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WILDLIFE RESEARCH UNIT STUDIES

by

David R. Klein, Leader

Volume X
Annual Project Segment Report
Federal Aid in Wildlife Restoration
Project W-17-1, Jobs A-9, B-9, B-13, B-14, K-8, M-10, N-9

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(Printed August, 1969)

WORK PLAN SEGMENT REPORT

FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT NO: W-17-1 TITLE: Small Game, Waterfowl & Furbearer Investigations

STUDY PLAN: A TITLE: Furbearers

JOB NO: 9 TITLE: Arctic Fox Population Ecology

PERIOD COVERED: July 1, 1968 to June 30, 1969

ABSTRACT

Arctic foxes on St. Lawrence Island show strikingly different summer diets dependent upon the location of their dens. Bird material occurred in 94.7% of the scats of those denning at cliffs. At two dens located one and two miles from cliffs only 22.3% of scats had bird material. Microtus oeconomus remains occurred in 84.7% of scats at dens not located near bird cliffs. Marine mammal remains were not a significant item in the summer diet.

WORK PLAN SEGMENT REPORT

FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

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STUDY PLAN: A TITLE: Furbearers

JOB NO: 9 TITLE: Arctic Fox Population Ecology

PERIOD COVERED: July 1, 1968, to June 30, 1969

OBJECTIVES

To investigate the food interrelationships of the arctic fox on St. Lawrence Island.

PROCEDURES

Primary sources of data on the summer diet of the arctic fox were scats and food remains collected at den sites. Some additional information was obtained through observation of hunting behavior of foxes although frequent fog reduced the effectiveness of this technique.

Originally, scats and food remains were to be collected at each den site at intervals of two weeks so that changes in summer diet could be detected and related to environmental changes. The general location of several dens had been obtained from Francis H. Fay (viva voce) and several people in the village of Gambell. However, limited mobility, the inconspicuous nature of fox dens on the plateau, and the author's lack of familiarity with the study area made the initial location of dens more difficult than expected. These factors and the comparatively short period of time I was able to spend in the cliff study area have resulted in the data being more heterogeneous, with respect to time and number of collections per den, than desired. Except for transportation to and from study areas, field investigation was carried out on foot.

Every scat found was collected. Those not associated with a den site were analyzed according to den number, date, and study area. Scats and food remains were placed in individual paper bags. As the fox on this island frequently harbor adults of the cestode *Echinococcus multilocularis* (Rausch, 1967) scats were handled with forceps and analyzed only after being autoclaved at the Arctic Health Research Center in College, Alaska.

Scats were composed primarily of undigestible matter, including hair, claws, bone, teeth, feathers, vegetation, and soil. When dry they could be pulled apart and their contents separated as to kind of material and species. Mammal remains were identified using color and texture of fur and dental, skeletal, and claw characteristics. Avian remains in scats were primarily body feathers and were classified using the size, color, and shape of quills as criteria. It was always possible to identify mammal remains at the species level but avian remains could usually be separated only into larger groups such as passerines, shorebirds, anatids, and alcids.

From a study in which captive red fox (*Vulpes regalis*) were fed known quantities of prey and their fecal emissions studied, Scott (1941) concluded that frequency of occurrence provided the best estimate of relative proportions of prey species consumed. He found that in general, fecal passages are produced approximately in direct proportion to the quantity of food consumed. From a similar study Lockie (1959) concluded that percentage weight is the most accurate way of interpreting the results of fecal analysis. For the purposes of the present study the frequency of occurrence method was employed as the volume of material and time considerations precluded the use of the latter method. Scott (1941) has shown that in order to avoid overemphasis of items with greater capacities for scoring and underemphasis of items with limited scoring power, group treatment is necessary. Thus, part of the computations in this study include the data in grouped form, the two major groups being birds and mammals. The need for grouping is emphasized by the impossibility of identifying by species all of the remains, especially those of birds.

Collections representing forty species of birds and the five species of small mammals found on St. Lawrence Island were made and their skins and skeletons prepared as reference material for the analysis of scats and food remains.

Whenever possible food remains were analyzed is the field. This treatment was especially effective at dens located in alcid nesting colonies where there was a considerable volume of material, primarily alcid remains, and an accurate determination of species composition was possible. The food remains data for each den indicate the minimum number of individuals of each species represented in the remains. Though they are an indication of some species taken by the fox, these data are undoubtedly biased in favor of large birds. Further, they are not an accurate indication of the number of individuals consumed as prey are not always consumed at the den, some remains may have been inside the dens; and foxes, larids (Bedard, 1967), and other scavengers may scatter or consume remains.

Though not all dens were visited in early summer there is reason to assume that most of the scats and food remains accumulated in the spring and summer of 1968. The condition of the majority of these indicated they were fresh. Assuming that some of these dens held litters of pups in previous years, the relatively low number of scats collected in the early summer of 1968 would indicate that many scats disappear during the winter months. Fay (viva voce) found scats in the stomachs of St. Lawrence arctic fox trapped in the winter months and he reports that in winter, food resources are so limited that any available organic material is likely to be ingested by foxes. Thus, my data are considered to be indicative of the spring and summer diet. The late summer collections at dens holding litters of pups should provide a good record of the diet of pups in adolescence as Lund (1962) suggests.

The relative availability of prey species was, with one exception, evaluated subjectively on the basis of the author's observations and those of Rausch (1953), Fay and Cade (1959), and Bedard (1967).

FINDINGS

The following is the result of initial analysis of the scat material. Complete reporting of all of the data is currently being done in thesis form.

The analysis of 1,514 scats collected in the summer of 1968 indicates that the summer food habits of the arctic fox on St. Lawrence Island vary quite markedly with the availability of prey. In the data presented below the major food items have been grouped together to avoid overemphasis of items with greater capacities for scoring and, conversely, underemphasis of items with limited scoring powers. Group treatment is also required by the impossibility of identifying by species all remains in fecal passages, especially those of birds. A random collection of 119 scats has been omitted from this analysis which is confined to those scats collected at den sites.

	Plateau-797 Scats		Cliffs-284 Scats		Dens 16 + 24-314 Scats	
	No.	%	No.	%	No.	%
Small Mammal	722	90.6	93	32.7	291	92.7
Avian	238	29.9	269	94.7	70	22.3

The Plateau area is characterized by lowland tundra, small lakes, and streams. The tundra vole (Microtus oeconomus), is by far the most common mammalian prey species and it occurred in 84.7% of the scats, the remainder of the small mammal total consisted of ground squirrel (Citellus undulatus), red-backed vole (Clethrionomys rutilus), and collared lemming (Dicrostonyx torquatus). Avian species identified in the scats included oldsquaw (Clangula hyemalis), emperor goose (Philacte canagica), eider (probably Somateria sp.), snow bunting (Plectrophenax nivalis) and lapland longspur (Calcarius lapponicus).

The contrast between the data from the plateau and that from cliffs is quite apparent. Avian material in the scats collected on the cliffs was entirely that of cliff nesting species, predominately alcids. As indicated above, small mammals composed a much smaller proportion of the diet than they did on the Plateau - Microtus was again the predominant species in the small mammal material.

Dens 16 and 24 were located in the Boxer River valley one and two miles from the alcid nesting colonies on the coast. The data above indicate a marked response to availability in this situation. The lowlands of the Boxer River valley apparently provided enough mammalian prey to satisfy the major requirements of the foxes inhabiting these dens, both of which held litters of pups.

Data indicated that carrion of marine mammals is almost absent in the summer diet of this fox population. Only three scats indicated use of these food resources. Two contained remains of walrus (Odobenus rosemarus), the other containing remains of a seal pup. None of these scats were judged to be fresh but instead were probably deposited during the previous winter. The entire carcass of a harbor seal (Phoca vitulina) lay on the beach near the Plateau base camp for the entire summer but was not utilized by fox although they were seen and heard in the vicinity. In addition, carcasses of walrus were available at several places along the coastline but these too did not appear to be utilized by fox. Thus, the arctic fox on St. Lawrence Island seems able to afford the predilection for fresh material during summer, something which it undoubtedly cannot do in the winter.

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WORK PLAN SEGMENT REPORT

FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT NO: W-17-1 TITLE: Small Game, Waterfowl & Furbearer Investigations

STUDY PLAN: B TITLE: Upland Game

JOB NO: 9 TITLE: Bald Eagle Nest Ecology

PERIOD COVERED: July 1, 1968 to June 30, 1969

ABSTRACT

Density of eagle nests in the study plots is 0.51 per mile of beach with 0.39 per mile within logged areas and 0.53 per mile in unlogged areas. In early July 41 eaglets were counted averaging 1.71 per nest, by late July this value was 1.52 per nest. Sitka spruce comprised 78 percent of the nest trees, western hemlock 12 percent, dead trees 8 percent and yellow cedar 2 percent. The average nest height was 99 feet in trees averaging 121 feet in height. Nest trees were an average distance of 108 feet from the shoreline.

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STUDY PLAN: B TITLE: Upland Game

JOB NO: 9 TITLE: Bald Eagle Nest Ecology

PERIOD COVERED: July 1, 1968 to June 30, 1969

OBJECTIVES

To determine factors governing the selection and use of nest trees by bald eagles in southeastern Alaska.

To determine the nesting density of bald eagles in relation to habitat characteristics. Data on nesting success and productivity was also recorded.

DESCRIPTION OF STUDY AREA

The base for field work is Petersburg, Alaska located midway in the southeastern panhandle of the state. The average January and July temperatures for the area are about 30° Fahrenheit and 59° Fahrenheit respectively. Average annual precipitation for the region is 99 inches, but because of the mountainous terrain there are variations with locality. The topography has been described as, "Steep, glacier ridden, fiord cut, mainland coast fringed with innumerable offshore mountainous islands, islets, and rocks" (Robards, 1967). This terrain provides many miles of protected waterways and beach frontage which provides excellent nesting habitat for bald eagles.

The vegetation of the area is climax forest of western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*) with understory shrubs of *Vaccinium*, devils club (*Echinipanax horridus*), and rusty menziesia (*Menziesia ferruginea*). The well drained beach frontage provides good sites for stands of large Sitka spruce and, in slightly wetter areas, western hemlock. Behind the beach fringe, in more poorly drained sites, are peat bogs with lodgepole pine (*Pinus contorta*), yellow cedar (*Chamaecyparis nootkatensis*), and mountain hemlock (*Tsuga mertensiana*).

The study plots are located in the Tongass National Forest within a 60 mile radius of Petersburg, Alaska. Sumner Strait and Frederick Sound border the plots which are located along the shore of Mitkof, Kupreanof, Woewodski, and Zarembo Islands. There has been some logging activity in the area since early 1900, but within the last 20 years logging of timber and pulp has become a major resource use. Within the study plots there are virgin stands, second growth stands from early logging, and logged plots with one or two year old seedlings.

MATERIALS AND METHODS

Location of Study Plots

Twelve study plots were located in the vicinity of Petersburg, Alaska. The Forest Service regional office in Petersburg has records of all logging activity since 1900 and with timber sales and dates of completion recorded on maps. Six plots were chosen to include stretches of logged beach frontage and six others were selected because of the absence of logging activity. The location of timber sales within the study plots and the dates of completion of logging were transferred to Forest Service Quarter-Quad maps (scale: 2 inches = 1 mile).

Location of Nest Sites

Nest trees were located by aerial survey during June and July of 1967 and 1968. Each stretch of beach was flown two or three times in order to locate all nests. The aircraft best suited for the work is the super-cub because of its slow air speed and the good visibility afforded the pilot and observer. Unfortunately, this aircraft was not available for charter in Petersburg and a Cessna 180 had to be used. Good coverage of an area may be obtained with this aircraft but with more difficulty. One pass at low level over the water, one above the beach timber, and, when possible, one behind the beach fringe are the best combination for observations of nests. Each nest found was plotted on the maps as accurately as possible to facilitate relocation of the site from the water. A small boat was used during the remainder of the summer to visit each nest site and data on the nest tree and site were collected.

Data Recorded

Nest Tree: For each nest tree the species was noted and each tree was classified according to crown class. The four classifications used were: dominant (tree top above the general forest canopy), co-dominant (tree top in the general forest canopy), and suppressed (tree top below general forest canopy). The height of the tree and nest were measured with an abney level and recorded to the nearest foot. Nest form was classified into five categories as follows:

1. Nests in the upper whorl of branches which formed a bowl after the tree top was damaged

2. Nests in the crotch of a U-shaped branch

3. Nests in upper whorl of branches with the dead top above the nest

4. Nests in a normal tree hidden by foliage

5. Nests in a dead tree, bare of foliage

Nest Site

At each nest site the following measurements were made: (1) the distance from base of nest tree to shore (feet), (2) the distance from nest tree to nearest logged area (yards), and (3) the width of exposed beach at low tide (yards). The beach type was recorded in the following classifications: ledge-steep slope, ledge-gentle slope, large rock, gravel and large rock, sand, and mud flat. Exposure of beach frontage was recorded as open coast, open bay, sheltered bay, or small island. Nest activity was determined from the aerial survey and was recorded as active, inactive, or abandoned. When possible, a count of eggs and eaglets was made from the airplane. Nest sites were plotted on maps (scale 2 inches = 1 mile) and straight line and shoreline distances between nest sites were measured with a map measurer and recorded in yards and miles.

RESULTS

In two summers 117 nests have been located from the air and 114 of them have been relocated from the water. Comparative data from 1967 and 1968 is available for 71 nests. Approximately 231 miles of beach frontage has been surveyed and included in the 12 study plots. Six plots with no logging activity have 123 miles of beach frontage; six plots, which have been logged to some extent, have 109 miles of beach frontage of which 52 miles (48 percent) have been logged.

Nest Density

The density of all nests located in the study plots is 0.51 nests per beach mile. The density of nests within logged sites was 0.39 nests per mile of logged beach, and the density of nests outside of logged sites was 0.53 nests per mile of unlogged beach.

Productivity

Only data for 1968 is available. During the first series of flights 41 eaglets were counted. These flights were conducted in early July and eaglets were easily counted. Another series of flights was made in late July and 32 eaglets were observed on the nests. From data from the first flight there were 1.71 eaglets per nest and the same value calculated from the late July data was 1.52 eaglets per nest. Survival cannot be calculated because different nests were involved.

Nest Tree

Species of Nest Trees

Of the four classifications used in Table 1, Sitka spruce was the most frequently used species including 78 percent of the nest sites. Western hemlock, with 12 percent, was second, dead trees third with 8 percent, and yellow cedar last with only 2 percent of the nests.

Table 1. Species of Nest Trees

Species	Number	Percent
Sitka Spruce	89	78
Western Hemlock	14	12
Dead Tree	9	8
Yellow Cedar	2	2
Total	114	100

Tree and Nest Height

Table 2 shows the overall average tree and nest height and also the averages for nest trees grouped by species. The average height of all nest trees was 120.8 feet and the average nest height was 98.9 feet. The height of sitka spruce nest trees averaged 125.2 feet compared to 110.4 feet for western hemlock. The averages of yellow cedar and dead trees were respectively lower. The average nest heights within each group were ordered in a similar manner.

Table 2. Average Tree and Nest Height

		Number	Average Height (ft)	Standard Deviation
Overall Nest Tree Height		114	120.8	25.0
Overall Nest Height		114	98.8	21.0
Sitka Spruce	Tree	89	125.2	23.0
	Nest	91*	101.6	19.4
Western Hemlock	Tree	14	110.4	28.0
	Nest	14	92.5	21.4
Dead Tree	Tree	9	97.6	33.0
	Nest	9	82.1	26.0
Yellow Cedar	Tree	2	108.0	2.8
	Nest	2	89.5	3.5

* There were two Sitka spruce with two nests per tree

Nest Form

Table 3 shows the distribution of nest form. The greatest number (48 or 57 percent) were in normal trees and hidden by foliage. The remaining nests were evenly distributed between the other categories.

Table 3. Nest Form

Category		
Nest in Bowl at Top of Tree	11	13
Nest in Crotch of U-Shaped Branch	7	8
Nest in Bowl with Dead Top	9	11
Nest in Normal Tree	48	57
Nest in Dead, Bare Tree	9	11
Total	84	100

Nest Site

Distance Between Nest and Shore

The average distance between the base of nest trees and the shore for 114 nest sites was 108 feet. Table 4 shows the averages and standard deviations for this distance for all nest trees, nest trees located within logged stretches of beach front, and nest trees outside of logged sites. The average distance between nest trees within logged sites and the shore was 83.4 feet and the same average for trees outside of logged sites was 112.4 feet. This difference proves significant at the 0.05 percent level.

Table 4. Distance Between Nest Tree and Shore

	Number	Average (feet)	Standard Deviation
Overall	114	108.0	64.0
Nests Within Logged Beach Frontage	20	83.4	47.5
Nests Outside Logged Beach Frontage	91	112.4	65.3

Distance Between Nest Tree and Logging Site

There were 68 nests in close proximity to logging sites; 11 of which were more than one mile away and have been excluded from the following analysis. Of 57 nests within one mile of a timber sale, the average distance between the nest tree and logging site was 371 yards (standard deviation 380). The range in distances was between zero and 1300 yards.

Beach Type

The division of nest sites according to beach type is shown in Table 5. It appears to be evenly distributed between the six categories with a slightly greater number in the large rock and gravel-large rock categories.

Table 5. Classification of Beach Type

Beach Type	Number	Percent
Ledge-Steep Slope	18	16
Ledge-Gentle Slope	16	14
Large rock	27	24
Gravel-large rock	32	28
Sand	8	7
Mud Flat	13	11
Total	114	100

Exposure of Nest Site

The distribution of nest sites between the four categories is shown in Table 6. Approximately 50 percent of the sites were found on open coast with 20 percent of the sites on both open bays and small islands. Only 11 percent of the nests were found in sheltered bays.

Table 6. Beach Exposure at Nest Site

	Number	Percent
Open Coast	57	49
Open Bay	23	20
Small Island	24	20
Sheltered Bay	13	11
Total	117	100

Length of Exposed Beach at Low Tide

The average distance calculated from 72 measurements was 113 yards with a standard deviation of 248. The range was between zero and 1760 yards.

Distance Between Nest Sites

The average distance between all nests, nests in plots with logged sites, and nests in unlogged plots is shown in Table 7. The straight line and shoreline distances are both given. The distance between nests in unlogged plots was greater in both instances than the overall average and the averages of nests in logged sites.

Table 7. Distance Between Nest Sites in Yards

	All Nests Distance	SD.	Logged Plots Distance	SD.	Unlogged Plots Distance	SD.
Straight Line	1838	1585	1759	1447	2020	1704
Shoreline	2483	2218	2360	2298	2839	3053

Comparative Data from 1967 and 1968

A comparison of 71 nest sites for two consecutive years is presented in Table 8. The 71 nests were divided into nests that were active in 1967 and 1968, nests that were active either in 1967 or 1968, and nests that were inactive both years. The distribution of tree species within the three categories are comparable (Sitka spruce being the most common, western hemlock second, dead trees third, and yellow cedar fourth). Little difference is noted in nest form between tree height, nest height, or distance from the shore. The length of the exposed beach at low tide appears to be greater in the "nests active both years" category. It also appears that nests in this category are located nearer to logging sites than the other nests, and that the logging activity in proximity to these nests is more recent than in the other two categories.

Table 8. Nest Activity - Comparative Data 1967 and 1968 - Averaged Values

Activity Category	Number	Tree Species (Percent)					Nest Form (Percent)					
		Sitka Spruce	Western Hemlock	Yellow Cedar	Dead Tree	Total	1	11	111	1V	V	Total
Nest Active 1967 and 1968	17	88	6	0	6	100	25	8	8	59	0	100
Nest Active 1967 or 1968	19	84	16	0	0	100	10	10	20	60	0	100
Nest Inactive 1967 and 1968	35	80	6	6	8	100	20	10	5	50	15	100

Activity Category	Number	1	11	111	1V	V	VI	Total	Tree Height	Nest Height	Tree to Shore	Length of Exposed Beach
Nest Active 1967 and 1968	17	6	12	35	41	0	6	100	123 ft.	99 ft.	124 ft.	134 yards
Nest Active 1967 or 1968	19	32	10	21	16	5	16	100	117 ft.	98 ft.	98 ft.	74 yards
Nest Inactive 1967 and 1968	35	28	6	23	31	6	6	100	118 ft.	94 ft.	112 ft.	83 yards

Activity Category	Number	Logging Activity	
		Distance from Nest	Years since Completion
Nest Active 1967 and 1968	17	304 yards	8.5
Nest Active 1967 or 1968	19	424 yards	12.0
Nest Inactive 1967 and 1968	35	407 yards	11.0

Legend

Nest Form:

1. Nest in bowl at top of tree
11. Nest in crotch of U-shaped branch
111. Nest in bowl with dead top above nest
1V. Nest in normal tree
V. Nest in dead, bare tree

Beach Type:

1. Ledge-steep slope
11. Ledge-gentle slope
111. Large rock
1V. Gravel - large rock
V. Sand
V1. Mud Flat

DISCUSSION

The density of nests in the study plots (0.51 nests per beach mile) compares with that found by Robards (1967) except that his values were calculated with active nests only. My figures are based on all nests found within the study plot. Not all nests within my plots may have been located or the density of nesting bald eagles is lower in the Petersburg region than that found on Admiralty Island.

The shoreline and straight line distances between nests are quite variable. The closest active nests found were only 528 yards apart. The nearest active nest Robards reported were approximately 0.5 miles apart. I feel that the influence of shoreline shape permitted such close association in this case. Both nests were located on points which were separated by a small bay.

Tree species selection seems to be for Sitka spruce first, followed by western hemlock. This, at first, appears to be opposite what would be expected by chance. In southeastern Alaska western hemlock comprises over 70 percent of the forest cover and Sitka spruce is taller and of a more stable limb structure than western hemlock, but this is not the entire reason for the apparent selection. Sitka spruce grows best on well drained sites and will dominate western hemlock in these areas. Because of the well drained beach frontage, Sitka spruce is found in much greater frequency than in the above figures indicate (the exact ratio had not yet been determined). Nest site selection is most likely related to crown class and presence of a clear flight path to the water (Robards, 1967) rather than species preference.

Nest form indicates that nesting in normal trees with protective foliage is most common. This may result from the fact that more trees of this type are available. The chance of finding a well shaped upper whorl of branches or a U-shaped crotch is much smaller than that of finding a normal tree.

All nests recorded were located within 350 feet of the shore; most of the nest trees were much closer. This places the nesting habitat of eagles well within the reach of present logging practices in southeastern Alaska.

There was apparently no selection for type of beach or width of exposed beach at low tide. The exposure of the beach frontage shows that most nests were located on open coast, followed by small islands and open bays. The results may be meaningful but must be placed on a comparative basis. How much of each type of exposure is present within the plots? The same criticism can be made of the beach type categories.

The comparison of data from both years shows very little difference between the three activity categories. Only the width of exposed beach at low tide and presence of logging activity show sizable differences. Statistical tests have shown that there are no significant differences at the five percent level of confidence.

The effect of logging activity on bald eagle nesting in southeastern Alaska is difficult to determine. Aside from the obvious loss of potential nest sites and the actual loss of some nests, the effects are not clear. There appear to be fewer nesting pairs in my study area (which has been logged heavily) than in the Admiralty Island region. The comparison of nests active in 1967 and 1968 with the other two activity classes has shown that these nests are closer to logging sites and that the sties were more recently logged than in the other two categories.

It can not be inferred from this that logging is beneficial to bald eagle nesting. Logging appears to be compatable with the eagle population of the Petersburg region at this time; whether or not this will continue under future conditions can not be stated. If the apparent lower nesting density is an effect of logging activity, it is obvious that increased logging will be further detrimental to bald eagle production.

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WORK PLAN SEGMENT REPORT

FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT NO: W-17-1 TITLE: Small Game, Waterfowl & Furbearer Investigations

STUDY PLAN: B TITLE: Upland Game

JOB NO: 13 TITLE: Relationships of Ptarmigan to Their Food Supply

PERIOD COVERED: July 1, 1968 to June 30, 1969

ABSTRACT

Ninety-three female rock ptarmigan were collected from a 20 square mile area during April 20 - May 22. Autopsies yielded weights, measurements, organs, tissues and gut contents which will be analyzed in relation to the nutritional status of the birds.

WORK PLAN SEGMENT REPORT

FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT NO: W-17-1 TITLE: Small Game, Waterfowl & Furbearer Investigations

STUDY PLAN: B TITLE: Upland Game

JOB NO: 13 TITLE: Relationships of Ptarmigan to Their Food Supply

PERIOD COVERED: July 1, 1968 to June 30, 1969

OBJECTIVES

To determine the factors involved in food selectivity by rock and willow ptarmigan in relation to species characteristics, habitat, season, sex and age.

To investigate the characteristics and importance of grit used by ptarmigan.

PROCEDURES

Prior to departure 1000 lbs. of field equipment (including a freezer and gas generator) was shipped by air to a point 12 miles from the future field camp.

On April 15, the investigator, his field assistant, Bruce P. O'Berg, and volunteer helpers, Dr. R. B. Weeden and Bud Burris of Alaska Department of Fish and Game departed from Fairbanks via the Steese Highway toward the study area, 12 miles west of mile 117 Steese Highway. Because of snow conditions the last 32 miles up the Steese were traversed on snow machine.

After 5-16 hour working days the party had transported the field equipment including 2 55 gallon barrels of gas to the field camp. Although snow machines were used for light loads it was necessary to use a "Ranger" vehicle to transport heavy articles over the soft snow.

The investigator wishes to acknowledge Dr. R. B. Weeden and Bud Burris for their whole-hearted help and willingness to continue when at numerous times it seemed impossible to reach the proposed destination.

From April 20 to May 22, 93 female ptarmigan were collected from a 20 square mile area.

From May 22 to June 15, five nests were located; two nests produced six to seven chicks respectively, one nest of five eggs was deserted and two nests of one and six eggs were unsuccessful because of predation.

The investigator and field assistant returned to Fairbanks on June 16.

Analysis of the extensive specimen material remains to be done under the continuing phase of this study.

Prepared By:

Ronald D. Modafferi
Graduate Student

Submitted By:

David R. Klein
Wildlife Unit Leader

WORK PLAN SEGMENT REPORT

FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT NO: W-17-1 TITLE: Small Game, Waterfowl & Furbearer Investigations

STUDY PLAN: B TITLE: Upland Game

JOB NO: 14 TITLE: Kittiwake Ecology

PERIOD COVERED: July 1, 1968 to June 30, 1969

OBJECTIVES

To determine the nesting ecology of the kittiwake on Chisik Island in Cook Inlet.

PROCEDURES

Although a graduate student was tentatively assigned to this project in September 1968 no research was initiated and the student changed his project to "The Role of Mineral Licks in the Ecology of Dall Sheep" (Job N-9) which is reported elsewhere.

Prepared By:

David R. Klein

Submitted By:

David R. Klein
Wildlife Unit Leader

WORK PLAN SEGMENT REPORT

FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT NO: W-17-1 TITLE: Big Game Investigations

STUDY PLAN: K TITLE: Moose

JOB NO: 8 TITLE: Winter Browse Preference

PERIOD COVERED: July 1, 1968 to June 30, 1969

ABSTRACT

Some moose-willow relationships were studied on several moose ranges in Alaska's interior. Certain species of willows were found to be preferred by moose over others--S. interior, S. alaxensis, S. arbusculoides, and S. pulchra being the most highly preferred. The results of a chemical analysis of several species suggest a possible relationship between the chemical compositions and palatabilities of willow species. S. alaxensis and S. pulchra, by virtue of their high palatability, wide distribution, and relatively high abundance, are probably the most important browse species. Moderately palatable willow species are eaten to a greater degree by moose when occurring with highly preferred species than when occurring in "pure" stands. In a given area neither the relative density nor relative abundance of a species visibly affect its degree of use. The densest of the willow stands that were studied apparently do not physically hinder moose movements sufficiently to cause such stands to be utilized less intensively than are sparse stands. The degree of browsing that is sustained by a given species seems to be positively correlated with plant height, but species preferability is evidently determined more by inherent palatability than by mean height.

The total amount of available browse on one study area was 4.5 pounds (oven-dried weight) per 100 square m. The percentages of available browse removed by moose from the various willow species during one winter ranged from 33.8 to 0.1 percent.

ACKNOWLEDGMENTS

This project was financed by the Alaska Department of Fish and Game, Project No. W-17-1, Work Plan K-8, and administered through the Alaska Cooperative Wildlife Research Unit. I want to express a sincere thanks to the following individuals for making the successful completion of this study possible:

Dr. David R. Klein, Leader, Alaska Cooperative Wildlife Research Unit, for a critical reading of the manuscript.

Mr. Samuel J. Harbo, Jr., Assistant Professor of Biometrics, University of Alaska, for many helpful suggestions pertaining to the analysis and interpretation of the data.

Dr. Bonita J. Neiland, Associate Professor of Botany, University of Alaska, for valuable aid in preparing the thesis.

Dr. Leslie A. Viereck, Research Botanist, Institute of Northern Forestry, U. S. Forest Service, for verifying the identification of willow specimens.

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Mrs. Colleen A. Schweinberg, for proofreading the manuscript and typing the final copy of the thesis.

WORK PLAN SEGMENT REPORT

FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT NO: W-17-1 TITLE: Big Game Investigations

STUDY PLAN: K TITLE: Moose

JOB NO: 8 TITLE: Winter Browse Preference

PERIOD COVERED: July 1, 1968 to June 30, 1969

OBJECTIVES

To determine the variation in preference and use of winter browse species of moose with major emphasis on the willows.

To determine the factors which alter the preference and use of willow species from area to area.

This project was completed and a thesis was prepared and accepted toward the Master of Science degree at the University of Alaska. A copy of the thesis is attached. One copy has been forwarded to the moose project leader and ten additional photo offset copies will be submitted as soon as they are received from the printers.

Prepared By:

Gary C. Milke
Graduate Student

Submitted By:

David R. Klein
Wildlife Unit Leader

SOME MOOSE-WILLOW RELATIONSHIPS IN THE

INTERIOR OF ALASKA

APPROVED:

Samuel J. Harbo Jr.

Bonita J. Neiland

David R. Klein

Chairman

Samuel J. Harbo Jr.

Department Head

APPROVED: Brina Kessel DATE 9 May 1969

Dean of College of Biological Sciences
and Renewable Resources

Vice-President for Research and
Advanced Study

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INTRODUCTION

The importance of willows as a food source for moose has been well documented. Willows are considered the most important food items for moose in Montana (Knowlton, 1960), Wyoming (Baker et al., 1953; Harry, 1957), and south-central Alaska (Chatelain, 1951). Pimlott (1961) sums up the situation by stating that in western Canada and the western United States, willows and moose are inseparable.

Due to the lack of adequate willow keys and the difficulties involved in species identification, most of the literature refers only to Salix spp. as being preferred by moose. The resulting implication is that all species of willows are equally preferred and, hence, of equal importance. Several workers (McMillan, 1953; Murie, 1961; Seiskari, 1956), however, have noted a species preference by moose. Murie's observations, which were made in Mt. McKinley National Park, and observations made by personnel of the Alaska Department of Fish and Game (R.A. Rausch, Alaska Department of Fish and Game, pers. comm.) have indicated that some willow species in Alaska are browsed by moose more intensively than are others.

The primary purpose of this study was to determine the identity and possible preferability to moose of the various willow species occurring on some of the important moose ranges in Alaska's interior. Secondarily, an attempt was made to explain the reasons for selection preference, if such was found to exist. Some of the data that were collected while pursuing these goals also made it possible to investigate other topics, such as effects of plant height, density, and location, on browsing intensity.

The study was conducted during the summers of 1967 and 1968. Since the same methods were not employed during both summers, the discussion of methods and results have been divided into two parts, each corresponding to one summer's work.

PART I

STUDY AREAS

The areas investigated were chosen on the basis of their importance to moose in interior Alaska and because they were known to support stands of willows suitable for study. During the course of the study, a helicopter, small, single engine aircraft, automobile, and canoe were used to gain access to the study areas.

Dry Creek

The Dry Creek study area (Fig. 1) is located in the extreme southern portion of the Tanana River flats, which lie north of the Alaska Range. (The location of the study area on the map is shown by the broken lines. The numbers refer to the locations of study plots.) At one time the study area was a black spruce (*Picea mariana*) muskeg, but a fire, occurring at some undetermined time in the past, destroyed the spruce. The stand of willows studied, which is approximately 2500 m long and 150 m wide, apparently is a seral community.

The composition of the willow stand varies with its proximity to the creek. The species *Salix alaxensis*, *S. lasiandra*, *S. arbusculoides*, *S. padophylla*, and *S. myrtillifolia* occur in a "belt" that is adjacent to Dry Creek. This "belt" of willows varies between 20 and 60 m in width and is closely associated with the stream levee, which normally is relatively dry. A marshy condition occurs on the floodplain further from the creek, and, here, *S. pulchra*, which grows in dense patches, and *S. arbusculoides* are the dominant species of willows present. *S. depressa* is occasionally found on the drier sites in this marshy area. The texture of the soil underlying the marshy area is finer than that of the stream levee.

Paxson Lake

Paxson Lake is located in the Alaska Range, approximately 150 miles southeast of Fairbanks (Fig. 2). Dwarf birch (*Betula nana*) and black spruce are the most abundant plant species in the area surrounding the lake, and willow stands suitable for study are rare. The most extensive willow stand in this region occurs in the marshy areas bordering the Gulkana River, which flows into the north end of Paxson Lake. The marsh near the lake was the only portion of this area examined, and *S. pulchra*, *S. lanata*, and *S. Barclayi* were the only willow species encountered. The soil in this region is finely textured and highly organic.

One other area, located along a section of the old Richardson Highway east of Paxson Lake, was examined. The most abundant plant species on the wet sites along this road are *S. pulchra*, *S. Barclayi* *S. lanata*, *S. reticulata*, horsetail (*Equisetem* sp.) and sphagnum moss (*Sphagnum* sp.), whereas *S. alaxensis*, *S. glauca*, *S. depressa*, and seed-

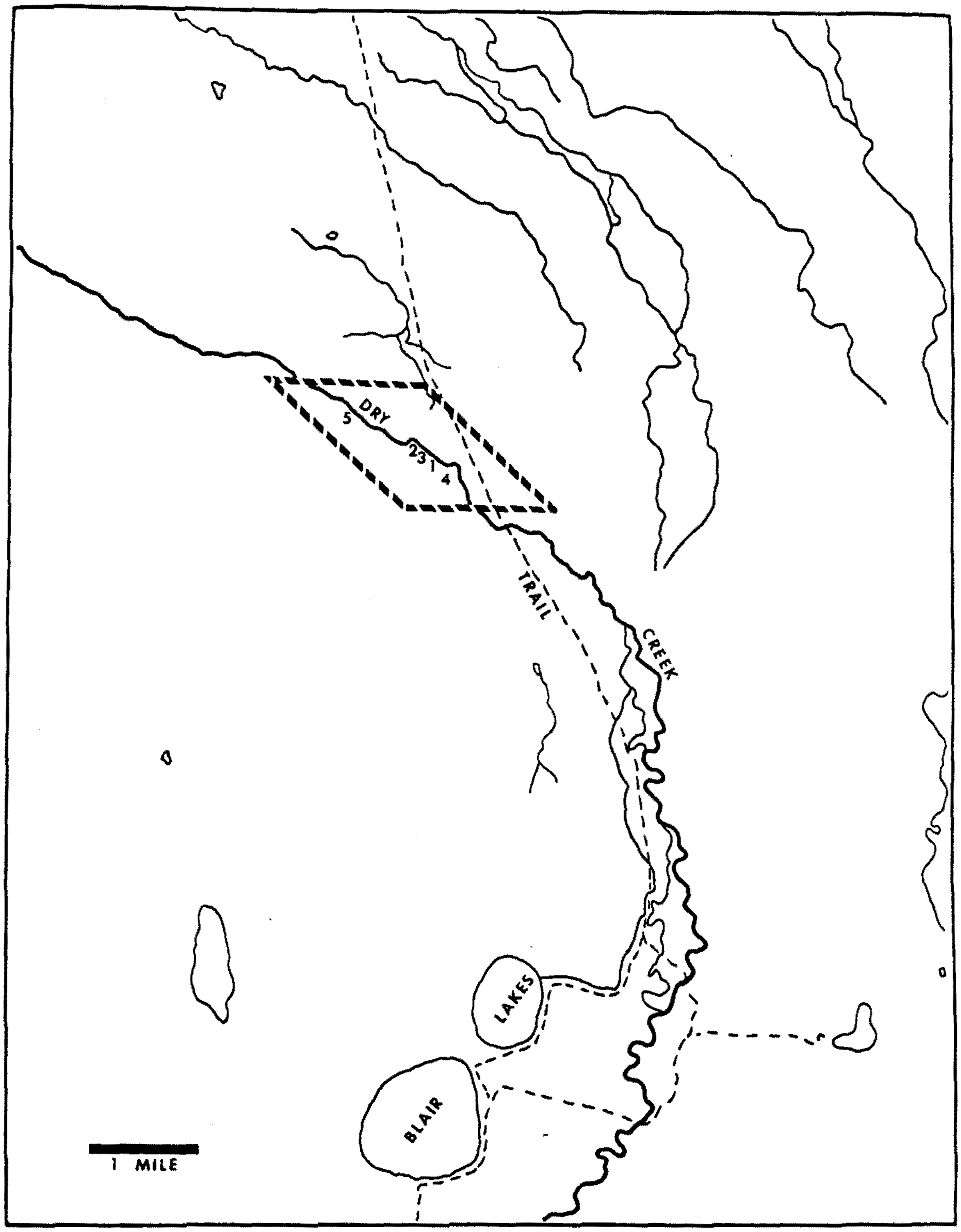


Figure 1. Dry Creek study area; 64°27' N, 147°22' W (From U. S. Geological Survey map B-1, Fairbanks quadrangle).

ling black cottonwood (Populus trichocarpa) occur on the dry sites. Generally, the soil on the wet sites has a finer texture than that occurring on the dry sites.

Little Clearwater Creek

Little Clearwater Creek is a glacier-fed stream that intersects the Denali Highway 54 miles west of Paxson, Alaska (Fig. 3). Dwarf birch is the dominant plant species on most of this hilly region. The overstory on the floodplain of the creek, however, consists primarily of willows.

The species *S. alaxensis*, *S. Barclayi*, *S. hastata*, *S. lanata*, and *S. Barrattiana* are present on the islands and along the creek in a strip that is approximately 50 m wide. Beyond this strip and extending to the outer boundaries of the floodplain the overstory consists of a dense stand of *S. pulchra* and *S. Barclayi*. This later willow type is particularly evident in the region north of the highway and east of the creek, where it covers an area about 3500 m long and 300 m wide. The differences in plant composition are probably due to the differences in soil texture and moisture content; the soil on those areas bordering the creek is of finer texture and drier than that occurring on the other areas of this region.

Gunn Creek Flat

Gunn Creek flat is a level area located just beyond the toe of the Gulkana Glacier, approximately 13 miles north of Paxson, Alaska (Fig. 4). This flat area is triangular shaped with sides that are four miles long; the apex is located at the glacier, and the base extends along the Richardson Highway. The area was formed by the deposition of glacial drift and outwash.

The surface material of the region located just beyond the glacier's terminus is very rocky, and *S. alaxensis* grows here in pure stands. Southeast of this area, where the soil is less rocky, the willow community consists primarily of *S. alaxensis*, *S. glauca*, *S. lanata*, and *S. Barclayi*. This willow type grades into a pure *S. Barclayi* type that extends all the way to the highway and nearly to Gunn Creek. This is a moderately wet area with finely textured soils. The region bordering Gunn Creek supports a stand of willows consisting of *S. alaxensis*, *S. pulchra*, *S. Barclayi*, and some *S. lanata* and *S. hastata*. The portion of the flat lying south of Gunn Creek is marshy, and *S. pulchra* predominates.

Taylor Highway

The Taylor Highway is located in eastern Alaska, and it intersects the Alaska Highway at Tetlin Junction, approximately 200 miles southeast of Fairbanks. Most of this mountainous region is densely timbered with white spruce (Picea glauca) and maintains few large willow stands. Mount Fairplay (Fig. 5), however, with an elevation of 1690 m (5545 ft)

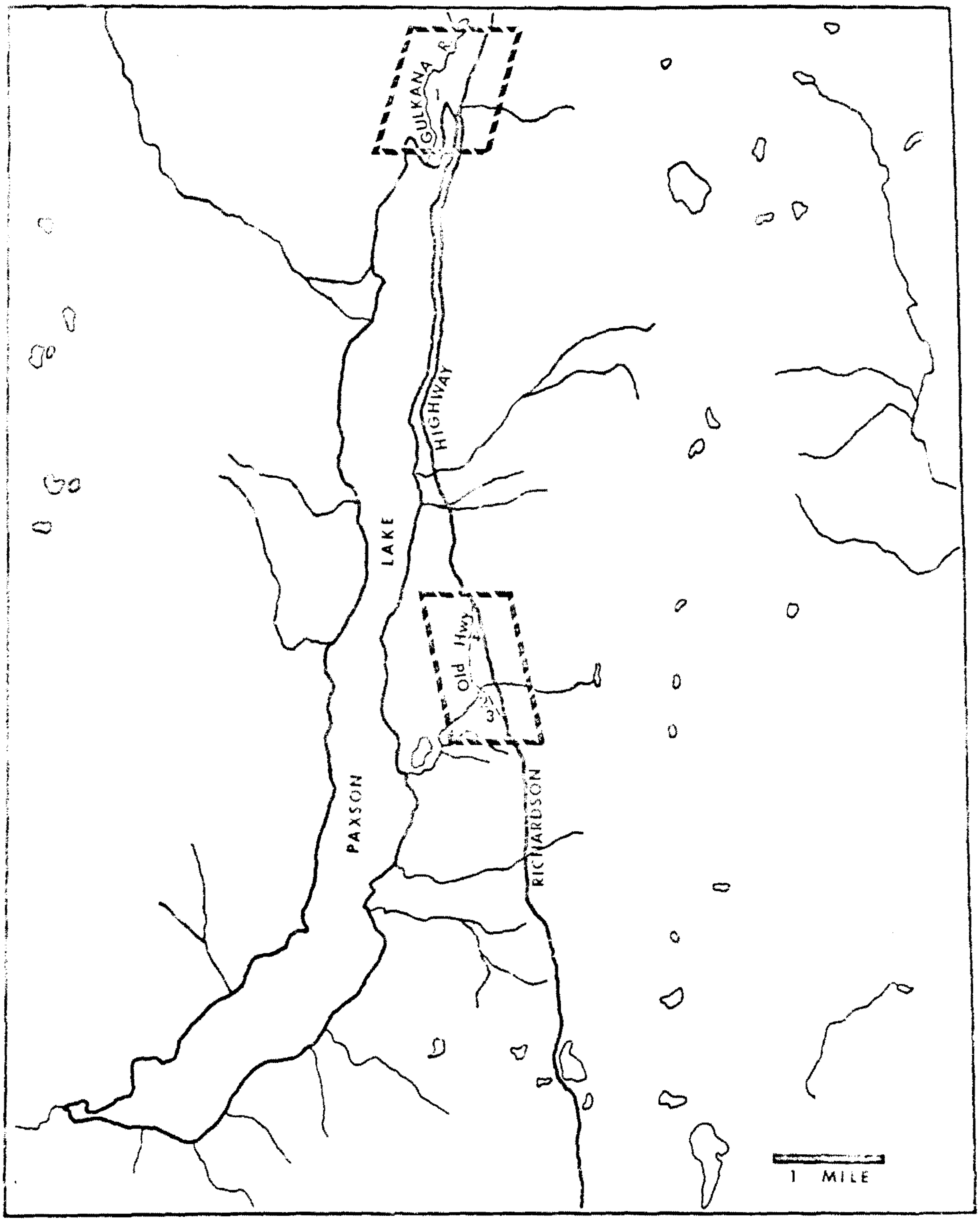


Figure 2. Paxson Lake study area; 62°55' N, 145°30' W (From U. S. Geological Survey maps D-3 and D-4, Gulkana quadrangle).

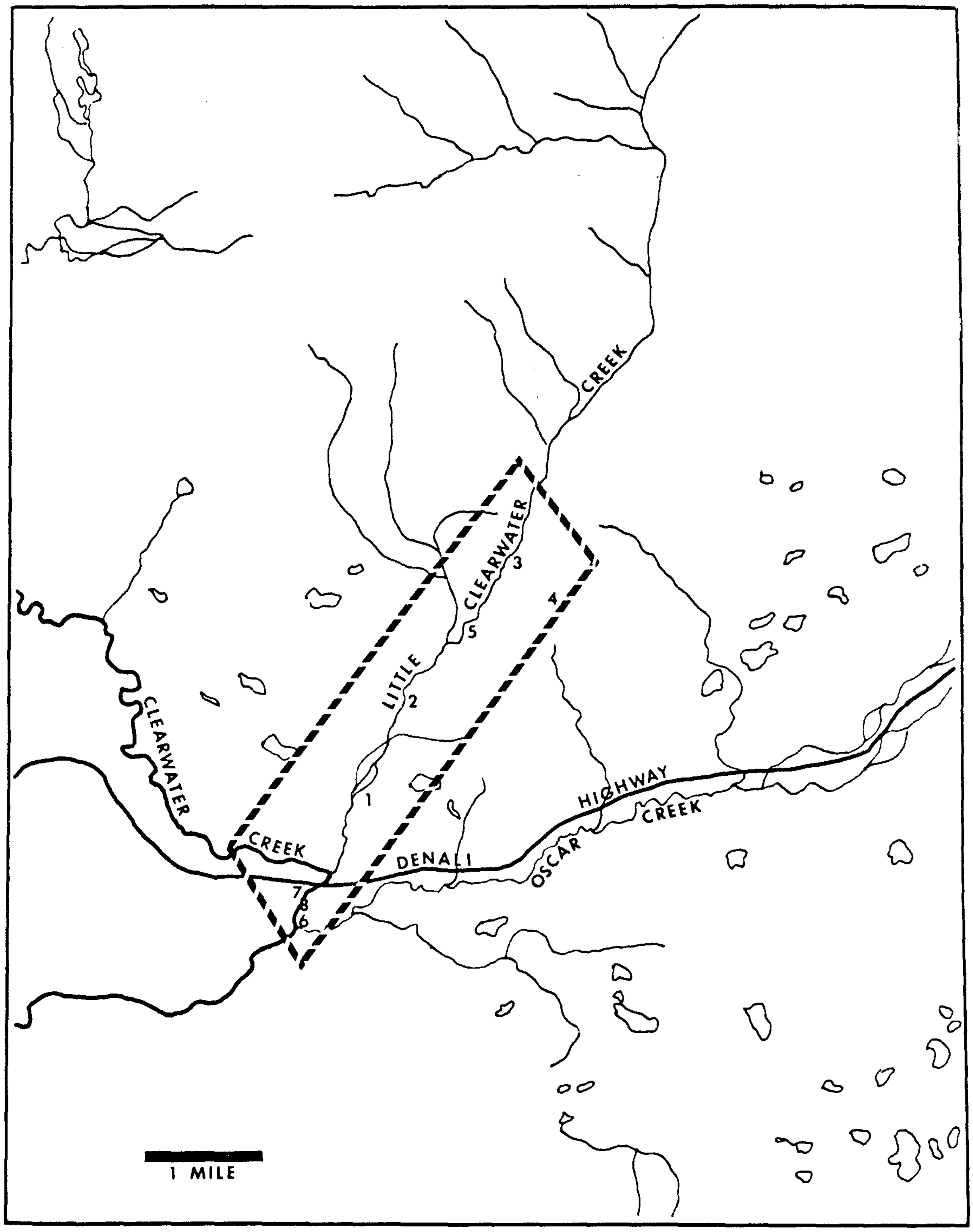


Figure 3. Little Clearwater Creek study area; 63°03' N, 146°52' W (From U. S. Geological Survey map A-6, Mt. Hayes quadrangle).

supports alpine tundra vegetation, and many of the small drainages radiating from this peak contain dense stands of S. pulchra interspersed with Calamagrostis sp. and dwarf birch. The rocky slopes extending into these "draws" are sparsely vegetated with S. glauca, dwarf birch, bog blueberry (Vaccinium uliginosum), and cranberry (Vaccinium vitis-idea).

Small stands of willows also grow adjacent to several of the major streams located north of Mount Fairplay (Fig. 6). A willow stand consisting mainly of S. pulchra, S. arbusculoides, S. glauca, and S. alaxensis is located next to Logging Cabin Creek, which intersects the Taylor Highway 43 miles north of Tetlin Junction. Salix pulchra is the most abundant willow species growing along the banks of the West Fork of the Dennison River at mile 49. A flat area just south of this river and west of the highway supports S. pulchra, S. alaxensis, S. arbusculoides, S. glauca, and S. depressa, in addition to dwarf birch and bog blueberry. The species of willows occurring at a dry, rocky, roadside site north of this area are S. arbusculoides, S. depressa, S. Scouleriana, S. alaxensis, S. glauca, and S. pulchra.

Wood River

Wood River is a glacier-fed river that flows out of the Alaska Range in a northwesterly direction and enters the Tanana River about 30 miles southwest of Fairbanks. Only the extreme upper portion of the river, located approximately 30 miles east of Mt. McKinley National Park, was examined; study plots were established along a four-mile stretch of the river beginning at the mouth of Young Creek and extending upstream (Fig. 7). This is a very mountainous region, with many peaks having elevations exceeding 2000 m.

The willows of importance to moose in the upper Wood River area are found on the old river floodplain and on the lower slopes of the mountains bordering the river valley. The active river floodplain, which often exceeds 100 m in width, is overlain with coarse gravel and does not support vegetation. The old river floodplain, with its finer textured soils, maintains a plant community comprised of S. alaxensis, S. glauca, S. arbusculoides, S. lanata, S. hastata, and scattered S. Barclayi, S. pulchra, white spruce, black cottonwood, and dwarf birch.

Dwarf birch and bog blueberry are the most abundant species on the lower slopes of the mountains bordering the river valley, but S. glauca and S. lanata occasionally occur in stands and as scattered individual plants. More substantial and diverse willow stands are found along the small streams that flow down these slopes and enter the river. Several small streams, which enter this section of Wood River from the north, are bordered by S. alaxensis, S. glauca, S. pulchra, and S. hastata. Bog blueberry, dwarf birch, black cottonwood, and soapberry (Shepherdia canadensis) also grow along these small drainages. The substrata along these small drainages is quite rocky in comparison to that occurring on other areas of these lower slopes.

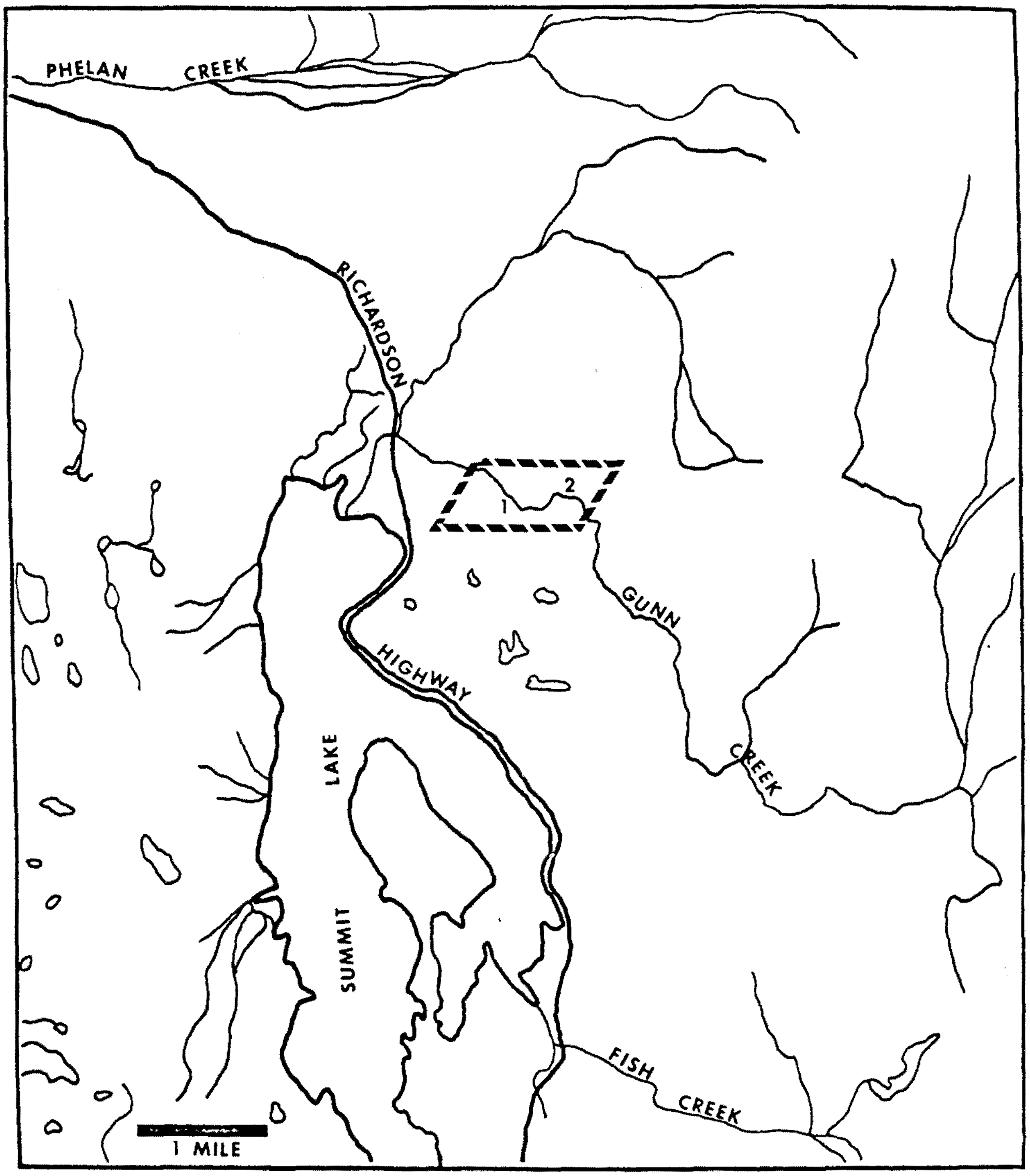


Figure 4. Gunn Creek study area; 63°10' N, 145°29' W (From U. S. Geological Survey maps A-3 and A-4, Mt. Hayes quadrangle).

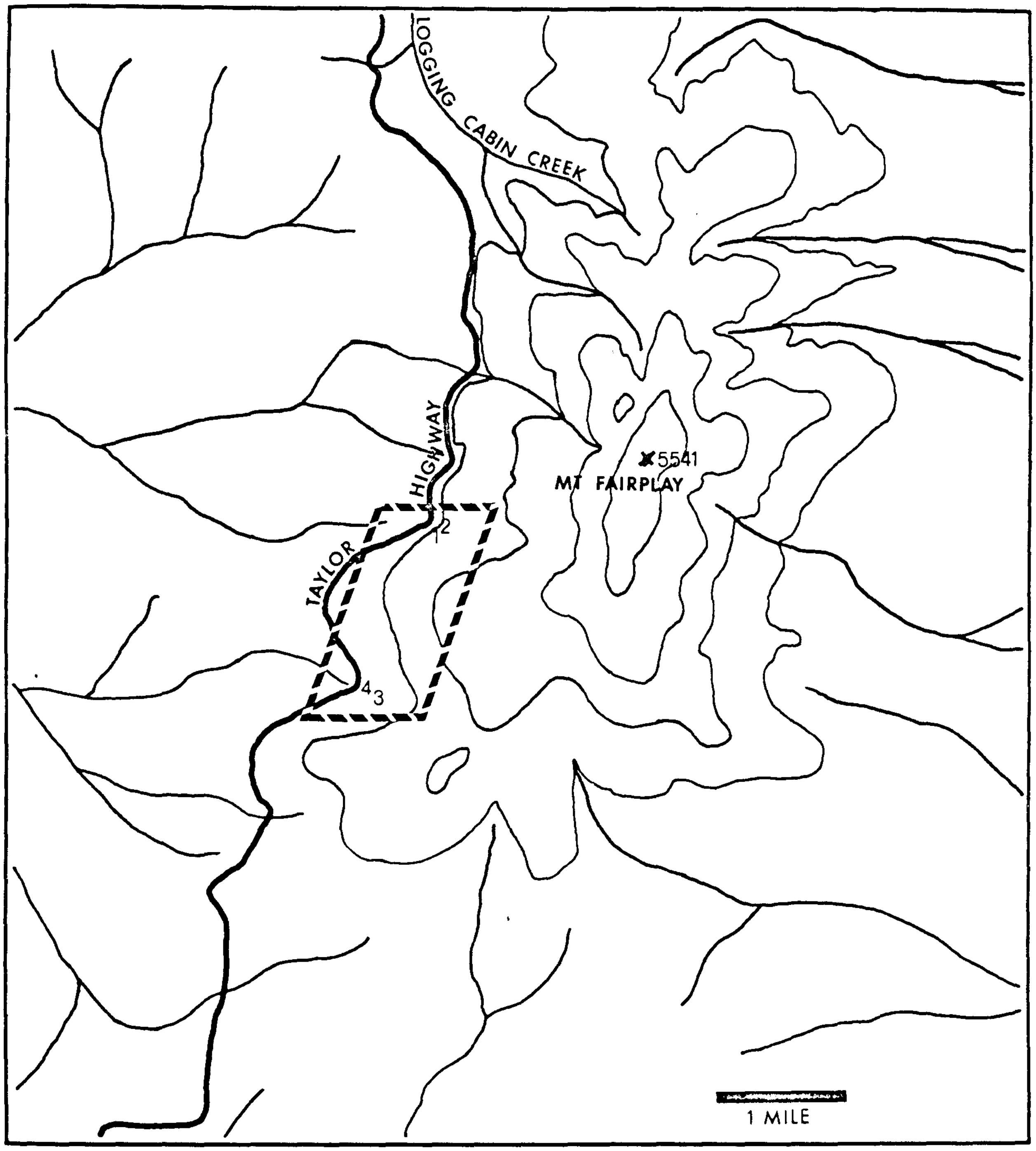


Figure 5. Taylor Highway (Mt. Fairplay) study area; 63°40' N, 142°15' W (From U. S. Geological Survey map C-3, Tanacross quadrangle).

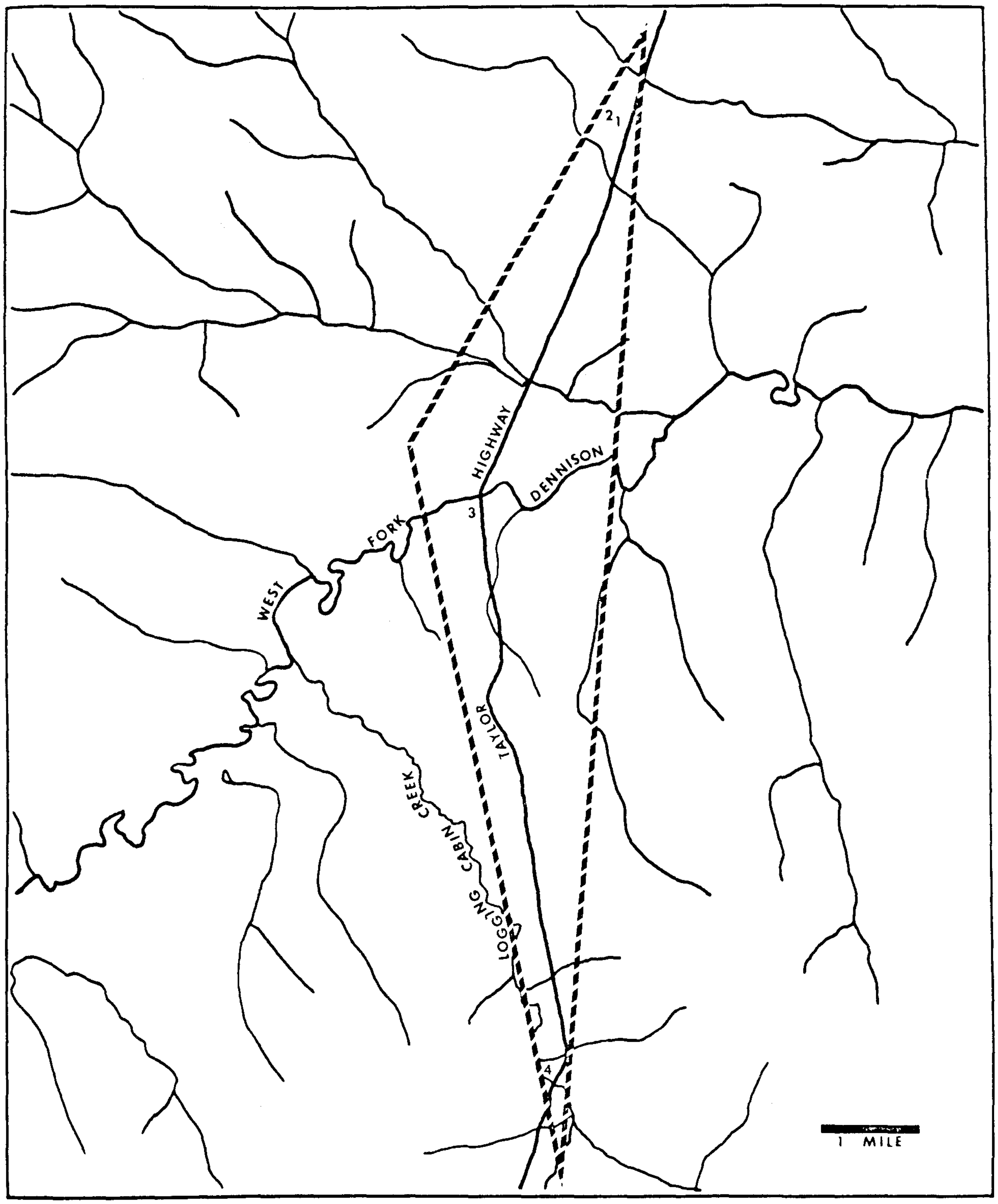


Figure 6. Taylor Highway (Other) study area; 63°55' N, 142°15' W (From U. S. Geological Survey map D-3, Tanacross quadrangle).

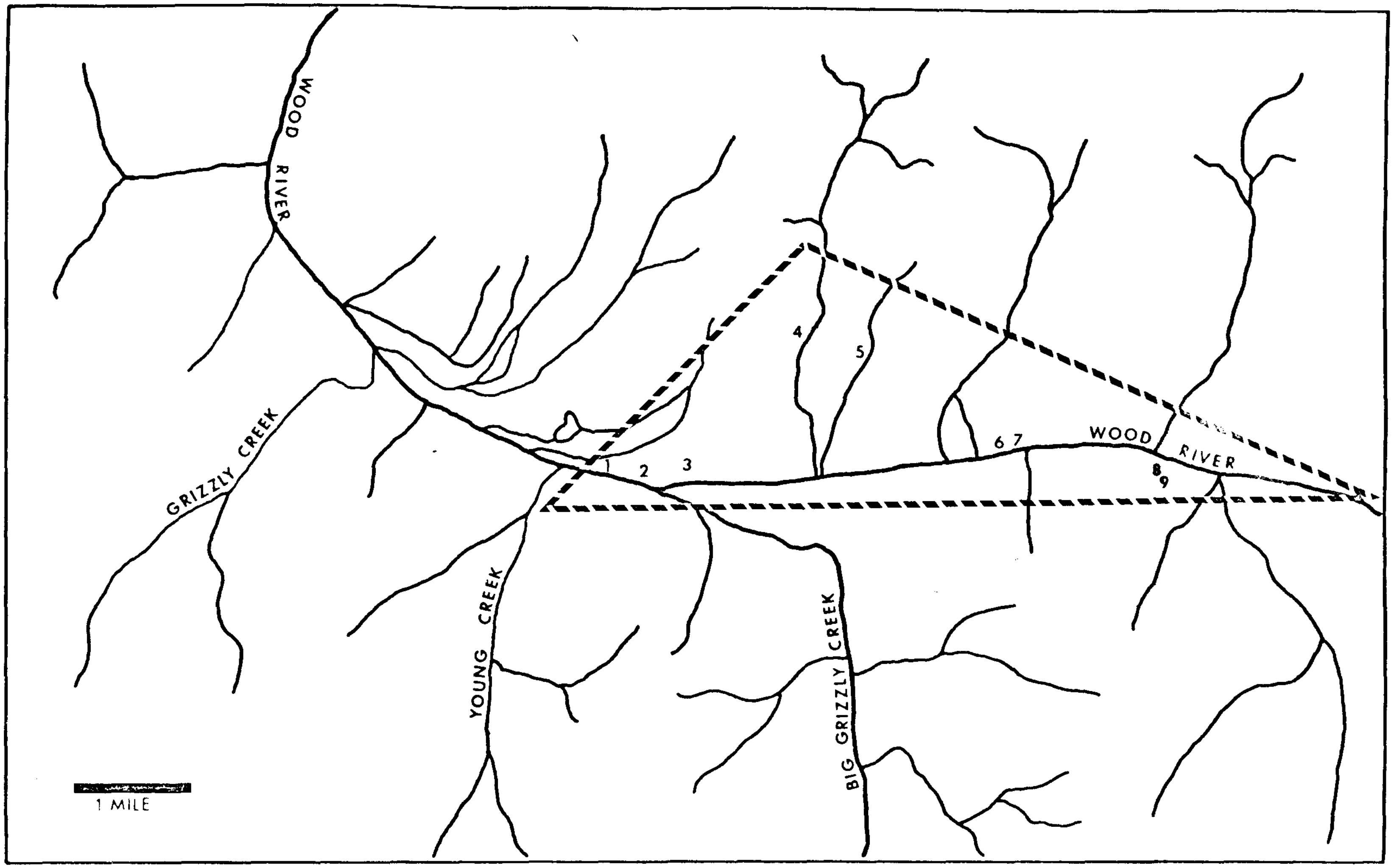


Figure 7. Wood River study area; 63°45' N, 147°55' W (From U. S. Geological Survey maps C-2 and D-2, Healy quadrangle).

METHODS

The purpose of this part of the study was to obtain information on browsing over a wide geographical area. Since time was limited, the methods were designed for acquiring only general data on a rather gross level. An IBM 360 computer was used to analyze the huge quantity of raw data that was collected.

Species Identification

After arriving in a study area, a general reconnaissance was made to identify the species of willows present. Specimens of all species were collected, preserved, and eventually stored in the University of Alaska herbarium. Unfamiliar species were identified with the aid of a key to the willows of boreal western America (Raup, 1959). It should be noted here, however, that the nomenclature used follows Hulten's (1968) flora, which was not available until after the field work was completed. Hulten's taxonomic system is slightly different from that of Raup; the three species _S. lanata_ L., _S. depressa_ L., and _S. hastata_ L. of Hulten are synonymous with Raup's _S. Richardsonii_ Hook., _S. Bebbiana_ Sarg., and _S. Farrae_ Ball respectively.

Locating Study Plots

Following the initial reconnaissance of a study area, a survey was made to determine the location, size, and apparent variability of each willow type. The decision as to the number of study plots to be established within a willow type was made on the basis of the plant size and density variability that were present; the greatest numbers of plots were used in the most variable types. After the size of a willow type was estimated by pacing, a map of its boundaries was roughly sketched on paper; the map was then divided into rectangular sections, which were scaled in proportion to the size of the study plots to be used. The sections were numbered consecutively, and several, the actual number depending upon the number of study plots to be used, were chosen from a list of random digits. The rectangular study plots, which corresponded to the sections chosen, were then located, and their boundaries were established.

The size of the study plots was generally based on the variability of the willow type in which they were located; the largest plots were used in those willow types displaying the greatest amount of variability in plant size or density. In some instances, however, the size of the plots was limited by the size of the willow stand. The study plots varied in size from 1,200 to 6,000 square m, although 3,000 square m was the most common size.

Locating Sample Frames

The collection of data in the study plots was made within a two-by-two meter wood frame. These four square meter sample frames were located according to the example in Fig. 8. If, for example, the study plot measured 100 by 30 m, one of the 100 m boundaries was used as a baseline and marked with stakes every 20 m. For each 20 m length, two numbers from zero to 20 were chosen from a list of random digits, and two stakes were located on each 20 m segment of baseline at a distance from the starting point of that segment equal in meters to the

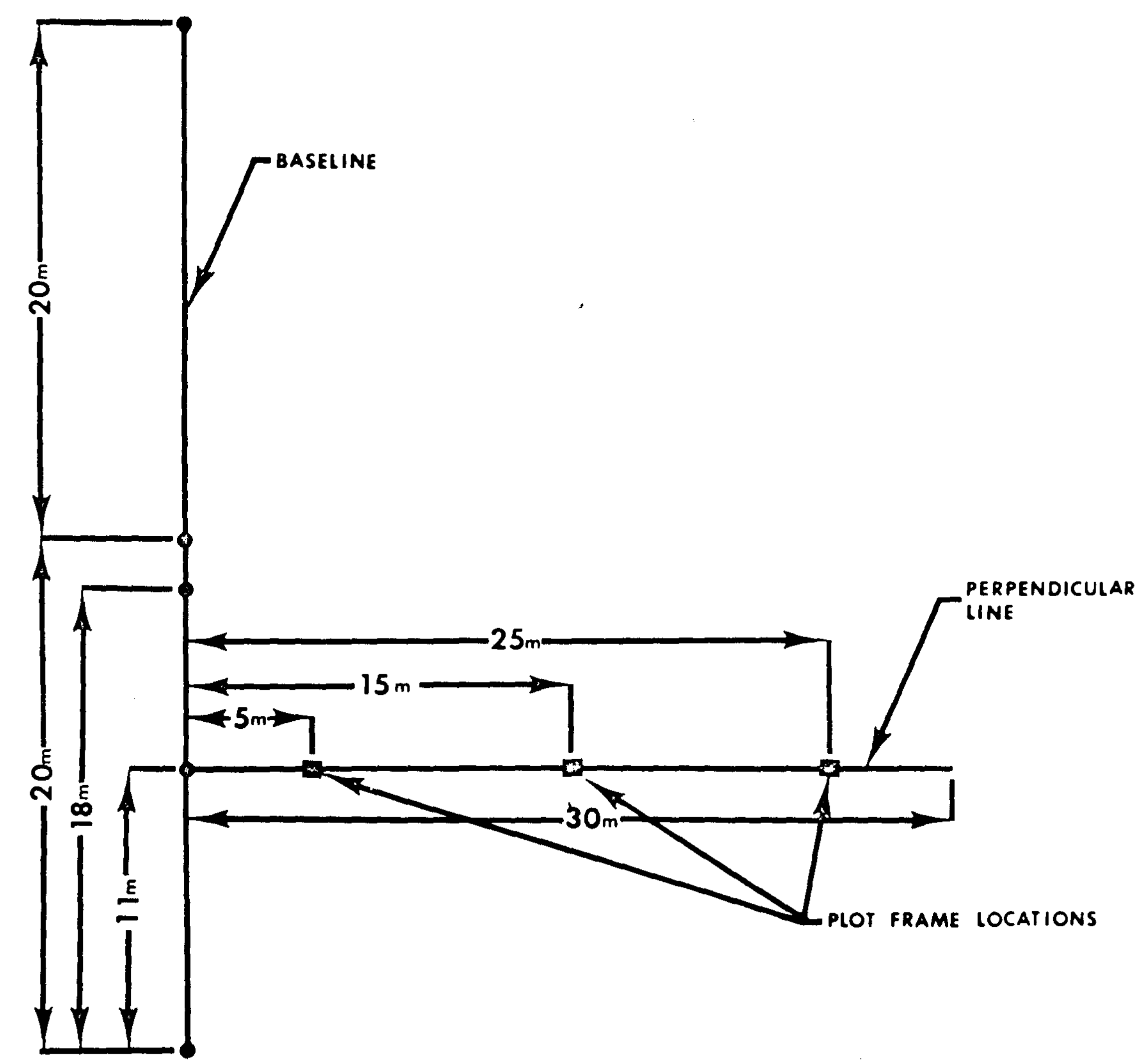


Figure 8. Example of the method used for locating sample frames.

numerical values of the numbers chosen; 11 and 18 m in the example shown. With the aid of a staff compass, a line was run perpendicular to the baseline at each of these stakes and extended across the width of the study plot. For each perpendicular line, a certain number of digits from zero to the width of the study plot in meters was chosen from a table of random digits, the actual number of digits chosen depending upon the number of sample plots to be used. If, for example, the study plot was 30 m wide, the determined number of digits would be randomly chosen within the range of zero to 30 for each perpendicular line, and if the numbers chosen for the first line were 5, 15, and 25, three stakes would be located at those corresponding distances in meters from the baseline (Fig. 8). The stakes on the perpendicular lines marked the location of that corner of the four square meter sample frame which was nearest the baseline starting point when the inside edge of the frame was lined up parallel to the baseline. The number of sample frames used in a study plot was based upon the size of the study plot and the variability of the willow stand; the greatest number of sample frames was used in the largest plots and the most variable willow stands. Generally, from three to six percent of each study plot was sampled.

Information Recorded

Each willow plant encountered within a sample frame was recorded as to species, height, measured to the nearest five cm, and browse class. A plant was considered to be that entity whose base was surrounded by soil, even though it was often obvious that a number of such plants had a common underground source. The criteria used in browse class determination were the percentage of the twigs browsed and the percentage of the plant growing within the available browse zone. The characteristics of each browse class are shown in Table 1.

A twig was judged as having been browsed if a portion of it had been removed or if it had been stripped of bark or leaves, although stripping was rarely encountered during this study. The determination of the percentage of a given plant available for browsing was based upon the minimum height at which browsing had occurred on that study plot. Prior to taking measurements on a study plot, a reconnaissance was made of the area, and the minimum browsing height, defined as the height below which browsing did not occur, was recorded. Every study plot had a particular minimum browsing height, which appeared not to be species-specific. If, for example, the minimum browsing height on a study plot was 50 cm, the following browse class scheme would be used: less than 50 cm in height--unavailable (browse class 8); 50 to 74 cm in height--1 to 33 percent available (browse classes 7-1 to 7-3); 75 to 149 cm in height--34 to 66 percent available (browse classes 4 to 6); greater than 149 cm in height--greater than 66 percent available (browse classes 1 to 3). None of the plants on any of the study plots appeared to be growing beyond the reach of moose; browsing was observed at heights exceeding four m. Browsing at such heights is possible since moose are known to "ride down" tall plants by straddling them and walking forward until the young, upper twigs are available. Also, snow accumulations on the upper branches cause them to droop and, thus, become more readily available. It should be noted that the term "percentage of plant available", as used here, does not refer to the percentage of plant mass available to browsing, but refers to the percentage of the linear height of the plant growing within the browsing zone on the study plot.

Table I. Browse class characteristics

Browse class	Twigs browsed (%) (previous annual growth)	Portion of plant available (%)
1	less than 33	greater than 66
2	34-66	greater than 66
3	67-100	greater than 66
4	less than 33	34-66
5	34-66	34-66
6	67-100	34-66
7-1	less than 33	1-33
7-2	34-66	1-33
7-3	67-100	1-33
8	---	0

DISCUSSION OF RESULTS

A compilation of the data from each study plot is listed in Appendix 1; the plot numbers listed under each study area correspond to the plot location numbers on the study area maps. The various categories of information listed will be dealt with separately under the appropriate subheadings of the discussion. For the sake of expediency, code letters are substituted for species names in all tables and graphs. The following code scheme is used: S. alaxensis = ALA; S. arbusculoides ARB; S. Barclayi = BAR; S. Barrattiana = ZZZ; S. depressa = DEP; S. lasiandra = LAS; S. myrtillifolia = MYR; S. padophylla = PAD; S. pulchra = PUL; S. Scouleriana = SCO.

Species Preference

Very little information is recorded in the literature concerning selection preference by moose for certain species of willows. This probably is primarily due to the difficulties involved in willow species identification. McMillan (1953), however, notes that of the two willow species encountered during a study in Yellowstone National Park, one was eaten by moose three times more frequently than was the other. Murie (1961) indicates that of the more than 20 species of willows in Mt. McKinley National Park, three species were particularly well liked by moose. He mentions that S. pulchra and S. Richardsonii (= S. lanata) were special favorites, and that S. alaxensis was browsed intensively along Igloo Creek. Murie's observations are particularly noteworthy since they agree closely with my findings.

To aid in evaluating a species' selection preferability, a quantity, which I have called the Browsing Intensity Index (BII), was calculated for each species on every study plot. To calculate the BII for a species, the percentage of plants in each browse class from 1 through 7-3 was determined by using the total number of plants in these browse classes and the number in each class. Using these percentages, the BII for a given species was obtained as follows: $\text{BII} = 1[X(1) + X(4) + X(7\text{-}1)] + 2[X(2) + X(5) + X(7\text{-}2)] + 3[X(3) + X(6) + X(7\text{-}3)]$, where $X(i)$ = percentage of plants in the i^{th} browse class. The smallest BII possible is 100 (i.e., 100% of the plants utilized from 0 to 33%), and the largest possible BII is 300 (i.e., 100% of the plants utilized from 67 to 100%). The BII, therefore, is based on the degree of browsing sustained by a species, and a comparison of the BIIs of the various species should indicate the relative degrees of browsing sustained by them.

Several factors that affect the accuracy of BII values should be discussed before proceeding further with the analysis. The BII value, for example, is influenced by plant form, as is indicated by the following hypothetical example: Suppose that two equally palatable species of approximately the same height occur on a study area. Species A is represented by ten plants, each of which supports only one browsable twig, and species B is represented by just one plant that supplies ten available twigs. A comparison of the BII values for the two species which maintain only a few browsable twigs may tend to have larger BII values than bushy species when the browsing is light and smaller BII values than bushy species when the browsing is intensive. The influence

Table 2. Comparison of the BIIs of species having different growth forms

Species	BII values									
	10%#	20%	30%	40%	50%	60%	70%	80%	90%	100%
A*	120	140	160	180	200	220	240	260	280	300
B**	100	100	100	200	200	200	300	300	300	300

Percentage of twigs browsed
* Ten plants, each with one available twig
**One plant with ten available twigs

of plant form on the BII values, therefore, represents a source of error in the species preference analysis, although with large sample sizes and with random browsing of twigs within each species this error approaches zero. This source of error could have been eliminated if the numbers of available and browsed twigs had been estimated and recorded for each sampled plant. The percentage of available twigs that had been browsed could then be tallied for each species, and a comparison of these percentages would indicate the relative degrees of browsing that had been sustained by the various species. I believe, therefore, that an analysis of the numbers of available and utilized twigs, rather than an analysis of browse classes (as was done in this study), would probably be a better method of determining browsing intensity.

Another possible difficulty is that BII values may be influenced by variations in the pattern of browsing, which result in conditional probabilities of twigs being browsed. An example will illustrate this point. Suppose that there are two plants of a species, each of which supplies four available twigs. If one twig was browsed on each plant, the BII would be 100, whereas if two twigs were browsed on one plant and none browsed on the other, the BII would be 150. Since the intensity of browsing on the species is the same in both cases, it seems evident that variations in the pattern or distribution of browsing would introduce a presently unmeasurable error in the analysis of BII values. It is possible that one a twig of a given plant is browsed, the probabilities of other twigs being browsed on the same plant are changed. It could be postulated, for example, that, when an animal browses a twig of a highly preferred plant, the probabilities of the other twigs being browsed by that animal are increased. Conversely, it also seems possible that if an animal browses a twig of a non-preferred plant, the probabilities of other twigs of that plant being eaten are reduced. If the probabilities of twigs being browsed were conditional in this manner, the browsing on non-preferred species might tend to be more uniform than that on preferred species. If this were true, the gap between the BII values of preferred and non-preferred species might be wider than it should be.

The mean BII for each species on a study area was calculated by using the BIIs of those study plots in which the species occurred at densitites greater than 0.4 plants with available twigs (i.e., plants in browse classes 1 through 7-3) per sample frame. Since the BII contains sources of error that were not realized at the time the study was made, only the relative ranking of the species as derived from comparisons of their BIIs, and not the absolute BII values, will be employed in the discussion. The ranking of the species, according to the decreasing sizes of their BII values, is shown for each study area in Table 3.

The table suggests that on most study areas S. alaxensis, S. arbusculoides, S. pulchra, and S. interior are generally browsed more intensively than are other willow species associated with them. Con-

Table 3. Ranking of species for each study area in the order of decreasing BII values

Wood R.	Paxson L.	Gunn Ck.	L. Clearwater Ck.	Taylor Hwy. (other)	Taylor Hwy. (Mt. Fairplay)	Dry Ck.
ARB	ALA	ALA	ALA	ARB	PUL	INT
ALA	LAN	LAN	PUL	PUL	GLA	PUL
PUL	PUL	PUL	BAR	DEP		LAS
LAN	GLA	BAR	HAS	GLA		ARB
GLA	BAR					
BAR						
HAS						

versely, S. glauca, S. Barclayi, and S. hastata seem to be almost without exception the most lightly browsed species. On the study plots, it was common to see well-utilized S. alaxensis or S. arbusculoides plants surrounded by untouched S. Barclayi or S. hastata plants, or to see a stand of substantially browsed S. pulchra adjacent to a stand of unbrowsed S. glauca.

These differences in browsing intensity were also observed in areas where study plots were not established. Much of the Gunn Creek flat north of Gunn Creek, for example, is covered with a nearly pure stand of unbrowsed S. Barclayi. Adjacent to this area and just beyond the base of the Gulkana Glacier, however, is a stand of willows comprised almost entirely of S. alaxensis, which has been utilized so intensively that it is virtually impossible to find a single plant that has not been severely browsed. The Gulkana River near Paxson, Alaska, is bordered by intensively utilized S. alaxensis plants, a number of which are dead probably as a result of overbrowsing, and S. hastata plants, most of which have not been touched by moose. The bottoms of the gullies on the slopes of Mt. Fairplay support well-utilized stands of S. pulchra, whereas the sides of these gullies are covered with stands of S. glauca that have not been browsed.

On nearly all of the study areas, the same species of willows are apparently browsed to a greater degree than are the other species with which they occur, and it is my contention that this indicates a species selection preference shown by moose. Therefore, the following species list, which is ordered according to decreasing magnitudes of the overall mean BII values, could be interpreted as approximating the order of decreasing preference for those willow species occurring on some of the important moose ranges in Alaska's interior: S. interior, S. alaxensis, S. arbusculoides, S. lasiandra, S. pulchra, S. depressa, S. lanata, S. Barclayi, S. glauca, and S. hastata. It should be noted that in the one study area where S. lasiandra occurs with S. pulchra, it does not appear to be browsed as intensively as is S. pulchra. For this reason, S. lasiandra probably should not be regarded as being preferred over S. pulchra.

Species Importance

The importance of a willow species to moose depends not only upon its degree of preferability, but also upon the amount of usable plant material that it supplies; e.g., some species, although high on the preference list, are not abundant or not frequently encountered and are not, therefore, of great importance to moose as a source of food. Although the data will not permit accurate quantification of the relative importance of the various species, some generalizations concerning this topic are possible.

Willow species of the greatest importance to moose should be those that are highly palatable and that supply a large amount of available plant material over a wide geographical area. It is notable that S. alaxensis and S. pulchra appear to be two of the most preferred and most widely distributed willow species in the interior of Alaska; S. pulchra is well represented on all seven study areas, S. alaxensis is relatively abundant on all but the Taylor Highway study areas, and both species are common on many areas not studied. During the study, these two species were encountered more frequently than any others. S.

interior and S. arbusculoides, the other highly preferred species, occur on only one and three study areas, respectively, although S. arbusculoides often is abundant where it does occur. S. lanata, although not a highly preferred species, is abundant and moderately browsed in some areas, such as the mountain slopes that border upper Wood River.

It is my opinion that S. alaxensis and S. pulchra, by virtue of their high preferability, wide distribution, and relatively high abundance, are the two willow species of the greatest importance to moose in the general study area. S. arbusculoides and S. lanata, although not as widely distributed, appear also to be important sources of food for moose in some areas.

Relative Species Abundance and Browsing Intensity

It is possible that the relative rarity or abundance of a species can affect its degree of utilization to a greater extent than does its inherent palatability. For example, a fairly unpalatable species that is rare in a given area might be browsed more intensively than the abundant species because of its demand to satisfy food variety or nutritional requirements. Since it would be very difficult to accurately determine the effects of relative abundance on browsing intensity from my data, a discussion of this topic must be primarily based on personal observations.

Certain species of willows, such as S. Barclayi and S. glauca, are poorly utilized, regardless of their relative abundance, on all of the study areas in which they occur. For example, S. Barclayi is browsed very lightly at Paxson Lake and along Little Clearwater Creek, where it is abundant, and at upper Wood River, where it is poorly represented. S. glauca is poorly utilized on the study areas where it is abundant, such as the upper Wood River and Taylor Highway areas, and also on those where it is scarce, like the Paxson Lake region.

Other willow species, such as S. alaxensis and S. pulchra, are well utilized on nearly all of the study areas. S. alaxensis is browsed intensively at Paxson Lake, where it is not well represented, and at Little Clearwater Creek and upper Wood River, where the species is quite abundant. S. pulchra is also heavily browsed whether it is very abundant, as it is at Dry Creek, or whether it is relatively uncommon, such as at upper Wood River.

An analysis of the data also suggests that species utilization is not inversely correlated with species density. Table 4 shows a comparison of the BIIs of the least dense and most dense species that occur on six of the study areas; the Mt. Fairplay area was not analyzed, since only two willow species occur in this region. The table indicates that on four of the six study areas the BII of the least dense species is smaller, instead of larger, than that of the most dense species.

The lack of correlation between the degree of utilization and the relative abundance of the species can also be observed in individual

Table 4. Comparison of the BIIs of least dense species with those of most dense species

Study area	BII of least dense species	BII of most dense species
Dry Creek	244	181
Little Clearwater	105	161
Paxson	127	141
Gunn Creek	120	116
Taylor Highway (other)	107	145
Wood River	114	120

willow stands. The preferred willow species seem to be browsed intensively whether they are the dominant species in a stand or whether they are represented by only a few scattered individuals. On the other hand, the non-preferred species are browsed lightly in all stands, regardless of their relative abundance.

There is at least one possible source of error in this analysis. It is quite possible that neither the abundance nor the density of a species is a good measure of the amount of browse that it supplies. For example, a tall, bushy species, although it may not be abundant, might provide more edible plant material than a relatively abundant, low-growing species that maintains only a few branches. If this were true, the short species would actually be the "rarer" in terms of the amount of available browse that is supplied.

The only conclusion that can be drawn from my observations and data, therefore, is that neither the relative abundance nor density of a species observably affect its degree of utilization. The probable explanation for this is that the inherent palatability of a species overrides the effects of relative abundance or density on browsing intensity. This appears to be an example of the important role that species identity plays in determining the amount of browsing that occurs.

Effects of the Presence of Highly Preferred Species

It was sometimes evident during the course of the study that the presence of a highly preferred species affected the degree of utilization sustained by other species. In the Dry Creek area, for example, S. interior, which grew most abundantly along the banks of the creek, sometimes occurred in small, isolated patches on the floodplain. These small patches were always heavily browsed, but it was also apparent that other species of willows occurring in proximity to these patches were utilized to a greater degree than was normal for them. This same phenomenon was also observed in other study areas. Quite often a S. glauca or a S. lanata plant that was growing very near a S. alaxensis or S. arbusculoides plant was browsed more intensively than was usual for a plant of these species. It seemed, however, that species occurring very low on the preference list were not utilized to a greater extent under these circumstances.

One possible explanation for this phenomenon becomes evident when a browsing moose is observed closely. A cow moose I observed browsing in the Wood River area, after browsing on a S. alaxensis plant for a period of time, would leave it and wander along until encountering another plant of this species before stopping to feed again. She rarely browsed on the other species present, S. lanata and S. glauca while traveling between S. alexensis plants. Occasionally, however, before leaving a S. alaxensis plant from which only a small proportion of the available browse was removed, she would briefly browse those plants of the other species that occurred within easy reach. It appeared as if she browsed on the non-preferred species only because she was standing still at the time, and they happened to be readily available. This type of feeding behavior suggests a possible explanation for the abnormal amount of browsing on the lower preference species that occur in the vicinity of a highly preferred plant.

The greater utilization of moderately preferred species when occurring near highly preferred species also occurs on a larger scale. It has been noted in the literature that Artemesia tridentata (Stoddart and Smith, 1955) and Agropyron smithii (Tomanek et al., 1958) are eaten more heavily by livestock when occurring in small quantities throughout a "better" forage than when growing in pure stands. Likewise, the nearly pure stands of S. glauca occurring on the lower slopes of Mt. Fairplay are not browsed, although moose frequent the area, as is evidenced by the substantial use of S. pulchra patches present in the draws. When S. glauca grows with S. pulchra and S. arbusculoides, however, as occurs on a dry roadside site along the Taylor Highway (mile 53.2), it is browsed to some extent. In the same manner, willow stands of S. glauca and S. lanata that occur on the slopes bordering upper Wood River are browsed very lightly. On the old floodplain, where these same species grow with S. alaxensis and S. arbusculoides, however, they, particularly S. glauca, are used more frequently.

These observations might be explainable by the apparent manner in which moose, and possibly livestock, feed. If animals generally stop to feed only when encountering a well-liked species, it would not be surprising to find poorly utilized stands of moderately preferred species. Where these same species grow with more preferred species, however, they might be occasionally eaten by animals that are using the area to procure the preferred species. If this explanation were correct, the presence of preferred species would enhance the possible forage value of an area in two ways: (1) the preferred species would themselves be valuable sources of food, and (2) their presence would entice animals into the area with the result that some moderately preferred species would also be utilized.

There is another possible explanation of the observations that moderately preferred species are utilized to a lesser degree where they occur in pure stands than where they occur in mixed stands with highly preferred species. The browsing sustained by individual species varies with the soil types on which they occur; this being probably due to differences in soil fertility and the resulting variation in the nutritive contents of the plants (Hurd and Pond, 1958). It is possible that preferred species grow only on fertile sites, and that their high palatability is due to their relatively high nutrient contents. Those moderately preferred species that also occur on these fertile sites might also be fairly palatable and, therefore, be utilized to some degree. Moderately preferred or non-preferred species might grow most successfully on the more infertile sites, where there is an absence of competition from preferred species. The moderately preferred species might be less nutritious when growing on these infertile sites and, consequently, be browsed to a lesser degree than when occurring on

Table 5. Species BIIs for plots on which individual species have the lowest and the highest mean heights

Study area	Species	BII values: Plot on which species is shortest	BII values: Plot on which species is tallest
Dry Creek	ALA	139	151
	ARB	199	118
	INT	227	262
	LAS	143	220
	PUL	145	183
Little Clearwater	ALA	270	280
	BAR	107	159
	HAS	102	106
	PUL	140	166
Wood River	ALA	206	241
	ARB	276	210
	BAR	109	118
	GLA	108	129
	HAS	100	115
	LAN	100	148

fertile soils. If this explanation were correct, the greater use of moderately preferred species when occurring in stands with highly preferred species would be a result of higher nutrient contents and not a result of the presence of preferred species.

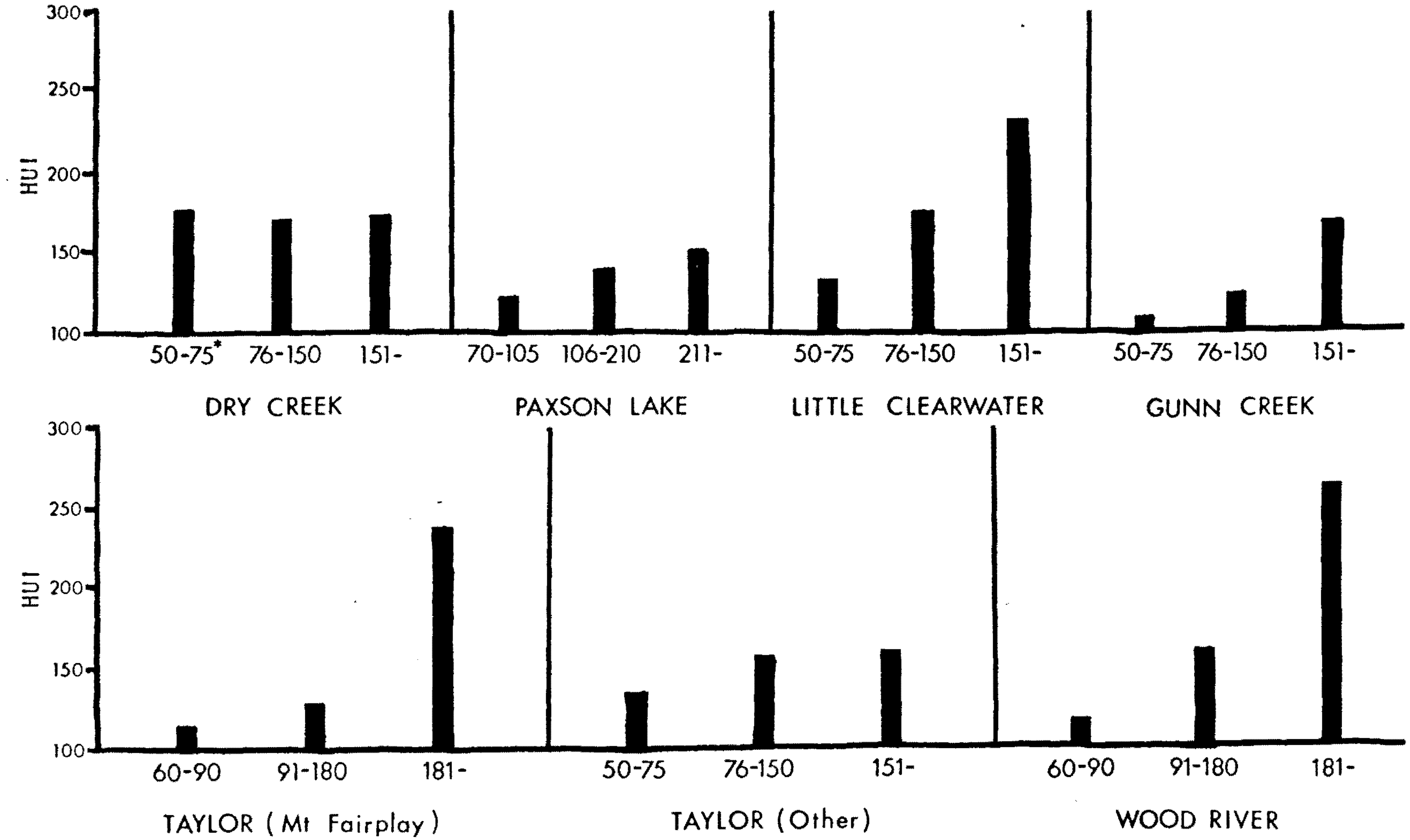
There is at least one other possible explanation of this phenomenon. It would seem that stands comprised of one or two moderately preferred species might be poorly utilized in relation to mixed stands, because moose may prefer to browse in stands where they can obtain a mixture of foods. It is interesting, however, that the nearly pure stands of S. pulchra at Dry Creek, the pure stands of S. pulchra on the lower slopes of Mt. Fairplay, the stand of willows located just beyond the base of the Gulkana Glacier, which is comprised almost entirely of S. alaxensis, and the stands of S. alaxensis occurring along the banks of Wood River are heavily browsed. Since moose do browse in pure stands of willows, the lack of food variety is probably not the reason why stands comprised of one or two moderately preferred species are lightly browsed.

Plant Height and Browsing Intensity

One method of determining whether there is a relationship between plant height and browsing intensity is to analyze each species separately. Each species received a BII value for every study plot in which it occurred on a study area. Consequently, a comparison could be made of the BIIs for those plots in which each species had the highest and the lowest mean heights; the results of such an analysis are shown for three study areas in Table 5. The table shows that in nearly all instances a species received a higher BII value where it was tallest than where it was shortest. This would seem to indicate that tall plants are browsed to a greater degree than are short plants.

Another method of investigating the effects of plant height on utilization is to compare the Height Utilization Indices (HUIs) of the availability classes; 1-33%, 34-66%, and greater than 66% available. The HUI for the 1-33% available class was calculated by using the numbers of plants in each of the browse classes from 7-1 through 7-3 as follows: $HUI = Y(7\text{-}1) \times 100 + Y(7\text{-}2) \times 200 + Y(7\text{-}3) \times 300/[Y(7\text{-}1) + Y(7\text{-}2) + Y(7\text{-}3)]$, where $Y(i)$ = number of plants in the i^{th} browse class. The HUIs for the 34-66% and the greater than 66% available classes were calculated in the same manner, except that the numbers of plants in browse classes 4 through 6 and 1 through 3, respectively, were used in the calculations. A HUI for each availability class was obtained for every species and for the sum of all plants, regardless of species, on each study plot.

The HUI is calculated in such a manner that the greater the amount of browsing sustained by plants of a given availability class, the larger will be the HUI for that class. By comparing the HUIs of the three classes, it should be possible to determine the size of availability range of plants most intensively utilized by moose. The mean HUI for each availability class is shown in Fig. 9 for all plants, regardless of species, on each of the study areas.



*Height in centimeters

Figure 9. Comparison of study area HUIs (Height Use Indices).

Table 6. Species BIIs for plots supporting the lowest and the highest total densities of plants over one m tall

Study area	Species	BII values	
		Plot with lowest density	Plot with highest density
Dry Creek	ALA	204	128
	ARB	199	118
	INT	227	262
	LAS	220	188
	PUL	201	179
Little Clearwater	ALA	252	280
	BAR	107	157
	HAS	110	100
	PUL	149	157
Wood River	ALA	206	249
	ARB	276	262
	BAR	110	119
	GLA	108	129
	HAS	100	102
	LAN	108	136

The graph indicates that plants in the greater than 66% available class are generally browsed most intensively, whereas plants in the 1-33% available class usually receive the least amount of browsing. This information may also indicate that moose prefer to browse tall plants, although this cannot be definitely concluded. It is quite possible that the intensive browsing on the tall, highly preferred species, such as S. alaxensis and S. arbusculoides, might strongly influence the HUI values for many study areas. Since the inverse occurs at Dry Creek--i.e., the low-growing species S. interior and S. pulchra are browsed more intensively than are the tall-growing ones--this might explain why the relationship between the HUI values for this study area is different from that of the other study areas.

Willow Stands as Physical Barriers

It would seem possible that, although a moose is a large animal, a stand of willows could be dense enough to impede the movements of moose. If this were the case, such stands would not be as effectively utilized as sparse stands. The data were examined to determine whether density was a factor in determining utilization by moose. For each species, the BII that was calculated for the study plot with the highest total density of plants over one m tall was compared with the BII that was obtained for the plot that supported the lowest total density of plants over one m tall; it was felt that plants shorter than one m in height would be totally ineffective in hindering the movements of moose. This analysis was made for three study areas (Table 6), and the results show that in nine instances the species BIIs for areas with the highest total density of plants over one m tall were greater than those for areas with the lowest density; in the remaining six cases, just the converse was true. In other words, the data indicate that in a majority of cases individual species were actually browsed more intensively where the total plant density was highest than where the density was lowest.

This information seems to suggest that the densest willow stands are not effective as physical barriers. It should be noted, however, that the highest densities of plants over one m tall at Dry Creek, Little Clearwater Creek, and Wood River are 16.9, 14.6, and 7.6 plants per sample frame, respectively. The majority of species at Dry Creek received smaller BIIs on plots with the highest total plant density than on plots with the lowest density of tall plants, and it might be argued that the densest stand was not utilized well because it effectively impeded the movements of moose. On the other hand, the highest density of tall plants at Little Clearwater Creek is nearly equal to that at Dry Creek, but at Little Clearwater Creek the species BIIs are larger where the total density is highest than where the total density is lowest. This seems to suggest that factors other than total plant density are causing browsing intensity variation in these areas.

Another method of investigating the effects of total plant density on browsing intensity is to analyze the amount of utilization on all plants, regardless of species. An index of the total browsing intensity, which I have called the Area Preference Index (API), was first computed

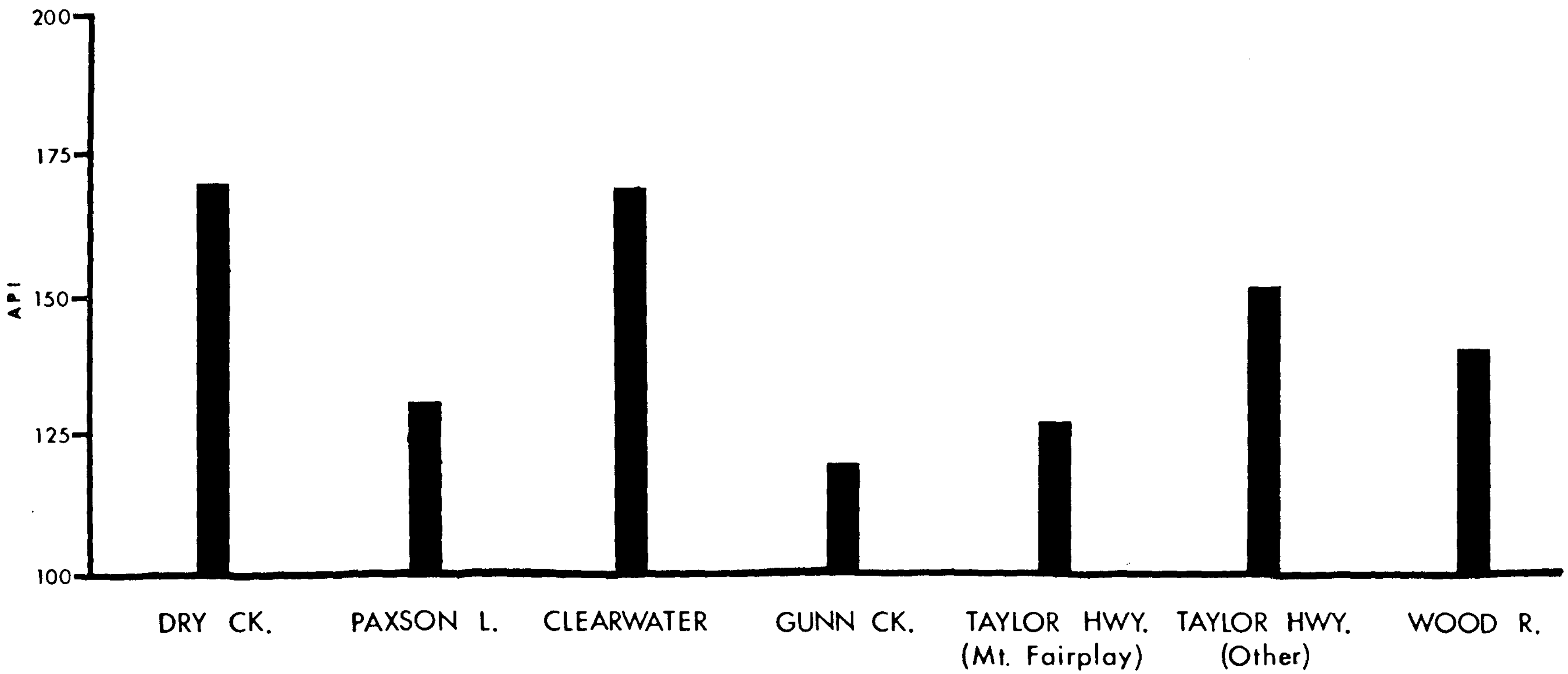


Figure 10. Study area APIs (Area Preference Indices).

for each study plot in the same manner as was the BII for each species, except that all plants occurring on the plot were used in the computation instead of just those plants of a particular species. The mean API for each study area is shown in Fig. 10. Calculations were then made to determine the degree of correlation between the study plot APIs and densities of plants over one m tall on the three study areas with the greatest number of plots. If dense stands are not utilized as effectively as sparse stands, there would be a negative correlation between total density and utilization. The correlation coefficients obtained - +0.26, +0.63, and -0.93 - seem to indicate that such a relationship does not exist.

Perhaps of greater significance is the fact that on five of the seven study areas the study plots supporting the highest density of plants over one m tall had larger APIs than the plots having the lowest density of plants exceeding one m in height. In other words, instead of there being a decrease of browsing pressure in the dense stands, as would occur if the dense stands were effective as barriers, they were actually browsed more intensively on a majority of the study areas. The total browsing intensity was probably high in the dense stands because the density of the tall, highly preferred species, such as *S. alaxensis* and *S. arbusculoides*, was high.

In general, the data suggest that the densest willow stands on the study areas are not effective as physical barriers. This does not necessarily mean, however, that moose are physically unhindered by plants in the dense stands. It is possible that these stands are particularly attractive because of the high density of preferred species in them, and that moose browse in dense stands despite being physically hindered. This possibility opposes the conclusion made by McMillan (1953) from observations in Yellowstone National Park. He found that the amount of browsing occurring in the center of willow clumps was equal to that occurring on their edges and concluded that moose were not impeded physically by the plants. It is possible, however, that plants growing in the center of willow clumps are somewhat more nutritious than those growing on the edges where the conditions for growth may be marginal, and that the central plants would be browsed to a greater degree than the peripheral ones if moose movements were not impeded. In view of these comments, it is only safe to conclude that if the densest willow stands on the study areas acted as physical barriers, the hindrance to moose movements was apparently not effective in reducing the amount of browsing below that which was sustained by sparse stands.

P A R T I I

STUDY AREA

The Tanana River study area is located on an island in the Tanana River about one mile south of Fairbanks (Fig. 11). The study area is 17,600 square m (4.4 acres) in size, representing approximately three-fourths of the total area of the island. The soil of the island, which is composed of silt-sized material, seems to have been formed in well defined stages. This interpretation is based on differences in the vegetational composition on the island.

S. alaxensis, some plants of which reach heights exceeding four m, and alder (*Alnus* sp.) dominate on the oldest and highest portion of the island. The other species found here, *S. niphoclada*, *S. interior*, *S. myrtillifolia*, and *S. lasiandra*, are represented mainly by small plants. On a somewhat younger portion of the island, alder and *S. niphoclada* predominate, although *S. interior* and *S. myrtillifolia* are also fairly abundant; many of the willows here are over 1.5 m tall. *S. interior* is the most abundant species on an even younger part of the island, although the other species are also present. Only a few of the plants in this area are over one m tall. The most recently deposited portion of the island supports the five species of willow already mentioned, but *S. lasiandra* is more abundant here than in the other areas. Since most of the plants here are under 0.5 m in height and, probably as a result of being buried under snow, are not utilized, this area was not sampled.

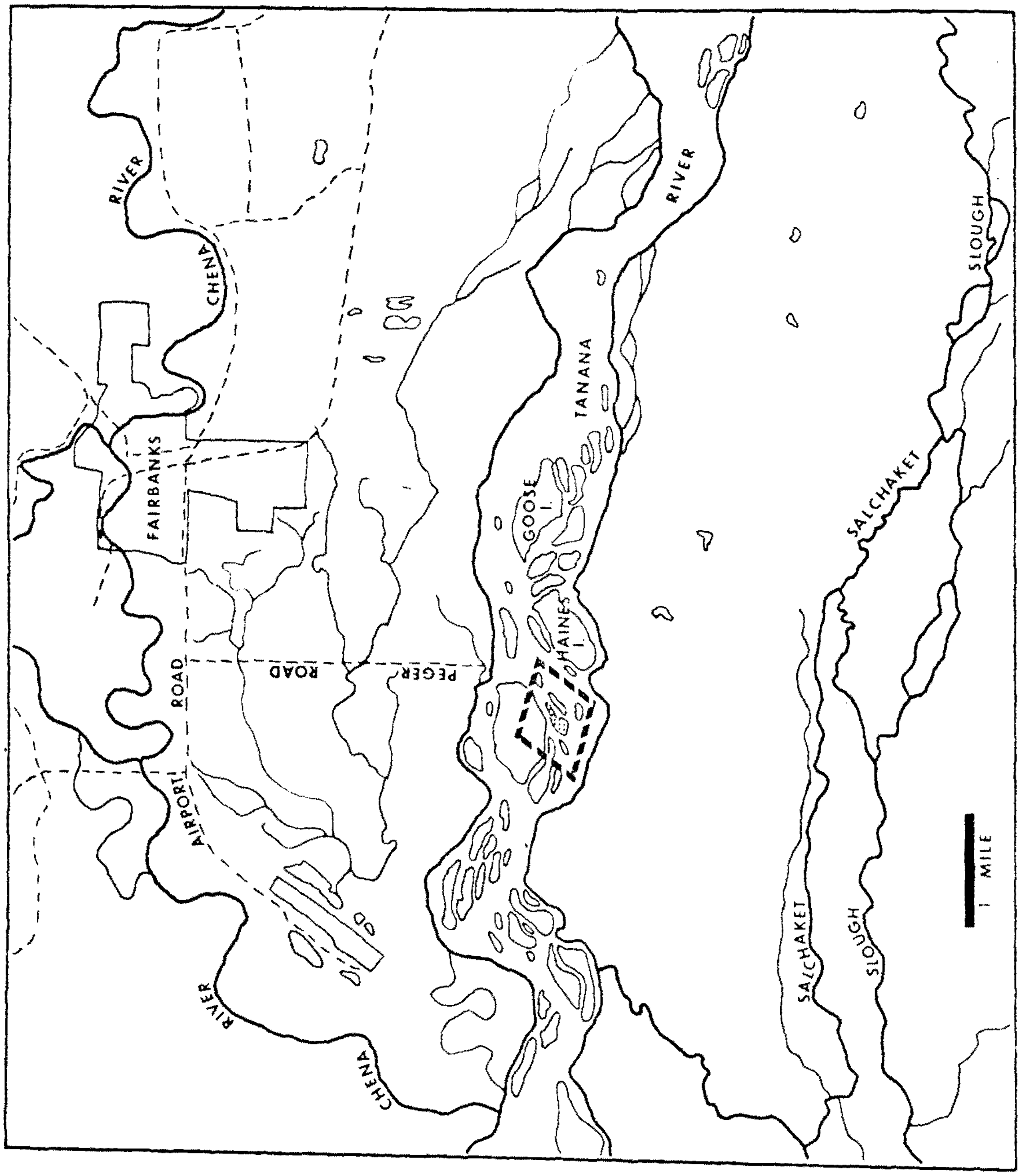


Figure 11. Tanana River study area; 64°47' N, 147°49' W (From U. S. Geological Survey maps C-2 and D-2, Fairbanks quadrangle).

METHODS

Selection of Study Area

The study island, which lies in the Tanana River south of Fairbanks, was selected because its vegetation is dominated by willows. Most of the islands in this area are covered with dense stands of black cottonwood and alder, and the willow group is poorly represented. Since the study island is atypical, the findings of this study do not necessarily describe the conditions that occur on the other islands in this area.

Locating Sample Frames

A baseline was established through the center of the island with the aid of a staff compass and was marked every 20 m. The line was terminated at the 240 m mark because the willows growing on the end of the island beyond this point were too short to be available for browsing. Four numbers from zero to 20 were chosen from a table of random digits for each 20 m interval, and the equivalent distances in meters were marked by stakes on the baseline from the starting point of each interval. From each of these stakes, lines perpendicular to the baseline were extended to the edge of the island, two lines being established to the left of the baseline and two lines to the right for every baseline segment. Since the lengths of these perpendicular lines varied, each line was measured and its length recorded. For each perpendicular line, two numbers from zero to its length in meters were chosen from a list of random digits, and each line was marked off with stakes at the equivalent distances in meters from the baseline. Each of these stakes marked the location of that corner of the 1.5 by 1.5 m sample frame which lay nearest the starting point of the baseline when one side of the frame was parallel to the baseline.

Information Recorded

The minimum height at which browsing had occurred was determined first. Every willow plant whose stem emerged from the ground within the 96 randomly located sample frames was then recorded as to species, height in centimeters, browse class, and the diameters in millimeters of the ends of those twigs which had been browsed. The browse class criteria were the same as those described previously, but class 7 was not subdivided into classes 7-1, 7-2, and 7-3, as was done on the other study areas. The browse class scheme used on the island is identical with that first described by Dasmann (1951). Metal calipers were used to measure the twig diameters.

Clipping

The mean diameter to which twigs had been browsed was then calculated for each willow species. Twigs of each willow plant that occurred within the sample frames were clipped at the appropriate mean diameter for that species if they extended above the minimum browsing height; no clipping was done below this height. The clipped twigs from each species and sample frame were bundled separately and were oven-dried for 48 hours. The bundles were then weighed separately to the neareast gram, and these weights were later used to determine the oven-dried weights of available winter browse supplied by each species; all clipping was accomplished after the growing season had ended. In addition, individual dried twigs from each species were selected randomly and weighed to the nearest gram, and the mean individual twig weight of each species was determined. This mean weight is the calculated weight of plant material that has been removed from a browsed twig of a given species.

Utilization Plots

Six utilization plots, each measuring six by six m, were also located randomly on the island during the same summer. The browsed twigs of all willows within these plots were clipped smoothly with shears just below their tips. This made it possible, after returning to the island in June of the next year, to differentiate between twigs that had been browsed during the preceding winter and twigs that had been browsed previous to that time. The number of twigs that had been browsed within the utilization plots during the winter was determined for each species. Since the average weight of the material that is removed from a browsed twig had also been obtained for each species, it was possible to determine the weight of the plant material consumed and the percentage of available browse removed by moose from each species during one winter.

DISCUSSION OF RESULTS

The mean heights, mean densities, and percentages of the various browse classes are shown by Appendix II for all willow species occurring on the island; the remainder of the data will be discussed under the appropriate subheadings. Code letters are substituted for species names on all tables and graphs. The following code system is used: S. alaxensis = ALA; S. interior = INT; S. lasiandra = LAS; S. myrtillifolia = MYR; S. niphoclada = NIP. Since the method of sampling that was employed resulted in unequal sampling probabilities, the data from each sample frame were "weighted" in relation to the probability of selecting that frame location. All results are based on the corrected data.

Species Preference

It is my assumption that the degree of browsing sustained by a given species is indicative of its selection preferability. To be able to quantitatively describe the degree of utilization received by a species, a Browsing Intensity Index (BII) was calculated for each willow species occurring on the island. The BII was calculated by using the percentages of plants in each of the browse classes from 1 through 6, as follows: $BII = 1[X(1) + X(4)] + 2[X(2) + X(5)] + 3[X(3) + X(6)]$, where $X(i)$ = percentage of plants in the i^{th} browse class. This method of BII determination differs slightly from that described previously, because browse class 7 was not subdivided for this portion of the study and could not be incorporated into the calculation. Therefore, the BIIs, as calculated from this method, would tend to have higher values, since, as discussed previously, plants in the lowest height class (i.e., browse class 7) are apparently browsed least intensively. The results from both methods range in value from 100 to 300. It should also be restated here that the BII's accuracy is probably affected by plant form and pattern of browsing. Therefore, the relationship between values, not the values themselves, will be considered when estimating the relative degrees of browsing that were sustained by the various species.

The ranking of the species, according to the decreasing sizes of their BII values, is as follows: S. alaxensis, S. interior, S. myrtillifolia, and S. niphoclada. This suggests that S. alaxensis and S. interior have been browsed to a greater degree than have the other willow species and, therefore, are considered to be the preferred species. These results compare favorably with those obtained on the other study areas. Likewise, S. niphoclada, which was not found on the other study areas, would be rated low on a preference list by virtue of the low degree of utilization that it sustained.

The differences between the amounts of browsing received by the various species cannot be overemphasized too strongly. It was difficult to find a S. alaxensis or S. interior plant that had not been browsed intensively; a number of S. interior plants had died and an even greater number were partially dead, probably as a result of over-browsing. In

Table 7. Results of a chemical analysis of samples collected from the primary willow species that occur on the Tanana River study area

Species	Moisture (%)	Protein (%)	Fat (%)	Crude Fiber (%)	Ash (%)	N_2 free extract	Kg cal./ 100 g
ALA	19.6	6.6	2.8	33.4	2.1	55.1	505
	19.6	7.4	2.6	33.7	2.4	53.9	499
	(19.6)*	(7.0)	(2.7)	(33.6)	(2.3)	(54.5)	(502)
INT	14.3	5.8	1.5	27.7	2.0	63.0	478
	14.9	5.2	1.2	30.4	2.2	61.0	499
	(14.6)	(5.5)	(1.4)	(29.1)	(2.1)	(62.0)	(489)
MYR	18.2	6.6	4.2	24.6	3.3	61.3	485
	13.0	6.1	2.8	30.7	2.4	58.0	492
	(15.6)	(6.4)	(3.5)	(27.7)	(2.9)	(59.7)	(489)
NIP	10.0	6.6	2.2	30.9	2.4	57.9	492
	11.8	5.5	2.2	33.4	3.5	55.4	478
	(10.9)	(6.1)	(2.2)	(32.2)	(3.0)	(56.7)	(485)

* Mean of two samples

contrast, it was equally difficult to find a S. niphoclada plant that had been utilized to any degree. Such observations make it quite evident that moose show a definite selection preference for certain species of willows.

Factors Affecting Species Preferability

A number of factors apparently influence the relative preferability of food plants. Heady (1964) discusses the effects of palatability, associated species, climate, soil, topography, kind of animal, and animal physiology on preference.

Palatability is generally defined as those plant characteristics or conditions that stimulate a selective response by animals (Heady, 1964). The chemical composition of a plant is one such characteristic affecting its palatability. A high positive correlation has been observed between the protein content of forage and preference by cattle and sheep (Cook, 1959; Hardison et al., 1954; Hobbs et al., 1945). Swank (1956) found that species consistently having a high moisture content are preferred by deer and cattle. Foods high in sugar content are preferred by cattle (Plice, 1952) and deer (Mitchell and Hosley, 1936). Studies with livestock have shown a positive correlation between preferability and fat content or percentage of either extract (Hardison et al., 1954; Blaser et al., 1960). Grasses with the highest phosphate and potash contents are apparently the most acceptable to livestock (Leigh, 1961), and calcium uptake affects phosphorous requirements (Swank, 1956). A high negative relationship has been noted between the tannin contents and preference by cattle for the various varieties of lespedeza (Wilkins et al., 1953). Several researchers have concluded, however, that the total nutritive value of a plant is a better indicator of preference than is the content of any single chemical compound (Albrecht, 1945; Cook et al., 1956).

Two samples of the preceding year's twig growth were collected in March from each of the willow species occurring on the island, and these were submitted for chemical analysis. The results of the analysis (Table 7) indicate that S. alaxensis has the highest moisture, protein, and caloric contents, S. interior has the highest nitrogen free extract or carbohydrate content, and S. niphoclada has the lowest moisture and caloric contents. It would seem that a combination of high moisture, protein, and caloric contents could be responsible for S. alaxensis being a highly preferred species, whereas the converse might explain why S. niphoclada is a non-preferred species. This conclusion supports the theory that the total nutritive value of a plant is the best indicator of preference.

There are several reasons, however, why it might be hazardous to formulate any conclusions based on the chemical analysis results. It will be noticed, for example, that calcium, potassium, phosphorus, and tannin, all of which may affect preference, were not analyzed. Furthermore, the nutrient contents of the various species, particularly S. interior and S. myrtillifolia, are so similar that their association with preference would seem dubious. In addition, several variables were not taken into account when the samples were collected, and, as a result, the samples may not be comparable. Bailey (1967), for instance, noted that the highest concentration of crude protein is located in those samples that (1) are clipped nearest to the terminal buds, (2) are collected from the lower rather than the upper portions of the crowns, and (3) include flower buds or lateral buds rather than only terminal vegetative buds. I did not consider the sample locations in reference to the plant crowns nor the number of buds supported by the clipped twigs. Swank (1956) stated that the protein content of a species varies seasonally, which suggests that if the samples had been collected at some other time the analytic results might have been completely different. The maturity and health of plants also affect their nutritive composition (Cook and Harris, 1950; McIlvanie, 1942); plant maturity was not considered when collecting samples, and many _S. interior_ plants appeared to be in poor condition, presumably as a result of over-browsing. If the small sample size is added to this list, the magnitude of the difficulties becomes awesome.

Another palatability factor is the external form of a plant. Heady (1964) states that stickiness, position of the leaves, texture, and hairiness probably affect preferability. None of the willow species discussed in this paper have sticky stems or leaves, and I am not able to comment about leaf position or texture differences. Of the species preferred most highly on all study areas, _S. alaxensis_ has extremely hairy twigs and leaves, whereas _S. arbusculoides_, _S. pulchra_, and _S. interior_ have glabrous stems and little or no hair on their leaves. Among the non-preferred species, _S. glauca_ and _S. niphoclada_ have quite hairy stems and leaves, while _S. Barclayi_ and _S. hastata_ have glabrous leaves and near-glabrous stems. These observations would seem to rule out hairiness as a factor of palatability among willows. McMillan (1953) mentions that preferability may be associated with the heights of species. He notes that a tall-growing willow species in Yellowstone National Park is browsed more intensively than another species, which rarely exceeds three feet in height, and suggests that this may be a result of moose being able to simultaneously hide in and feed on the tall-growing species. McMillan also reasons that the low-growing species may be less easily browsed upon than the other species. My data from all study areas, however, indicate that _S. interior_ and _S. pulchra_, neither of which commonly exceed two feet in height, are two of the lowest-growing and most highly preferred species. This would seem to indicate that, although browsing intensity might be correlated with plant height, the inherent palatability of a species affects its preferability to a greater degree than does its average height.

It seems possible that an animal might selectively browse a certain species of plant, regardless of its nutritive value, simply because it tastes good; a high content of certain nutrients does not necessarily imply a high palatability. I have tasted all of the willow species occurring on the study areas and find that they differ in taste. Although all of them taste bitter, some species taste markedly less so than others. _S. interior_, which has a high carbohydrate content (Table 7), is the sweetest tasting species, but the other preferred species are quite bitter. I have not been able to distinguish a taste common to preferred or to non-preferred species and can only conclude that differences in taste do exist.

Table 8. Oven-dried weights of available browse, by species

Species	Wt. (g) per sample frame	Wt. (g) per 100 sq. m.
ALA	8.3 (56.7)*	368.5
INT	4.5 (6.8)	199.8
MYR	3.4 (9.4)	151.0
NIP	29.7 (58.0)	1318.7
Total =	45.9	2038.0 (4.5 lbs.)

* Standard deviation

Factors that are external to the plants also affect their preference. The browsing sustained by individual species varies with the vegetation and soil types in which they occur (Hurd and Pond, 1958), temperature and rainfall (Castle and Halley, 1953), topography, and the physiology of the browsing animals (Heady, 1964). Although the willows that were encountered during this study occurred under a variety of environmental conditions, certain species were nearly always preferred over others. This would seem to indicate that certain palatability factors, and not environmental conditions, are responsible for willow species preferability, and it is my belief that these factors are characteristic of individual species.

Amount of Available Browse

The actual amount of plant material available for browsing is seldom determined by field workers because of the difficulties involved in obtaining this quantity. The methods employed during this study, however, made it possible to determine the oven-dried weights of the available browse supplied by the various species of willows on the island. The average oven-dried weights of browse available per sample frame (i.e., 2.25 square m) and per 100 square m is shown in Table 8.

Although the leaves were removed from the clipped stems to simulate winter conditions and the weights listed are oven-dried weights, the results indicate that a seemingly small amount of plant mass is available for browsing on the study area: 2,038.0 g (4.5 pounds) per 100 square m. These results, however, compare favorably with those obtained by several other field workers. Taber (1956) states that shrubland in California supplies 324,160 pounds (oven-dry weight) and chaparral offers 115,960 pounds of deer browse per square mile; these weights are equivalent to 12.5 and 4.4 pounds, respectively, per 100 square m. Harlow (1955) lists the air-dried weights of available deer browse on a number of areas in Florida, the majority of which range between 100 and 200 pounds per acre or between 2.5 and 5.0 pounds per 100 square m. It should be noted that the average plant heights and densities on the island are quite similar to those occurring on the other study areas. This may mean that comparable amounts of browse are available on the other study areas.

Amount of Browse Removed During One Winter

To be able to calculate the amount of browse removed by moose during one winter, a count was conducted in the spring of the number of twigs of each species that had been browsed on the 36 square m utilization plots during the previous winter. Since the mean oven-dried weight of plant material removed from a browsed twig was also determined for each species, the weight of the browse removed during the winter was easily calculated. The mean weight of the plant mass removed from a browsed twig, the number of twigs browsed per utilization plot, the calculated weight of browse removed per 100 square m, and the calculated percentage of available browse removed are shown for each species in Table 9.

Table 9. Oven-dried weights of clipped twigs, number of twigs eaten per utilization plot, calculated weights of browse eaten per 100 sq. m, and calculated percentages of available browse removed during one winter

Species	Wt. (g)/ clipped twig	No. twigs eaten/ utiliz. plot	Cal. wt. (g) eaten/ 100 sq. m	Calc. % avail. browse removed
ALA	3.2 (0.76)*	13.9 (26.89)	124.6	33.8
INT	2.0 (0.44)	3.9 (6.53)	21.8	10.9
MYR	2.0 (0.40)	0.1 (0.40)	0.6	0.4
NIP	2.9 (0.54)	0.2 (0.81)	1.6	0.1

* Standard deviation

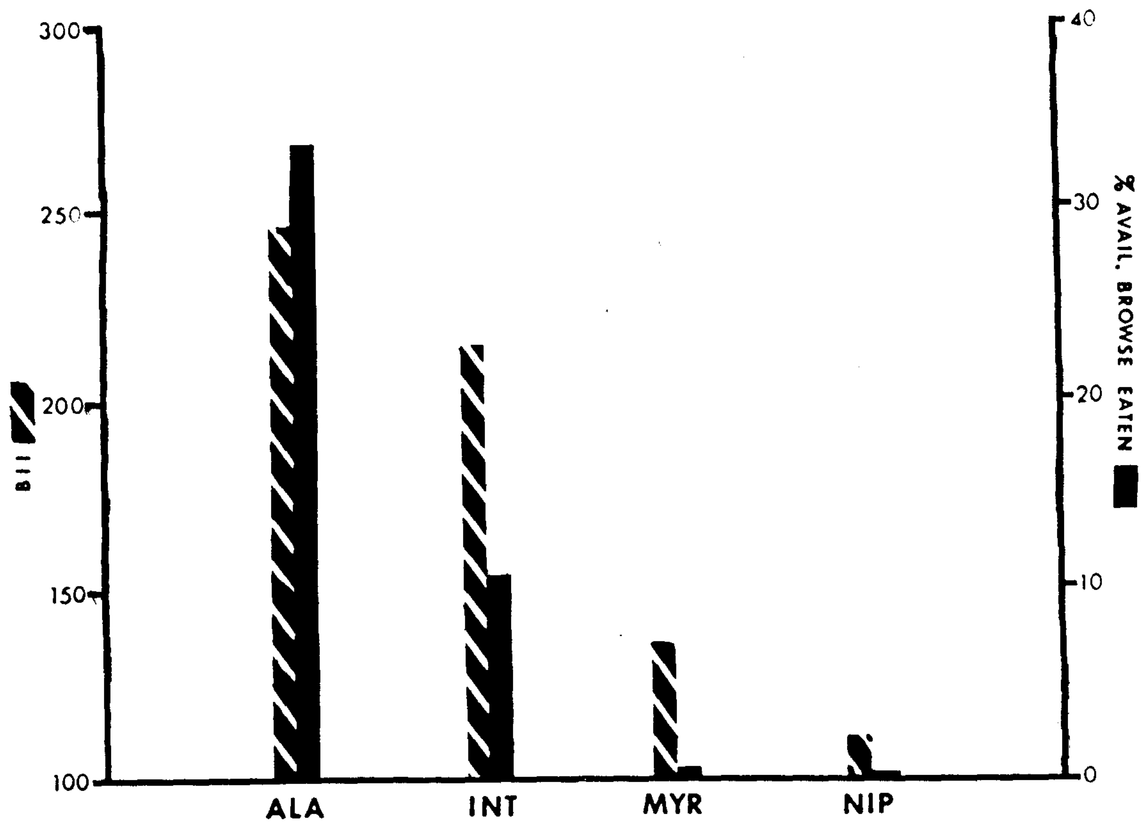


Figure 12. Comparison of BII (Browsing Intensity Index) values and percentages of available browse removed during one winter.

The results indicate that extreme differences exist in the percentages of available browse removed from the various species during the winter. Observe, with respect to the various species, that the same general relationship exists between the percentages of available browse removed from the species and their BIIs (Fig. 12). This association would seem to suggest that the relationship between species BIIs approximates the relationship between the degrees of browsing that the species sustained. With respect to the actual values for the species, however, the association between the BIIs and percentages of available browse that was removed is not very close; e.g., the BII for S. alaxensis is 14% larger than that for S. interior, while the percentage of available browse removed from S. alaxensis is 210% greater than that from S. interior. This is not surprising, since the BII is a measure of the percentage of twigs that have been browsed and not a measure of how much of the available browse has been removed from the twigs. It seems probable that a certain percentage of twigs browsed on one species represents the removal of a different percentage of available plant material than the same percentage of twigs browsed on another species. For example, a browsed twig on a species that maintains numerous, slender twigs will probably represent a smaller removal of available browse than a twig eaten on a species that supports a few, thick twigs. The different relationship between the BII values and the percentages of available browse removed might also be partially due to the fact that the BII represents an average value over a number of years, whereas the percentage of browse removed is based on the browsing that occurred during one winter. Errors in the BII values might also have contributed to this discrepancy.

SUMMARY AND CONCLUSIONS

Following is a summary of the principal results of this study:

1. Certain species of willows are preferred by moose over others. S. interior, S. alaxensis, S. arbusculoides, and S. pulchra are the most highly preferred species on the areas that were studied.

2. Among the various willow species occurring in Alaska's interior, S. alaxensis and S. pulchra, due to their high preferability and wide distribution, are probably of the greatest importance to moose.

3. Moderately palatable species are eaten to a greater extent when occurring in mixed stands with highly preferred species than when growing in "pure" stands. The amount of browsing on species that are located very low on the preference list is not affected in this manner.

4. In a given area, neither the relative abundance nor density of a species noticeably affect its degree of use, this being possibly due to the overriding influence of inherent palatability.

5. The densest of the willow stands that were studied either do not physically hinder moose, or, if they do impede movements, the hindrance does not appear to reduce the amount of browsing on these stands below that which is sustained by sparse stands.

6. Although the degree of browsing that is sustained by a given species seems to be correlated with plant height, species preferability is not related to height; preferability is probably influenced more by inherent palatability than by average plant height.

7. The amount of available browse on one study area is 4.5 pounds (oven-dried weight) per 100 square m.

Results of this study suggest several possible applications to the future moose management program in Alaska. When assessing moose range conditions or the relationship of moose density to the food supply, only the amount of browsing sustained by the highly and moderately preferred willow species should be considered, since even where these species are severely utilized, certain non-preferred species will scarcely be touched by moose. When environmental manipulation becomes possible, only the growth of preferred species should be encouraged. If possible, the establishment of strips of highly preferred species within a stand of moderately preferred species could be beneficial; the highly preferred species would themselves be valuable sources of food, and their presence might increase the utilization of those moderately preferred.

This study was, in effect, only a pilot study of some of the important moose ranges in Alaska's interior. Before range condition surveys can be accomplished efficiently, a more adequate method of willow species identification must be developed. A method by which species can be identified after they have lost their leaves would be highly beneficial. Further research on the ecology of the various willow species is needed before moose ranges can be artificially improved. To estimate the carrying capacities of moose ranges, the amounts of usable browse that they supply and the food requirements of moose must first be determined. I believe, from personal observations, that the various willow species are differentially resistant to browsing. It would be necessary to know the degree of browsing that the different species can tolerate before range condition or carrying capacity analyses can be made. My data suggest that there might be a complex interaction between plant height, density, volume, form, location, and palatability that affects utilization; information about this possible interaction could be useful. Finally, if only for academic reasons, it would be of interest to determine how and why a species selection preference occurs.

APPENDIX I. Heights, densities, and percentages of plants in each browse class for all willow species on the study plots.

Study area	Study plot	Species	Ht. (cm)	#Stems/ Sample frame	Percent in each browse class 1	2	3	4	5	6	7-1	7-2	7-3	8
Dry Creek	1	LAS	118.2	11.0	19.5	10.3	2.4	28.3	9.1	4.0	14.0	2.7	2.4	7.3
		INT	77.8	4.6	2.9	0.0	0.7	13.8	6.5	27.5	9.4	5.1	21.0	13.0
		MYR	65.2	1.5	0.0	0.0	0.0	19.6	2.2	0.0	19.6	10.9	23.9	23.9
		PAD	58.0	0.2	0.0	0.0	0.0	20.0	0.0	0.0	20.0	0.0	0.0	60.0
		ALA	130.9	13.9	18.0	8.4	6.0	38.7	6.0	2.4	11.1	1.9	1.7	5.8
		DEP	12.9	0.4	0.0	0.0	0.0	33.3	8.3	8.3	0.0	8.3	0.0	41.7
		PUL	51.5	3.2	0.0	0.0	0.0	3.2	1.1	0.0	34.7	14.7	5.3	41.1
		ARB	97.7	3.8	7.9	0.9	1.8	46.5	9.6	7.0	15.8	2.6	0.9	7.0
	2	LAS	120.0	0.8	21.7	0.0	8.7	21.7	0.0	8.7	26.1	0.0	0.0	13.0
		INT	87.9	0.4	0.0	0.0	0.0	25.0	0.0	50.0	0.0	0.0	25.0	0.0
		MYR	57.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
		PAD	130.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
		ALA	284.5	6.1	53.6	10.4	16.4	6.0	1.6	1.1	3.8	0.0	0.5	6.6
		DEP	115.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
		PUL	83.1	4.1	4.8	4.0	1.6	16.1	9.7	11.3	16.9	8.9	10.5	16.1
		ARB	105.6	1.2	16.7	5.6	0.0	38.9	5.6	0.0	19.4	0.9	2.8	11.1
	3	LAS	141.2	1.7	23.5	14.7	14.7	17.6	8.8	17.6	2.9	0.0	0.0	0.0
		INT	77.9	0.8	5.9	0.0	0.0	5.9	11.8	11.8	0.0	0.0	58.8	5.9
		MYR	82.9	0.3	0.0	0.0	0.0	57.1	0.0	0.0	14.3	0.0	0.0	28.6

APPENDIX I (Continued)

Study area	Study plot	Species	Ht.(cm)	#Stems/ sample frame	Percent in each browse class									
					1	2	3	4	5	6	7-1	7-2	7-3	8
Dry Creek	3	ALA	157.2	12.8	45.3	7.0	3.5	32.4	4.7	3.5	2.0	0.4	0.8	0.4
		PUL	75.8	6.3	0.0	0.0	0.0	26.4	8.8	15.2	20.8	11.2	12.0	5.6
		ARB	127.5	6.5	22.9	3.8	0.0	58.0	3.1	3.1	3.8	3.1	0.8	1.5
	4	LAS	61.9	0.3	0.0	0.0	0.0	15.4	0.0	0.0	61.5	0.0	0.0	23.1
		PAD	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
		ALA	46.2	2.0	0.0	0.0	0.0	5.0	0.0	0.0	35.0	0.0	0.0	60.0
		DEP	79.9	1.7	1.4	0.0	0.0	33.3	13.0	10.1	15.9	5.8	0.0	20.3
		PUL	66.4	17.7	0.3	0.1	0.6	7.2	4.9	14.4	26.7	12.6	17.9	15.4
		ARB	113.7	3.3	6.8	4.5	9.8	15.2	18.9	24.2	9.8	0.8	1.5	8.3
	5	LAS	180.3	0.5	20.0	20.0	40.0	0.0	6.7	6.7	6.7	0.0	0.0	0.0
		ALA	197.9	0.9	28.6	14.3	42.9	7.1	3.6	0.0	3.6	0.0	0.0	0.0
		PUL	59.9	28.2	0.0	0.0	0.0	7.1	4.5	5.7	22.4	16.9	24.5	18.9
		ARB	78.6	9.8	0.3	0.7	0.7	21.6	25.0	22.3	12.0	7.2	9.9	0.3
Paxson Lake	1	BAR	55.8	4.4	0.0	0.0	0.0	15.2	0.0	0.0	49.2	0.0	0.0	35.6
		LAN	64.5	20.8	0.2	0.2	0.0	23.8	5.0	1.1	46.9	1.6	0.3	21.0
		PUL	52.1	14.0	0.0	0.0	0.0	10.0	0.0	0.0	47.3	0.7	0.2	41.8
	2	GLA	98.3	1.1	0.0	0.0	0.0	33.3	3.0	0.0	30.3	3.0	3.0	27.3
		BAR	65.6	48.0	0.0	0.0	0.0	5.3	1.0	0.3	24.7	0.8	0.6	67.3
		LAN	79.2	3.8	0.0	0.0	0.0	5.3	0.9	5.3	29.8	2.6	2.6	53.5
		ALA	87.5	12.6	0.0	0.0	0.0	6.6	5.3	9.8	25.4	3.2	5.6	44.2

APPENDIX I (Continued)

Study area	Study plot	Species	Ht.(cm)	#Stems/ sample frame	Percent in each browse class									
					1	2	3	4	5	6	7-1	7-2	7-3	8
Paxson Lake	2	DEP	148.3	0.1	0.0	0.0	0.0	66.7	0.0	0.0	0.0	0.0	0.0	33.3
		PUL	70.9	38.3	0.1	0.0	0.0	4.3	1.9	1.6	26.2	3.2	2.8	60.0
	3	GLA	115.0	0.1	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0
		BAR	122.4	15.0	0.0	0.0	0.0	44.9	6.9	3.1	24.9	1.1	1.1	18.0
		LAN	136.6	2.0	0.0	0.0	0.0	15.3	16.9	32.2	28.8	15.1	1.7	0.0
		ALA	101.4	0.2	0.0	0.0	0.0	0.0	0.0	42.9	28.6	0.0	14.3	14.3
		PUL	113.3	26.1	0.0	0.1	0.0	17.9	12.1	12.9	26.6	3.6	5.4	21.4
	4	GLA	75.9	2.6	0.0	0.0	0.0	9.6	3.8	0.0	25.0	1.9	5.8	53.8
		BAR	53.9	4.9	0.0	0.0	0.0	0.0	0.0	0.0	13.1	0.0	0.0	86.9
		LAN	35.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
		DEP	99.7	3.7	0.0	0.0	0.0	29.7	2.7	0.0	31.1	1.4	0.0	35.1
		PUL	51.9	12.6	0.0	0.0	0.0	0.0	0.0	0.0	8.7	5.2	2.4	83.7
Little Clearwater Creek	1	HAS	67.3	5.1	0.0	0.0	0.0	42.2	2.9	1.0	20.6	2.0	0.0	31.4
		BAR	40.8	2.5	0.0	0.0	0.0	5.9	0.0	0.0	21.6	2.0	0.0	70.6
		LAN	70.0	0.1	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0
		ALA	108.6	9.8	0.0	1.5	18.5	7.7	8.2	44.1	8.7	1.0	1.5	8.7
		PUL	68.3	11.9	0.0	0.0	0.0	24.7	10.9	5.4	26.8	1.3	7.1	23.8
	2	HAS	92.8	8.4	1.2	0.0	0.0	65.7	6.5	3.0	15.4	1.2	0.6	6.5
		BAR	86.5	1.8	0.0	5.4	0.0	37.8	8.1	18.9	16.2	0.0	0.0	13.5

APPENDIX I (Continued)

Study Area	Study plot	Species	Ht.(cm)	#Stems/ sample frame	Percent in each browse class 1	2	3	4	5	6	7-1	7-2	7-3	8
Little Clearwater Creek	2	LAN	105.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
		ALA	106.3	12.8	0.0	1.2	11.7	21.8	16.7	32.3	5.8	1.6	1.9	7.0
		PUL	95.6	6.5	2.3	1.5	0.8	40.5	19.1	14.5	9.9	1.5	5.3	4.6
	3	HAS	66.8	1.5	0.0	0.0	0.0	35.5	0.0	0.0	41.9	0.0	0.0	22.6
		BAR	112.1	9.2	3.3	1.1	1.1	47.3	25.0	13.6	7.1	0.5	0.0	1.1
		LAN	100.0	0.1	0.0	0.0	0.0	33.3	66.7	0.0	0.0	0.0	0.0	0.0
		ALA	137.6	2.9	0.0	1.7	37.3	3.4	11.9	45.8	0.0	0.0	0.0	0.0
		PUL	95.2	16.5	0.3	0.3	0.3	47.4	21.1	15.1	9.7	0.6	0.6	4.5
	4	HAS	92.4	0.8	0.0	0.0	0.0	70.6	5.9	0.0	23.5	0.0	0.0	0.0
		BAR	119.9	8.6	7.0	3.5	0.0	47.7	20.9	16.9	2.3	0.0	0.0	1.7
		PUL	90.0	21.0	0.0	0.5	0.2	35.0	20.7	21.9	8.6	2.9	5.2	5.0
	5	HAS	58.0	6.1	0.0	0.0	0.0	19.2	0.0	0.0	38.4	1.4	0.0	41.1
		BAR	35.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
		ALA	95.0	29.4	0.0	1.1	0.6	19.3	21.2	34.3	11.0	4.8	2.3	5.4
		PUL	63.0	1.8	0.0	0.0	0.0	22.7	4.5	9.1	27.3	4.5	0.0	31.8
	6	HAS	71.4	2.1	0.0	0.0	0.0	50.0	0.0	0.0	19.0	0.0	0.0	31.0
		BAR	96.1	9.3	1.1	0.0	0.0	67.0	9.7	5.4	10.3	1.1	0.5	4.9
		PUL	93.8	20.3	1.2	0.7	0.7	31.3	19.2	29.3	9.6	0.7	1.2	5.9

APPENDIX I (Continued)

Study Area	Study plot	Species	Ht.(cm)	#Stem/ sample frame	Percent in each browse class									
					1	2	3	4	5	6	7-1	7-2	7-3	8
Little Clearwater Creek	7	HAS	72.9	0.6	0.0	0.0	0.0	52.9	0.0	0.0	17.6	0.0	0.0	29.4
		BAR	90.2	7.4	0.0	0.0	0.0	53.6	19.1	7.7	14.5	1.8	0.0	3.2
		ZZZ	37.5	10.1	0.0	0.0	0.0	2.3	0.0	0.0	9.9	0.0	0.0	87.8
		PUL	81.8	18.6	0.0	0.2	1.6	31.0	17.6	11.1	20.1	3.0	0.4	15.1
	8	HAS	66.9	9.9	0.0	0.0	0.0	40.3	2.3	0.0	28.2	0.3	0.0	28.9
		BAR	95.4	12.8	1.0	0.5	1.0	50.5	15.1	10.4	8.1	1.6	0.0	11.7
		LAN	56.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
		ALA	105.6	3.9	0.8	0.0	5.9	5.1	9.3	72.0	3.4	0.8	0.0	2.5
		PUL	73.5	15.4	0.2	0.4	0.0	30.5	12.1	4.3	22.9	5.6	6.7	17.1
Gunn Creek	1	HAS	55.8	0.4	0.0	0.0	0.0	16.7	0.0	0.0	41.7	0.0	0.0	41.7
		BAR	69.3	18.1	2.2	0.4	0.0	31.9	2.4	0.4	27.3	0.2	0.0	35.4
		LAN	90.6	3.3	1.0	1.0	0.0	57.6	7.1	1.0	22.2	0.0	0.0	10.1
		ALA	97.7	5.9	1.1	3.4	11.4	18.2	10.8	14.8	21.6	1.7	0.0	17.0
		PUL	80.3	43.2	3.0	0.7	0.2	44.8	3.2	0.9	22.8	0.2	0.1	24.1
	2	BAR	74.3	3.3	2.0	0.0	0.0	39.0	6.0	0.0	23.0	5.0	0.0	25.0
		LAN	124.5	1.0	16.7	0.0	3.3	60.0	16.7	3.3	0.0	0.0	0.0	0.0
		ALA	149.1	0.7	4.5	0.0	40.9	13.6	4.5	36.4	0.0	0.0	0.0	0.0
		PUL	88.7	60.7	3.1	1.9	1.2	44.2	8.1	3.7	23.6	0.8	0.3	13.2

APPENDIX I (Continued)

Study area	Study plot	Species	Ht.(cm)	#Stems/ sample frame	Percent in each browse class									
					1	2	3	4	5	6	7-1	7-2	7-3	8
Taylor Highway (Mt. Fairplay)	1	PUL	104.1	16.6	0.0	0.0	1.5	21.0	14.5	13.6	24.1	9.6	3.9	11.7
	2	GLA	67.9	8.3	0.0	0.0	0.0	21.4	0.0	0.0	34.7	0.0	0.0	44.0
		PUL	53.8	1.9	0.0	0.0	0.0	3.6	0.0	0.0	30.4	1.8	0.0	64.3
	3	GLA	79.9	2.6	0.0	0.0	0.0	32.5	1.3	0.0	41.6	0.0	0.0	24.7
		PUL	64.3	0.8	0.0	0.0	0.0	13.0	0.0	0.0	34.8	8.7	0.0	43.5
	4	PUL	92.7	18.7	0.0	0.3	0.0	18.7	11.0	4.3	42.2	6.7	0.3	16.6
Taylor Highway (Other)	1	GLA	60.2	3.1	0.0	0.0	0.0	27.0	0.0	0.0	39.2	0.0	0.0	33.8
		ALA	61.9	0.3	0.0	0.0	0.0	25.0	0.0	0.0	50.0	0.0	0.0	25.0
		DEP	81.5	18.0	3.9	2.1	0.0	38.4	9.0	1.4	18.8	2.5	1.2	22.7
		SCO	69.7	0.8	0.0	5.6	0.0	11.1	11.1	0.0	22.2	5.6	11.1	33.0
		PUL	45.8	1.4	0.0	0.0	0.0	6.1	3.0	0.0	24.2	3.0	0.0	63.6
		ARB	82.2	2.9	0.0	1.4	2.9	26.1	5.8	14.5	27.5	7.2	5.8	8.7
	2	GLA	80.0	7.8	2.9	1.4	0.0	48.6	5.0	0.7	22.1	3.6	1.4	14.3
		MYR	82.5	0.3	0.0	0.0	0.0	66.7	0.0	0.0	33.3	0.0	0.0	0.0
		ALA	130.0	0.2	0.0	0.0	25.0	25.0	0.0	50.0	0.0	0.0	0.0	0.0
		DEP	124.9	11.5	9.2	11.6	3.9	22.2	22.2	18.4	2.9	2.9	2.9	3.9
		PUL	73.2	4.5	0.0	0.0	0.0	16.0	13.6	16.0	19.8	1.2	17.3	16.0
		ARB	91.1	6.8	0.8	1.6	1.6	9.0	16.4	45.1	4.1	3.3	14.8	3.3
	3	GLA	71.3	0.1	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0
		ALA	135.8	0.2	16.7	16.7	0.0	16.7	0.0	33.3	16.7	0.0	0.0	0.0

APPENDIX I (Continued)

Study area	Study plot	Species	Ht. (cm)	#Stems/ sample frame	Percent in each browse class									
					1	2	3	4	5	6	7-1	7-2	7-3	8
Taylor Highway (Other)	3	DEP	79.7	1.9	5.2	0.0	0.0	4.8	1.7	0.0	19.0	0.0	0.0	29.3
		PUL	51.3	10.8	0.0	0.0	0.0	14.9	0.9	0.0	30.3	0.6	0.0	53.3
		ARB	89.9	2.4	0.0	2.7	0.0	38.4	27.4	2.7	16.4	2.7	0.0	9.6
	4	GLA	153.3	1.3	56.5	0.0	0.0	34.8	4.3	0.0	4.3	0.0	0.0	0.0
		ALA	135.0	0.1	0.0	0.0	50.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0
		DEP	68.1	0.4	0.0	0.0	0.0	12.5	25.0	12.5	12.5	12.5	12.5	12.5
		PUL	72.7	23.1	0.0	0.2	0.0	22.9	16.9	12.3	22.4	2.9	4.6	17.8
		ARB	91.1	4.7	1.2	1.2	0.0	14.3	20.2	39.3	8.3	3.6	11.9	0.0
Wood River	1	GLA	95.1	6.6	1.1	1.5	1.9	43.4	5.3	0.4	34.3	0.4	0.0	11.7
		HAS	38.7	24.4	0.0	0.0	0.0	0.1	0.0	0.0	6.6	0.0	0.0	93.3
		BAR	56.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0
		LAN	59.2	4.4	0.0	0.0	0.0	8.5	0.0	0.0	41.5	0.0	0.0	50.0
		ALA	203.3	0.1	33.3	0.0	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		PUL	41.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	30.8	0.0	0.0	69.2
		ARB	129.7	5.3	1.4	1.9	19.6	17.3	11.2	21.0	14.0	2.3	1.4	9.8
	2	GLA	79.2	0.1	0.0	0.0	0.0	50.0	0.0	0.0	33.3	0.0	0.0	16.7
		HAS	43.7	31.5	0.0	0.0	0.0	0.7	0.0	0.0	12.7	0.1	0.0	86.5
		BAR	36.4	0.5	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	0.0	95.2
		LAN	61.5	15.2	0.0	0.0	0.0	12.5	4.1	2.8	25.2	2.0	0.5	53.0
		ALA	138.8	7.5	3.6	7.9	11.9	17.2	13.9	18.2	8.3	3.3	5.6	9.9
		ARB	92.9	1.3	0.0	0.0	9.8	9.8	7.8	7.8	21.6	21.6	5.9	15.7

APPENDIX I (Continued)

Study area	Study plot	Species	Ht.(cm)	#Stems/ sample frame	Percent in each browse class									
					1	2	3	4	5	6	7-1	7-2	7-3	8
Wood River	3	GLA	97.3	1.7	2.0	4.0	0.0	28.0	8.0	6.0	36.0	2.0	0.0	14.0
		HAS	46.1	18.6	0.0	0.0	0.0	1.4	0.0	0.0	18.1	0.4	0.0	80.1
		LAN	79.2	20.2	0.0	0.0	0.2	19.1	6.9	7.4	40.5	3.6	1.3	20.9
		ALA	194.8	2.1	6.3	6.3	35.9	7.8	20.3	17.2	1.6	1.6	3.1	0.0
		ARB	124.1	2.7	1.2	15.9	3.7	9.8	36.6	3.7	8.5	0.0	11.0	9.8
	4	GLA	103.0	12.0	0.3	1.7	0.8	46.3	13.6	2.2	25.2	0.8	2.2	6.9
		ALA	153.9	2.4	0.0	8.3	20.8	9.7	9.7	41.7	5.6	2.8	1.4	0.0
		PUL	70.5	3.1	0.0	0.0	0.0	10.6	9.6	1.1	33.0	11.7	2.1	31.9
	5	GLA	87.9	11.6	0.0	0.0	0.0	30.5	9.9	6.9	36.5	9.0	2.1	5.2
		HAS	76.4	1.0	0.0	0.0	0.0	14.3	4.8	0.0	66.7	9.5	0.0	4.8
		ALA	99.7	0.9	0.0	0.0	0.0	16.7	16.7	38.9	22.2	0.0	5.6	0.0
	6	HAS	54.3	4.0	0.0	0.0	0.0	3.8	0.0	0.0	37.5	0.0	0.0	58.8
		BAR	60.1	8.8	0.0	0.0	0.0	0.6	0.0	0.0	57.4	5.1	0.6	36.4
		LAN	60.0	9.6	0.0	0.0	0.0	9.8	0.5	0.0	33.2	3.1	0.0	53.4
		ALA	83.3	0.3	0.0	0.0	0.0	0.0	16.7	16.7	16.7	0.0	33.3	16.7
		PUL	62.6	12.0	0.0	0.0	0.0	7.1	4.2	1.3	33.3	11.7	3.3	39.2
	7	GLA	82.2	1.8	0.0	0.0	0.0	43.4	7.5	0.0	26.4	0.0	0.0	22.6
		HAS	48.5	17.5	0.0	0.0	0.0	1.5	0.0	0.0	25.9	0.8	0.0	71.9
		BAR	53.9	8.4	0.0	0.0	0.0	5.1	0.8	0.0	30.4	5.5	0.8	57.3
		LAN	66.1	0.8	0.0	0.0	0.0	17.4	0.0	4.3	30.4	0.0	0.0	47.8

APPENDIX I (Continued)

Study area	Study plot	Species	Ht.(cm)	#Stems/ sample frame	Percent in each browse class									
					1	2	3	4	5	6	7-1	7-2	7-3	8
Wood River	7	ALA	130.3	6.4	0.0	2.1	15.1	6.3	10.9	42.2	8.3	5.7	5.2	4.2
		DEP	90.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
		PUL	28.9	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
		ARB	94.4	0.6	0.0	0.0	0.0	0.0	11.8	41.2	0.0	11.8	35.3	0.0
	8	GLA	69.7	5.4	0.0	0.0	0.0	21.1	5.0	0.6	34.2	1.2	0.0	37.9
		HAS	30.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
		LAN	84.2	2.2	0.0	0.0	0.0	21.5	18.5	4.6	23.1	9.2	0.0	23.1
		PUL	41.3	1.5	0.0	0.0	0.0	0.0	0.0	0.0	9.1	0.0	0.0	90.9
	9	GLA	58.3	6.3	0.0	0.0	0.0	10.2	1.6	0.4	32.7	0.8	0.4	53.9
		LAN	60.8	4.5	0.0	0.0	0.0	8.3	3.9	0.0	33.9	3.9	0.6	49.4
		PUL	41.9	2.0	0.0	0.0	0.0	0.0	2.5	0.0	10.0	1.3	0.0	86.3

APPENDIX II. Heights, densities, and percentages of plants in each browse class for all willow species on the Tanana River study area

Species	Ht. (cm)	#Stems/ sample frame	Percent in each browse class							
			1	2	3	4	5	6	7	8
LAS	52.5	0.2	0.0	0.0	0.0	27.8	11.1	0.0	33.3	27.8
INT	69.3	3.4	0.9	0.9	1.2	13.5	19.4	22.8	34.2	7.1
MYR	77.3	1.3	10.5	3.2	4.0	29.8	8.1	2.4	29.8	12.1
ALA	131.3	0.6	5.1	1.7	40.7	10.2	8.5	10.2	15.3	8.5
NIP	70.0	5.9	11.2	2.5	0.4	27.8	2.3	0.4	30.1	25.5
ARB	110.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0

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WORK PLAN SEGMENT REPORT

FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT NO: W-17-1 TITLE: Big Game Investigations

STUDY PLAN: M TITLE: Bear Studies

JOB NO: 10 TITLE: Assessment of Hunter Harvest and Productivity of the Black Bear

PERIOD COVERED: July 1, 1968 to June 30, 1969

ABSTRACT

Hunting pressure on black bears is being extended along the coastline further from Valdez as hunting success declines close to Valdez. Most successful hunters now go on guided hunts. Available data indicates that black bears are declining in numbers, this showing up in reduced sightings, reduced hunter success, and a lowered age ratio in heavily hunted areas. However, black bear availability in heavily hunted areas could also be reduced by increased wariness.

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OBJECTIVES

To determine the magnitude and characteristics of the hunter harvest of black bears in the study area.

To investigate the breeding biology and productivity of black bears in the study area.

PROCEDURES

To accomplish my first objective, i.e., to assess the magnitude and characteristics of the black bear harvest in the study area during 1968, I relied primarily upon three principle means of information gathering: (1) a check station for military hunters, (2) interviews with local guides and residents and (3) interviews made after the hunting season with successful hunters whose names I had obtained during the hunting season. Carl Grauvogel, in a study which preceded this one, reported data on hunting pressure for the years 1966 and 1967. A history of the hunter-bear interreaction was accumulated by interviewing selected local residents.

The primary difficulty facing potential hunters is transportation. The road system around Valdez is quite limited. Other than the Richardson Highway and residential roads, there are approximately 10 miles of sideroads in the vicinity of Valdez (Mineral Creek and the Valdez Glacier Road). For road hunters, I initially tried to patrol the road systems and visit the campground to check hunter success. This proved to be quite unrewarding because of difficulties with dilution of hunters with large amounts of tourists and multipurpose recreationists.

Based on campground interviews, a large proportion of tourists, hikers, campers, and fishermen are equipped and motivated to shoot a bear should they get a chance. For road-based hunters, I tried only to keep track of their total bear kill. To this end, I frequently contacted "key" local residents - sportsmen and, primarily, personnel of the auto service stations in town. This was based on the fact that most vehicles leaving Valdez were charged with fuel just prior to leaving, and service station personnel had a fair probability of hearing about a hunter's success.

To accomplish my second objective, i.e., to gather information which would support conclusions about the effects of hunting on black bears in the study area, it was first necessary to hypothesize certain effects and then design tests to check the hypotheses. Hypothetically, hunting pressure may cause the following changes in a bear population of a given region:

1) Reduced numbers due to removal and/or emigration

2) Compensatory immigration and/or natality

3) An altered sex ratio due to hunter selection, of the larger male bears for example

4) An altered age structure due to hunter selection for size, legal protection of sows with cubs, and/or proportional removal of the more abundant older age classes

5) Behavioral changes reducing the vulnerability of bears

Ideally, then, I was interested in hunter-induced changes in numbers, sez and age ratios, breeding biology, movements, and behavior. These changes were to become apparent by comparing lightly and heavily hunted areas, that is, similar areas at corresponding times. In practice, I found it very difficult to measure parameters of the black bear population.

No known method appeared to be entirely suitable for measuring black bear abundance or numbers. A total census is impossible. Estimates based on recapture ratios may be biased because the assumptions probably wouldn't be satisfied, time available for trapping is insufficient, and a high recapture is necessary for meaningful confidence limits. Carl Grauvogel used two methods of assessing total numbers. In one method he assumed that the hunter harvest was 10% of the total kill. In another method he counted black bears in a cleared area and extrapolated for the coastline. This latter method assumes that the bears aren't congregated in a feeding area while being counted.

An aerial survey was attempted in the spring just as foliage began to leaf out. The aircraft was single-engined, fixed-winged, and had a cruising speed of 110 to 145 m.p.h. A two-hour flight along the coastline in the morning at mid-tide exposed approximately 235 miles of coastline to view. Visibility of bears along the coastline was excellent, in the conifers - zero, above the conifers - fair. Although both heavily-hunted and lightly-hunted areas were covered and three observers were present, only four bears were seen. I concluded that most of the bears must have been in conifers at the time of the survey. I don't believe aerial counts are very promising for black bears in this region. In support of this conclusion, only 112 observations of black bears in my study area have been recorded in four years of aerial stream salmon surveys by personnel of the Commercial Fisheries Division of Cordova. The records indicated that all salmon streams in the study area were surveyed at least once or twice each year.

Most black bears don't loiter about salmon streams in heavily hunted areas. I saw one bear step into a stream, catch a salmon, and disappear back into the bush with his meal - all within a timed six seconds. Also, I'm not at all certain that all coastal bears feed on salmon. I have an impression that a significant proportion of black bears never ate a salmon in 1968. Counting black bears or their tracks about salmon streams may be misleading.

There are indications that the low snowline and bared deciduous vegetation may make an early spring visual spot census meaningful. This coming spring should see this possibility resolved.

For an indication of the change of abundance with time, the subjective assessment of Valdez residents of trends in the number of annual black bear sightings provides one clue. Another clue is provided by comparing hunting success in one area over several years. Carl Grauvogel, my predecessor in this study, accumulated hunting pressure data for 1966 and 1967. For 1968, data and locations of kills were obtained, where possible, so that I was able to compare the hunting success on a seasonal and geographic basis.

I assumed at first that emigration and immigration could and did occur laterally along the coastline, but that bare rock crests were barriers. This may generally be true, but while mountain goat hunting in the fall, I found black bear tracks in the snow at the same elevation as the goats. I doubt now that isolated black bear populations exist on my study area. No trapping and tagging operations were utilized in 1968 as a technique for measuring movements.

Sex and age population structure was determined from hunter-killed bears. Age was determined by counting the cementum annuli of stained tooth sections. However, the sample of hunter-killed bears may not be representative of the population. Although I think the sample is biased, based on unreasonable sex ratios, I believe the bias to be due less to hunter selectivity than to differential availability of the black bear sex and age classes. However, the bias could apply approximately equally to heavily and lightly-hunted areas, so that comparisons may be meaningful.

FINDINGS

In terms of absolute density a charter boat operator's clients shot eleven bears in Long Bay in the fall of 1967 and an additional fourteen black bears there in the spring of 1968. Yet, this operator knew of an additional five bears that continued to elude him. This accounts for thirty black bears in a bay with an approximate 18 mile shoreline. The area of the coastal slope facing Long Bay is approximately 27.5 square miles. Minimum density is, therefore, 1 bear/0.9 square mile. However, most of the bears were killed at the head of the bay, and ecological density is many times greater.

Another clue to density can be derived from observations of identifiable individuals at Jonah Bay. In time, I was able to recognize eight different black bears at Jonah Bay. Earlier hunter kills accounted for another three black bears. The area of the coastal slope facing Jonah Bay is approximately 11 square miles giving a density of approximately 1 bear per square mile.

Both of these values for absolute density are minimum values, and both are approximate. Moreover, both values pertain to areas classified as lightly-hunted. I have no comparable density approximations for heavily hunted areas.

Another index of changing abundance with time is given by hunting pressure data. The total number of black bears killed within 30 miles of Valdez was only approximately 18% of the kill over the same area in 1966.

Population Age and Sex Structure and Productivity

Age structure of the population, as revealed by examination of tooth cementum annuli, differs between heavily and lightly hunted areas. Carl Grauvogel found an average age difference of one year (6.9 and 7.8) with the older segment coming from the more isolated areas. Breaking the specimens into different age classes, he found that there was a larger percentage of young bears in heavily-hunted areas. The bear skulls collected in 1968 are too few for comparisons and will have to be lumped with 1969 collections.

The sex structure for the spring-killed bears in 1966, 1967, and 1968 is listed in Table 1. Such fluctuations in the sex ratio in successive years is suggestive of differential availability between sexes causing nonuniform hunter sampling.

I have no data on black bear productivity. Only one first-year cub was seen out of over 75 black bear sightings by myself, hunters I've interviewed, and two charter boat operators.

Breeding biology has not been assessed. Only three female reproductive tracts were obtained, and two of these came from bears killed by Cordova-based hunters. Subsequent collections of material this coming summer may open up this area of investigation.

Observations on black bear behavior were directed towards those aspects of behavior that are important to the hunter-bear interaction. Observations were found to be relatively infrequent and of short duration. A large effort was required for a small return in number of sightings.

It was assumed that food habits would strongly determine black bear behavior. Food habits were assessed by scat analysis and cropped vegetation in the field. Stomach samples and scats were also collected for laboratory investigation, but they haven't been analyzed.

TABLE 1

Comparison of Black Bear Hunting Data for the Spring Season for 1966, 1967, and 1968

	1966		1967		1968	
Bears emerged from hibernation	Late May		Early May		Early May	
Hunter success	56.8%		53.2%		17%	
based on hunters	51, unguided		77, guided & unguided		76, unguided	
Guided hunter success (approx)					65%	
based on hunters					29	
Mean Number of Hunting Days per kill	23		4.4		9.7	
Bear Kill (approx)						
unguided military	ca. 50		19		11	
local residents	5-10	75	2	28	0	19
"Outside" hunters	15		7		8	
"Guided" hunters	10		12		29	
Total	80-85		40		49	
Percent of Bear Kill "Guided"	ca. 12		30		30	
Site of Kill, distance from Valdez:						
0-30 miles	70-75		28		19	
30-80 miles	10		12		29	
Sex ratio of Known hunter-kill	29/11		22/21		28/5	

General Description and Life History

Although several color phases of the black bear are reported for Alaska, by far the majority of black bears in Valdez are "black". In size an average male may stand 2 1/2 feet at the shoulder, by 5 feet total length and weigh 200-250 pounds. Females are noticably smaller, perhaps 2 feet tall and 3 1/2 feet long, weighing between 100-150 pounds. There is a difference in size, therefore, which could mean hunter selection. Black bears have long guard hairs covering an underfur and seem impervious to any varieties of summer weather - they may be seen feeding in cold, rainy weather. The spring coat differs from the fall coat, the latter being longer and duller. However, most hunters don't appear to consider pelage quality other than wanting a bear which hasn't shed. There appears to be differential shedding among ages and sexes. Young bears shed later in the summer; also, by mid-June, one mature female was badly rubbed while no males were observed that were rubbed during this period. This could be a basis for hunter selection.

Black bears have moderate vision, but their apparent disinclination to use it may be one reason for their reputation of being of poor vision. They appear to rely greatly on their senses of hearing and smell. Consequently, feeding black bears can be approached relatively easily on tidal flats, but a hunter-black bear encounter in heavy brush is an unusual event.

Certain aspects of the black bear life history are especially pertinent to the bear-hunter interaction. Black bears are primarily controlled by available food and cover. For bears, food and cover is a function largely of vegetation which varies greatly in the study area with climate and topography. The outstanding physical features of the region have already been described, but can be summarized here. The snow-capped land ridges cause sharp differences in vegetation between sea level and alpine peaks, between north and south-facing slopes. The ocean influences cause high precipitation, even temperatures, and early snow melt close to waterline. These factors apply to bear hunting in the following ways. Bear emerging from hibernation early in the spring find deep snows on higher slopes but no snow near the waterline. Their food at this time of the year is grasses growing near the waterline, sedges on tidal flats, and forbs in clearings mainly on low-altitude south-facing slopes. In early spring, bears are concentrated by the snow and available food and exposed by the deciduous vegetation which hasn't yet leafed out. In the spring, 1968 hunt, hunting success was far higher early in the spring and decreased sharply with time. Some authors report that sows with cubs emerge relatively later from winter denning. This may help explain the fact that the sex ratio of the black bear harvest was heavily in favor of males.

As the snowline climbs later in the season, some bears follow it up the slopes, eating the emerging vegetation. The total apparent bear density decreases since they are less exposed to view, scattered over a larger area, and feed in areas further from the majority of hunters. Generally, concerning foods, bears eat a wide variety of plant and animal matter, but some foodstuffs are eaten more exclusively at certain seasons than others. Cover continues to increase as the alders leaf out, the forbs gain height, and snow melts under the conifers. Black bears tend to occupy heavy cover when not actively feeding on tidal flats or open slopes. In heavily-hunted areas, most bears have, by now, voluntarily or involuntarily left the tidal flats. Bear hunters, therefore, now have greater success climbing up to the higher, open feeding areas on south-facing slopes.

As summer advances, black bears tend to shift their feeding areas from south-facing slopes to open north-facing slopes, frequently below snow packs which are still melting. Sedges and Beach ryegrass at low elevations are becoming too coarse for digestion. Salmon become a major dietary source for many bears, although some black bears occupying high country probably don't know salmon exist. Later, berries, especially salmon berries, become a major food source. Because of the dense vegetation, however, fall hunters probably have greater success by hunting those bears which are still feeding on salmon.

I don't know when black bears den. Two dens were found, both on north-east facing slopes under root systems of tilted trees. Both were at low elevation. One local theory is that black bears choose dens on north slopes so that, by the time they are aroused in the spring, snow will have receded and vegetation will be emerging on south-facing slopes.

Black bears may normally be limited by their ability to store sufficient fat to last the winter. Possibly a deficiency of food or poor physical condition of the bear could result in reduced fat deposits and the necessity to break winter dormancy early. At this time there would be little to eat except sea weed, invertebrates, and possible beach carrion.

Hunting Pressure

The black bear hunting season in the Valdez area extends from September through June, or ten months of the year. Because of winter dormancy, the hunting season is, in effect, in two parts - the spring and fall seasons. The bag limit per calendar year is presently three bears.

The numbers of spring bear hunters, their categories, and the effectiveness of the categories are tabulated on Table 1. In summary, four trends become apparent by inspection:

1) Fewer bears are being killed each year by unguided hunters.

2) Overall, there are indications of decreasing hunter success and an increase in numbers of days required to kill a bear.

3) The relative amount of bears killed by guided hunters has approximately doubled each year.

4) Bears are increasingly being killed at greater distances from Valdez. Thus, hunting pressure is being transferred

to more remote areas along the coast which tends to keep the total harvest higher than if equal pressure were confined to one area.

Fall hunting statistics are incomplete. For 1966, Carl Grauvogel recorded that 16 hunters spent 37 days hunting to kill 14 bears. This figures out to be 7.6 days spent per bear and a 75% hunter success.

No data is available for the fall of 1967. For 1968, 27 hunters spent 84 days hunting to kill 0 bears. One charter boat operator obtained two black bears for his client at Unakwik Inlet. The major "guide" was inactive, his boat being continually chartered by oil company representatives.

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WORK PLAN SEGMENT REPORT

FEDERAL AID IN WILDLIFE RESTORATION

STATE: Alaska

PROJECT NO: W-17-1 TITLE: Big Game Investigations

STUDY PLAN: N TITLE: Mountain Sheep

JOB NO: 9 TITLE: The Role of Mineral Licks in the Ecology of Dall Sheep

PERIOD COVERED: July 1, 1968 to June 30, 1969

OBJECTIVES

To determine the mineral content of natural mineral licks used by Dall sheeps in central and south-central Alaska and establish what minerals specifically attract sheep to them.

The characterize the daily and seasonal patterns of usage by population as well as by sex and age groups within populations.

PROCEDURES

Field investigations were initiated in early June and mineral licks in the Wood River, Dry Creek and Little Delta River of the Alaska Range were visited, samples collected, and observations made on their degree of use by mountain sheep. Similar work was begun in the Chugach and Talkeetna Mountains in late June to continue into July. Emphasis was directed to selection of a suitable mineral lick as a location for intensive observations and photorecording of characteristics of use by sheep.

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