium uliginosum. Other species

contributing significantly to the cover were Ledum decumbens, Vaccinium vitis-idaea, Equisetum sylvaticum, Rosa acicularis, Epilobium angustifolium, Calamagrostis canadensis, Petasites frigidus, and Rubus chamaemorus. Lichen fragments were too dry to determine if they were alive or dead. Spruce seedlings were sparse. Where the fire was not too severe willow shoots grew from old crowns. The first lichens to invade such burned areas are the crustose-like Cladonia pleurota, C. coccifera, and similar species. As succession proceeds debris and partly decomposed organic matter accumulate and the shrubs and spruce increase in density, especially in the depressions (Stands 46 and 36). Lichens such as Cladonia gracilis, C. cornuta, C. gonecha, C. amaurocraea, Stereocaulon tomentosum, Peltigera aphthosa, and Nephroma arcticum (the last two under shrubs) become more abundant and taller (Stand 69). Cladonia sylvatica, C. rangiferina, and Cetraria spp. invade; as Cladonia sylvatica and C. rangiferina grow taller and denser other species of Cladonia lose out (Stand 42), and under favorable conditions, such as freedom from ground fire and overuse by caribou, Cladonia alpestris may invade. The spruce trees increase in height and density (Stand 77), and in time the climax may be reached. Climax or near-climax stands were seen in only three places (Stands 54, 68, and 70), but ground fire or overuse may prevent the lichens from reaching the climax stage, even if the trees do reach the climax.

Secondary succession also takes place where the forest is removed along roads, building sites, etc., by bulldozing or other operations. Calamagrostis and Epilobium angustifolium soon become dominant in such disturbed places.

Primary succession appears to take place in the invasion of Eriophorum-Carex marsh, similar to Stand 41 (see below under Bog Type), by the invasion of Sphagnum and mosses which form hummocks. This seems to be occurring especially in Stands 41 and 71. Rubus chamaemorus and heath shrubs invade these hummocks, resulting in bogs. The hummocks enlarge and coalesce and black spruce invades them. This appears to be accompanied by frost action and mound-like centers of polygons are formed (Stands 47, 39, 49, and 40). In most of the stands the polygons are well defined, frost action may be active, and the prescence of species such as Carex rotundata, Eriophorum vaginatum, Rubus chamaemorus, and Oxycoccus microcarpus may indicate earlier bog conditions.

Primary succession occurs on bare areas formed by frost boils in polygon centers, as in Stand 52. Mosses first invade the wet frost

boils, and then hummocks of other species of moss develop. Juncus castaneus and Carex capillaris elongata are also early invaders. As growth continues the hummocks coalesce and heath shrubs and lichens appear.

The conclusion appears warranted that on the whole the range condition of the spruce type for winter use is usually poor to fair. This condition has been brought about by several factors such as heavy use by caribou for a number of years prior to the last two or three, widespread fires, including ground fires, following which succession of lichens is very slow; frost action which also retards succession; and unfavorable reactions of mosses and of trees and shrubs, such as shading. The range condition is good to excellent usually in the spruce type on the borders of the Nelchina Caribou Range along the Glenn and Denali Highways, where use by caribou has been light or lacking, and where fire has not occurred recently.

The descriptions of three characteristic stands of the spruce type appear below.

Stand 54. Climax White Spruce: This stand is located near the center of the Nelchina Caribou Range, in the angle at the junction of Tyone River and Tyone Creek, at an altitude of 2350 feet, Lat. 62°39', Long. 147°2'. This open climax stand of white spruce consisted of scattered old trees, some dead, as tall as 50 to 60 feet. Living trees were more numerous near the river bank than farther inland. Death of trees seems attributable to old age. Reproduction of the spruce was very good. Young trees varied from as short as a foot to 20 to 30 feet tall, some of these occurring in dense parts of the stand. Some down trees appear to have been blown over by the wind. None of the trees showed any indication of ground fire. Mounds of earth 2 feet high, 6 to 7 feet long, and about 2 feet wide covered the base of the trees. These mounds were covered with mosses, dwarf heath shrubs, and some lichens.

The ground surface was irregular because of these earth mounds, and because of hummocks formed by mosses and Sphagnum, and trails and tracks formed chiefly by moose. Tussocks of Eriophorum vaginatum were scattered. Dead trunks and branches on the ground were usually covered with moss. Ledum decumbens, Vaccinium vitis-idaea, and V. uliginosum were the chief vascular species in the moss hummocks. The hummocks varied greatly in size, from a few inches to 18 inches high. Polygons were not well defined, depressions separating the centers were 4 to 8 feet wide and 6 to 10 inches deep.

The soil profile showed dark sandy loam soil to a depth of 29 inches. Partly decayed pieces of wood, some as large as 5 inches in diameter and showing growth rings, were found to a depth of 19 inches. An olive gray layer of sand occurred at 29-31 inches, and permafrost was encountered at 31 inches. The pH was 6.3 and 6.4 between 2 and 29 inches, 6.9 below 29 inches. The soil showed no reaction to 20 percent HCl. Roots were very numerous to depth of 2 inches, and the working depth (the depth to which a large number of roots penetrates) was about 14 inches.

The total number of vascular species seen in this stand is 26. As shown in Table 1, the chief species are Vaccinium uliginosum, V. vitis-idaea, Ledum decumbens, and Calamagrostis inexpansa. Ledum decumbens averaged about 10 inches high. L. groenlandicum, much less numerous, averaged 15-18 inches tall. Salix spp., 5-8 feet high and widely scattered, had been browsed considerably by moose. Betula glandulosa was very sparse. Mosses were very abundant, lichens were sparse but in good condition, 1-2 inches high. The chief kinds were Cladonia gracilis, C. cornuta, C. rangiferina, C. sylvatica, and Peltigera aphthosa. C. alpestris and Cetraria spp. were sparse.

Moose have cut and kicked loose many of the clumps of lichens, moss, and Sphagnum, thus exposing roots and branches which were growing in the partly decomposed organic matter immediately beneath the litter and living plants. Packed trails, shattered lichens, and broken stems were fairly common. Caribou also frequent this area, but there were no indications of over-use, at least in recent years. The sparse and short growth of the lichens seems to be attributable to ground fire in the past. The range condition (suitability for caribou winter range, based on lichens) is rated as poor to fair, in a four-class basis: poor, fair, good, excellent. Lichens appear to be improving in height and area covered.

Stands 42 and 43 were on a similar site on the east side of Betty Ann Lake, altitude 2525 feet, Lat. 63°37', Long. 146°57'. Stand 42 was burned over some 33 to 50 years ago; Stand 43 only 5 or 6 years ago. They were located about 2.2 miles northwest of the climax white spruce stand, 54, described above.

Stand 42. Spruce Type--old burn: This stand was open, the black spruce trees averaging 10-12 feet tall, maximum about 25 feet. The ground surface was hummocky and formed polygons. The rounded

Table 1. Stand 54, at Junction of Tyone River and Tyone Creek. White Spruce Climax. August 9, 1957

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover, %	100	99	90	100	100	98	100	100	99	100	99	
Arctostaphylos alpina											x	
Betula glandulosa						2	1				0.3	20
Empetrum nigrum	2	1	1			1	1	1			0.7	60
Ledum decumbens		1	2	3	1	1	1	1	3	2	1.5	90
Ledum groenlandicum			1		2						0.3	20
Picea glauca				1	4					2	0.7	30
Rosa acicularis	1	2	1	1	1		1		2	1	1.0	80
Rubus chamaemorus				1	2	1	2				0.6	40
Salix alaxensis				1							0.1	10
Salix pulchra						2					0.2	10
Vaccinium uliginosum	2	2	1	3	1	1	2	1	2	2	1.7	100
Vaccinium vitis-idaea	3	1	2	1	1	1	1	3	1	2	1.6	100
Potentilla fruticosa							1				0.1	10
Epilobium angustifolium				1							0.1	10
Equisetum scirpoides		1	1	1	1	1	1	1	1	1	0.9	90
Equisetum sylvaticum		1			1	1	1	1		1	0.6	60
Mertensia paniculate											x	
Pedicularis sp.											x	
Petasites frigidus						1					0.1	10
Polemonium acutifolium										1	0.1	10
Arctagrostis latifolia											x	
Calamagrostis inexpansa	1	2	1	1	3	1		1	1	2	1.3	90
Eriophorum angustifolium											x	
Eriophorum vaginatum			1			1				1	0.3	30
Carex sp.						1	2				0.3	20
Poa pratensis	1			1	1					1	0.4	40
Mushroom												
Sphagnum Girgensohnii	2		1	4						1	0.8	40
Mosses	4	4	5	4	5	5	5	6	4	5	4.7	100
Lichens	1	1	2	1	1	1	3	2	3	3	1.8	100

Number of vascular species in quadrats - 21
Additional vascular species in stand - 5

mound-like centers varied from 4 to 15 feet wide and up to 25 feet long. The borders varied from 3 to about 20 feet wide, 8 to 20 inches deep, and usually contained water. The mounds were usually covered with living and dead lichens, matted into a layer 0.5 inch thick or less. They were much shattered, with only a few upright plants, chiefly Stereocaulon. Small moss hummocks, 2-10 inches high,were scattered, resembling pedestals with vertical sides. They were more or less disintegrated and loose tufts were also scattered. A few dwarf shrubs such as Vaccinium vitis-idaea, Ledum decumbens, and Betula glandulosa usually occurred (Table 2). Broken branches of shrubs, especially Vaccinium uliginosum, were frequently seen on the mounds. Lower parts of many branches of V. uliginosum and B. glandulosa were exposed, instead of being in the organic material. Spruce and shrubs were more numerous and taller in the borders of the polygons than in the centers. Betula glandulosa and Salix spp., the former 2-4 feet tall, the latter 3-10 feet tall, were scattered. Vaccinium uliginosum, 3-15 inches tall, and Ledum decumbens, 6-15 inches, were the most numerous shrubs. Under the spruce and the shrubs lichens such as Cladonia sylvatica, C. rangiferina, an occasional C. alpestris, and Peltigera aphthosa, 2 to 4 inches tall were found. They were often abundant under the denser thicket-like clumps. These dense clumps evidently are not pawed by caribou in the winter as the polygon centers are. The depressions also contained much moss and some sphagnum and much saussurea. Their color is green in contrast to the gray, lichen-covered centers. The packed condition of the lichens on the mounds seems to be attributable chiefly to trampling by caribou during the winter. Contributing factors may be the weight of the snow and ice, for the snow may become as deep as four feet, and exposure of the lichen mat to drying and cracking during dry periods in the summers. The range condition for winter grazing by caribou may be classified as fair; the lichens under the shrubs are apparently used very little, if at all.

The soil profile showed organic matter, well decayed below 0.5 inch to depth of 2 inches, and dusky red. The 2-6 inch horizon was silt loam, dark brown to brown, well developed crumb structure, and containing many stones. The 6.0-20.5 inch layer was a silt loam, dark gray brown, compact, with scattered stones. The 20.5-22.5 inch layer, apparently a former surface horizon, consisted of well decomposed organic matter with very little mineral material, reddish black, very loose structure and showed some evidence of fire. From 22.5 to 50 inches was sandy silt, very sticky, containing much gravel and small stones, and dark gray. This horizon was very wet, water seeped into the pit and the soil had a pronounced tendency to flow.

Table 2. Stand 42, Betty Ann Lake, Black Spruce-Dwarf Heath. August 8, 1957

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover, %	80	85	90	100	95	100	99	85	94	96	92.4	
Arctostaphylos alpina		1									0.1	10
Betula glandulosa		1				2	1			1	0.5	40
Empetrum nigrum	1	1	1	2					1	1	0.7	60
Ledum decumbens	2	2	1	2	2	3	3	2	2	1	2.0	100
Oxycoccus microcarpus											x	
Picea mariana	1	2		3	1	2	3	4	2	1	1.9	90
Rosa acicularis	1			1					1	1	0.4	40
Vaccinium uliginosum	1	2	2	2	2	2	2	2	2	3	2.0	100
Vaccinium vitis-idaea	1	1	1	2	1	1	2	2	2	1	1.4	100
Rubus chamaemorus	1	1	1	1		1	2	1		1	0.9	80
Salix alaxensis									1		0.1	10
Salix pulchra		1		2				2			0.5	30
Calamagrostis canadensis	1	1	1	1	1	1	1	1	1	1	1.0	100
Carex podocarpa											x	
Eriophorum vaginatum											x	
Equisetum sylvaticum						1				1	0.2	20
Petasites frigida	1	1	1	2		3	2	1	1		1.2	80
Saussurea angustifolia			1								0.1	10
Sphagnum sp.				4							0.4	10
Mosses	1	3	2	3	2	6	3	4	4	2	3.0	100
Mushrooms					1						0.1	10
Lichens	4	4	5	3	6	3	6	3	5	6	4.5	100

Number of vascular species in quadrats - 15
Additional vascular species in stand - 3

About ten inches of water collected in the bottom of the pit in half an hour. The pH varied from 4.3 in the top organic layer, to 5.4 immediately below, and 6.1, 6.4, and 6.2, respectively in the layers below. There was no effervescence with 20 percent HCl. No permafrost was encountered. The working depth of the roots was only 7 inches, but the roots were very numerous in the uppermost 2 inches.

Stand 43. Spruce Type--recent burn: This stand was burned over 5 or 6 years ago. Before the burn it was similar to adjoining Stand 42. Dead snags of black spruce, up to about 25 feet high, were scattered over the area. The fire must have been fairly light as most of the spruce were still standing and sprouts have appeared from the bases of the willows. The stand was conspicuous because of the occasional green clumps of willow, 4-5 feet high, in the matrix of the yellow-green Equisetum sylvaticum, 6-10 inches high, and Calamagrostis canadensis. The polygonal ground structure was not as conspicuous as in Stand 42. The mound-like centers were somewhat firmer and the moss had been mostly burned or was very much disintegrated. The surface of the mounds was covered with a dry, crust of organic material, too dry to determine if the lichen fragments in it were alive or not. The numerous cracks in this crust were as much as one inch wide. Except for this crust, and Equisetum and Calamagrostis, the mounds were mostly bare. No frost scars were seen.

In the border depressions, as much as 12 inches below the centers, mosses were building up. The chief kinds were Polytrichum strictum, P. juniperinum, Paludella squarrosa, Ceratodon purpureus, Aulocomnium palustre in wet spots, and Drepanocladus uncinatus. The chief shrubs, mostly in the depressions, were Vaccinium uliginosum, 2-6 inches high, and Ledum decumbens, 2-8 inches high. Spruce seedlings, 2-3 inches high, were scarce. Table 3 shows the analysis of this stand.

The winter range condition for caribou rated poor. For moose, however, it appeared to be good because of the abundance of young willow shoots. The lichen succession has a long ways to go, but the presence of organic matter to a depth of 3 inches on the surface was favorable for as rapid a rate as possible.

The 0-3 inch horizon of the soil profile consisted of organic material, dusky red with very little mineral matter. The silt loam horizon between 3 and 13 inches varies from dark gray brown to very dark gray brown with stones scattered below 4 inches. The very dark

Table 3. Stand 43, Betty Ann Lake, Burned-over Black Spruce-Dwarf Heath Stand. August 8, 1957

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover, %	50	75	85	70	60	55	80	95	75	92	73.7	
Arctostaphylos alpina											x	
Betula glandulosa	1					3			1		0.5	30
Ledum decumbens	1		1	2	1	3	3	1	1		1.3	80
Oxycoccus microcarpus					1						0.1	10
Rosa acicularis	1	1		1	2	1	1		1		0.8	70
Rubus chamaemorus			1	1	1	1	1	1	1	1	0.8	80
Salix alaxensis				2							0.2	10
Salix pulchra		1	1								0.2	20
Spiraea beauverdiana						1	1				0.2	20
Vaccinium uliginosum	3	3	1	4	1	1	4	3	3		2.3	90
Vaccinium vitis-idaea		1	1			1	1	3	1	1	0.9	70
Calamagrostis canadensis	1	1	2	1	1	1	1	1	1	1	1.1	100
Epilobium angustifolium	2	1	1	1	1			1		1	0.8	70
Epilobium palustre											x	
Equisetum scirpoides	1	1								2	0.4	30
Equisetum sylvaticum				1	2	1	1	2	1	1	0.9	70
Petasites frigidus	1	1	2		1	1	1	1	1	1	1.0	90
Pyrola secunda											x	
Marchantia polymorpha					1						0.1	10
Mosses	2	2	4	4	4	1	1	3	3	6	3.0	100
Lichens	1	x	x	x	x	x	x	x	x		0.1	90

Number of vascular species in quadrats - 15
Additional vascular species in stand - 3

gray material resembled the old surface horizon seen in Stand 42. The horizon from 13 to 33 inches was a somewhat mottled silt, rocks increasing with depth. The colors varied from dark gray to strong brown. pH varied from 4.6 in the top horizon, 6.8 to 6.9 at 4-13 inches, 7.8 at 21 inches, and 8.2 at 28 inches. Slight effervescence upon application of 20 percent HCl was noted in soil from a depth of 24 inches. At 31 inches the effervescence was strong. No permafrost was encountered. The working depth of the roots was at 13 inches. Roots were very numerous in the 0.3 inch organic layer, and numerous in 4 inches and in the very dark gray brown material below this.

This recently burned stand differs from Stand 42 in having less prominent border depressions in the polygonal structure, firmer centers, pH above 7.0 below 20 inches, presence of lime at 24 inches and below, more abundant mosses, fewer lichens, only seedlings of Picea mariana, and a much more open cover of shrubs. The herbage cover was much less, 73.7% compared to 92.4% in Stand 42 (Tables 2 and 3).

Glandular Birch Type

The birch type covers more area than any other type in the Nelchina Caribou Range. It is also widespread in neighboring regions such as Mt. McKinley National Park and north of the Alaska Range. It covers wide expanses, almost without interruption, on rolling hills and plateaus between about 3000 and 4000 feet, and it is also the chief type on burned-over spruce forest. The height and density of the chief dominant, Betula glandulosa, vary considerably. Two subtypes may be distinguished: the tall subtype averaging about 4 to 6 feet tall, and the low subtype averaging from 0.5 to 2.0 feet tall. Nine of the 24 stands in this type were classified in the taller group, namely 17, 37, 61, 73, 4, 78, 22, 75, and 11; fifteen in the low subtype, 14, 23, 32, 27-28, 29, 26, 63, 60, 38, 16, 72, 31, 59, and 6.

The constants (species present in 80 percent or more of the stands) among the vascular species were as follows:

	Tall subtype	Low subtype	Both subtypes
Vaccinium uliginosum	90	100	96
Betula glandulosa	100	100	100
Vaccinium vitis-idaea	100	100	100

	Tall subtype	Low subtype	Both subtypes
Ledum decumbens	90	100	96
Empetrum nigrum	100	100	100
Salix pulchra	(67)	80	(75)
Festuca altaica	90	(47)	(62)

Five species were common to both, and there was only one additional species in each subtype. Other common species in both subtypes were Calamagrostis canadensis, Carex bigelowii, Anemone narcissiflora interior, Antennaria monocephala, Artemisia arctica, and Pedicularis labradorica. Species found only, or mostly, in one or the other of the subtypes were as follows:

Species in Tall Subtype	Species in Low Subtype
Cornus canadensis	Cassiope tetragona
Aconitum delphinifolium	Arctostaphylos alpina
Rubus stellatus	Dryas octopetala
Ledum groenlandicum	Loiseleuria procumbens
Vaccinium caespitosum	Diapensia lapponica obovata
Linnaea borealis	Campanula lasiocarpa
	Luzula multiflora
	Luzula confusa
	Pedicularis capitata
	Pedicularis lanata
	Polygonum bistorta plumosum
	Salix arctica
	Salix polaris selwynensis
	Salix polaris interior
	Carex capillaris
	Carex podocarpa
	Andromeda polifolia
	Chamaedaphne calyculata

The total number of species varied considerably from stand to stand, for various reasons. The average number for nine stands in the tall subtype was 18.8, varying from 8 in Stand 75 to 44 in Stand 4. The low number in Stand 75 may be related to unfavorable soil conditions such as the 1 or 2 cemented layers between 8 and 18.5 inches, the sandy gravelly material above this, exposed mineral soil, and a south-facing slope of 5-15 degrees, all conducive to rapid loss of moisture during dry periods. The high number of species in Stand 4

seems attributable to the invasion and growth of many species in the sandy loam soil on which the moss and lichen layer had been partly shattered by much trampling of caribou during the calving season. Furthermore, the site was favorable for invasion because of its location on a bench on the lower slopes of a hill, below or near stands of other types (Stands 5 and 7, and Stand 6 in the birch type).

The average number of species in the low subtype is 22.7, ranging from 12 in Stand 72 to 41 in Stand 29. There was somewhat less variation than in the tall subtype, but the difference is not significant. There does seem to be greater opportunity for invasion and growth of herbaceous species in the low subtype because of the larger area of bare ground in frost boils and because of somewhat less competition with the shrubs for light. The larger development of moss hummocks in the tall subtype may have a depressing effect on herbaceous growth. The low number of vascular species in Stand 72 may be caused by the closed cover of lichens, low shrubs, and mosses; not disturbed by caribou. The relatively high number of species in Stand 29 may be explained partly by the method used in analyzing the stand. Both centers and borders of this polygon mosaic were included in the analysis, whereas in the polygon mosaic of 27-28 the centers and borders were analyzed separately. The latter analysis showed that some species occur in the centers and not in the borders, and vice versa. The centers are much richer in species, for Stand 28 (the centers) had 37 species whereas Stand 27 (the borders) had only 15. In a more detailed classification the centers and borders should be placed in different community types because of the great differences in vegetation, as well as in soil conditions.

The cover and frequency of mosses were similar in the two subtypes; average cover 3.86 in the tall subtype and 3.67 in the low one. Hummocks were usually taller in the former. The chief mosses were Pleurozium schreberi, Hylocomium splendens, Aulocomnium palustre, A. turgidum, Dicranum bergeri, D. fuscescens, Polytrichum strictum, P. commune, Rhacomitrium lanuginosum, and Paludella squarrosa. The last five occurred usually in bare soil such as frost boils.

The lichens had an average cover of 4.1 in the tall subtype and 4.7 in the low one. The frequency was nearly 100 percent in both. The vegetative cover ranged in thickness from 0.5 to 5.0 inches. The low cover in Stand 4 can be attributed to the considerable trampling by caribou for several seasons during the calving season. The 2.7 cover in Stand 31 was caused, it appears, by the bog-like conditions, with an

abundance of moss, Carex, and Salix. The greatest cover (6.0 in each) was found in Stands 37, 38, and 60. In each of these the moss cover was low and the organic material in the upper part of the soil profile was large, with well drained material below. Neither was there excessive shading by shrubs. The height growth of lichens in Stand 38 had suffered under heavy use by caribou during the two preceding seasons, but in the other two, with little or no use by caribou, the height was 4-6 inches. The shortest lichens (0.5-2.0 inches) were in stands that had been heavily used, such as 4, 75, 78, 32, 29, 27, 26, and 38. Usually the lichens were also matted down and more or less shattered. The chief lichens in well developed mesic stands, not subjected to overuse by caribou, were Cladonia rangiferina, C. alpestris, and C. sylvatica. Other species, more characteristic of less developed stands were as follows:

Cladonia uncialis
C. deformis, on bare ground
C. gracilis, " " "
C. amaurocraea
C. cornuta, on bare ground
C. coccifera, " " "
C. gonecha, " " "
Peltigera aphthosa, under shrubs especially
P. pulverulenta, Do.
Nephroma arcticum, Do.
N. aphthosa, Do.
Lobaria linita
Thamnolia vermicularis, often on bare soil
Cetraria cucullata
C. nivalis, in open areas
C. richardsonii, in damper spots, such as in cracks or tracks.
C. islandica, increases under use
C. chrysantha, on bare soil
Cornicularis divergens, on bare soil
Alectoria ochroleuca, " " "
A. nigricans, " " "
Sphaerophorus globosus, " " "
Stereocaulon paschale, " " ", and increases apparently under use.
Pertusaria pangyra, on bare soil
Ochrolechia frigida, " " "
Dactylina arctica

A layer of litter, usually 1-2 inches thick, partly decayed and containing many roots, covered most of the ground in all the stands. Bare mineral soil was exposed usually in frost boils, in the vicinity of ground squirrel dens, and in caribou trails. Under the litter was a horizon of well decomposed organic material, usually 1-2 inches thick, with numerous roots. Below this the profiles usually consisted of horizons of loam or sandy loam, sandy loam, and in places sand; all with intermixed gravel and stones. Flow earth and seepage were present in only a few stands, namely, 72, 27, 28, and 63; and a buried surface horizon in only the last two. Cemented layers, preventing the growth of roots, and probably also water penetration, were found only in Stand 75. The soil reaction in nearly every instance showed a gradient from greater acidity near the surface to 2 to 3 feet

below. The range near the surface was from pH 4.0 in Stand 75 to pH 6.1 in Stand 27. The range at 2-3 feet below the surface was from pH 5.2 to 6.7. Usually the gradient was from about 4.5 to 5.9. The working depth of roots varied from as shallow as 6.5-8.5 inches in Stand 75, to 28 inches in Stand 28 with a buried surface horizon. Usually the working depth was at 11-14 inches.

The range condition of the 9 stands in the tall subtype were classified as follows: for winter use--excellent 37, 61, 11; good 22; fair 17, 73, 75; for spring or summer use--good 4, 22; fair 78, 75. The range condition of the fifteen stands in the low subtype was as follows: for winter use--excellent 14, 23, 63, 60, 38, 59; good 16, 72, fair 32, 27, 28, 29; poor 26, 31; for spring or summer use--good 12. It appears that if soil conditions are favorable for invasion and growth of vascular species moderate to heavy use of the range during calving season, such as occurred in Stands 4 and 22, the range improves in value for spring or summer use. This is because the herbaceous species increase in number and abundance, and the mosses decrease. Heavy use during the winter season, however, results in rapid deterioration, as seen in stands 26, 27, 31, 32, and 38. Non-used or lightly utilized range produces excellent growth of lichens, as seen in stands listed as excellent above. Deterioration of the range is marked by packing and disintegration of the lichen-moss layer, decumbent short growth and shattering of lichens, formation of moss pedestals and breaking of moss hummocks, exposed roots and lower branches of shrubs, pieces of branches of shrubs scattered over the ground, nipped branches, presence of trails, and changes in the species composition of mosses and lichens. Comparison of Stand 38 with 60, and Stand 73 with 37, shows how rapidly deterioration can occur under 2 or 3 years of heavy use. As deterioration continues the taller lichens such as Cladonia alpestris, C. rangiferina, and C. sylvatica are replaced by shorter and more decumbent forms, such as C. gracilis, C. deformis, C. cornuta, C. gonecha, Cetraria spp., and others. Mosses such as Pleurozium schreberi, and Hylocomium splendens are replaced by Polytrichum spp., Rhacomitrium lanuginosum, and Dicranum fuscescens.

Various stages of plant succession were especially noticeable on frost boils, in the vicinity of ground squirrel dens, and in trails made by caribou or ground squirrels (see Stands 4, 27, 29, and 73, especially). Invaders on mineral soil in such sites are several species of moss, particularly Rhacomitrium lanuginosum, Polytrichum strictum, and P. commune. Other species are Paludella squarrosa and Dicranum fuscescens. Early lichen invaders were low species of Cladonia such as C. coccifera, and C. pleurota, Alectoria spp., Ochrolechia frigida, Cornicularia divergens, Stereocaulon paschale, and Cetraria

chrysantha. Lichens characteristic of an early intermediate stage are Cladonia uncialis, C. gracilis, C. gonecha, C. cornuta, Thamnolia vermicularis, Cetraria nivalis, and others. A later intermediate stage is characterized by greater abundance of Cladonia amaurocraea, C. sylvatica, Cetraria cucullata, C. islandica, C. richardsonii; and under or close to shrubs, Nephroma spp. and Peltigera spp. The climax is characterized by dominance of Cladonia rangiferina, especially under or close to shrubs; C. alpestris, mostly between the shrubs; intermixed C. sylvatica; and usually several species from earlier stages are sparsely represented. In the climax stage the lichens tend to suppress mosses and vascular plants, including low shrubs, as indicated in Stands 60 and 61. In some dense, tall stands of Betula glandulosa (Stand 17), however, the shrubs have a depressing effect upon the lichens. In some marshy stands (31, 32) the mosses are dominant in the lowest layer. The importance of a substratum of decaying mosses, especially Polytrichum spp., and of the presence of much organic matter in the uppermost soil horizon in the succession of lichens are demonstrated in a number of stands such as 61, 63, 72, 73, 38, and 60. The chief vascular species invading frost boils and trails were Carex scirpoides, C. capillaris, Luzula spicata, L. multiflora frigida, L. triglumis, Juncus biglumis, Empetrum nigrum, Antennaria arctica, Festuca brachyphylla, and Epilobium spp. Other invaders were Petasites frigida, Tofieldia pusilla, Arctagrostis sp., Dodecatheon frigidum, Salix arctica, Vaccinium vitis-idaea, Calamagrostis canadensis, Lupinus arcticum, Salix reticulata, and Polygonum viviparum; the last two on bare ground near ground squirrel dens. Species appearing later in the succession are Betula glandulosa, Vaccinium uliginosum, Ledum decumbens, Salix glauca, Carex bigelowii, and C. montanensis. Festuca altaica and associated herbs appear to increase in abundance where mineral soil is exposed by trampling, as in stands 4 and 78.

On the whole, the range condition of the birch type, as indicated by the 24 stands analyzed in detail, and as indicated by observations of numerous other areas, is in good condition. If soil conditions are good, it appears at the present time that heavy use during the calving season has increased the variety and quantity of plants for grazing at this season. Apparently only rather limited use has been made so far of the large area of winter range of the birch type. Areas of poor to fair condition, according to the present survey, seem to be restricted to certain portions of the type, such as the vicinity of Tangle Lakes and eastward, and in the vicinities of Big Lake and Clarence Lake. It appears that heavy use of a winter range area for 2 or 3 seasons results in rapid deterioration and that a period of at least 30 years without utilization is needed for recovery to the near-climax or

or climax stage, provided that deterioration has not been too severe. If a fair amount of debris and organic material remains in the soil after deterioration, succession to the near-climax or climax stage can be expected to proceed within this time.

The descriptions of four characteristic stands of the Glandular Birch type appear below.

Stand 17. Tall, Dense, Climax Birch Community: This stand was located on a south-facing slope of 5 degrees or less, about 27 miles west of Paxson close to the Denali Highway, at an altitude of 3550 feet, Lat. 63°4.5', Long. 146°11'. This stand represents about the maximum of density and height found in the Betula glandulosa type, and many square miles are similar to this in the Nelchina Caribou Range. The height of B. glandulosa varied from 4 to 8 feet, averaging about 5.5 feet. The bases of the shrubs were from 1 to 4 feet apart. Because of the density and partly decumbent branches, walking through the stand was difficult. Occasional small grass openings were dominated by Festuca altaica and Calamagrostis canadensis. At the base of the shrubs were low, rounded moss hummocks.

The soil surface was covered with about an inch of litter. The soil profile was as follows: 0-2 inches, mostly organic matter with a little silt; 2.0-2.5 inches, silt; 2.5-8.5 inches, fine sandy loam; 8.5-24.0 inches, coarse sand and gravel with many small stones, especially below 12 inches. The pH changed progressively from 4.4 at 0-2 inches to 5.2 at 8.5-24 inches. Large horizontal and small roots were very numerous at 0-2 inches, and the working depth was at 12 inches.

As shown in Table 4 the chief species beneath the Betula glandulosa canopy were Empetrum nigrum, Vaccinium vitis-idaea, Cornus canadensis, Spiraea beauverdiana, and Ledum decumbens. Vaccinium uliginosum and Salix pulchra were sparse. Mosses covered most of the ground. The chief species were Pleurozium schreberi very abundant and common, Hylocomium splendens common and abundant, Polytrichum strictum common as invader in bare spots, and Dicranum fuscescens scarce. Lichens were growing mostly between the Betula bushes. They were well developed with average cover of 3.4. The most common and abundant was Cladonia alpestris, and next in abundance was Peltigera aphthosa. Other species were Cladonia uncialis frequent (in clumps), C. sylvatica infrequent (mixed with C. alpestris), C. cornuta infrequent (in clumps), C. coccifera infrequent

Table 4. Stand 17, 27 Miles West of Paxson, Betula glandulosa Climax. July 16, 1957

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover	98	100	100	100	100	100	99	100	100	100	100	
Betula glandulosa	4	4	5	5	3	3	2	4	3	5	3.8	100
Empetrum nigrum	4	3	3	3	4	3	5	4	4	4	3.7	100
Ledum decumbens	1	2	1	2	2	2	1	1	1		1.3	90
Salix pulchra				2	1		1				0.4	30
Spiraea beauverdiana	1	1	1	2	3	1	2	2	1	1	1.5	100
Vaccinium uliginosum							3		1	2	0.6	30
Vaccinium vitis-idaea	1	2	2	3	2	3	1	2	1	3	2.0	100
Calamagrostis canadensis	x	1	1	1		1	1	1	1	x	0.7	90
Carex bigelowii						1		1	1		0.3	30
Festuca altaica	1		1	1	1	1	x	1	1	x	0.7	90
Anemone narcissiflora interior	1		1		1		1		1	1	0.6	60
Artemisia arctica					1	1			1	1	0.4	40
Cornus canadensis	2	2	2	2	2	2	1	2	2	2	1.9	100
Pedicularis labradorica											x	
Lycopodium alpinum											x	
Lycopodium clavatum monostachyon											x	
Mosses	5	6	6	6	6	6	6	6	6	6	5.9	100
Lichens	3	3	4	2	4	3	4	2	5	4	3.4	100

Number of vascular species in quadrats - 13
Additional vascular species in stand - 3

in bare spots, C. gonecha scarce, Cetraria islandica frequent, C. cucullata scarce, Nephroma arcticum frequent, and Thamnolia vermicularis infrequent.

The range condition was rated fair. While there was much Cladonia alpestris, it appears that caribou do not utilize the lichens much, if at all, in such dense and tall stands of Betula glandulosa. No signs of use by caribou or moose were seen.

Stand 37. Medium Tall, Dense Climax Birch Community: This stand was located on the upper gentle slope, of not over 5 degrees, and top of a hill about a mile north of Eureka, at an altitude of about 3400 feet, Lat. 61°57', Long. 147°11'. Analysis was made on July 31, 1957. This stand appeared to be typical of many square miles in this part of the Caribou Range. This dense, medium tall Betula glandulosa stand is near the upper limit of the spruce. As indicated by well decomposed stumps and charcoal under considerable accumulation of organic material, this site burned over many years ago. Trees before the fire were as much as 14 inches d. b. h. Occasional living white spruce, as tall as about 30 feet, were widely scattered. Betula glandulosa, cover 3. 4, was usually about 4 feet tall (2. 5-5 feet). The shrubs were usually on hummocks, up to a foot high, consisting of lichens, mosses, and heath shrubs. These hummocks were separated by firm, apparently packed areas, 1 x 4 feet wide, which have a shorter cover of lichens and fewer heath shrubs than the hummocks.

The organic horizon in the soil was 2. 5 inches thick. The 2. 5-4. 0 inch layer consisted of organic material with considerable intermixed silt. The very dusky red color and pieces of charcoal indicated that it was the surface horizon at the time of the fire. The 4-10 inch layer was sand with very little silt and with scattered gravel and small stones. Below this to 25 inches was sand with stones and very much gravel. It was very wet at the bottom. The structure was loose throughout and the drainage was good to 22 inches. The pH increased from 4. 2 at 2. 5-4. 0 inches to 5. 5 at 10-25 inches. Roots were numerous at 0. 0-2. 5 inches and the working depth was at 14 inches.

As seen in Table 5 the species composition was similar to that in Stand 17 (Table 4). Vaccinium uliginosum, up to 15 inches high, was much more abundant however. Ledum decumbens was up to 12 inches high. Empetrum nigrum and Vaccinium vitis-idaea were abundant. Calamagrostis canadensis and Spriaea beauverdiana were scattered, and Festuca altaica was scarce.

Table 5. Stand 37, 1 Mile North of Eureka, Betula glandulosa Climax. July 31, 1957

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover	100	100	100	100	100	100	100	100	100	100	100	
Betula glandulosa	3	4	4	4	3	4	4	3	2	3	3.4	100
Empetrum nigrum	2	3	3		3	3	4	2	3	3	2.6	90
Ledum decumbens	3						2	3	2	1	1.1	50
Rubus chamaemorus				1							0.1	10
Salix glauca angustifolium											x	
Spiraea beauverdiana		1		1		1	1	1	1	1	0.7	70
Vaccinium uliginosum	3	3	3	2	4	3	3	3	3	3	3.0	100
Vaccinium vitis-idaea	1	2	3	1	2	2	2	2	1	3	1.9	100
Calamagrostis canadensis	1	1	2	1	1	1	1	1	1	1	1.1	100
Carex brunnesoens											x	
Festuca altaica		1			1				1		0.3	30
Cornus canadensis	2			1	1						0.4	30
Mosses	3	2	3	2	1	3	2	1	2	2	2.1	100
Mushrooms						1			1		0.2	20
Lichens	6	6	6	6	6	6	6	6	6	6	6.0	100

Number of vascular species in quadrats - 10
Additional vascular species in stand - 2

Lichens were very abundant, cover rating of 6 and height of 4-6 inches under the Betula, 1-3 inches between the shrubs. The chief species were Cladonia rangiferina very common and very abundant, C. sylvatica abundant, C. alpestris abundant, C. gracilis frequent, C. deformis infrequent, C. amaurocraea infrequent, C. coccifera scarce, Stereocaulon paschale frequent between shrubs, Cetraria islandica infrequent, Nephroma arcticum infrequent, Peltigera pulverulenta and P. aphthosa infrequent. The range condition was rated excellent. The density and height of Betula did not appear to be sufficiently great to prevent use by caribou during the winter. At present only a few caribou bulls frequent this vicinity occasionally. Successionally this stand appears to be climax or near-climax. It does not seem likely that a spruce forest will develop here under present conditions, at least not for a very long time.

Stand 4. Birch Community--Heavily Utilized Spring Range: This stand was located on the first bench above the valley bottom of Tyone Creek at an altitude of 3650 feet, Lat. 62°11', Long. 147° 22'. The slope was gentle, about 5°, facing west. The hill above extended to about 4100 feet. It is in the calving range, used by many caribou cows and their calves during the spring. Analysis was made on June 28, 1957.

This Betula glandulosa stand varied greatly in density, from thickets difficult to walk through to open grassy areas as large as 100 x 150 feet. Betula averaged about 4.5 feet tall, ranging from 1.5 to 6 feet. Salix glauca, about the same height, occurring mostly in lower, moist spots, was much less abundant. Moss hummocks, 1-2 feet high, had developed around the lower parts of Betula and Salix. The chief mosses were Hylocomium splendens common and abundant, Pleurozium schreberi common and abundant, Polytrichum strictum frequent, Aulocomnium palustre infrequent, and Dicranum fuscescens infrequent. As the hummocks increase in height new roots of shrubs are formed in the upper part. The chief species growing in these hummocks were, in addition to Betula and Salix, Empetrum nigrum, Vaccinium vitis-idaea, Carex spp., and Ledum decumbens. Lichens on the sides and tops of these hummocks were in good condition. The most important species were Cladonia rangiferina common and abundant, C. sylvatica common and abundant, C. gracilis common and abundant, Cetraria cucullata fairly abundant, C. islandica scarce, Peltigera aphthosa abundant, and Alectoria ochroleuca scarce.

Festuca altaica and Carex montanensis were the chief species in the openings. Other prominent species were Salix reticulata, Valeriana capitata, Polemonium acutiflorum, and Artemisia arctica. The scattered moss hummocks were low and lichens were scarce and shattered by trampling of caribou.

The organic layer in the soil profile was 1.5 inches thick. At 1.5-10.5 inches was sandy loam; at 10.5-23 inches sandy loam with many gravel particles and stones, and at 23-25 inches sandy loam with interspersed stone. The silt content was high also below 1.5 inches. The pH varied from 5.8 at 1.5-10.5 inches to 6.0 at 10.5-23 inches. Water seepage appeared at 24 inches.

The unusually large number of species in this stand (Table 6) appears to be attributable, in part at least, to the exposure of mineral ground by trampling, frost action, and burrowing by ground squirrels. Species invading bare ground in trails and frost boils were Carex scirpoidea, Luzula spicata, Empetrum nigrum, Petasites frigida, Arctagrostis latifolia, Dodecatheon frigidum, and Antennaria arctica. Invaders on bare gound adjacent to ground squirrel dens were Salix reticulata and Polygonum viviparum. It appears that in this stand and in this vicinity the heavy use by caribou has caused enlargement of the Festuca openings. The mineral soil exposed by trampling and trailing seems to be favorable for invasion of Festuca altaica and associated species. This appears to be taking place also in Stand 78 (see below).

The large number of species in this stand offers a wide variety of forage for the caribou cows and their calves. Some erosion is occuring in places in trails, but it is not serious. The condition of the range for use during the calving season is rated as good. As winter range it would be rated poor because of the rather low cover and shattered condition of the lichens, broken moss hummocks, exposed roots and lower stems of shrubs, fragments of stems on the ground, and the numerous trails.

Stand 14. Low, Open Birch Community: This stand is located on a ridge-top north of the Denali Highway, 27 miles west of Paxson, at an altitude of 3600 feet, Lat. 63°4.5', Long. 146°11'. This stand is above Stand 13 on the west-facing slope. Analysis was made on July 14, 1957. This low, open Betula glandulosa-Empetrum nigrum stand, rich in lichens, is representative of vegetation on tops of hills and ridges below 4000 feet in this vicinity. Several of the following stands are similar. They are exposed to winds, so there

Table 6. Stand 4 on First Bench Above Tyone Creek, Betula glandulosa Climax Stand. June 28, 1957.

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover	95	100	95	95	98	95	80	95	100	100	95	
Betula glandulosa	3	3	3	4	5	4	3	3	5	2	3.5	100
Dryas integrifolia											x	
Dryas octopetala											x	
Empetrum nigrum		3	2					2			0.7	30
Ledum decumbens		2									0.2	10
Potentilla fruticosa											x	
Rubus stellatus		1							2	2	0.5	30
Salix glauca angustifolia								3			0.3	10
Salix pulchra		2						1	1	4	0.8	40
Salix raticulata			3	2	x	3					0.8	40
Vaccinium uliginosum	3		1	3	3						1.0	40
Vaccinium vitis-idaea	1	2	1	x	2	1	1	2	2	2	1.4	100
Carex bigelowii											x	
Carex montanensis	1		2	2	1	1				1	0.8	60
Carex scirpoidea				1		1					0.2	20
Festuca altaica	1	1	2	2	4	4	1	1	3	3	2.2	100
Hierochloe alpina								1			0.1	10
Luzula spicata				1		1					0.2	20
Poa arctica									x		0.1	10
Aconitum delphinifolium				1		x					0.1	20
Anemone narcissiflora											x	
Antennaria monocephala			1	x							0.1	20
Arctagrostis latifolia											x	
Arnica lessingii											x	
Artemisia arctica				1	1	1			1	1	0.5	50
Astragalus alpinus											x	
Astragalus umbellatus											x	
Cardamine bellidifolia			x								0.1	10
Claytonia sarmentosa				x	1						0.1	20

Table 6. Stand 4 on First Bench Above Tyone Creek, Betula glandulosa Climax Stand. June 28, 1957. (Continued)

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Dodecatheon frigidum											x	
Gentiana glauca											x	
Linnaea borealis										1	0.1	10
Pedicularis labradorica	1					1		1			0.3	30
Pedicularis langsdorfii arctica											x	
Petasites frigidus	x	1									0.1	20
Polemonium acutiflorum			1		1	1			1	x	0.4	50
Polygonum viviparum				x		1					0.1	20
Saussurea angustifolia											x	
Sedum roseum											x	
Senecio atropurpureus			x								0.1	10
Senecio lugens											x	
Solidago multiradiata				1	x	1				1	0.3	40
Stellaria laeta			x	1	1	1			x	x	0.3	60
Valeriana capitata			x	1	2	x			1	1	0.5	60
Sphagnum sp.		6									0.6	10
Mosses	5		3	6	5	5	4	4	6	6	4.4	90
Lichens	3		2	2	2	2	4	4	2	2	2.3	90

Number of vascular species in quadrats - 29
Additional vascular species in stand - 15

probably is not much snow accumulation during the winter. Betula averaged about 16 inches in height with a range of 8-30 inches, and had a spreading growth habit. Salix pulchra was similar but about one-third as abundant. Low hummocks, 2-8 inches high, composed chiefly of mosses and lichens, with some dwarf shrubs, were usually at the bases of these shrubs. The shrubs were separated by open spaces as much as 10 feet across. The chief plants on these spaces were lichens, 2-4 inches high, mosses and Empetrum nigrum. The chief dwarf shrubs (see Table 7) were Empetrum nigrum, with average cover of 2.6, Vaccinium vitis-idaea 2.2, and V. uliginosum 1.9. The most abundant herbs were Festuca altaica, Anemone narcissiflora interior, Calamagrostis canadensis, and Hierochloe alpina. The total number of vascular species was 21.

The chief mosses were Polytrichum commune which was common and abundant, Pleurozium schreberi, and Dicranum fuscescens. The chief lichens were, in order of abundance: Cladonia sylvatica, common and abundant; C. rangiferina, common and abundant; Cetraria richardsonii, frequent; Nephroma arcticum, frequent; Cetraria islandica, frequent; Dactylina arctica, frequent; Stereocaulon paschale, frequent in bare spots; Ochrolechia frigida, frequent in bare spots; Cetraria nivalis, infrequent; C. cucullata, infrequent; and Cladonia gracilis, scarce

In the soil profile the 0-1 inch layer was mostly organic matter with a little silt; 1-7 inches, sandy loam; 7.0-11.5 inches, sandy loam with scattered gravel particles; 11.5-20.0 inches, brown sandy loam with much gravel and many stones; 20-24 inches, gray brown sandy loam with much gravel and many stones. The pH varied from 5.1 at 1-3 inches, 5.7 at 10.5 inches, to 5.5 at 20-24 inches. The working depth of the roots was at 16 inches.

The scattered bare spots caused by rodent activity or frost action were being invaded by several species of moss and lichens, and by vascular plants such as Empetrum nigrum, Festuca altaica, Salix arctica, and Cassiope tetragona. A few old caribou droppings were seen but very little use has been made of the vegetation. Only a few bulls seem to be in this area in the summer. The range condition was excellent. The vegetation may be considered as climax for this kind of site.

Table 7. Stand 14, About 27 Miles West of Paxson, Climax Low Betula glandulosa Stand, Rich in Lichens and Mosses. June 14, 1957

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover	99	98	100	100	99	99	100	100	98	99	99	
Betula glandulosa	3	3	4	2	3	3	2	4	3	3	3.0	100
Cassiope tetragona				1						1	0.2	20
Empetrum nigrum	3	4	4	4	3	2	2	1	2	1	2.6	100
Ledum decumbens		2			2						0.4	20
Salix arctica											x	
Salix pulchra	1	2	1	1	3	1		1			1.0	70
Spiraea beauverdiana											x	
Vaccinium uliginosum		1			3	3	3	3	3	3	1.9	70
Vaccinium vitis-idaea	2	2	3	1	2	2	2	3	2	3	2.2	100
Calamagrostis canadensis				x		x	1	1	1	1	0.4	60
Carex bigelowii	1			1				1			0.3	30
Festuca altaica	1	1	1	x	x	1	1	1	1	x	0.7	100
Hierochloe alpina		1	1		1			1	1		0.5	50
Anemone narcissiflora interior	2	1	1		1	1			1		0.7	60
Antennaria monocephala	1										0.1	10
Artemisia arctica	1		1	1	1						0.4	40
Campanula lasiocarpa											x	
Gentiana glauca	1	1									0.2	20
Lycopodium alpinum	1										0.1	10
Pedicularis labradorica				1						1	0.2	20
Pyrola minor	1										0.1	10
Mosses	4	4	5	4	3	5	4	4	4	5	4.2	100
Lichens	6	5	4	6	6	6	6	5	6	5	5.5	100

Number of vascular species in quadrats - 18
Additional vascular species in stand - 3

Dwarf Heath Shrub Type.

This type is widely distributed, mostly above about 3100 feet, but also on exposed slopes below 3000 feet, as for example Stand 76 on the south side of one of the Fog Lakes at an altitude of 2200 feet. This type appears to cover in the aggregate considerable area in the northwestern part of the Nelchina Caribou Range, west of the Susitna River and north of the Black and Talkeetna rivers. It resembles the low glandular birch type, particularly the centers of polygons in stands such as 27, 28, and 29 along the eastern part of the Denali Highway. In the heath type, however, the heath shrubs assume greater dominance than the glandular birch, and the depressed borders, when present, do not have such an abundance of the birch. The physiognomy of the heath type is distinctive because of the open stand of dwarf shrubs, usually 6-12 inches high, and the cover of lichens and mosses between the shrubs. Bare soil is present in areas disturbed by ground squirrels, followed by wind and water erosion, and also in frost boils.

This is a composite type, as indicated by the floristic composition, topography, and soil conditions. For convenience the stands are grouped into three subtypes. Subtype A comprises Stands 24, 15, and 5. The chief dominant is Cassiope tetragona. Usually the site is a moderate to steep, well drained, northerly slope. The subtype is conspicuous because of the very dark green clumps of Cassiope in the pale gray background of lichens. Subtype B comprises Stands 56, 58, and 62. The chief dominants are Vaccinium uliginosum, Empetrum nigrum, Ledum decumbens, Vaccinium vitis-idaea, Cassiope tetragona, Arctostaphylos alpina, and Carex bigelowii. The site is a gentle slope (5 degrees or less), with poor drainage, and with active solifluction and frost action. It is fairly conspicuous because of the mosaic pattern of polygons, the somewhat raised centers covered with lichens, the depressed borders with dense growth of shrubs and sedges. Subtype C comprises Stands 57 and 76. The chief dominants are Empetrum nigrum, Vaccinium vitis-idaea, V. uliginosum, Ledum decumbens, and Loiseleuria procumbens. The site has moderately steep to steep slopes that are well drained and much exposed to winds. The total numbers of vascular species in the three stands in subtype A were 28, 28, and 35; in B, 24, 30, and 18; and in C, 16 and 12. As shown in Table 8 the number of constants (present in 7 of the 8 stands) was 9. Several herbs were present in subtype A, but not in the other subtypes. The more abundant were Anemone narcissiflora interior, Artemisia arctica, Antennaria monocephala, Arnica lessingii, and Gentiana glauca. Some of the species in subtype B, not present in the others, were Andromeda polifolia, Eriophorum angustifolium, and Tofieldia pusilla.

Table 8. Comparison of Cover and Frequency of Chief Species in the Dwarf Heath Shrub Type.

	Subtype A						Subtype B						Subtype C			
Stand Number	24		15		5		56		58		62		57		76	
Location	Tyone Cr.		28 W Paxson		36 W Paxson		42 E Cantw.		42 E Cantw.		46 E Cantw.		42 E Cantw.		Fog L.	
Altitude (ft.)	4150		3600		4000		3100		3100		3100		3150		2200	
Slope(Degrees)	25-45°		25-40°		25-40°		5-10°		5°		5°		10-30°		10-35°	
Exposure	N		W		N		N		N		N		N-W		N	
pH	-		4.7-5.6		5.1-5.9		4.8-5.8		-		-		3.0-5.6		3.9-5.5	
Herbage Cover (%)	100		97		100		100		100		99		100		100	
	Ave. c.	Freq. %	Ave. c.	Freq. %	Ave. c.	Freq. %	Ave. c.	Freq. %	Ave. c.	Freq. %	Ave. c.	Freq. %	Ave. c.	Freq. %	Ave. c.	Freq. %
Arctostaphylos alpina	-	-	-	-	1.0	50	0.4	30	0.8	70	1.2	70	1.4	90	2.9	90
Petula glandulosa	1	1	0.4	30	0.3	30	0.9	90	1.0	90	0.8	60	1.0	40	0.2	10
Cassiope tetragona	3.3	100	2.8	100	2.5	100	1.1	80	1.3	100	x		0.5	50	-	-
Empetrum nigrum	-	-	0.5	20	1.9	80	1.3	100	1.0	100	1.6	100	1.9	100	2.9	100
Ledum decumbens	-	-	0.4	30	1.1	80	1.0	100	1.0	100	1.2	100	1.3	100	1.2	70
Loiseleuria procumbens	-	-	0.2	20	2.6	100	1.1	100	-	-	1.5	70	1.5	70	-	-
Salix pulchra	0.1	10	1.1	90	x		0.1	10	0.7	40	0.1	10	x		-	-
Vaccinium uliginosum	0.1	10	0.6	50	1.9	90	1.5	100	2.2	100	0.9	100	1.5	100	0.6	60
Vaccinium vitis-idaea	0.4	30	1.3	100	2.1	100	0.4	40	1.1	100	1.0	100	1.7	100	1.5	100
Calamagrostis canadensis	0.1	10	0.9	90	x		-	-	x		0.5	50	0.3	30	1.0	100
Carex bigelowii	-	-	0.8	80	0.1	10	1.1	100	2.3	100	1.0	90	0.9	90	0.1	10
Mosses	4.2	100	4.8	100	2.6	100	1.4	90	2.4	100	2.0	100	1.0	90	2.3	100
Lichens	3.6	100	4.6	100	2.2	100	6.0	100	5.3	100	5.7	100	5.8	100	3.9	100
No. vascular spp. in stand	32		28		35		24		30		18		16		12	

Comparison of the soil profiles shows that the organic horizon was thinner in subtype A (1.0 to 1.5 inches thick) than in B (2 to 3 inches thick), and C (2 to 5 inches thick). There were fewer stones and more silt in B than in C or A. Solifluction and frost action were pronounced in B, but usually lacking in the other two. Large stones were usually closer to the surface or more numerous on the surface in A than in C, and they were usually lacking in B. Seepage began at a depth of 10-12 inches in B; there was no seepage in A and C. Snow cover is probably deeper and remains for a longer time in the spring in B, and least in C. The soil reaction was fairly similar in all subtypes, ranging from pH 3.9 (Stand 76) to 5.1 in the surface soil, and 5.5 to 6.5 below 1 foot. Root penetration was similar in all of the subtypes. The working depth of the root systems was usually at 16-18 inches. No effervescence with 20 percent HCl was found in any of the profiles.

Mosses were usually not as abundant nor as tall in the heath type as in the spruce and glandular birch types. The cover was somewhat greater in subtype A (2.6-4.8) than in B (1.4-2.4) and C (1.0-2.3). Important species were Polytrichum commune, P. strictum, Pleurozium schreberi, Dicranum fuscescens, and Hylocomium splendens.

The lichen cover was usually good, ranging from 2.2 in Stand 5 (heavily utilized in the spring) to 4.6 in subtype A; 5.3 to 6.0 in subtype B, and 3.9 to 5.8 in subtype C. The height was usually from 1 to 4 inches in all the stands, except in Stand 76 (C), which was probably too exposed to winds and dried out too rapidly for good growth of Cladonia spp. The chief lichens were as follows:

Cladonia alpestris, usually ab. to v. ab.
C. sylvatica, Do.
C. rangiferina, usually ab.
C. amaurocraea, sparse
C. gracilis, Do.
Cetraria cucullata, usually ab.
C. nivalis, sparse to abundant
C. islandica, usually sparse
C. richardsonii, Do.
Stereocaulon paschale, sparse to abundant
Alectoria ochroleuca, Do.
A. nigricans, Do.
Cornicularia divergens, Do.
Dactylina arctica, sparse
Thamnolia vermicularis, sparse
Ochrolechia frigida, Do.
Sphaerophorus globosus, Do.
Peltigera aphthosa, Do.
Nephroma arcticum, Do.

Some of the pioneer lichens on mineral soil in sites exposed to wind and water erosion are Alectoria spp., Cornicularia divergens, and Stereocaulon paschale. Important invaders somewhat later are Cetraria nivalis and C. cucullata, followed by Cladonia sylvatica and other species; and finally C. alpestris and C. rangiferina become dominant. The last two species are capable of suppressing dwarf shrubs if conditions are favorable for lichen growth. Peltigera aphthosa and Nephroma arcticum usually grow under shrubs.

The range condition usually rated excellent for winter use, because of the abundance of lichens, especially Cladonia spp., and the presence of a variety of willows, sedges, and grasses. Furthermore, the open, low growth of the shrubs, and apparently thin cover of snow during winter make the plants available for grazing. Heavy use of this type leads to rapid deterioration and recovery is slow, because the sites are exposed to winds and sunlight, causing rapid evaporation, and because drainage is rapid in stands in subtypes A and C.

The descriptions of two characteristic stands in the Dwarf Heath Shrub type appear below.

Stand 24. Cassiope tetragona: This stand, rich in mosses and lichens, is located about 36 miles west of Paxson, a short distance east of the Maclaren River valley: altitude 4150 feet, Lat. 146°25', Long. 63°5'. The north-facing slope was very steep, about 45 degrees, and rocky. The aspect was conspicuous because of the dark green clumps of Cassiope, separated by the pale gray of lichens between the clumps. Analysis was made on July 23, 1957. The lichens varied greatly in cover (see Table 9) and in height (from 1 to 3 inches).

The total number of vascular species in the stand was 28. As shown in Table 9 the chief species were Cassiope tetragona, Salix polaris selwynensis, Artemisia arctica, Luzula multiflora frigida, L. parviflora, and Carex montanensis. Mosses, with cover of 4.4, were abundant. A soil profile description was not made.

Moister, shallow draws, where snow probably is deeper in the winter and lies later in the spring, alternate on parts of the slope with the exposed Cassiope areas. The vegetation in the draws was meadow-like, consisting chiefly of Festuca altaica, many forbs, dwarf willow, and an occasional Salix pulchra.

This stand has been used very little, if at all by caribou. The range condition for winter, spring, or summer use was rated good to excellent.

Table 9. Stand 24, 36 Miles West of Paxson, Cassiope tetragona Community. July 23, 1957

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover	96	100	99	99	90	75	99	97	95	99	95	
Cassiope tetragona	3	4	3	4	3	3	4	3	3	3	3.3	100
Diapensia lapponica obovata		1	1				1		2	2	0.7	50
Salix polaris selwynensis	3	2	3	2	4	3	3	4	3	2	2.9	100
Salix pulchra										1	0.1	10
Salix reticulata										2	0.2	10
Vaccinium uliginosum									1		0.1	10
Vaccinium vitis-idaea				1					2	1	0.4	30
Calamagrostis canadensis				1							0.1	10
Carex montanensis			1	1	1	1	1	1	1	1	0.8	80
Carex podocarpa					1						0.1	10
Festuca altaica		1		1				1		1	0.4	40
Hierochloe alpina									1	1	0.2	20
Luzula multiflora frigida	2	2	2	1	1	2	2	2	1	1	1.6	100
Luzula parvilflora		1	1		1	1	1		1	1	0.7	70
Trisetum spicatum											x	
Anemone narcissiflora interior			2	1					1	1	0.5	40
Antennarai monocephala					1						0.1	10
Arnica lessingii					1	1			1	1	0.4	40
Artemisia arctica	2	2	2	1	1	2	2	1	1	1	1.5	100
Campanula lasiocarpa									1		0.1	10
Cardamine bellidifolia						1					0.1	10
Castillaja hyperborea											x	
Claytonia sarmentosa											x	
Dodecatheon frigidum			2		1			1			0.4	30
Gentiana glauca	1		1		1	1	1				0.5	50
Lycopodium selago				1	1		1		1		0.4	40
Pedicularis capitata								1		1	0.2	20
Pedicularis langsdorfii arctica										1	0.1	10
Polygonum bistorta plumosum		1		1			1		1	1	0.5	50
Polygonum viviparum					x						0.1	10
Saxifraga punctata pacifica				1		1		1			0.3	30
Sedum roseum	1		1	x					1		0.3	40
Mosses	4	3	4	3	3	4	6	6	4	5	4.2	100
Lichens	3	3	4	4	4	3	4	3	4	4	3.6	100

Number of vascular species in quadrats - 29
Additional vascular species in stand - 3

Stand 58. Sedge-Heath Polygon Mosaic: This sedge-heath complex, rich in lichens, was located on a long gradual slope of 5 degrees or less, about 42 miles east of Cantwell: altitude 3100 feet, Lat. 63°14', Long. 147°47'. It adjoined Stands 57 and 56. Stand 58 is a polygon mosaic, apparently formed by frost action and solifluction. This type of vegetation is widespread on gentle slopes. The firm centers were covered mostly with lichens and dwarf heath shrubs. The borders, 1-2 feet lower than the centers, were wet and often contained water. Frost boils occurred occasionally in them. Analysis was made on August 24, 1957. The borders were occupied by such characteristic species as Juncus arcticus, J. triglumis, Scirpus caespitosus austriacus which formed dense tufts and grew best in water, Eriophorum angustifolium, E. russeolum albidum, E. scheuchzeri, and Saxifraga hieracifolia. Salix pulchra 1.0-3.5 feet high, and Betula glandulosa, 6-18 inches, were scattered, mostly in the depressions. The total number of vascular species in this mosaic was 30 (Table 10).

Mosses were moderately abundant. Lichens were very abundant. The chief species were Cladonia alpestris, v. ab., C. sylvatica v. ab., C. rangiferina ab., Cetraria cucullata ab., C. nivalis ab., C. islandica sc., Alectoria nigricans freq., and A. ochroleuca freq. Cladonia spp. were 2-4 inches high; Cetraria spp. 1-3 inches.

The range condition, for winter use, was rated excellent. Soil profile was not taken.

Fescue Type.

Eight stands are classified in this type, chiefly on the basis of altai fescue, the abundance of herbs, and the paucity of glandular birch and the dwarf heath shrubs. Willows were fairly numerous in some of the stands. The stands are situated at elevations of 3100 to 4300 feet, usually on level to gently sloping land (5-10 degrees). This type is most extensive on hills and ridges north from Eureka in the southwestern part of the Nelchina Caribou Range. Large areas also occur between willow or glandular birch stands along the Denali Highway, especially between 28 and 57 miles west of Paxson. Eastward and westward from this vicinity the type occurs more commonly as small patches; but southward the type apparently becomes more extensive on suitable sites.

The surface of the soil was usually covered with 1 to 2 inches of litter and moss. The organic layer in the soil profile varied from 1 to 3 inches thick. In most places the soil profile was moderately well

Table 10. Stand 58, a Sedge-Heath Complex, [illegible] in Lichens, 42 Miles East of Cantwell. August 2[illegible] 1957

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover, %	100	100	100	100	100	100	100	100	100	100	100	
Andromeda polifolia	1	1	1	1		1		1			0.6	60
Arctostaphylos alpina		1	1	1	1	2		1	1		0.8	70
Betula glandulosa	1	2	1		1	1	1	1	1	1	1.0	90
Cassiope tetragona	1	1	1	1	3	1	1	2	1	1	1.3	100
Empetrum nigrum	1	1	1	1	1	1	1	1	1	1	1.0	100
Ledum decumbens	1	1	2	1	1	1	1		1	1	1.0	90
Rubus chamaemorus								1			0.1	10
Salix arctica	1										0.1	10
Salix pulchra				2	2		2			1	0.7	40
Salix reticulata	1			1	1				1		0.4	40
Salix sp.								1			0.1	10
Vaccinium uliginosum	2	3	2	3	1	1	3	2	2	3	2.2	100
Vaccinium vitis-idaea	1	1	1	1	1	1	1	1	1	2	1.1	100
Calamagrostis canadensis											x	
Carex bigelowii	1	2	2	2	2	3	2	3	2	4	2.3	100
Carex capillaris											x	
Eriophorum angustifolium											x	
Eriophorum russeolum albidum											x	
Eriophorum scheuchzeri											x	
Juncus arcticus											x	
Juncus triglumis											x	
Scirpus caespitosus callosus											x	
Equisetum scirpoides											x	
Pedicularis capitata				1		1			1		0.3	30
Petasites frigidus										1	0.1	10
Polygonum bistorta plumosum	1	1	1		1	1	1	1	1	1	0.9	90
Saussurea angustifolia					1			1			0.2	20
Saxifraga hieracifolia										1	0.1	10
Stellaria laeta											x	
Tofielda pusilla											x	
Sphagnum											x	
Mosses	1	1	1	3	4	1	2	5	2	4	2.4	100
Lichens	6	6	6	6	4	6	6	3	6	4	5.3	100

Number of vascular species in quadrats - 19
Additional vascular species in stand - 11

developed, dark soil extending in most stands to more than 15 inches. Stones and gravel were intermixed in the usually sandy loam soil below the organic layer. The pH near the surface varied in the eight stands from 4.7 to 5.4, and below about 18 inches from 5.1 to 6.0. No effervescence with 20 per cent HCl was found, so the lime content was very low. Roots were numerous to the working depth, which varied from only 12 inches in Stand 18 to 21 inches in Stand 25. Usually the drainage was good in the surface layers.

In species composition this type is highly distinctive in contrast to all the other types, chiefly because of the dominance of Festuca altaica and the abundance of herbs. This distinctiveness is clearly apparent when the analysis tables are compared. Festuca altaica grows in tufts or bunches. The leaves were about a foot tall and the flower stalks extend to a height of 2 feet or more. The grass appears in places to invade mineral soil in disturbed areas, replacing mosses, lichens, and shrubs. The ecological amplitude for soil moisture is evidently wide as it grew well in the moist to wet soil in Stand 9 near Eureka and in the fairly dry Stand 13, 28 miles west of Paxson. The constants (species present in at least 80 per cent of the stands) were Carex montanensis, Artemisia arctica, Anemone narcissiflora interior, Antennaria monocephala, Salix pulchra, Salix reticulata, and only one heath shrub, Vaccinium vitis-idaea. Other prominent herbs were Carex bigelowii and Solidago multiradiata. The total number of vascular species varied from 21 in Stand 10 to 38 in Stand 7.

Mosses were usually abundant, cover mostly 4.0 or more. They formed a layer about 1 to 2 inches thick. The chief species were Aulocomnium turgidum, Polytrichum strictum, P. commune, Hylocomium splendens, Dicranum fuscescens, Rhacomitrium lanuginosum, Pleurozium schreberi, and Pohlia nutans, the last restricted largely to disturbed ground.

Lichens varied considerably in cover: 1.1 in Stand 7, 0.5 in Stand 10 in which Cetraria islandica was the only conspicuous species, and 3.6 or more in the others. The chief species were Cladonia sylvatica, C. alpestris, C. rangiferina, C. uncialis, C. coccifera, C. cornuta, Cetraria islandica, C. nivalis, C. richardsonii, Dactylina arctica, Stereocaulon paschale, Ochrolechia frigida, and Nephroma arcticum.

Ground squirrels, lemmings, and mice were numerous in most of the stands, but some, especially Stand 13 were too wet apparently.

This type is apparently more valuable for spring and summer grazing by caribou than for winter grazing because of the abundance and variety of forbs and the sparseness or short growth of lichens in many of the stands. The presence of willows adds much forage value in both seasons. None of the stands examined showed much evidence of use by caribou. It appears from the limited study of this type that caribou prefer other types more than the fescue type. The range condition for spring and summer grazing was rated good to excellent. For winter grazing the condition varied considerably: Stands 7 and 10 rated poor, Stands 9 and 13 excellent, and the other four stands were intermediate.

The descriptions of three characteristic stands of the Fescue Type appear below.

Stand 7. Fescue-Sedge Community: This stand was located on a 5-10 degree west-facing slope near the top of a long, rather flat-topped hill in the calving range in the upper part of the Tyone Creek drainage. The altitude is 4100 feet, Long. 147°22', Lat. 62° 11'. Snow cover is probably fairly deep in winter. This kind of site and type of vegetation covers many square miles in the southwestern part of the Nelchina Caribou Range. Analysis was made on June 30, 1957.

The fescue-sedge vegetation, rich in herbs, appears to be climax for the site. Clumps of Salix pulchra, 2-5 feet high, were widely scattered. As shown in Table 11, the chief species in order of abundance were Festuca altaica, Carex montanensis, Anemone richardsonii, Dodecatheon frigidum, Artemisia arctica, and Salix reticulata. Vaccinium vitis-idaea was scattered, other heath shrubs and Betula glandulosa were scarce. The total number of vascular species in the stand was 38.

The layer of litter and moss on the surface was usually 1-2 inches thick. In the soil profile the 0-3 inch layer was very dusky red organic material; 3-7 inches, dark reddish brown silty loam with scattered small stones; 7-14 inches, very dark gray brown silty loam with scattered small stones; 14-22 inches, dark gray brown silt loam with many small stones and gravel particles; 22-27 inches, dark yellowish brown sandy silt loam with many stones and gravel particles. The pH from the top down was 5.5, 5.4, 5.6, 5.7, and 6.0 in the respective layers. Roots were very numerous at 0-3 inches and the working depth was 17 inches.

Table 11. Stand 7, Fescue-Sedge Community, Rich in Herbs, in Upper Part of Tyone Creek Drainage. June 30, 1957

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover, %	100	100	99	99	99	99	99	100	98	98	99	
Betula glandulosa			x								0.1	10
Dryas octopetala			1							1	0.2	20
Potentilla fruticosa											x	
Salix glauca angustifolia											x	
Salix pulchra	1	1									0.2	20
Salix reticulata	2		2	2	2	2	1	2	1	2	1.6	90
Vaccinium vitis-idaea		1	1	x			1	1	1	1	0.6	70
Calamagrostis canadensis										1	0.1	10
Carex bipartita			1	2	1	1	1	1			0.7	60
Carex montanensis	3	2	2	3	2	2	3	3	2	2	2.4	100
Carex podocarpa								1		1	0.2	20
Carex scirpoidea	1			1	1	1	1	1			0.6	60
Carex vaginata					1		1	1	1	1	0.5	50
Festuca altaica	6	4	5	3	4	4	4	4	5	4	4.3	100
Hierochloe alpina											x	
Poa arctica											x	
Trisetum spicatum									1		0.1	10
Luzula confusa		1	1			1		1			0.4	40
Aconitum delphinifolium		1		1	1	1		1			0.5	50
Anemone narcissiflora interior	1	2	1	1	1	2	1	1	1	1	1.2	100
Anemone richardsonii	2	2	2	1	2	2	2	2	2	2	1.9	100
Antennaria monocephala	1	1	1	1	1	2	1	1	2	2	1.3	100
Artemisia arctica	2	1	1	1	2	1	1	2	2	2	1.5	100
Claytonia sarmentosa	1	1	1	2	1	1	1	1	1		1.0	90
Dodecatheon frigidum	2	3	1	1	2	2	2	1	2	2	1.8	100
Equisetum scirpoidea	1	1	1	1	1	1	1	1	1	1	1.0	100
Gentiana glauca											x	
Myosotis alpestris asiatica											x	
Pedicularis langsdorfii arctica			1			1					0.2	20

Table 11. Stand 7, Fescue-Sedge Community, Rich in Herbs, in Upper Part of Tyone Creek Drainage. June 30. 1957. (Continued)

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Petasites frigidus	1	1		1	x				1		0.4	50
Polemonium acutiflorum	x	1				1		1	x		0.3	50
Polygonum bistorta plumosum	1	1		2	1	1	1	1	1	1	1.0	90
Saxifraga hieracifolia						1					0.1	10
Senecio lugens	1	1	1	1	1	1		x	1	1	0.8	90
Solidago multiradiata		2	1	1				x	1	1	0.6	60
Stellaria laeta	1	1	1		1	1		x			0.5	60
Thalictrum alpinum					1						0.1	10
Valeriana capitata	1	1				1					0.3	30
Mosses	5	5	5	4	6	6	3	5	5	4	4.8	100
Lichens	1	2	2	1	1	1	1	1	x	1	1.1	100

Number of vascular species in quadrata - 32
Additional vascular species in stand - 6

Mosses were abundant, but lichens were not, only 1.1 in cover, and 1-2 inches high. Range condition for spring and summer grazing rated good to excellent. Although close to other heavily used stands, such as 4, 6, and 8, this stand had not apparently been much used.

Stand 9. Fescue-Willow Community: This stand, rich in forbs, is located on the nearly level top of a large hill about 3 miles north of Eureka: altitude 4250 feet, Lat. 61°58', Long. 147°14'. Analysis was made on July 10, 1957. This stand is representative of extensive grassland areas in the southwestern part of the Nelchina Caribou Range. Shallow wet draws with an abundance of sedges occur occasionally. Clumps of Salix pulchra, 2-5 feet high,were scattered. The ten quadrats were located in the areas between the draws.

The chief herbs were Festuca altaica, Artemisia arctica, Anemone narcissiflora interior, and Carex aquatilis. The abundance of the last species seems to be related to the shallow water table. Heath shrubs, mostly Vaccinium vitis-idaea and Empetrum nigrum were sparse, and Betula glandulosa very sparse. The total number of vascular species was 26 (Table No. 12).

Lichens, mosses, and debris formed a layer about 2 inches thick over the surface. In the soil profile the 0-2 inch layer consisted of dark reddish brown organic material; 2-4 inches, dark reddish gray loam with scattered small stones; 4-19 inches, variable, dark gray brown to dark reddish brown gravelly loam. The profile was saturated throughout with water, seepage began at depth of 12 inches. The working depth of the roots was at 15 inches. The pH at 2-4 inches was 4.8, at 4-19 inches 5.6.

Mosses were moderately abundant; lichens very abundant, 2-4 inches high. The area has been used very little by caribou, as indicated by the very few trails and droppings, and the good condition of the lichens. Ground squirrels were absent, probably because of the shallow water table, but lemmings and meadow mice did occur. The range condition (winter, spring, or summer grazing) was excellent.

Stand 21. Fescue-Willow Community: This stand, rich in herbs and mosses, is located on an east-facing slope (about 5 degrees) on the south side of the Denali Highway about 28 miles west of Paxson. The altitude is about 3600 feet, Lat. 63°4.5', Long. 146°11'. It is about one-fourth of a mile southwest of Stand 13, which it resembles, except that Salix pulchra is somewhat more abundant and taller in Stand 21. Analysis was made on July 20, 1957. This stand was bordered, lower on the slope, by a dense, medium tall glandular birch stand (Stand 22).

Table 12. Stand 9, Fescue-Willow Stand, Rich in Forbs, 3 Miles North of Eureka. July 10, 1957

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover, %	95	98	100	100	100	100	100	100	96	99	99	
Betula glandulosa											x	
Empetrum nigrum						1				3	0.4	20
Salix polaris selwynensis										1	0.1	10
Salix pulchra	x	1	3		1		2	1	3	1	1.2	80
Salix reticulata						1		3	1		0.5	30
Vaccinium vitis-idaea	1	1	1	2	2	1	1	1	1	1	1.2	100
Calamagrostis canadensis							1				0.1	10
Carex aquatilis	1	x	2	1	3	2	2	1	3	1	1.6	100
Festuca altaica	2	3	3	3	2	2	3	2	2	2	2.4	100
Aconitum delphinifolium			1			1			1		0.3	30
Anemone narcissiflora interior	1	2	2	3	3	3	1	2	2	2	2.1	100
Anetennaria monocephala	1	1	1	1	1	1	x	2		1	0.9	90
Arnica lessingii								1			0.1	10
Artemisia arctica	1	1	3	2	3	2	3	2	3	2	2.2	100
Claytonia sarmentosa					x						0.1	10
Dodecatheon frigidum			1	1				2		1	0.5	50
Pedicularis capitata											x	
P. Langsdorfii arctica			x					x		x	0.1	30
Petasites frigidus	1				1	1	1		1		0.5	50
Polemonium acutiflorum	1					1	x	x	1	1	0.4	60
Polygonum viviparum	1							1			0.2	20
Pyrola minor				1	1	1		1			0.4	40
Seedling			x							x	0.1	20
Stellaria laeta	x	x	1			1	x		1		0.3	60
Swertia perennis	1		1	x							0.2	30
Valeriana capitata											x	
Mosses	1	2	4	2	2	4	4	4	4	2	2.0	100
Lichens	5	6	5	6	5	5	5	4	4	6	5.1	100

Number of vascular species in quadrats - 23
Additional vascular species in stand - 3

Stands of these two, and in addition the dense willow type, and the low glandular birch type make up most of the vegetation mosaic in this general area.

Salix pulchra, averaging about 4 feet high, was widely scattered, occurring in fairly dense clumps to scattered plants, 10-20 feet apart. Under the willows moss hummocks were about 6-12 inches high, with few lichens on them. Among the herbs the hummocks were about half as high, as much as 2 feet in diameter, and separated by depressions as much as 2 feet wide. The chief herbs were Festuca altaica, Artemisia arctica, Anemone narcissiflora interior, and Carex montanensis. The total number of vascular species was 26.(Table 13).

Mosses and lichens were 2-4 inches high. The moss cover was unusually good, 5.9; the lichen cover was medium, 4.0. The range condition was rated good for winter grazing, excellent for spring and summer. The stand has been used little if any by caribou or moose.

Willow Type.

Willows are common throughout the Nelchina Caribou Range. There are many species, ranging in height from a few inches or less in the decumbent forms such as Salix reticulata, to low trees, such as S. alaxensis. They are usually intermixed with other species as codominants, for example S. scouleriana with aspens, or S. pulchra with glandular birch. Some species are major dominants in communities, as for example S. alaxensis on borders of streams, and S. pulchra, S. barclayi, and S. richardsonii on poorly drained sites as along lakes, in stream valleys, on lower slopes of hills, and along drainage ways or depressions on hillsides.

The willows are important in succession because various species are pioneers or early invaders in burned spruce stands (see especially Stands 43 at Betty Ann Lake and 35 near the junction of Glenn and Lake Louise Highways); on bare areas caused by ground squirrels (Stand 8, Dryas-Kobresia) or by frost action (Stands 27 and 29 in glandular birch type); and on newly deposited sand and gravel in stream bottoms (Stands 1-2 and 8A). The willows are well adapted to this successional role because of the production of numerous seeds which can be carried long distances by the wind, the exposure of wet soil in many places which favors germination and establishment, and the vegetative propogation by runners or horizontal roots. The ability of the crowns to survive fire and produce new shoots is another important feature, well demonstrated in Stand 43.

Table 13. Stand 21, Fescue-Willow Stand, Rich in Herbs and Mosses, 28 Miles West of Paxson. July 20, 1957.

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover, %	99	100	100	100	99	98	99	100	100	99	99	
Betula glandulosa		1									0.1	10
Empetrum nigrum		1			1						0.2	20
Rubus stellatus	1										0.1	10
Salix pulchra	3		3	1	3	3	3	2	4	3	2.5	90
Salix reticulata											x	
Vaccinium caespitosum	1	1	1	1	1	1	1	1	1	2	1.1	100
Vaccinium vitis-idaea	1		1	1	1	1	1	1	1		0.8	80
Carex montanensis	1	1	1	1	1	1	2	1	1	1	1.1	100
Carex nardina											x	
Eriophorum angustifolium											x	
Festuca altaica	3	2	2	3	3	2	3	3	3	3	2.7	100
Luzula multiflora firgida	1				1						0.2	20
Aconitum delphinifolium	2	1	1	1	1	1	1			1	0.9	80
Anemone narcissiflora interior	1	1	2	2	2	1	1	3	4	2	1.9	100
Antennaria monocephala	1	1		2		1				1	0.6	50
Artemisia arctica	2	1	3	3	3	1	2	2	2	3	2.2	100
Campanula lasiocarpa		1	1	1			2			1	0.6	50
Gentiana glauca	1	1	1	1						1	0.5	50
Lupinus arcticus	2										0.2	10
Polemonium acutiflorum	1				1		1		1	1	0.5	50
Pyrola minor	1	1	1	1		1	1	1	1	1	0.9	90
Sibbaldia procumbens					1	1					0.2	20
Solidago multiradiata		2		2		2			1	1	0.8	50
Stellaria laeta									1		0.1	10
Trientalis eurpoaea arctica			1	1	1			1	1	1	0.6	60
Lycopodium alpinum	1	2		2	1	1				1	0.8	60
Mosses	6	6	6	6	6	5	6	6	6	6	5.9	100
Lichens	3	6	3	4	2	5	5	5	3	4	4.0	100

Number of vascular species in quadrats - 23
Additional vascular species in stand - 3

The willows are very important as forage for both caribou and moose, especially for the latter. In summer moose strip off the leaves and break off the tips of branches, in the winter they nip off branches as much as 3/8 inch in diameter. Salix alaxensis seems to be the most preferred by moose, as well as by horses. Caribou appear to graze the delicate parts of a number of species, and these plants may form a very important part of the forage that is used both summer and winter.

As the openings in the shrub willow types enlarge a transition to the altai fescue type occurs. Herbs in small openings between dense willow are often the same as those in the fescue type.

The descriptions of four characteristic stands of the Willow Type appear below.

Stand 12. Salix pulchra Community: This willow stand, rich in herbs and mosses, is located on low, nearly level land on the east side of a small lake about 28 miles west of Paxson on the north side of the Denali Highway. The altitude is 3550 feet, Lat. 63°4.5', Long. 146°11'. It is situated lower on the same slope where the Fescue-Willow Stand 13 is. This stand is representative of vegetation which occurs occasionally in this region in similar sites, especially westward for a few miles. The willow shrubs varied from 2.5 feet to about 6 feet in height and were usually growing on hummocks which were about 14-15 inches high and from a foot to 4.5 feet across the top. The distance between the hummocks was 1 to 4 feet. The willow branches overlapped, forming thickets in places. In other spots the shrubs were separated as much as 10 feet. The hummocks had been built up of moss around the base of the shrubs. Frost boils were scattered.

There was no standing water in any of the depressions although the surface drainage was poor. The soil was very wet and showed a tendency to flow at 14-18 inches. The surface was covered with a layer of debris, moss, and lichens about 4 inches thick. In the soil profile the 0-4 inch layer was dark reddish brown loam, rich in organic matter, with scattered large stones; 4-24 inches, dark brown gravelly loam changing to dark gray brown gravelly loam at 20 inches, with stones scattered throughout; below 24 inches, fine sandy loam. The pH was 5.1 at 0-4 inches, 5.3 at 4-12 inches. Roots were very numerous in the bottom part of the litter and in the 0-4 inch layer. The working depth was about 12 inches.

As indicated in Table 14 Salix pulchra (cover 3.1) was the dominant. The most abundant associated species were Artemisia arctica, Rubus arcticus, Carex bigelowii, Festuca altaica, and Sedum roseum. The number of herb species was large, the number of heath shrubs few, so the stand showed considerable resemblance to stands in the fescue type. The total number of species was high, 38. Mosses were very abundant, cover 5.8, and were distributed throughout except on some of the higher exposed hummocks where there was much dead moss. The chief species were Aulocomnium turgidum, Dicranum fuscescens, Pleurozia schreberi, Paludella squarrosa, and Hylocomium splendens. Sphagnum compactum was also abundant.

Lichens were moderately abundant and were growing mostly on the tops and sides of hummocks. The most common species were, in approximate order of abundance: Cladonia sylvatica the most common and abundant, C. alpestris intermixed with the preceding, C. gonecha ab., C. uncialis ab., C. coccifera ab., Nephroma arcticum ab., Cetraria nivalis mod. ab., C. islandica mod. ab., Cladonia gracilis freq., C. rangiferina inf., Dactylina arctica, and Stereocaulon paschale.

No caribou droppings or trails were seen, and only a few caribou and moose seem to be in this area in the summer. The shrubs may be somewhat too tall and dense for grazing during the winter. The snow probably becomes deep and melts fairly late in the spring. The range condition for winter use was rated fair to poor; for spring-summer use, good. The site is probably not very suitable for spring-summer grazing because of unsuitable topographic conditions and the presence of many lakes and marshy land in the vicinity. Insect pests appear to be numerous, especially on warm summer days.

Stand 8A. Gray-leaved Salix alaxensis: This stand is located on bottomland along a stream close to its junction with Tyone Creek at an elevation of about 3600 feet. The community formed a zone, varying greatly in width, averaging about 100 feet wide, on mostly gravelly soil on the depositing bank, adjacent to the stream. Flooding occurs causing erosion or deposition of gravel and rocks. This type of vegetation is widespread, occurring commonly as narrow zones in similar sites in valley bottoms along streams. Observations were made on July 3, 1957.

Salix alaxensis varied from 3 to occasionally 20 feet in height. Most of the upper part of the plants were dead, and the green growth usually did not exceed about 7 feet tall. Many branches had been nipped off by moose. There were many uprooted trees, caused apparently by erosion and wind. The green-leaved Salix richardsonii was scattered.

Table 14. Stand 12, Salix-Pulchra Community, Rich in Herbs and Mosses, About 28 Miles West of Paxson. July 14, 1957.

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover, %	99	98	100	99	95	98	98	99	95	100	98	
Cassiope tetragona											x	
Empetrum nigrum	3						1	3	1	1	0.9	50
Ledum decumbens								1			0.1	10
Loiseleuria procumbens											x	
Salix pulchra	3	3	3	4	4	2	3	2	3	4	3.1	100
Spiraea beauverdiana										2	0.2	10
Vaccinium caespitosum			1		3		1	1	x	1	0.7	60
Vaccinium vitis-idaea	1	1	1	1	1	1			1	1	0.8	80
Calamagrostis canadensis			1			1					0.2	20
Carex bigelowii	2	1	2	2	2	1	2	1	2	2	1.7	100
Carex montanesis										1	0.1	10
Carex nardina	1										0.1	10
Deschampsia caespitosa		1									0.1	10
Festuca altaica	1	1	1	1	1	2	2	1	2	3	1.5	100
Luzula multiflora	1	1	1					1			0.4	40
Luzula parviflora			1	1	1						0.3	30
Poa arctica	1	1	1	1		1	1		1		0.7	70
Aconitum delphinifolium	1	1	1							1	0.4	40
Anemone narcissiflora interior	2	1	1	1	x		1	1	1		0.8	80
Artennaria monocephala	1	1	1		2			2	1		0.8	60
Artemisia arctica	4	3	2	3	2	2	3	3	3	2	2.7	100
Castilleja pallida mexiae											x	
Epilobium angustifolium			1		1						0.2	20
Gentiana glauca	1	1	1		1		1		1		0.6	60
Lupinus arcticus	2	2					2	2	1		0.9	50
Lycopodium alpinum	2	3	3		2		2	2	2		1.6	70
Lycopodium selago											x	
Pedicularis langsdorfii arctica											x	
Polemonium acutiflorum	1	1	1	2		1	1		1	1	0.9	80
Pyrola minor		1	1	1	1			1			0.5	50
Rubus stellatus	2	2	2	2	2	3	1	1	2	2	1.9	100
Sanguisorba sitchensis											x	
Sedum roseum	1	2	2	1	1	1	1	1	3	1	1.4	100

Table 14. Stand 12, Salix-Pulchra Community, Rich in Herbs and Mosses, About 28 Miles West of Paxson. July 14, 1957. (Continued)

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Sibbaldia procumbens							1				0.1	10
Solidago multiradiata											x	
Stellaria laeta	1	1	1	1	1	1	1		1	1	0.9	90
Veronica wormskjoldii			1						1		0.2	20
Viola langsdorfii											x	
Sphagnum compactum			2								0.2	10
Mosses	6	5	6	6	6	6	6	6	5	6	5.8	100
Lichens	3	5	2	2	4	3	3	4	2	3	3.1	100

Number of vascular species in quadrats - 30
Additional vascular species in stand - 8

Dense mats of mosses were growing generally except where recent erosion or deposition had occurred.

The most common and abundant species growing with or alternating with the moss in the lower spots was Salix reticulata, and, in spots, S. polaris selwynensis. On slightly higher knolls grasses, including Poa alpina, P. sp., Calamagrostis canadensis, and Trisetum, and Equisetum sp. were abundant. Additional species associated with them were Salix reticulata, Sedum roseum, mosses, Stellaria laeta, Mertensia paniculata, Potentilla fruticosa, P. diversifolia, Polemonium acutiflorum, Artemisia arctica, and Parnassia palustris. In the lowest, poorly drained spots, often containing standing water, sedges, especially Carex montanensis and C. aquatilis, were dominant. In many places on rocky and gravelly areas the sparse vegetation cover comprised Anemone narcissiflora, Epilobium latifolium, Aster sibiricus, Potentilla fruticosa, Trisetum spicatum, Poa alpina, Rubus stellatus, Equisetum sp., and Arabis lyrata kamtschatica.

Stand 8B. Salix richardsonii-Carex: Between the above Salix alaxensis zone and the slopes of the hills occurs a zone, 200 feet more or less in width, somewhat hummocky, often containing water in the depressions. Sedges, especially Carex membranacea, are dominant in the depressions. Carex aquatilis, C. montanensis, and C. bipartita also occur. Salix richardsonii forms dense thickets over rather wide areas. In the openings between the willows, which may be as large as 10 x 20 feet, was grassland dominated by Calamagrostis canadensis and Carex aquatilits. Associated with them were Petasites frigidus (close to the willows), Potentilla fruticosa (1-2 feet high), Salix reticulata, Rubus stellatus, Festuca altaica, Trisetum spicatum, Polemonium acutiflorum, Sedum roseum, and mosses. The chief mosses were Pohlia natans, Drepanocladus uncinatus, Mnium rugosum, Aulocomium palustre, Paludella squarrosa, Oncophorus virens, and Tomenthypnum nitens; the last species was associated with Sphagnum capillaceum var. tenellum.

Lichens were sparse. Range condition for winter grazing rated poor; for spring-summer, good. Rodents present were the ground squirrel, shrew, lemming, and Microtus.

Stands 1 and 2 are located at Kelly Camp in the valley of Boulder Creek, altitude 3050 feet, Lat. 61°54', Long. 148°4'. Lists of species (Table 15), soil profile descriptions, and notes were made on June 23, 1957.

Table 15. Species Composition of Stands 1 and 2 at Kelly Camp in Boulder Cree Valley. June 23, 1957

Species	Stand 1 Green Willows	Stand 2 Gray Willows
Arctostaphylos alpina	-	frequent
Arctostaphyllos rubra	infrequent	-
Betula glandulosa	-	varies, inf.-ab., 2-4'
Empetrum nigrum	inf., ab. higher	-
Picea glauca	scarce	scarce
Populus balsamifera	-	scarce
Potentilla fruticosa	infrequent	infrequent, 2-3' high
Rosa acicularis	scarce, small	-
Rubus stellatus	freq. - abundant	frequent
Salix arbusculoides	-	inf.-sc., tall
Salix barclayi	very ab., 5-10' tall	-
Salix commutata	-	scarce, tall
Salix glauca acutifolia	inf., 2-3' tall	very ab., dom., 2-3' t
Salix pulchra	freq., 5-10' tall	-
Salix reticulata	freq., openings	frequent
Shepherdia canadensis	scarce	scarce
Vaccinium uliginosum	scarce	-
Vaccinium vitis-idaea	inf., openings	-
Calamagrostis canadensis	scarce	-
Carex atrata	scarce, among shrubs	scarce
Carex capillaris	-	sc. along trail, 4-6"
Festuca altaica	common and abundant	abundant
Hierochloeodorata	sc. amon shrubs	-
Luzula parviflora	freq. in openings	scarce
Poa arctica	infrequent	infrequent
Poa pratensis	infrequent	-
Trisetum spicatum	infrequent	scarce
Aconitum delphinifolium	-	scarce
Adoxa moschatelliana	sc. under shrubs	-
Anemone richardsonii	infrequent	-
Antennaria nitida	-	inf., open spots
Arenaria lateriflora	frequent	infrequent
Artemisia alaskana	-	scarce
Epilobium angustifolium	common and abundant	frequent
Geranium erianthum	sc. openings	-
Hedysarum alpinum americanum	-	frequent
Mertensia paniculata	frequent to abundant	infrequent to frequen
Petasites frigidus	-	scarce
Petasites hyperboreus	infrequent	-
Polemonium acutiflorum	scarce	scarce-infrequent
Senecio lugens	infrequent	scarce
Stellaria laeta	inf. openings	infrequent
Trientalis europaea arctica	freq., openings	-
Valeriana capitata	infrequent	infrequent

Stand 1. Green Willow: On the side of the above low ridge opposite the creek the elevation is somewhat lower than on the ridge. The elevation then increases gradually on the outwash slopes from the mountains farther back. Tall green willows are dominant on the lower parts of these outwash slopes and extend down into the poorly drained depression inland from the low ridge. On some outwash slopes, balsam poplar stands are found, and alder thickets are numerous higher on the slopes. The green willow type is widespread on lower slopes of the hills. The willows, 5-10 feet tall, form dense stands usually, but grassy, meadow-like openings up to 20 feet square are fairly common. The chief dominants were Salix barclayi and S. pulchra. In the openings the chief dominant was Festuca altaica. Associated species are listed in Table 15, Stand 1.

The surface was covered with a layer of moss and debris about 1 inch deep. In the soil profile the 0-1 inch layer was dark reddish brown decaying moss and other litter; 1-2 inches, very dusky red organic matter, very wet; 2-23 inches, dark gray brown silt loam, clay content increases slightly with depth, some frozen ground at 18 inches, decaying and probably charred wood to depth of 19 inches; below 23 inches, mottled, dark reddish brown, gray, and gray brown silt loam. The pH at 1-2 inches was 6.1, at 9-10 inches 6.2, at 23 inches 6.2. A few roots were seen in the bottom of the litter layer, they were very numerous at 0-1 inch, numerous to moderately numerous to working depth at 18 inches.

Stand 2. Gray Willow: The first level or bench above the rocky creek bed was occupied mostly by first invaders such as the pale fireweed, scattered willows, and buffalo berry. This bench is subject to flooding, as indicated by channels and recent deposition. Above this level is a low, rounded or flat-topped ridge-like bench, which apparently is not flooded. It had very likely been formed by river deposits. The vegetation on this bench, and on similar sites along this creek and other streams, was conspicuous because of the dense patches of the low gray willow, Salix glauca acutifolia, 2-3 feet high. These shrubs also grew more scattered with Festuca altaica grassland between them. The species composition is shown in Table 15, Stand 2.

On the surface the layer of moss and litter was 1-1.5 inches deep. Large stones were scattered over the surface. The 0-2 inch soil horizon consisted of dark reddish brown organic matter; 2-7.5 inches, dark brown coarse sand and gravel with scattered small stones; 7.5-18 inches, coarse sand, gravel, and stones up to 6 inches in

diameter; sand decreases with depth. Roots were abundant to depth of 8 inches, decreased rapidly below that and were sparse at 17 inches. Large roots of willow were numerous in the upper 3 inches. The pH was 6.3 at 6-7 inches.

Aspen and Balsam Poplar Type.

Aspen and balsam poplar are widespread below altitudes of about 3000 feet in the southeastern quarter, in the southwestern corner, and in the drainage basins of the Susitna and Nenana rivers of the Nelchina Caribou Range. Both species are pioneers following fire, preferring mineral soil (Lutz, 1956). They regenerate quickly from root sprouts. Scattered straggly trees of balsam poplar may be seen along streams between 3000 and about 3500 feet. These species may be intermixed in stands with each other or with willows and spruce, or they may be the chief dominants of communities.

Aspen stands occur on well drained low hills and banks along streams where the soil usually has a high content of sand, gravel, and stones, which may be very compact below about 12 inches. Only a few aspen stands were studied in detail. Characteristic associates of the aspen were bearberry, wild rose, buffalo berry, certain willows, fireweed, Calamagrostis, and Geocaulon. Shrubs usually formed more of the undergrowth than the herbs.

Balsam poplar stands occur in alluvium along streams, on outwash slopes on the sides of valleys, and occasionally on slopes of hills. The soil usually contains more fine material than that in the aspen stands. Common species associated with the balsam poplar were bearberry, buffalo berry, wild rose, fireweed, Calamagrostis, altai fescue, and lupine.. The moss, Hylocomium splendens, may be very abundant, forming large cushions. Lichens, except the large foliose kinds, were sparse.

In many places at lower altitudes spruce trees were replacing the balsam poplar and aspen. On drier sites, however, especially at about 3000 feet, it appears that these stands will continue to persist for a long time. The grazing value of these stands for caribou seems to be very low; but for moose, and some other forms of wildlife, they probably rate high.

A description of a few characteristic stands of this type appear below.

Stand 55. Aspen: This stand was located on the top and upper slopes of a low, rounded hill on the north side of Susitna Lake. The altitude is 2425 feet, Lat. 62°28', Long. 146°40;. Analysis was made on August 17, 1959. Stands similar to this and Stand 74 occur on occasional small hills and ridges, surrounded by spruce forest, chiefly in the southeastern part of the Nelchina Caribou Range. These hills and ridges contain mostly gravel and stones, with very little fine material.

The aspen, Populus tremuloides, was dominant, ranging in height from 1 to about 30 feet, and in diameter from an inch or less to 6.5 inches. The stand varied from dense, trees 1-2 feet apart, to rather open, trees 12-15 feet apart. The willow, Salix scouleriana, up to 20 feet tall and 3 inches in diameter, usually grew in clusters of 8-12 stems from one root system. Black and white spruce were scattered and were usually shorter than the aspens. Scattered spruce trunks on the ground and stumps that were charred indicated that the site had been burned over. The low shrub layer consisted chiefly of Vaccinium vitis-idaea, 1-4 inches high, Ledum groenlandicum, V. uliginosum, and Empetrum nigrum. Herbs were very sparse. Mosses and lichens were also sparse. The lichen cover (1.7) consisted of about 90 percent Peltigera aphthosa. Other species present were Stereocaulon tomentosum, Cladonia sylvatica, and C. spp. The total number of vascular species in the stand was 21 (Table 16). The herbage cover, not including the trees, was very low, only 60 percent.

The loose litter, about an inch thick, on the surface was very dry, following ten days or more of warm sunny weather. Other aspen stands are often more open and have less ground vegetation and less litter than this stand. The soil profile was slightly moist to 30 inches, but on the whole it was the driest of all soils examined preceding this one. A few leaves of willow and aspen were turning yellow. The soil profile was as follows: 0-1 to 2 inches, dark reddish brown organic material; 1 to 2-4.5 inches, dark brown loam with many scattered gravel particles and small stones; 4.5-24.0 inches, olive gray silt, with many stones and gravel particles, very compact and hard when dry; 24-30 inches, gray silt, very compact when dry, very sticky when moist. The pH was 4.8 at 1-2 inches, 5.4 at 2.0-4.5 inches, 6.5 at 4.5-24 inches, and 7.6 at 24-30 inches. Roots were numerous in the upper 2-3 inches; the working depth was at 19 inches.

Table 16. Stand 55, Aspen Community, North Side of Susitan Lake. August 13, 1957

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover, %	60	65	80	80	30	40	50	80	25	90	60	
Arctostaphylos alpina	3		1	1	1		1	3			1.0	60
Arctostaphylos uva-ursi								1	3		0.4	20
Betula glandulosa											x	
Empetrum nigrum	2	1	1	2			3	1			1.0	60
Ledum groenlandicum	1	1	1	1	1	1	1	2		1	1.0	90
Rosa acicularis					1	1					0.2	20
Salix myrtillifolia											x	
Salix scouleriana			1	1	2	1	1	1			0.7	60
Vaccinium uliginosum	1	1	1	1		1	1	1		2	0.9	80
Vaccinium vitis-idaea	1	3	4	3	2	3	1	3	1	3	2.4	100
Picea glauca			2	1			2				0.5	30
Picea mariana							2				0.2	10
Populus tremuloides	p	p	p	p	p	p	p	p	p	p	p	100
Calamagrostis canadensis							x	x	1	x	0.1	40
Carex sp.	1										0.1	10
Epilobium angustifolium									1	x	0.1	20
Lycopodium clavatum monostachyon											x	
Lycopodium complanatum									1		0.1	10
Pedicularis sp.										1	0.1	10
Pyrola asarifolia											x	
Mosses		1	1	1	1		1	1	1	3	1.0	80
Lichens	1	3	2	2	1	1	1	1	1	4	1.7	100

Number of vascular species in quadrats - 16
Additional vascular species in stand - 5

p indicates aspen canopy above quadrat

Trails indicated that moose have frequented this stand considerably. There was also evidence of activity of the red squirrel (Sciurus hudsonicus) and the snowshoe hare. The range condition for winter use by caribou rated poor.

Stand 74. Aspen-Bearberry: This community was located on the south slope (20-40 degrees) and the top of a rather low hill north of the FWS landing at the southwest part of Lake Louise. The altitude is 2450 feet, Lat. 62°16', Long. 146°30'. Fire occurred here a long time ago, as indicated by scattered charred and broken trunks and stumps of spruce, some well rotted, and up to 18 inches in diameter. Examination was made on September 5, 1957.

Populus tremuloides was moderately dense to dense, up to 24 feet tall, and 1-12 feet apart. P. balsamifera was scattered, more abundant toward the east end of the stand. No spruce plants were found. Arctostaphylos uva-ursi (cover 3.3) was very abundant. Rosa acicularis and Shepherdia canadensis, both up to 3 feet tall, were moderately abundant. Only six species of herbs were noted (Table 17). The most abundant were Lupinus arcticus, Calamagrostis purpureus, and Epilobium angustifolium. Mosses and lichens were sparse.

The surface and subsurface were very well drained. The litter was 0.5 to 1.0 inch thick. In the soil profile the 0-1 inch layer was very dark to dark gray-brown organic material with very little mineral matter; 1.0-4.5 inches, brown sandy loam with gravel particles and small stones; 4.5-13.5 inches, brown, compact loam with much gravel and many stones; 13.5-21.0 inches, brown to pale brown sand and gravel with very many stones, compact. The pH was 6.4 between 1.0 and 13.5 inches, 4.1 at 13.5-21.0 inches. Roots were very numerous to 16 inches, the working depth.

No indication of use by caribou was seen. It appears that this stand is of little, if any, grazing value to caribou. Plant succession on this dry site is apparently very slow, so this vegetation probably persists for a long time.

Other Aspen Stands: A dense aspen stand along the Richardson Highway, near the junction with the Glenn Highway, was examined on July 28, 1957. The altitude is about 1500 feet, Lat. 62°7', Long. 145°8'. A few balsam poplars were scattered among the aspens. The shief shrubs in this stand were Shepherdia canadensis, Arctostaphylos alpina, A. uva-ursi, Salix myrtillifolia, and Ross scicularis. Grasses and sedges

Table 17. Stand 74, Near Fish and Wildlife Service Landing, Southwest Corner of Lake Louise. Aspen-Bearberry Stand. September 5, 1957.

Species	1	2	3	4	5	6	7	8	9	10	Ave. c.	Freq. %
Herbage cover, %	93	94	95	100	96	90	65	25	45	75	78	
Arctostaphlos alpina											x	
Arctostaphylos uva-ursi	5	5	4	5	5	1	4	1	2	1	3.3	100
Juniperus communis montana				4							0.4	10
Populus balsamifera							2	1			0.3	20
Populus tremuloides	p	p	p	p	p	p	p	p	p	p	p	100
Rosa acicularis	1	2	3	2	2	1	2	1	1	1	1.6	100
Salix babbiana											x	
Shepherdia canadensis	1			1		4		2	2	3	1.3	60
Vaccinium vitis-idaea											x	
Viburnum edule											x	
Calamagrostis purpurascens	1	1	2	1	1		1	1	1	1	1.0	90
Castilleja pallida mexiae		1			1		1			1	0.4	40
Epilobium angustifolium	1	1	1	1	1	1	1		1	1	0.9	90
Linnaea borealis	3						1				0.4	20
Lupinus arcticus	2	1	1	2	1	2		1	1	1	1.2	90
Pyrola secunda						2	1				0.3	20
Mosses	1	1			1	1	1	1	1	1	0.8	80
Mushroom				1							0.1	10
Lichens		1					1	1	1	1	0.5	50

Number of vascular species in quadrats - 12
Additional vascular species in stand - 4

p indicates aspen canopy above quadrat

were Agrostis scabra, Carex atrata, and C. concinna. The most abundant herbs were Epilobium angustifolium, Parnassia palustris, Senecio indecorus, S. humilis, S. acris elatus, Oxytropis deflexa, Pyrola asarifolia, Equisetum scirpoidea, Hedysarum alpinum americanum, Gentiana propinqua, and Castilleja pallida caudata. The moss, Drepanocladus uncinatus, formed scattered clumps.

The vegetation along the Richardson Highway from the junction with the Glenn Highway to Paxson varies considerably because of differences in drainage, character of the soil (rockiness, etc.), steepness of slope, altitude, and successional stage following fire. The altitude increases from about 1500 feet at the junction to 2700 feet at Paxson. Aspen increases in height, density, and frequency from north to south, in suitable sites such as bluffs and hillsides, and especially on the banks of the Gulkana River. In places the aspen is dominant in usually small stands, in other places it is intermixed with spruces, willows, and a few balsam poplars. The spruce-willow and spruce types cover most of the ground. Sedge marshes, bogs, and aquatic communities also occur.

Stand 3. Balsam Poplar: This stand was located on an outwash slope in the valley of Boulder Creek near Kelly Camp. The altitude is 3050 feet, Lat. 61°54', Long. 148°4'. It was studied on June 23, 1957. The dominant trees, Populus balsamifera, were up to 8-11 inches d. b. h. Buffalo berry, Shepherdia canadensis, was common and abundant, forming a layer 3-4 feet high. Other shrubs were Empetrum nigrum, Vaccinium vitis-idaea, V. uliginosum, and Juniperus communis montana. The chief herbs were Epilobium angustifolium, Mertensia paniculata, Festuca altaica, Cornus canadensis, Pedicularis labradorica, P. capitata, and Pyrola grandiflora. Hylocomium splendens was very abundant, forming cushions, 4-5 inches high, in which Empetrum and V. vitis-idaea were growing. Lichens were scarce, except for the large foliose species. White spruce was widely scattered. Fire and cutting had destroyed some of the spruce trees, but apparently the spruce was never dense enough here to be dominant.

The soil was covered with a loose layer of moss and litter with many roots in the lower part. Below this the 0-2 inch layer consisted of well decayed vegetation, with numerous roots. This layer and the one above it formed a mat that could be lifted off the ground. The 2-5 inch layer was brown, fine sandy loam. From 5 to 18 inches was very dark gray brown fine sandy loam, with interspersed small stones. The pH was 5.7 at 2-5 inches, 6.7 at 5-10 inches. Most of the tree

roots, 1/4 to 1/2 inch in diameter, were in the 3-5 inch layer, but large roots did occur as deep as 16 inches. Most of the fine roots extended to depth of 8 inches, considered as the working depth. This profile differed from that in the low gray willow, Stand 2, on a low ridge close to the river, in having a much greater amount of fine material and less gravel and stones.

Other Balsam Poplar Stands: A stand on a steep south-facing slope at the mouth of Billy Creek (altitude 3000 feet) was covered with an open, straggly growth of balsam poplar, as tall as 15-20 feet. There were many dead trees and dead branches on the living trees. Associated species were Arctostaphylos uva-ursi com. and ab., Calamagrostis canadensis inf., Hedysarum alpinum americanum, and Epilobium angustifolium. Because of the exposure and steep slope, it appears that the trees were having great difficulty in maintaining growth in this comparatively xeric site.

Miscellaneous Types.

The Alpine Meadow Type, found along the Denali Highway, was very rich in species of seed plants, but poor in lichens. It is a stage in succession following sedge marsh. Alpine sedge meadow occurs at elevations of 4000 feet or more, as along the Denali Highway.

The Dryas-Kobresia Type was found in a limited area on hilltops in the Tyone Creek calving area. It had been very heavily utilized and much of the Kobresia had been destroyed. This type is important for winter grazing by mountain sheep according to Adolph Murie.

The Sedge Type is widely distributed along ponds, lakes, and streams and as marshes in recently filled lake and pond beds. Usually lichens are not present.

The Bog Type, characterized by species such as Sphagnum spp., Andromeda polifolia, Oxycoccus, Rubus chamaemorus, Carex spp., and Eriophorum spp. is widespread in poorly drained areas. Extensive areas are occupied by it in the Flat and in the Monahan Flat. Lichens are usually not well developed.

Environmental Factors

Many environmental factors affect the plant communities in this region. Some of the chief factors may be classified as follows:

Climatic	Physiographic & Edaphic	Biotic
Precipitation	Altitude	Caribou
Depth and duration of snow cover	Slope and exposure	Moose
Humidity	Surface	Ground Squirrels
Temperature	Kind of soil	Small Rodents
Length of frostless season	Depth of permafrost	Porcupines
Wind	Soil temperatures	Insects
Light	Frost action & solifluction	Man (fire especially)
	Soil moisture	
	Erosion	
	Drainage conditions	
	pH and lime content	

A few examples of effects of factors will be given. The early part of the summer is apparently usually dry compared to late summer, so, it appears, lichens are shattered considerably by trampling of caribou on areas in which they range in early summer. While the humidity and temperature conditions throughout the region are favorable for the growth of lichens, some parts as near Cantwell and open spruce and glandular birch stands seem especially favorable. The calving range appears to be somewhat drier than other parts, possibly because of exposure to drying winds. Areas covered by snowdrifts that melt late are unfavorable for the growth of lichens, and usually support a rapid-growing meadow type of vegetation. Some kinds of lichens and shrubs require snow cover during the winter, other kinds grow without the cover.

The kind of soil varies greatly, from peat in bogs to gravel ridges. Polygon mosaics with firm centers covered by lichens, widespread in the Tangle Lakes section, are caused by frost action. Solifluction terraces are common on many slopes. The pH of the soil was determined for more than 235 soil horizons, usually rating below 6.5. Nearly all the horizons showed no effervescence with 20% HCl., indicating absence of lime. A number of soils were strongly acid, pH 3.9 to 4.3. Some species such as the spruces, Hedysarum, and buffalo berry have a narrow range of altitude; others, as most of the heaths and lichens, have a broad range. The most shallow permafrost was found in bogs, the deepest or none at all, in fescue

grassland and dwarf heath shrub. Excessive moisture, severe erosion, a mineral soil surface, and frost "boil" spots are not suitable for the growth of the more desirable lichens such as Cladonia alpestris and C. rangiferina. Mosses and the roots of grasses, sedges, and shrubs are especially important in building up the organic matter of the soil.

Packing of the soil by trailing of caribou, as in the calving range, tends to destroy the lichen and moss cover, and may lead to erosion by wind and water. Ground squirrels by destroying vegetation in the vicinity of their dens produce erosion areas, especially on hilltops. The most serious biotic factor is man-caused fire, especially in the spruce forests. Probably no area of appreciable size has not burned over in the past 60-70 years. A long time is required for lichens to recover, as a number of stages of moss and lichens is required to produce suitable conditions for the climax species.

Plant Succession

The chief kinds of succession in the Nelchina region may be classified as follows:

Primary

Hydroseres; in lakes and ponds, marshes, bogs, and in wet frost "boils".

Xeroseres; bare areas caused by frost action, rock exposures, bare areas on hillsides and hilltops caused by erosion.

Secondary

Fire; caribou and ground squirrels especially; destruction of vegetation in road making, tractor trails, building construction, camping.

The filling of ponds and lakes by invasion of water lilies, followed by sedge borders, sedge-grass marshes, bogs, and spruce forest is proceeding rapidly. Lichens accompany the dwarf heath shrubs and spruce in invading bogs and marshes. The lichens, Stereocaulon, Alectoria nigricans, A. ochroleuca, Cornicularia divergens and the dwarf shrubs Empetrum nigrum and Arctostaphylos alpina are found commonly in early stages on bare areas on hillsides. The moss, Polytrichum, lichens such as Cladonia pleurota, C. uncialis, and

Peltigera aphthosa, and horsetail (Equisetum) are early invaders following fire in the spruce forest. These invaders, especially the moss, are important in the formation of partly decomposed organic matter which seems to be required by the larger fruticose lichens which are important for caribou. Many years are required for the succession of lichens to reach the climax stage. Willows regenerate commonly from root sprouts after the fire. There is some indication that trampling and trailing by caribou on the calving range, as at Black Lake and upper Tyone Creek, favor the invasion of Festuca altaica, following the destruction of much of the lichen cover. This may not be undesirable on calving range, as the young shoots of Festuca are eaten by caribou at this time (Skoog).

Effects of Caribou upon the Vegetation

Criteria used in evaluating the effects of caribou upon the vegetation are: 1) number and depth of trails, 2) packing of the lichen mat by trampling, 3) disintegration of the lichen mat by pawing, trampling, and pulling out of lichens while grazing, 4) horizontal or vertical growth and height of lichens, 5) destruction of hummocks of moss or Sphagnum, especially by trampling, 6) uncovering of roots and basal parts of stems of shrubs, especially Betula glandulosa and Vaccinium uliginosum, 7) broken-off branches of shrubs, caused probably by pawing, 8) dead or partly dead shrubs caused by uncovering basal parts and breaking branches, 9) kinds of lichens present in an area, 10) number of droppings.

According to these criteria the most heavily used area is the calving range between approximately the upper Tyone Creek and Black Lake. The effect of this heavy use on the carrying capacity at calving time depends upon the kinds of plants that are grazed and required. It is possible that the loss of lichens and destruction of much moss and shrub growth is accompanied by increases in grasses, sedges, and forbs that have greater forage value for the caribou at this season. The spruce region on the Flat has apparently suffered from both fire and from use by caribou, the first being apparently more severe.

Range Condition

Four range condition classes, based upon criteria listed in the preceding section, for winter grazing by caribou, are characterized tentatively below. Additional research should be done on this important subject. Each class description should be accompanied by photographs

which illustrate the various criteria. The classification below of range condition is limited to winter grazing in the Nelchina range where lichens occur over the entire region and appear to be very important in the diet. Similar classifications of range condition should be made for other seasons such as the calving time, mid-summer, and early autumn, when the lichens are less important.

Excellent Range Condition--Good cover (20 per cent or more of the ground covered), all or almost all upright, 2.5 to 6 inches high. Usually Cladonia alpestris is present and may be the chief dominant in the lichen layer; usually much C. sylvatica and C. rangiferina. No packing or fragmentation of lichens. No moss pedestals, no cut hummocks, few to no trails, few to no broken branches of shrubs, few to no exposed roots or lower branches of shrubs.

Good Range Condition--Good cover (20 per cent or more) but short (1 to 2.5 inches), or with fair cover (10-20 per cent) and good height (2 to 5 inches). Usually much Cladonia sylvatica and C. rangiferina, and some C. alpestris. Packing and fragmentation of lichens slight. Few or no pedestals, or cut hummocks, or trails. Few to no broken branches, or exposed roots or lower branches.

Fair Range Condition--Good cover (20 per cent or more) but short (1/2 to 1 inch), or with low cover (5 per cent) and good height (2 to 4 inches). Usually little to no Cladonia alpestris, C. sylvatica usually common, little if any C. rangiferina, often much Stereocaulon. One half to most of the lichen cover packed and/or fragmented. Pedestals and/or cut hummocks and trails moderately numerous. Moderate number of scattered broken branches and exposed roots and lower branches.

Poor Range Condition--Good cover (20 per cent or more) but short (about 1/2 inch), or with low cover (0 to 5 per cent) and moderate height growth (1 to 2 inches). Usually no Cladonia alpestris, little if any C. rangiferina. Stereocaulon, Cladonia sylvatica, Cetraria nivalis, C. cucullata usually present. Often much Alectoria, and species such as Peltigera aphthosa, Thamnolia vermicularis, Cladonia pleurota, and C. uncialis. Most of lichen surface fragmented and packed. Pedestals and/or cut hummocks and trails numerous, some of the trails well worn (as deep as 5 inches or more). Many scattered broken branches, exposed roots and lower branches. Some of the shrubs may be entirely dead because of trampling and pawing. Mineral earth exposed in places and erosion may be occurring.

General Evaluation of the Nelchina Caribou Range

The Nelchina Caribou Range as a whole is in excellent condition, it appears, for spring, summer and early autumn use, when grasses, sedges, forbs, and certain shrubs constitute the forage that is eaten. The Dryas-Kobresia type, because of small areas occupied, appears to have deteriorated greatly because of heavy use. It remains to be determined how important this type is, especially on the calving range.

The lichen growth on the Lake Louise Flat varies greatly in area occupied and in height, because of fire, heavy winter use by caribou until the winter of 1954-55, and because of unsuitable habitats. In a large part of the area of the Flat the lichens rate only Condition Poor, or a low Fair. In open spruce or scrub birch stands, not burned recently, scattered through the Flat the condition is Good, and in the vicinity of the Glenn Highway the condition is Good to Excellent. The herbaceous and woody vegetation in the Flat is composed of a great variety of species in vigorous condition.

The northern part of the Nelchina Caribou Range is generally in Good to Excellent condition in regard to both lichens and seed plants. The range has been heavily used during the past 2 or 3 autumns and winters in the vicinity of Tangle Lakes and Twelve-mile Summit so some formerly good lichen range has deteriorated to Fair condition. West of Tangle Lakes to Cantwell the range, both lichens and seed plants, is in Excellent to Good condition.

In conclusion, it appears, on the basis of the summer's investigation, that the winter range is sufficiently large and in good condition for the population of caribou now in the Nelchina Caribou Range. The calving range is, however, heavily used and shows deterioration in the numerous trails, the broken hummocks, the packed lichens and firm surfaces, exposed and broken branches and roots of shrubs, erosion in places, exposed rocks on the surface, and decreased density of shrubs. There appears to be sufficient forage, as yet, for this season of the year; but the deterioration that has taken place tends to indicate that the present population of caribou is somewhat excessive during the time the caribou are in the calving area.

RECOMMENDATIONS

In the preceding part of this report suggestions requiring additional research have been stated. Some of these are repeated in the list below.

1. Determining percentages of the various range types in the total area of the Nelchina caribou range.

For convenience the region can be divided into units such as 1) the eastern half of the Flat, 2) the western half of the Flat, 3) the Tangle Lakes unit, 4) Tangle Lakes to Susitna River, a plateau, 5) Monahan Flat, 6) Susitna River bend plateau, 7) Susitna and Maclaren River valley unit, 8) Talkeetna foothills calving and summer grazing unit, 9) upper Nenana River valley. The division of each unit into chief range types can be determined by aerial transect flights and by examination of aerial photographs of a sufficiently large scale, as 1:5000.

2. Characterization of range condition classes and testing in the range (see preceding section). The application of range condition classification should be most valuable in determining if the range is being fully or under used in relation to the number of caribou in the region.

3. History of caribou migrations along the Nenana River east of Cantwell in relation to condition of the range. At present the range condition is excellent. If migrations included numerous caribou in 1926 and earlier years, as reported, the range must have been heavily used. If so, the recovery in the past 31 years has been rapid.

4. Establishment of additional permanent quadrats and plots. The Flat, units 1 and 2, have 14 stations with 2 permanent meter-square quadrats in each; one protected from grazing, the other open to grazing. Stations should be established in each of the other units, each with 4 one-meter-square quadrats, 2 open to grazing and 2 protected from grazing. Several stations should be established in the calving-summer unit (No. 8), at least one in units 3, 5, 7 and 9, and at least 2 in units 4 and 6 (one is in 6 now).

5. Determination of preferences and requirements of caribou for various species of plants in all seasons of the year. Additional data are needed in order to make the range condition classes more specific and to determine carrying capacity of the range types.

6. Research on plant succession. Improvement of the caribou range is dependent to a very high degree upon plant succession. It is important to know the sequence of species and the time required for recovery from burning, especially in the spruce type, and from heavy use by caribou. Succession following fire can be studied, particularly by means of permanent quadrats, on areas where the dates of the burns can be ascertained and by controlled burning on experimental plots. Use should be made of any stands that are burned by accident or otherwise. Permanent quadrats and study plots located in all of the range units provide excellent opportunity to determine the succession of species while undergoing use by caribou, and the succession following their migration from an area.

Successional studies are also desirable on frost boils, on sites used by ground squirrels, and other bare areas. Such studies aid greatly in determining the habitat preferences and behavior of plant species and thus facilitate the "sizing up", or evaluation of the range.

The effects of vigorous lichen growth upon low shrubs such as Vaccinium vitis-idaea, Empetrum nigrum, Vaccinium uliginosum, Arctostaphyios alpina, Salix spp., etc., need additional study. It appears that as lichen succession nears the climax such shrubs tend to be suppressed.

The sequence of species of lichens in different kinds of habitats is important and little is definitely known about it.

The succession in sedge marshes and bogs to the spruce forest needs more precise determination, especially in relation to their use by caribou and moose.

The susceptibility to fire of various range types, particularly the glandular scrub birch type, is not definitely known. It appears that it would burn in dry seasons, especially where there is much debris. If so, much good lichen growth would be destroyed.

7. The Dryas-Kobresia type merits special attention because of its heavy use in the calving range and because it appears to be a highly relished type of vegetation. It probably occurs more widely than it appeared during the summer of 1957. It may be of special importance on calving and summer ranges. It appears to be the climax stage on certain hilltops and upper slopes, above 4000 feet in altitude, perhaps limited to soils containing at least a low lime content.

8. Indicator plants are species which are characteristic of certain stages in succession or of certain habitats. The moss, Polytrichum sp., the liverwort, Marchantia, and certain crustose-like species of Cladonia are early invaders following fire in the spruce type, and may be considered as indicators of recent burns. The cotton-grass, Eriophorum vaginatum, is characteristic of marsh habitats, and its presence in dwarf heath-scrub birch stands indicates probable succession from sedge marsh. The presence of a few plants of Cladonia alpestris in an area undergoing heavy use by caribou indicates that this species was formerly more abundant, and that when the area is abandoned by the caribou it will very likely increase and become dominant again.

Every plant species has indicator significance of more or less value. It is important to learn the indicator value of as many species as possible in order to evaluate the present condition of the vegetation, to state its probable recent history and its probable future.

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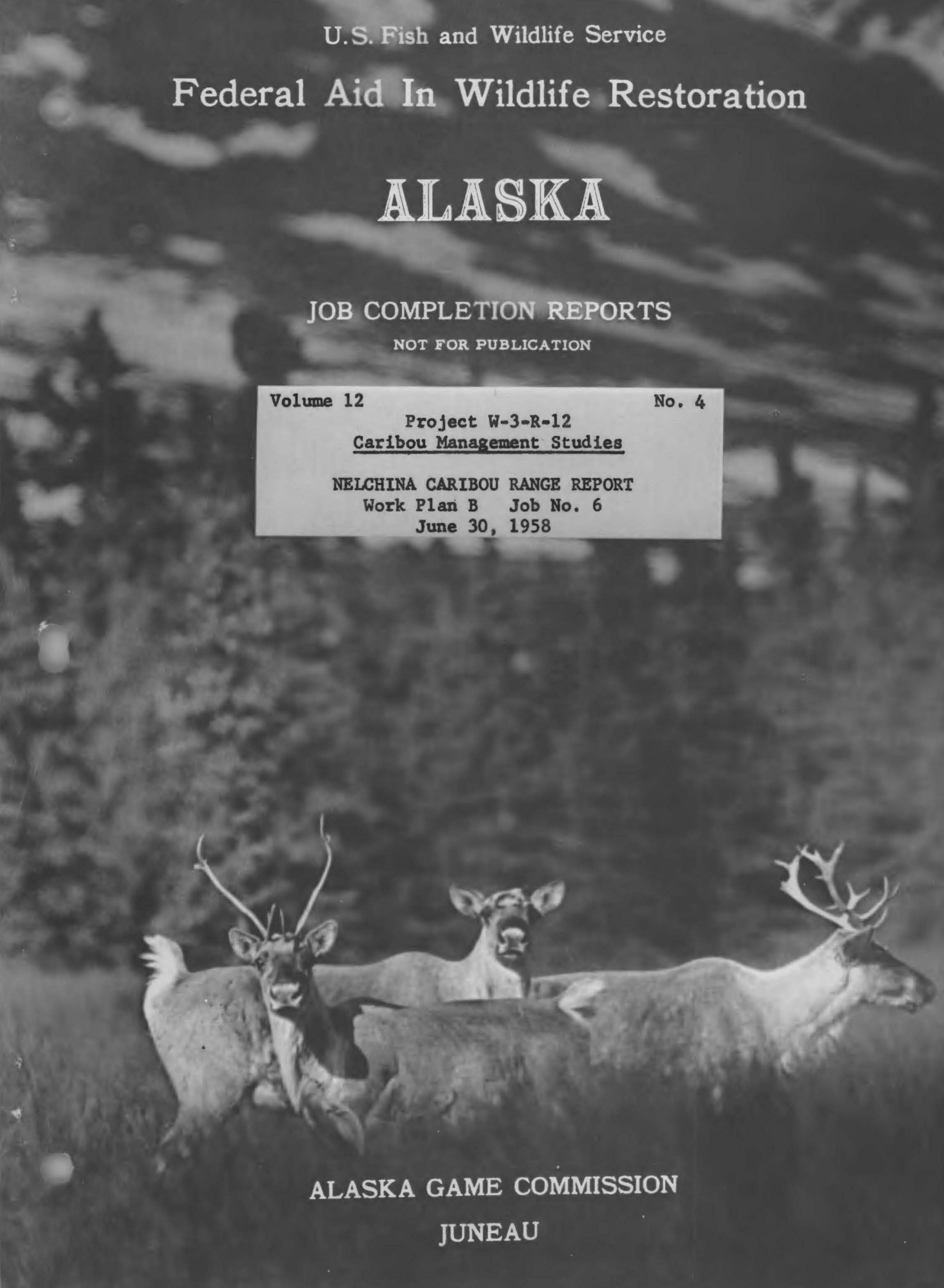

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