FEEDING ECOLOGY AND HABITAT PREFERENCE OF THE MOUNTAIN GOAT IN ALASKA

A

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FEEDING ECOLOGY AND HABITAT PREFERENCE OF THE

MOUNTAIN GOAT IN ALASKA

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ABSTRACT

Feeding ecology and habitat preference of the mountain goat were studied on the Kenai Peninsula and on Kodiak Island in 1969 and 1970. Comparative field observations were also made in the Port Houghton area, southeastern Alaska, in the fall of 1969.

Goat populations on Kodiak and Kenai show common features in their adaptations to range and habitat. Summer ranges of the goats are located toward the summits of the mountains. The vegetation type preferred in summer on Kodiak is the forb-sedge meadow, commonly found in south-facing bowls. On Kenai, the animals also spend considerable time feeding on prostrate vegetation on high ridges. The bulk of the forage consists of forbs, while broad-leaved sedges are used to a lesser extent. The selection of forage as well as the use of different vegetation types are to some extent governed by the occurrence of new growth or the presence of particularly succulent plant tissue.

In winter goats utilize the lower slopes of the mountains when snow is sparse there. In these sites they feed mainly on the rhizomes and petioles of Athyrium filix-femina. When heavy snow limits access to this forage, they retreat to high wind-blown ridges and rock outcrops, where bunch grasses and "bunch" sedges are the principal forage plants. These species both contain a significant amount of green tissue. In early spring goats are found on the lower alder slopes feeding on the new growth of Calamagrostis canadensis; forbs and browse are utilized to a lesser extent.

After the arrival of the first snow of winter, goats in the Port Houghton area fed mainly on evergreen ferns and dwarf shrubs on snow-free spots under mountain hemlock (Tsuga Mertensiana).

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INTRODUCTION

Because of its inaccessible and remote habitat, the mountain goat remained an obscure animal to white man far into the nineteenth century; as late as the 1880's some even questioned the existence of the animal (Whitney, 1904). In this century, also, knowledge of the mountain goat has accumulated slowly when compared to the work done on other big game species in North America. However, in the last two or three decades some extensive studies, largely of a reconnaissance type, have described the overall life history of this relatively unknown animal. Today general knowledge of the mountain goat's taxonomy, population structure, reproductive behavior, mortality factors, morphological characters, and feeding habits has accumulated sufficiently to enable the investigator to focus on more specific aspects of the animal's life history.

The present study concentrates on feeding ecology and habitat preference of the mountain goat in Alaska. From the limited amount of work done on the species in North America, the mountain goat appears to be exceptionally adaptable to a wide variety of vegetational and climatic conditions. The present study investigates this pattern of adaptation in selected areas along the south coast of Alaska. Two main study areas were chosen: one in the

Crown Mountains on Kodiak Island, where goats were introduced in 1952 and 1953, and the other in the Kenai Mountains north of Seward on the Kenai Peninsula. Twenty weeks during late winter, spring, and summer were spent in the field. Furthermore, a week in November 1969 was spent in the mountains north of Port Houghton in southeastern Alaska.

However, as the weather in the coastal mountains of Alaska is characterized by frequent storms and high precipitation, during part of this time conditions were unsuitable for field observations, particularly the late winter of 1970. Furthermore, the work was done out of a small portable tent, and, in order to maintain enthusiasm, during certain periods time and energy that otherwise could have been put into direct field studies had to be devoted to keeping dry and warm.

As this study deals with only a limited aspect of the mountain goat's ecology, those interested in general data regarding the animal's status in the state are referred to Klein's reconnaissance study of the mountain goat in Alaska (1953).

The source of nomenclature for plants is Hultén's Flora of Alaska, for lichens Krog's The Macrolichens of Alaska.

THE STUDY AREAS: GENERAL DESCRIPTION

The majority of the field work was done on the Kenai Peninsula and on Kodiak Island. The study area on the Kenai Peninsula is located within the Kenai Mountains; it is bounded by Kenai Lake and the Seward-Anchorage highway to the north and east, and by Resurrection River and Boulder Creek to the south and west. The study area on Kodiak is located to the north of Hidden Basin, mainly comprised of the drainages of Wild Creek and the creek running southward from Terror Lake (Figs. 1, 2, and 3).

Climate

As the study areas are situated on the ocean-facing slopes of the coastal mountains of south and southeastern Alaska, they are subjected to the same climatic controls as the rest of the northwest coast of North America. The equable climate is a consequence of the proximity of the waters of the North Pacific Drift, and the humid character results from the cooling effect of the coastal mountains on the moisture-laden air as it advances inland. Precipitation is usually maximal during fall and early winter and minimal during spring and summer. The prevailing westerly winds, modified in winter by the presence of a dominant low pressure center in the area of the Aleutian Islands and in summer by a corresponding North Pacific high pres-

sure center, are an important feature of this part of the coast. In winter these winds tend to blow northward as they circulate counter-clockwise about the low pressure system. In summer, by contrast, because of the barometric gradient and the circulation pattern they blow more often from the west and northwest, clockwise around the area of high pressure (Sverdrup, 1940; Kincer, 1941).

Local conditions, however, may vary from these generalities. Topography plays a large role in altering wind directions; glaciers also strongly affect local air movements.

The metrological stations closest to the three study areas are listed in Table 1. Their distances from the study areas on Kenai (Seward), Kodiak, and in Port Houghton (Wrangell) are 15, 50, and 80 miles, respectively. The insular conditions on Kodiak account for the temperatures being slightly more equable here than on the mainland. The stations are located at sea level and with increasing altitude one can expect decreasing temperature and increasing precipitation.

Physiography and Relief

Pleistocene glaciation has been an important natural force, acting both directly and indirectly, upon the south coast of Alaska, and giving rise to its present landscape. Ice moving through the valley systems has created a classi-

Table 1. Climatic summary from Kodiak, Seward, and Wrangell (U. S. Weather Bureau, 1969*)

Precipitation (in)	Seward	Kodiak	Wrangell
Annual	67.35	60.64	88.16
October	10.--	6.97	12.61
June	2.23	4.43	3.96
Temperature (F^{o})			
Annual	39.5	40.6	43.7
January	24.7	30.2	29.7
July	55.5	53.8	57.3
Length of growing season (days)**	152	162	172
Annual snowfall	73.4	46.9	64.2

* Mean values for the period 1931-1960.

** Number of days between last and first record of temperatures below $32^{o}F$ in spring and fall, respectively.

cal glacial topography. While there are no glaciers on Kodiak today, several remain in the Kenai Mountains; the largest, the Harding Icefield, borders the study area to the south. Geologically and topographically the Kenai Mountains are related to the Kodiak mountain mass and are continuous with the Chugach Mountains to the northeast. They belong to the Chugach-Kenai Mountain province of U. S. Geological Survey terminology (Williams, 1958). The mountains are formed predominantly of Mesozoic or older rock with some tertiary marine sandstone and nonmarine sandstone and shale. Slate, graywacke, and conglomerate are in abundance, along with greenstone, tuff, chert, and other rock, and the whole has been folded, faulted, and intruded (Capps, 1937).

The peaks of the mountains in the Kenai study area reach 4500-5300 ft. In the Kodiak area they are lower, reaching only 2500-3000 ft.

Vegetation

Kenai:

The forested part of the study area on the Kenai Peninsula lies within the Hemlock (Tsuga)-Sitka spruce (Picea sitchensis) complex of the Pacific Coastal Forest (Heusser, 1960). The western hemlock (Tsuga heterophylla) of the eastern part of this region is largely replaced by mountain hemlock (Tsuga Mertensiana) in the study area.

Sitka spruce is common on the lowlands bordering the ocean, but mountain hemlock becomes progressively more dominant with increasing altitude and commonly is the only coniferous tree at timberline. Hybrids between Sitka spruce and white spruce (Picea glauca) have been observed in several locations (Heusser, 1960). Along main river valleys there are frequently pure stands of cottonwood (Populus balsamifera).

A common vegetation type in this area is an association comprised of dense stands of mountain alder (Alnus crispa) together with lush growth of Calamagrostis canadensis and Athyrium filix-femina; forbs such as Veratrum album, Aruncus sylvester, Rubus spectabilis, Sorbus sitchensis, and Echinopanax horridum occur more irregularly. This vegetation type, here termed the alder society, covers steep outwash slopes from sea level to timberline, and is also a characteristic plant association in the zone extending for several hundred feet above the coniferous forest, frequently reaching 1700-2000 ft. The alder society together with higher alpine tundra are the principal components of goat habitat throughout the year, and will be dealt with in more detail in later sections.

Kodiak:

The vegetation on Kodiak shows considerable similarity to that on Kenai. The most apparent difference is the

lack of coniferous forest on Kodiak. Sitka spruce is found only on the northeastern-most part of the island. Except for semi-arboreal alder and the limited occurrence of spruce, the only tree on Kodiak is cottonwood, which is found in river valleys and on alluvial flats. The alder society is the most dominating vegetation type in the study area and has a distribution similar to that on Kenai, but in the absence of coniferous forest it generally covers a larger proportion of the slopes. Possibly because of the stronger maritime climatic influence on Kodiak, the upper limit of alder is lower than on Kenai (approximately 1000-1200 ft). The vegetation appears more lush on Kodiak than on the mainland, particularly the alpine tundra above timberline. This will be dealt with in more detail in later sections.

Port Houghton:

Port Houghton shares the general climatic and physiographic features of the study areas to the north. Compared to Kenai the area has higher precipitation and higher annual temperature. Also, the growing season is longer; 172 days compared to 162 for Kenai (Table 1). Vegetationally, Port Houghton also belongs to the hemlock-Sitka spruce complex of the Pacific Coastal Forest (Heusser, 1960), but western hemlock predominates here over mountain hemlock. Mountain hemlock and yellow cedar

(Chamaecyparis nootkatensis) form the timberline at about 2000-2400 ft. Other common plant species at timberline are Sorbus sitchensis, Cladothamnus pyrolaeflorus, Vaccinium alaskensis, V. uliginosum, Cassiope Mertensiana, Phyllodoce glanduliflora, Empetrum nigrum, Luetkea pectinata, Cornus canadensis, Lycopodium selago, and Veratrum album.

STUDY APPROACH

The object of the study has been to determine qualitatively and quantitatively the forage utilization of goats at various seasons, and to determine habitat preference in relation to general topography, vegetative cover, and season.

Goat habitats in the different investigation periods were located by searching for feeding animals. In preparation of data the unit used is a specific feeding site at a specific time. The number of animals feeding in an area is not necessarily an indication of the attractiveness of the specific habitat, but rather may be a result of the yearly pattern of gregariousness.

Habitat has been classified according to general topography and vegetation type. The general description includes:

Altitude

Slope (steepness)

Exposure

Topography (smooth-broken-extremely broken)

Depth of soil (estimated)

In addition, qualitative data of a general nature on snow accumulation, snow melting, and soil humidity have been recorded. Time of snow melt and consequently avail-

able growth time was also estimated where this was believed to be of significance in forage selection by the goats (young vs. old plant tissue).

Determination of vegetation type on feeding sites was done by plot sampling with a rectangular frame 20 by 40 cm. The vertically projected coverage of the different plant species was recorded as a per cent of the total frame area. Sampling with the frame was done along a tape at 60 cm intervals. Between 10 and 30 samples were taken from each vegetation type depending on subjective estimations of variation in species coverage and composition.

Range use was recorded along with determination of the vegetation type and was quantified as follows: 1) amount of coverage removed from each plant species in per cent of total coverage of the species (including removal that only decreases intraspecific leaf overlap); 2) average per cent of tissue removed from each utilized species; 3) part of the plant removed. 1) and 2) were estimated by comparison with untouched plants at the location.

Vegetational analyses of known and potential winter ranges were done during summer. The location of the winter ranges was determined partly on the basis of the author's winter experiences on Kodiak in March 1969 and partly from interviews with local people.

The applied method of estimating coverage removal will give only a relative indication of the forage utilization

since constant and random errors varying with plant form and abundance will be introduced. Later tables of plant usage should therefore be regarded as showing degrees of magnitude rather than absolute measurements. It would have been more accurate to estimate the weight of the plant tissue eaten. Weight estimates are, however, time-consuming, and appear most valuable when related to measurements of daily food consumption and energy requirements. As the object of the present study has been to collect data related to food preference, it is believed that the applied method was more appropriate to this study. Also, this is felt to be an improvement over the traditional subjective indications of forage preference of grazing ungulates such as "highly preferred," "less preferred," etc.

THE SUMMER RANGE IN THE KODIAK AND KENAI MOUNTAINS

Goats are usually on the move on summer range, rarely grazing intensively at one place for any length of time. Along ridges they maintain distinct paths indicating that the topography plays a part in directing their movements.

Feeding sites were located by searching for animals in different parts of the summer range, rather than by following specific herds. This was done in order to get a representative picture of the total goat population. The slope, exposure, topography, and altitude of the different feeding sites are presented in Table 2.

Physiography of the Habitats

Although steep and broken terrain is abundant in both study areas, the feeding sites are generally located on relatively gentle slopes (Table 2). In general, it might be said that goats usually feed in areas where a human being also may easily walk or climb about. The tendency towards steeper and more broken habitats on Kodiak is a result of the more precipitous nature of the mountains in this area.

The highest peaks of the mountains on the Kodiak and Kenai ranges reach 3100-3600 ft and 3500-5000 ft, respectively. By comparing this with Table 2 it is seen that the goats tend to concentrate toward the summits of

Table 2. Characteristics of mountain goat feeding sites on summer range in the Kodiak and Kenai Mountains

Site Characteristics	Number of Feeding Sites	
	Kodiak	Kenai
Slope %		
10 - 30	4	1
31 - 50	2	3
51 - 70	6	5
71 - 90	7	10
90	3	--
Exposure		
S	8	7
SE	6	3
SW	2	--
N	--	--
NE	3	1
NW	3	2
W	2	4
E	1	--
Topography		
Smooth	9	6
Broken	11	13
Extremely broken	2	--

Table 2. Contd.

Site Characteristics	Number of Feeding Sites	
	Kodiak	Kenai
Altitude (ft)		
1100 - 1500	1	--
1600 - 2000	1	--
2100 - 2500	6	1
2600 - 3000	9	2
3100 - 3500	5	5
3600 - 4000	--	6
4100 - 4500	--	5

the mountain complexes.

The high occurrence of goats on south-facing slopes, as is evident from Table 2, is probably the result of more favorable conditions for plant growth there.

The Different Vegetation Types

The vegetation of the different feeding sites is classified into types on the basis of species coverage. The main difficulty encountered in such a classification is the enormous variation evinced by alpine vegetation. The great variation in topography both in micro- and macro-scale results in a heterogeneous distribution of the plants and, in order to fit the plant associations on the different feeding sites into a limited number of types, it was necessary to make some rather broad generalizations. The degree of similarity between the associations making up a vegetation type can be judged from Tables B 29 through B 37.

The listing of the vegetation types that follows starts with the sites offering the best conditions for plant growth and ends with the environmentally stressed types of the alpine habitat. The most luxuriant growth in the alpine regions generally occurs in well sheltered areas at the lower part of the alpine slopes. Here moisture is persistent throughout the year and soil conditions are good because of leaching from above. On Kodiak

and Kenai the vegetation on these sites is dominated by tall-growing sedges, especially Carex macrochaeta, interspersed with grasses, predominantly Calamagrostis canadensis, and such forbs as Geranium erianthum and Erigeron peregrinus. From these sites the abundance and richness of the flora generally decreases towards the exposed ridges. The high windswept ridges provide the most severe environment in terms of low temperature, drought stress, and wind abrasion. Higher plants common on the exposed ridges on Kodiak and Kenai are dense tussocks of Festuca altaica and Carex circinnata (Kodiak) and prostrate evergreen shrubs, such as Rhododendron camtschaticum and Salix rotundifolia. With increasing altitude cushion forms such as lichens and bryophytes acquire increasing dominance.

Vegetation types on Kodiak:

Carex meadow. A sedge meadow found in sheltered areas, particularly common in lower parts of south-facing bowls. The soil is deep, moisture is good, and there is often a snow drift above. The vegetation is dominated by tall dense Carex macrochaeta. Forbs as Geranium erianthum, Erigeron peregrinus, and Lupinus nootkatensis are frequently mixed in.

Erigeron slope. A forb meadow found in sheltered areas, usually located higher up on the slopes where the soil is

drier and more shallow than in the case of the previous type. The number of species is high and forbs are abundant. The dominating species are Erigeron peregrinus, Arnica latifolia, Artemisia arctica, Lupinus nootkatensis, Luetkea pectinata, and Carex macrochaeta.

Lupinus ridge. This type is not as sheltered as the previous ones. It is usually found in limited areas near the summit of ridges. The soil is dry and shallow with rocks on the surface. Bryophytes and lichens are common. The dominating vascular plants are Sibbaldia procumbens, Luetkea pectinata, Hieracium triste, Carex microchaeta, Luzula Wahlenbergii, and Lupinus nootkatensis.

Carex ridge. This dry, exposed type is found at high altitudes and has shallow soil and a rock-covered surface. Bryophytes and lichens dominate. Carex microchaeta and C. pyrenaica grow in patches, and there is a sparse growth of other species such as Luzula Wahlenbergii, Sibbaldia procumbens, Artemisia arctica, Carex circinnata, Campanula lasiocarpa, and Salix rotundifolia.

Snow bed. This type occurs in late snow free areas at high altitude; the ground cover is mostly rock, with Carex microchaeta and Luzula Wahlenbergii growing on patches of earth.

Vegetation types on Kenai:

The vegetation on the goat ranges in the Kenai Mountains is not as rich as that in the investigation area on Kodiak. Although this may be due to various reasons, the most important factor is believed to be the generally higher altitude of the feeding areas on Kenai. As the vegetation differs both in abundance and species composition from that on Kodiak, it is necessary to treat it separately. The vegetation on the feeding sites is divided into four types.

Artemisia slope. This type is found in sheltered areas with rather shallow earth and moderate moisture. It is most typical as stripes of vegetation on rock-strewn slopes at medium and high altitude. Bryophytes and lichens are common. Salix phlebophylla, Artemisia arctica, Festuca altaica, Solidago multiradiata, and Geranium erianthum dominate among vascular plants.

Carex slope. This type occurs in more sheltered areas than the previous type and usually has deeper soil and higher humidity. It is generally found below steep rock outcrops at medium altitude. The dominant species are Carex macrochaeta, Artemisia arctica, Festuca altaica, Solidago multiradiata, and Geranium erianthum.

Sedum ridge. Exposed areas located at high altitude.

Soil is sparse and rocks and rock outcrops cover the surface. Bryophytes and lichens are abundant; of vascular plants, Carex macrochaeta, Artemisia arctica, Sedum roseum, and Sibbaldia procumbens occur, and in sheltered spots, Cassiope stelleriana. This type shows similarity to the Carex ridge type on Kodiak.

Stellaria ridge. An uncommon type on dry, well sheltered moraine ridges at low altitude. Soil is very sparse, with the surface mostly a matrix of broken rock. The vegetation has few species; the most dominant are Stellaria sp., Polemonium acutiflorum, Lupinus nootkatensis, and Veronica Wormskjöldii.

The distribution of feeding sites according to vegetation types is shown in Table 3. The use of the different vegetation types will be discussed in the following chapter.

Forage Selection

Range utilization by the goats is presented in Tables 4 and 5. The utilization of each plant species is expressed as: usage, preference, and tissue removed. The meaning of these terms is as follows:

Usage: coverage removed (CR) times coverage (C), (CRxC), of a particular plant species. Usage therefore is an indication of absolute amount of forage contributed by a

Table 3. Vegetation types of mountain goat feeding sites on summer range in the Kodiak and Kenai Mountains

Kodiak		Kenai	
Vegetation Type	Number of Feeding Sites	Vegetation Type	Number of Feeding Sites
Carex meadow	5	*Artemisia* slope	4
Erigeron slope	8	*Carex* slope	6
Lupinus ridge	4	*Sedum* ridge	7
Carex ridge	2	*Stellaria* ridge	2
Snow bed	2		

Table 4. Usage of the summer range on Kodiak; symbol explanation in the text

Vegetation type / Species	Carex meadow			Erigeron slope			Lupinus ridge			Carex ridge			Snow bed			Usage accumulated	Preference average	Tissue removed average
	Usage	Preference	Tissue removed	Usage	Preference	Tissue removed	Usage	Preference	Tissue removed	Usage	Preference	Tissue removed	Usage	Preference	Tissue removed			
Epilobium angustifolium	67	37	50	8	14	32	--	--	--	--	--	--	--	--	--	75	25	40
Lupinus nootkatensis	12	10	6	117	18	6	365	98	33	--	--	--	--	--	--	494	40	14
Artemisia arctica	93	30	27	176	30	16	--	--	--	30	30	35	--	--	--	299	30	26
Erigeron peregrinus	72	13	5	82	12	4	--	--	--	--	--	--	--	--	--	154	12	4
Carex macrochaetae	32	1	70	95	9	45	7	1	20	--	--	--	--	--	--	134	4	43
Arnica latifolia	19	5	3	126	7	3	--	--	--	--	--	--	--	--	--	145	6	3
Castilleja unalaschcensis	2	2	3	8	3	2	--	--	--	--	--	--	--	--	--	10	2	2
Geranium erianthum	15	15	3	--	--	--	--	--	--	--	--	--	--	--	--	15	15	3
Hieracium triste	--	--	--	3	1	3	--	--	--	--	--	--	--	--	--	3	--	3
Poa stenantha	--	--	--	2	4	2	--	--	--	--	--	--	--	--	--	2	4	2
Anemone narcissiflora	--	--	--	15	5	2	--	--	--	--	--	--	--	--	--	15	5	2
Sanguisorba stipulata	--	--	--	3	1	2	--	--	--	--	--	--	--	--	--	3	1	2
Carex microchaeta	--	--	--	--	--	--	15	1	40	106	40	40	170	100	55	291	--	45
Sedum roseum	--	--	--	--	--	--	--	--	--	25	50	60				25	50	60
Total usage of veg. type	312			635			387			161			170					

Table 5. Usage of the summer range on Kenai; symbol explanation in the text

Vegetation type / Species	Artemisia slope			Carex slope			Sedum ridge			Stellaria ridge			Usage accumulated	Preference average	Tissue removed average
	Usage	Prefer-ence	Tissue removed	Usage	Prefer-ence	Tissue removed	Usage	Prefer-ence	Tissue removed	Usage	Prefer-ence	Tissue removed			
Artemisia arctica	148	37	25	101	30	20	79	8	32	--	--	--	328	25	26
Carex macrochaeta	62	20	40	63	18	50	--	--	--	--	--	--	125	19	45
Epilobium latifolrum	89	38	14	16	25	20	--	--	--	4	3	15	109	22	17
Solidago multiradiata	2	4	7	27	10	6	--	--	--	---	--	--	29	7	6
Epilobium angustifolium	--	--	--	5	10	40	3	2	20	--	--	--	8	6	30
Aconitum delphinifolium	--	--	--	1	5	2	--	--	--	--	--	--	1	5	2
Geranium erianthum	--	--	--	7	4	2	--	--	--	--	--	--	7	4	2
Carex microchaeta	--	--	--	--	--	--	286	13	48	--	--	--	286	13	48
Sedum roseum	--	--	--	--	--	--	208	70	46	--	--	--	208	70	46
Hierochloe alpina	--	--	--	--	--	--	5	4	50	--	--	--	5	4	50
Cetraria sp.	--	--	--	--	--	--	11	1	4	--	--	--	11	1	4
Polemonium acutiflorum	--	--	--	--	--	--	--	--	--	60	20	10	60	20	10
Poa stenantha	--	--	--	--	--	--	--	--	--	58	46	55	58	46	55
Draba cinera	--	--	--	--	--	--	--	--	--	26	23	25	26	23	25
Lupinus nootkatensis	--	--	--	--	--	--	--	--	--	60	11	20	60	11	20
Total usage of veg. type	301			220			592			208					

particular plant species.

Preference: let CR1, CR2, CR3, and CR4 represent the coverage removed from four utilized species on a vegetation type. Preference for species 1 is then $\frac{CR1}{CR1 + CR2 + CR3 + CR4}$ on that vegetation type.

Tissue removed: is an indication of selection for certain plant specimens (described under study approach).

The goats rarely remove as much as 1% of the above ground biomass of plants on the feeding sites (Tables B 29 through B 37). They are frequently seen moving along with noses close to the ground for long periods of time, apparently searching for the favored plants. The goats' preference for certain plant species is apparent (Tables 4 and 5), and this preference seems to vary with vegetation type. In general the bulk of their food and to some degree their preferred forage consists of the most abundant forbs and sedges in the area. For example, Artemisia arctica is abundant on Kodiak and Kenai and shows high usage and preference in both areas. A considerable part of the goats' forage on Kodiak consists of flowers whereas on Kenai they are insignificant in the goats' diet. This is probably caused by the lack of lush forb meadows (Erigeron slope on Kodiak) within the summer habitat on Kenai. While these meadows are found near rugged summits of the mountains on Kodiak, goats on Kenai must

descend to the lower altitudes to utilize this vegetation. This is probably too far away from rocky refuge areas to be attractive to goats. Also, Lupinus nootkatensis is of little importance on Kenai compared to Kodiak. This species borders the goat trails along ridges at high altitude on Kodiak, and therefore receives relatively heavy use. On the Kenai range this species is uncommon.

The high preference for, and usage of Sedum roseum on Kenai is an exception to the previous statement about the most abundant plants being those most heavily utilized. S. roseum is very succulent and probably low in lignin and fibrous matter. The preference for this species would account for the high number of feeding sites on the dry, exposed Carex ridges on Kenai (Table 3). A selection for certain plants seems to be the case for most of the utilized species. This is especially true for Carex macrochaeta and C. microchaeta. The thick meadows of C. macrochaeta common on Kodiak are rarely utilized in midsummer. Here C. macrochaeta is eaten in depressions, which are freed of snow late in the year. Goats are apparently attracted to this high quality, new growth vegetation. Also the heavy use of C. microchaeta along snow patches at high altitudes on Kodiak (Snow beds, Table 3), is a similar response to the appearance of new plant shoots. The meadows of tall, dense C. macrochaeta on Kodiak might have been used in their earlier growth

stages as evidenced by signs of grazing. But in mid-summer, being more lignified and therefore unpalatable, plants in these meadows are apparently no longer used by goats.

The preference for Carex meadows and Erigeron slopes on Kodiak is evident from Table 3. This lush vegetation is particularly common in south-facing bowls on Crown Mountain, and due to late snow melt in these bowls portions of the vegetation will be in an early state of growth even in late summer. According to Fish and Game biologist Bernhard Ballenger, a large part of the goat population is found here during summer (pers. comm.). On the annual aerial goat survey in August 1970 Mr. Ballenger spotted 49 goats in one such bowl.

Only a small number of quantitative investigations have been carried out on goat summer range; however, some general trends seem to be present. There is common agreement among the different investigators that goat summer habitat is located at high altitude and that rock outcrops and rugged terrain are important characteristics of this habitat. Klein (1953) found that when goats descend to lower, more gentle slopes to feed during the day, they generally return each night to the high ledges and outcrops to bed down. This was also observed during the present investigation. It was noted, however, that goats rarely moved as far as 200-300 yards away from their rocky

escape terrain.

Saunders (1955), studying goats in the Crazy Mountains of southwestern Montana, found that grassy slide-rock slopes were the major feeding areas during spring, summer, and fall. Ridge tops were next in importance, while alpine meadows were covered by snow until late summer, but were frequently used after that. Casebeer (1948), from his observations in western and northwestern Montana, concluded that goats feed on south-facing slopes in early summer, but as the vegetation on these sites acquires xerophilous and lignified character they search for newer and more succulent growth on recently snow-freed north-facing slopes.

Table 6 shows some quantitative data related to the goats' feeding habits on ranges in different parts of North America. Unquantified data from Brandborg (1955) in Idaho and Klein (1953) in Alaska indicate that grasses, sedges, and forbs are of primary importance in the summer diet. Hanson (1950) gave shrubs and lichens high ratings in addition to grasses and forbs.

Although it appears that grasses, sedges, and forbs make up the bulk of the diet of goats on summer ranges in North America, there are some exceptions. Casebeer and Anderson (Table 6) list dwarf huckleberry (Vaccinium caespitosum) and snowbush (Ceanothus velutinus, Muntz), respectively, as being the most preferred species. Ander-

Table 6. Forage utilization in per cent by mountain goats on various summer ranges in North America

Investigator	Location	Forage utilization, per cent				
		Sedges, grasses, and rushes	Herbs	Conif. trees	Decid. trees	Winter - green shrubs
Anderson 1940	Washington	12	18	--	54	16
Casebeer 1948	Montana	3	2	--	1	94
Cowan 1944	Alberta	63	14	--	23	--
Hibbs 1967	Colorado	82	14	tr	3	tr
Saunders 1955	Montana	3	2	--	1	94
This study	Alaska	36	64	--	--	--

tr: traces

son states that mountain goats in Washington browse more than they graze, with snowbush, huckleberry (Vaccinium sp.) and aspen (Populus tremuloides) making up 60% of the species fed on. The high preference and utilization of dwarf huckleberry found by Casebeer in western Montana is surprising. Species of the genus Vaccinium comprise only a small amount of the diet in most other investigations, and, although dwarf huckleberry is found in the Crazy Mountains of Montana, the species shows comparatively low preference and utilization in this area (Saunders, 1955). On the goat ranges investigated by Casebeer, dwarf huckleberry is apparently preferred to grasses and forbs.

FALL INVESTIGATIONS IN THE PORT HOUGHTON STUDY AREA

Field work was not carried out in the Kodiak and Kenai study areas during fall and early winter, but in late October five days were spent studying goats in the mountains to the north of Port Houghton in southeastern Alaska.

On October 19, these mountains were still snow-free, and twenty-five goats were observed on south-facing slopes. The majority of the animals were concentrated just above timberline, but several were observed farther down on steep rocky slopes with scattered spruce and a few were higher up.

The only quantitative measurement of forage utilization was done on a ridge exposed to moderate wind intensities just above the timberline (Table 7). The utilized species of Carex spp. (broad leaved Carex species not identified) appeared dry and weathered, but they were still preferred to C. circinnata, Trisetum spicatum, Festuca ovina, and Festuca altaica in spite of the latter having considerable amounts of green tissue.

The vegetation type described in Table 7 was replaced in depressions by nearly pure stands of Cassiope Stelleriana, mixed with Phyllodoce aleutica. Where the earth formed only a shallow mantle over the bedrock, the C. Stelleriana-P. aleutica was again replaced by a cover

Table 7. Feeding site of mountain goats in southeastern Alaska; dry ridge association

Species	Coverage	Per cent Coverage Removed	Per cent Tissue Removed
Bryophyta	50	--	--
Carex sp.	12	6	60
Vaccinium ovalifolium	7	--	--
Cladonia sp.	6	--	--
Silene acaulis	5	--	--
Festuca ovina	3	--	--
Lupinus nootkatensis	2	1	10
Carex circinnata	1	--	--
Polygonum viviparum	1	--	--
Trisetum spicatum	1	--	--
Festuca altaica	1	--	--

of Peltigera sp. with sparse growth of Saxifraga sp. This whole vegetation complex was only slightly used by the goats; no feeding was recorded on C. Stelleriana, but some of the outermost tips of P. aleutica were eaten. Also, there was light feeding on Saxifraga sp. Peltigera sp. showed some utilization, but the exact amount eaten was difficult to determine as part of the growth was pulled up without being consumed. This is the only significant lichen feeding recorded throughout the entire study.

A number of goats fed on Carex meadows, and, although no close investigation was carried out on these sites, it is believed that these animals were also feeding mainly on broad leaved species of Carex spp.

On October 20 the first snow of the winter arrived. After two days of snowfall the depth averaged one and a half feet in the alpine country and no spots remained free of snow. The arrival of the snow markedly influenced the distribution of goats. During the days following the snow nearly all goats were found below timberline, feeding on snow-free spots under mountain hemlock (Tsuga Mertensiana). The plant association the goats were feeding in, a Bryophyte-P. aleutica-B. spicant type with few additional species, showed small variance from spot to spot. Average plant coverage and utilization within feeding sites under 19 different trees is presented in Table 8.

In order to determine usage, on the second day after

Table 8. Average coverage and utilization of plants on snow-free sites under mountain hemlock, southeastern Alaska

Species	Coverage	Per cent	
		Coverage Removed	Tissue Removed
Bryophyta	70	--	--
Phyllodoce aleutica	30	40	10
Blechnum spicant	18	50	50
Cassiope Stelleriana	12	--	--
Luetkea pectinata	8	25	10
Rubus pedatus	3	--	--
Cornus canadensis	2	--	--
Vaccinium sp.	2	--	--

snowfall bands of goats were followed and their feeding sites examined. As seen from Table 8 the figures for coverage removed are high. This together with the presence of old feeding signs on some of the plants indicated that this vegetation had been fed on prior to the snowfall. This is supported by the observations of goats below timberline while the ground was still free of snow. Snow-free areas other than the sites under coniferous trees were found along the steep alder-covered walls of a river canyon. These areas were apparently used to a lesser extent, and only light feeding on sedges and broad leaved grasses occurred after the snowfall.

Only three goats were observed above treeline after the arrival of the snow. These animals were feeding along the previously described ridge, pawing away the snow in order to reach the vegetation. When digging for food in this manner, they would commonly select locations along the edges of elevations where the snow could be easily pushed away. There was evidence of only slight feeding in the "pawed out" spots, with only Carex spp. and Phyllodoce aleutica being utilized.

As already mentioned, goats were concentrated just above timberline prior to the snowfall. According to Harry Merriam (pers. comm.), an Alaska Department of Fish and Game biologist, goats commonly descended from the high summer habitat around the time of the first freeze up. At

this time they apparently feed mostly on dry Carex spp., P. aleutica, and B. spicant, with herbs being used only to a minor extent. With the exception of B. spicant this vegetation may also be found at higher elevations although in lesser quantity. It is therefore not self evident that forage is the only factor causing the downward movement of goats in fall. A contributing factor may be the onset of bad weather in October, as the yearly precipitation usually reaches its peak in this month.

As snow accumulates throughout the winter, goats are found at decreasing altitudes foraging in the tall timber (Klein, Merriam, pers. comm.). Since grasses and sedges are sparse under this dense coniferous canopy, it is likely that goats feed increasingly on dwarf evergreen shrubs and ferns in late winter.

Although most investigators state that the downward migration of goats in the fall is a response to snowfall on the high ranges that decreases the availability of food, Klein (1953) believes that the need for shelter is also of importance. In his early winter studies on Kenai, he found that the return of clear skies after a snow-storm brought a return movement to higher slopes blown free of snow. This was not found to be the case in the Port Houghton study area; the goats stayed below timber-line, in spite of several days of good weather following the snowfall.

Forage investigations during fall were done by Saunders (1955), who found that most of the plant species identified in stomachs in summer were present also in stomachs examined in the fall. He also found that forbs increased and shrubs decreased in abundance compared to the summer diet. Coniferous trees which were used most often in winter appeared first in a stomach from an animal collected about the middle of October.

From the limited studies in Port Houghton it appears that the forage composition in fall is transitive between summer and winter. Even the arrival of the first snow did not seem to change the feeding habits of goats abruptly. P. aleutica and B. spicant, both probably of high importance in the goats' winter diet, had been fed on prior to the snowfall. A gradual change in diet from summer to winter also appears logical from the standpoint of rumen physiology.

THE WINTER RANGE IN THE KENAI AND KODIAK MOUNTAINS

Winter studies were carried out on Kodiak during March 1969 and during February-March 1970, while on the Kenai they were restricted to March-April 1970.

Weather Data from the Study Period

Along the south coast of Alaska the winter of 1968/69 was colder than usual. Temperatures at Kodiak and Seward averaged 0.5 and 1.4°F below the normal, respectively, for the months November through April. In contrast, the winter of 1970 was exceptionally mild with the same temperatures averaging, respectively, 2.0 and 4.2°F above the normal (Tables 9 and 10). These differences had a pronounced influence upon the extent of the snow cover. Although precipitation during the prevailing high pressure conditions of the winter of 1968/69 was below the normal for nearly every month from November throughout April, the snow averaged 11.4 in. and covered the ground for 149 days at the weather station in Seward compared with 1.8 in. and 92 days for that station in the winter of 1969/70. The same figures for the two winters at the weather station in Kodiak were 6.7 in. and 126 days and 2.5 in. and 62 days, respectively (Tables 9 and 10).

Throughout virtually the whole winter of 1968/69 on both Kodiak and the Kenai, there was a permanent snow cover

Table 9. Weather data for Kodiak for the winters 1968/69 and 1969/70 (U. S. Weather Bureau, 1968-70)

Month	Temperature (F°)				Precipitation (in.)						Snow on Ground			
	Average		Dep. from Normal		Total		Dep. from Normal		Snow, Sleet Total		Days		Depth (in.) Average	
	68/69	69/70	68/69	69/70	68/69	69/70	68/69	69/70	68/69	69/70	68/69	69/70	68/69	69/70
November	35.6	33.3	.7	-1.6	7.34	5.96	-1.65	.27	--	3.6	--	9	--	tr
December	25.1	36.8	-4.9	6.8	2.99	12.19	-2.15	7.05	28.2	3.0	30	5	7.0	tr
January	25.9	26.2	-4.3	-4.0	.24	3.62	-4.75	-1.37	.1	20.2	31	26	2.0	3.0
February	30.3	36.0	-1.0	4.7	4.13	8.39	-1.02	3.24	32.1	22.5	28	12	13.5	4.9
March	33.8	37.8	2.1	6.1	3.89	5.96	- .09	1.98	28.9	2.7	30	4	5.1	tr
April	38.8	35.8	2.2	- .8	5.46	1.43	.95	-3.08	.5	5.2	7	6	tr	2.0
Average	31.6	34.1	- .5	2.0									6.7	2.5
Total					24.05	37.55	-8.71	8.05	89.8	57.2	126	62		

Table 10. Weather data for Seward for the winters 1968/69 and 1969/70 (U. S. Weather Bureau, 1968-70)

	Temperature (F°)				Precipitation (in.)				Snow on Ground					
	Average		Dep. from Normal		Total		Dep. from Normal		Snow, sleet Total		Days		Depth (in.) Average	
Month	68/69	69/70	68/69	69/70	68/69	69/70	68/69	69/70	68/69	69/70	68/69	69/70	68/69	69/70
November	33.0	31.1	1.8	- .1	5.44	6.25	-1.85	-1.04	9.5	5.0	14	15	2.6	1.0
December	19.9	35.3	-5.2	10.2	2.45	17.60	-3.98	11.17	24.0	20.0	31	20	6.0	2.1
January	16.7	19.2	-8.0	-5.5	.67	1.00	-5.12	-4.79	14.5	10.2	31	31	7.0	2.0
February	26.6	34.8	-1.2	7.0	4.79	8.58	- .88	2.91	33.4	5.0	28	15	12.0	2.0
March	32.7	36.9	2.1	6.3	2.12	6.78	-1.63	3.03	9.0	6.0	31	8	17.5	1.5
April	39.8	36.4	1.9	-1.5	3.76	7.85	- .66	3.43	--	6.0	14	3	4.0	4.0
Average	28.1	32.3	-1.4	4.2									11.4	1.8
Total					19.23	48.06	-14.12	14.71	90.4	52.2	149	92		

Table 11. Weather data for Cooper Lake for the winters 1968/69 and 1969/70 (U. S. Weather Bureau, 1968-70)

Month	Temperature (F°) Average		Precipitation (in.) Total		Precipitation (in.) Snow, Sleet Total		Snow on Ground Days		Snow on Ground Depth (in.) Average	
	68/69	69/70	68/69	69/70	68/69	69/70	68/69	69/70	68/69	69/70
November	31.1	27.6	2.54	5.23	12.0	6.6	22	21	4.1	3.0
December	14.3	34.0	1.52	11.78	22.2	25.5	31	19	8.8	3.0
January	6.8	12.6	.56	.46	10.0	11.0	31	31	14.0	4.0
February	19.5	33.1	1.87	3.58	28.0	8.0	28	16	23.2	6.5
March	28.0	35.7	1.00	2.18	4.5	8.0	31	1	23.5	tr
April	38.4	35.1	.46	1.61	--	1.0	20	2	14.0	1.0
Average	23.0	29.6							15.0	3.9
Total			7.95	24.84	76.7	52.9	163	90		

from sea level to the mountain tops. In March the snow depth below the alderline averaged 2-3 ft in the Hidden Basin area on Kodiak. At the cattle farm 6-7 miles from the head of the bay the situation was approaching an emergency, requiring forage to be dropped to the cattle from the air.

During the winter of 1969/70 conditions were entirely different. At lower altitudes most of the precipitation fell as rain or sleet. Throughout most of the winter there was no permanent snow cover below 300 to 800 ft on Kodiak and below 100 to 400 ft on the Kenai, depending on exposure. Also, for several hundred feet above this altitude the ground was partly free of snow.

Table 11 presents the weather data for Cooper Lake. This station is located at an altitude of 445 ft just north of the study area on Kenai. By comparing the data for Cooper Lake with those for Kodiak and Seward (Tables 9 and 10) it is evident that Cooper Lake has a more continental climate than the latter; a lower average winter temperature, lower precipitation, and a higher proportion of the precipitation falling as snow. By applying the relation between total precipitation and average snow depth for Cooper Lake, and assuming that the figures for precipitation for Kodiak and Seward also represent minimum figures for snowfall on the high alpine goat habitats in the respective study areas, a computation of approximate

snow depth in these areas is possible. This gives an average snow depth in 1968/69 of 3 and 4 ft, respectively, in the alpine habitats on Kodiak and Kenai, and 6 and 7 ft in 1969/70. Although there was less snow at low altitude in 1969/70 than in 1968/69, the reverse was the case for the high mountains.

Goat Distribution in Relation to Snow Cover

While the goats' summer range is widely dispersed, they used extremely restricted areas during the winter. Some movement between one feeding site and another takes place, but to a great extent goats appear to stay in the same area for prolonged times.

Distribution of goats on Kodiak Island during March 1969 and February-March 1970 is shown in Table 12. Areas where goats were seen for two or more consecutive days are referred to as winter habitat.

In March 1969, the goats on Kodiak were found almost entirely above timberline, at altitudes varying from 1000 to 2500 ft. They were feeding on windblown slopes and ridges and on south-facing rock outcrops (here termed the alpine habitat). During February-March 1970, on the other hand, more than 90% of the goat population occurred on subalpine habitat, feeding on alder-covered slopes generally adjacent to ravines coming down from the high country.

The Kodiak study area was not surveyed as thoroughly

Table 12. Number of goats in different habitats on Kodiak in March 1969 and in February-March 1970

Altitude (ft)		500	500 - 1200						1200 - 2000				2000 - 3000			
Habitat**		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Number of goats	1969	0	0	*	*	4	0	3	3	2	3	6	6	5	6	9	0
	1970	15	7	28	6	3	3	3	8	2	8	3	0	0	0	0	5

* Not checked
** See Figs. 1 and 2

Table 13. Number of goats in different habitats on Kenai in March 1970

Altitude (ft)	500		500 - 1000				2500
Habitat*	A	F	B	C	D	E	G
Number of goats	12	7	13	6	8	7	1

* See Fig. 3

Fig. 1. Map of the Kodiak study area

Map from U. S. Geological Survey, Kodiak (C-3), Alaska, 1952

Scale 1 inch = 1 mile

Legend:

= Summer range

= High density summer range

= Winter range, February-March 1970, letters refer to the habitat designations in Table 12

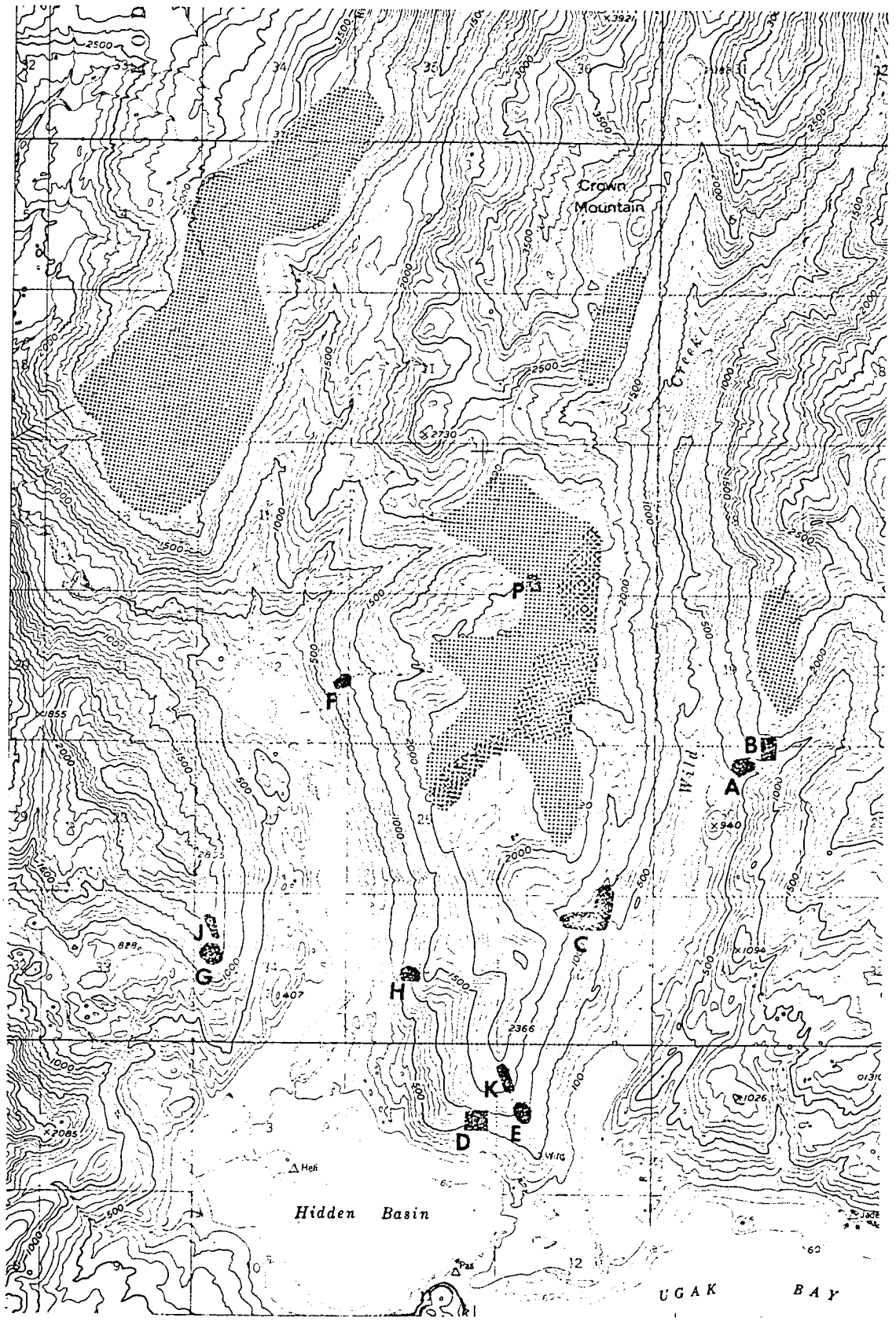


Fig. 2. Map of the Kodiak study area

Map from U. S. Geological Survey, Kodiak (C-3), Alaska, 1952

Scale 1 inch = 1 mile

Legend:

= Winter range, March 1969, letters refer to the habitat designations in Table 12

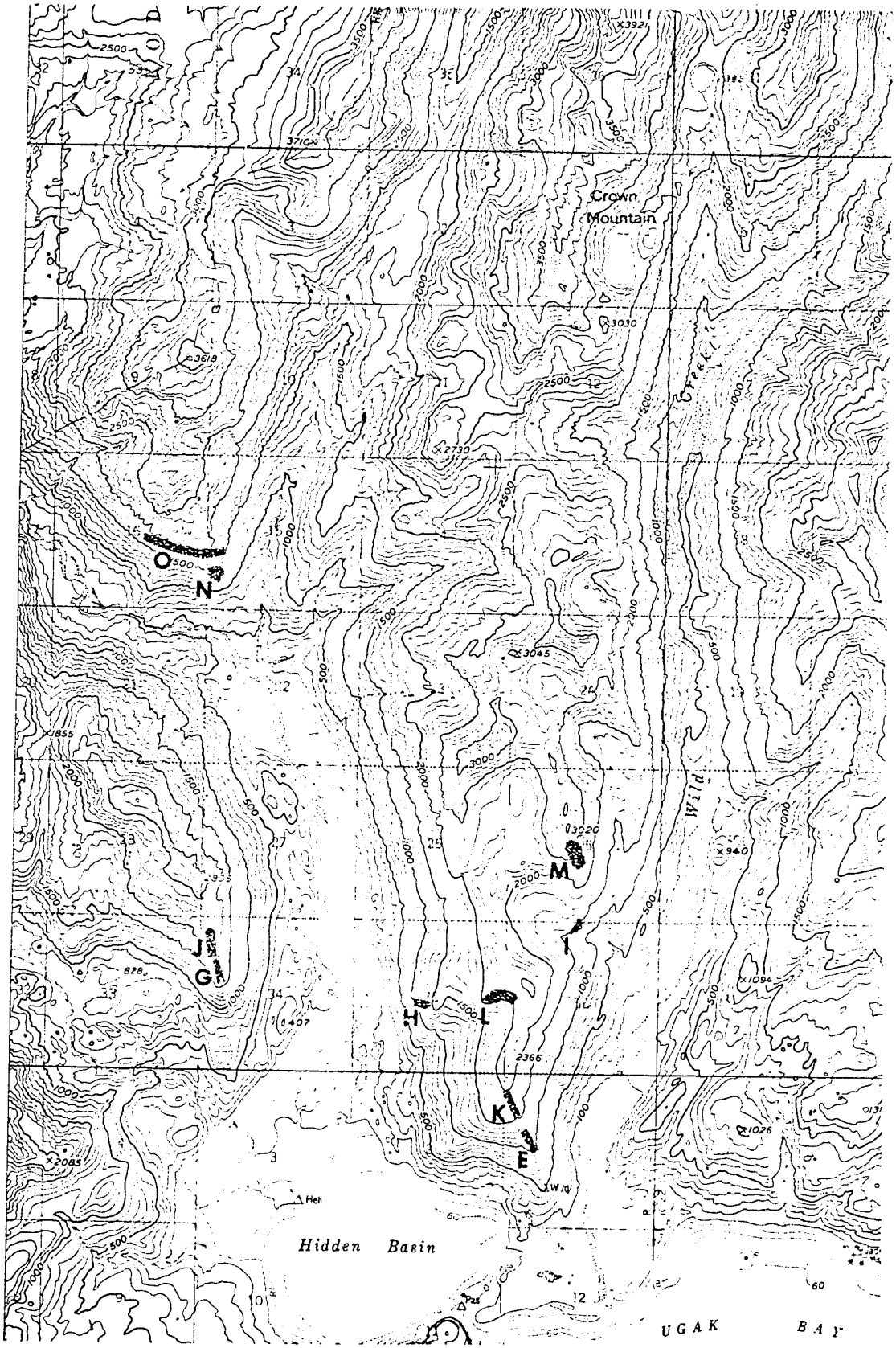


Fig. 3. Map of the Kenai study area

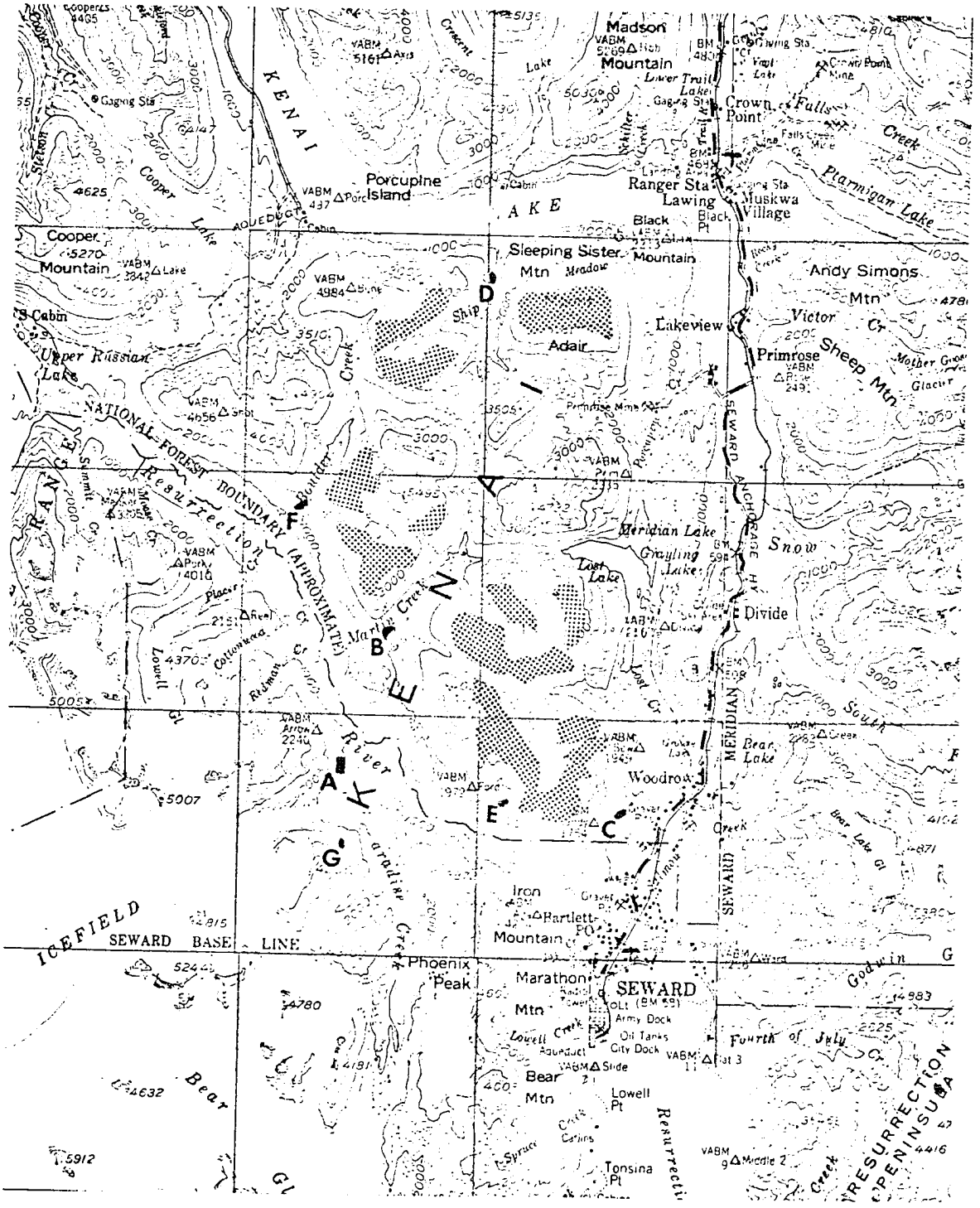
Map from U. S. Geological Survey, Seward, Alaska, 1953

Scale 1.5 inch = 5 miles

Legend:

 = Summer range

 = Winter range, March 1970, letters refer to the habitat designations in Table 13



in 1969 as in 1970. Subalpine habitat C which supported the largest number of animals in 1970 was not checked in 1969; it seems unlikely that these habitats could support appreciable numbers of animals under such conditions. The lack of animals at habitats A and B which offered similar conditions supports this conclusion.

Although considerably more time was spent in the study area in 1970, very few animals were spotted above timberline. Most striking was the absence of animals from alpine habitats L, M, N, and O, which in 1970 were blown partly free of snow, although the snow free areas were considerably smaller that year than in 1969. Apparently the subalpine habitat was more attractive to goats in 1969/70. The animals were also dispersed over a larger area in 1969. This appears logical as a result of the lower carrying capacity of the barren alpine ridges and rock outcrops compared to the subalpine slopes. This will be dealt with in more detail in later chapters.

Goat distribution on the Kenai in March 1970 was found to be similar to that on Kodiak (Table 13), but goats on Kenai seemed to be even more restricted to the subalpine habitat. In areas below the alder line, goats on Kenai also preferred canyons and ravines eroded by mountain streams. The only exception is habitat A which is made up of several steep and broken rock walls facing the main valley.

Forage Utilization on the Winter Ranges

The alpine habitat on Kodiak in March 1969:

Depending upon altitude and topography the utilized feeding sites are divided into the following types: 1) windblown south-facing ridges just above timberline; 2) the same ridges higher up and more exposed; 3) extremely exposed narrow ridges at high altitudes; and 4) south-facing rock outcrops at 1500 to 2000 ft. Time was insufficient to determine the relative importance of each type, but approximate figures for forage utilization are listed in Table 14. Summer analyses of vegetation composition of feeding sites are presented in Tables A 24 through A 28.

Type 1 is represented by habitat G, N, and E in Fig. 2 (see also Fig. 10). Goats descended to these slopes to feed during the daytime and returned to rock outcrops to bed down at night. The vegetation on these ocean-facing slopes on Kodiak is very rich. A summer analysis of habitat G and N is shown in Table A 24. Forbs such as *Geranium erianthum*, *Angelica lucida*, and *Sanguisorba stipulata* are dominant with grasses and sedges comprising less than 10% of the total coverage.

In mid-March the area of the elevated tussocks in Type 1 was free of snow, while there was still snow on the main part of the ridges. The snow-free area was covered with a thick layer of dry forbs, sedges, and

ferns. This old vegetation was flattened to the ground by snow and wind pressure, and apparently was not touched by the goats. Only one species, the bunch grass Festuca altaica, had maintained an upright stature on the ridge throughout the winter. This species covered 15-35% of the exposed area and was 95-100% utilized by the goats, which left only 1/2 in. stalks above the ground (Fig. 11, Table 14). No positive evidence of feeding on other plants was found. F. altaica constitutes only 3% and 6% of the plant coverage in the two vegetation analyses from this Type (Table A 24). In other words, the majority of the plant species on these ranges are not utilized by goats as winter forage.

Type 2 is represented by habitat J, K, and M in Fig. 2. Analyses of the summer vegetation on ranges J and K are shown in Table A 25. With increasing altitude there is a decrease in soil depth and a decrease in the richness of the vegetation from Type 1. Tall-growing forbs either disappear or acquire a dwarfed, prostrate growth form. Grasses, mainly F. altaica and sedges, tend to retain their abundance. Due to a more broken relief and severe exposure, more ground is generally free of snow in this type.

Type 3 is represented by the ridges near the summits. Since southwest winds prevail on Kodiak, large snowdrifts build up at high altitude on the eastward (leeward side) of the narrow ridges. As snow accumulates throughout the

Table 14. Usage of the alpine winter range by mountain goats on Kodiak

Species	Type No. 1 Coverage	1 Coverage Removed	1 Tissue Removed	2 Coverage	2 Coverage Removed	2 Tissue Removed	3 Coverage	3 Coverage Removed	3 Tissue Removed	4 Coverage	4 Coverage Removed	4 Tissue Removed
Festuca altaica	3	98	80	3	95	80	1	60	70	3	95	90
Carex circinnata	--	--	--	1	70	65	3	35	40	10	60	45
Potentilla villosa	--	--	--	--	--	--	--	--	--	2	80	90
Festuca ovina	--	--	--	1	5	60	--	--	--	--	--	--
Carex microchaeta	--	--	--	3	15	20	3	10	25	--	--	--
Salix sp.	--	--	--	2	10	15	--	--	--	--	--	--

winter, these drifts tend to stretch toward the windward side of the mountain, leaving few sites free of snow. The bulk of the vegetation is made up of bryophytes and lichens. Carex circinnata and C. microchaeta dominate among higher plants and F. altaica is found in sheltered spots (Table A 26). Snow accumulation together with sparse plant growth decrease the importance of this type as a goat range. Goats rarely stay within this type for any length of time, but use the ridges extensively when traveling.

Type 4 is represented by habitat L and O in Fig. 2 (see also Fig. 7). The rock outcrop habitat possesses a variety of growth sites for plants, ranging from those with extreme exposure to protected and sheltered ledges with a fairly deep soil. Therefore, in spite of the high altitude, a variety of plant species is found in this habitat. As is seen from the results of the vegetation analyses in Table A 27, grass-like plants dominate with C. circinnata and C. microchaeta as the most prominent. Forage selection by goats in this habitat, as in the previous ones, appears rather limited in variety (Table 14). With the exception of C. circinnata and F. altaica, the majority of the vegetation was pressed flat to the ground and showed little use by goats.

On all ranges combined, the plant species showing heaviest accumulative feeding signs were F. altaica and C. circinnata. These species show striking similarities

in that both have a considerable amount of green tissue during winter (Table 18). Also, they both possess narrow, springy stems and stiff, filiform, folded leaves, which enable them to withstand the snow pressure and maintain an upright position throughout the winter. F. altaica grows on elevated tussocks while C. circinnata frequently is found along the fringe of ledges and in narrow cracks of rock outcrops. Besides becoming free of snow early in spring, protruding ledges and tussocks also leave the plants more easily accessible to the goats when snow covers the ground.

The subalpine habitat:

As explained earlier, goats were found almost entirely below the alderline in the winter of 1970. In several instances they were seen feeding on the lower part of the slopes close to the valley bottom, and the highest concentration of animals appeared to be between 400 and 800 ft on both Kodiak and Kenai (Tables 12 and 13). As is evident from Figs. 1, 2, and 3, broken, rocky escape terrain on the subalpine habitat is usually provided by river canyons. During the day goats fed on the slopes adjacent to the canyon; then each night they bedded down either on the brink of the canyon or on a sheltered spot in the rock wall itself. Almost without exception these places offered security from predators because they provided a good view

of the surrounding terrain and were difficult to approach. Judging from the accumulation of pellets, the bedding grounds had been used throughout most of the winter. When seriously disturbed, when shot at, or when the observer stayed near their habitat for the greater part of the day, the goats would retreat to the highest peaks of the alpine country above. Usually, by the following morning they would again have descended to the alder slopes.

The subalpine habitats on Kodiak and Kenai belong to the same vegetation type. The tree cover consists of semi-arboreal alder, 5 to 8 inches in diameter and 14 to 17 ft high on the lower slopes, diminishing in height with increasing altitude. At its altitudinal limit alder becomes a prostrate dwarf shrub. The ground cover of the alder slopes is relatively homogenous. The dominant species are Athyrium filix-femina and Calamagrostis canadensis. Two transect lines from the valley bottom to timberline on the west side of Box Canyon on Kenai (habitat C) showed a combined coverage of 65% for the two species. In dense alder stands A. filix-femina is often the only species present with a ground cover of almost 100%. In the more open alder stands C. canadensis and several species of forbs and shrubs will move in. Of the shrubs, Sambucus racemosa is the most dominant, and on dryer spots

Fig. 6. Winter range in the Kenai Mountains. Arrows indicate subalpine habitats A and F (April 4, 1970).

Fig. 7. Winter range in the Crown Mountains, Kodiak Island, alpine habitat L (March 20, 1969)

Fig. 8. Winter range in the Crown Mountains, Kodiak Island, subalpine habitat C. Picture taken in early May; in mid-February the snow line was approximately 200 ft lower on the slopes (1970).

Fig. 9. Rhizomes of Athyrium filix-femina eaten by mountain goats, subalpine habitat C, Kodiak (March 13, 1970)

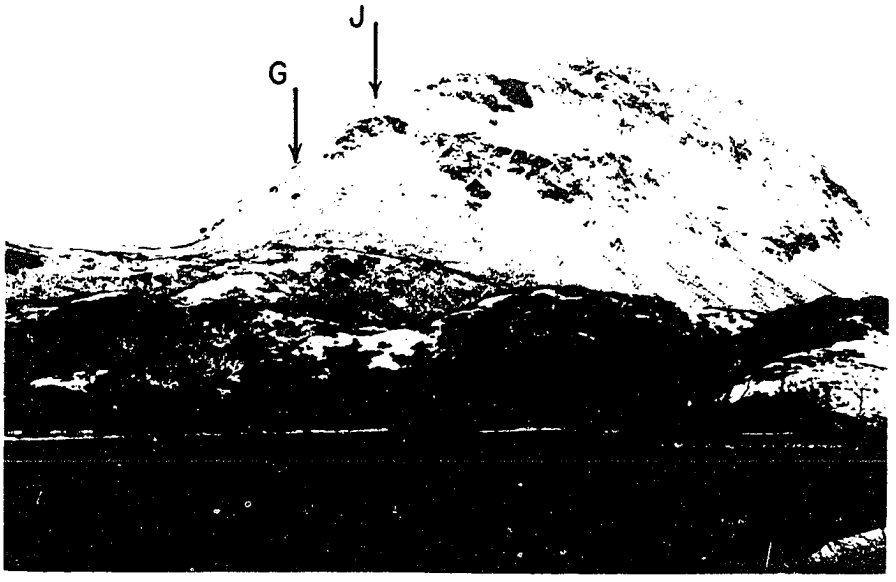


Fig. 10. Winter range, Hidden Basin, Kodiak Island. Arrows indicate alpine habitats G and J (March 18, 1969).

Fig. 11. Festuca altaica eaten by mountain goats, alpine habitat J, Kodiak

with sparse soil Menziesia ferruginea, Ribes triste, Rubus pedatus, R. idaeus, and R. spectabilis occur frequently. Common forbs are Streptopus amplexifolius, Aruncus sylvester, Tiarella trifoliata, Cornus canadensis, and Trientalis europaea. Gymnocarpium dryopteris is found almost everywhere; its small size and fine structure, however, give it a low coverage of three to four per cent. Thelypteris phegopteris is also commonly found but not as frequently as G. dryopteris.

In late winter most of the ferns, other forbs, and grasses are pressed flat to the ground by snow; winter erect species, mainly bunch grasses, are not found on this habitat.

Preliminary studies of the forage utilization on these subalpine goat habitats revealed interesting results. The goats appeared to eat mainly rhizomes of A. filix-femina, digging down through the litter and chopping off approximately one-third of the upper enlarged part of the rhizomes. An ocular survey of these ranges showed few signs of feeding in addition to those on rhizomes; and only some light browsing was recorded on Sambucus racemosa, Rubus spectabilis, and Ribes laxiflorum.

In order to quantify the forage utilization, three animals on Kodiak and two on Kenai were observed through a 20 X spotting scope, and the vegetation fed upon was recorded in two minute intervals. As the different species

of the ground cover could not be distinguished through the scope, feeding on the ground was recorded simply as "ground feeding." The results are presented in Table 15.

A visual inspection of the feeding sites revealed that the majority of the ground feeding had been done on the rhizomes of A. filix-femina (Fig. 9). In fact, no feeding could be said with certainty to have occurred on other species. However, while feeding signs on the principal forage species on the winter range can be readily detected and measured (Fig. 11), random feeding on less preferred species may pass unnoticed. It is often impossible to say whether a single dry grass has been cropped by goats or broken off by snow and wind pressures. Therefore, to verify the ocular estimation of forage utilization on the winter range, three animals were killed and their rumen contents analyzed (Table 16). The animals were collected on subalpine habitats A, B, and E on Kenai in March 1970.

As is evident from Table 16, the results from the rumen analyses support the field observations. The amount of gramineae, for example, is so insignificant that it most likely has been eaten accidentally. Apparently, therefore, the major food item of the goats in the two study areas during the winter of 1970 was rhizomes and petioles of A. filix-femina. Although the habitat below alderline probably had been used through the greater part

Table 15. Per cent time devoted to "ground feeding" and browsing by mountain goats on subalpine habitat, Kodiak and Kenai, February-March 1970

Location	Animal no.	Ground feeding	Browsing		
			Sambucus racemosa	*Rubus spectabilis*	*Ribes laxiflorum*
Kodiak	1	95	--	5	--
"	2	90	5	5	--
Kenai	1	65	25	--	10
"	2	100	--	--	--
"	3	100	--	--	--

Table 16. Species composition of three mountain goat stomach samples collected on subalpine habitats on Kenai in March 1970 (per cent of dry weight)

Plant species	Samples 1	2	3
Athyrium felix-femina (rhizomes and petioles)	91	94	60
Ribes laxiflorum	7	5	17
Sambucus racemosa	tr	tr	13
Gramineae	1	1	tr
Saxifraga tricuspidata	--	tr	2
Tsuga Mertensiana	tr	tr	4
Rubus pedatus	tr	tr	--
Alnus rubra	--	--	tr
Bryophyta	tr	tr	tr
Lichens	tr	tr	tr

tr: traces

of the winter, accumulative use of the range appeared to be relatively light. On Kodiak the average number of rhizomes on 1 meter square plots in habitat E was 2.6; utilization of these by goats was 35 per cent. The figure for utilization is probably lower as the rhizomes were covered by a layer of old vegetation and therefore difficult to find.

The accumulative use of fern rhizomes was greatest under the down-bent alders, due to the influence of these upon snow depth. On level ground alders possess a straight upright growth form, while the branches and stems of the shrubs on the slopes are more or less bowlike and bend under the snow pressure. The lower half of each alder plant, sometimes the entire shrub, will bend down the slope parallel to the ground. Furthermore, alders grow in bunches of equal sized stems, spreading out laterally from a common root. This growth form acts as a collecting surface for the snow, causing less accumulation under the stems, and the goats will search out these spots for fern rhizomes. As viewed from the air goat trails can be seen leading from one alder to another. However, during a winter when abnormally deep and crusted snow covers the slopes, as was the case in March 1969, forage in such areas is unavailable to the goats.

While there are no coniferous trees in the study area on Kodiak, the slopes on Kenai are partly covered

with mountain hemlock and to a lesser extent with Sitka spruce. These conifers have a still greater effect than the alder in decreasing the snow depth on the ground. However, the vegetation under hemlock and Sitka spruce on Kenai is sparse. Due to competition for nutrients and light the growth of both grasses and ferns is poor. Rubus pedatus is one of the few higher plants commonly found on these sites, but in spite of having green leaves in winter it is not used by the goats. Important forage plants on similar habitats in the Port Houghton area, such as Phyllodoce aleutica and Blechnum spicant, are not recorded under coniferous trees on Kenai. Snow free ground under coniferous trees might be of some importance to the goats early in the winter on Kenai, but its ability to offer sustained forage is believed to be limited.

Observations in the Alpine Habitats in February-March 1970

On Kodiak only two habitats above timberline, J-G and E-K were regularly visited by goats during the study period. While only a nanny and her two kids were observed on habitats J-G in 1969, a total of eight animals used this same area in February-March 1970. This apparently reflected a greater carrying capacity of the range in 1970. Besides utilizing Festuca altaica on the ridge to the same extent as in 1969, the goats also descended to the upper fringe of the alder zone where they foraged on

fern rhizomes.

For two days five adult goats stayed at habitat P. This range belongs to the high alpine ridge type and the animals were feeding on Festuca altaica. As the ridge was completely snow covered, the goats had to paw away the snow to reach the forage. This observation together with the snow-pawing in the Port Houghton area are the only records of such behavior during the entire study.

Tracks along the ridges were less common during the winter of 1970 than during the winter of 1969, and only light feeding had occurred on Carex circinnata, C. microchaeta, and Festuca altaica at high altitudes. The rock outcrop habitat L, which was heavily utilized by goats during the winter of 1969, showed no feeding signs in March 1970.

On Kenai only one feeding site above timberline indicated prolonged use. One adult male goat was feeding on the wind-blown south-facing slope of a small ridge at 2500 ft. The utilized vegetation was an evergreen, dwarf shrub society dominated by Empetrum nigrum, Phyllodoce aleutica, Lycopodium alpinum, Arctostaphylos alpina, Loiseleuria procumbens, Luetkea pectinata, and Arctostaphylos uva-ursi, and including a sparse growth of Salix sp. Utilization, measured as per cent coverage removed, was P. aleutica 24%, L. pectinata 16%, and Salix sp. 10%.

Probably because of greater distances between the

winter habitats on Kenai, goats appeared to travel less there than was the case on Kodiak. Tracks leading from the lower slopes to high peaks, however, indicated that the animals made periodic visits to the high country now and then throughout the winter. F. altaica and C. microchaeta showed limited use along the ridges.

F. altaica slopes, similar to those of Type 1 on Kodiak, are also found on Kenai although they are less common there. Feeding was not noted on these gentle slopes in the winter of 1970, possibly because of their remoteness from rocky refuge areas. Data collected during the vegetation analysis in the early summer of 1969, however, suggested that they had been rather heavily utilized during the preceding winter. This was probably a consequence of snow conditions being similar to those on Kodiak, thus forcing the animals to use the wind-blown ridges.

Vegetation studies from the high alpine ridges on Kenai are presented in Table A 28. As is seen Carex circinnata is absent from these analyses. This important forage species is not recorded in other parts of the Kenai study area, and, as no other forage species seems to replace it on Kenai, this obviously will lower the range value of the high alpine habitats compared to Kodiak.

Nutritional Value of the Forage on the Winter Range

Samples of F. altaica, C. circinnata, C. microchaeta,

and rhizomes of Athyrium filix-femina from the winter range on Kodiak were analyzed for content of protein, fat, crude fiber, ash, and nitrogen-free extract. The dry and green leaves were analyzed separately for the two species C. circinnata and F. altaica (Table 17).

The green plant tissue is high in protein content and low in crude fiber, a condition associated with high forage value. The per cent of protein in the winter green tissue is approximately the same as that found by Klein (1953) for summer growth of C. microchaeta and Artemisia arctica collected on goat ranges on Kenai. The rhizomes of A. filix-femina are rich in nitrogen-free extract and low in crude fiber, as is to be expected in a storage organ.

Both F. altaica and C. circinnata possess considerable amounts of winter green tissue during winter. In F. altaica, the live material is found inside the cylinder formed by the basal sheaths and old leaves. C. circinnata retains the green leaves from summer throughout fall and winter. The tips of the leaves and the outer fringe of the tussocks are killed either by desiccation or by low temperature directly, but the leaves toward the center of the tussocks remain green throughout the winter. Therefore, although appearing dry and lifeless in late winter, these species actually contain a significant amount of green tissue (Table 18).

Table 17. Chemical composition of eight mountain goat forages; samples collected in mid-February on Kodiak (per cent composition, dry weight, 105°C)

Species	Protein % N x 6.25	Fat Petroleum Ether Extract	Crude Fiber %	Ash %	Kilogram Calories 100 grams	Nitrogen Free Extract %
Festuca altaica						
Dry leaves	2.9	0.9	36.7	5.2	407	54.3
" "	3.3	2.0	33.8	4.9	421	56.0
" "	4.3	0.9	34.5	5.6	410	54.7
Green leaves	14.1	1.8	27.8	5.2	423	51.1
Carex microchaeta						
Dry leaves	4.5	1.9	30.1	7.2	420	56.3
Carex circinnata						
Dry leaves	3.5	1.9	23.1	6.2	---	65.3
Green leaves	16.3	2.8	18.7	3.5	---	58.7
Athyrium felix-femina						
Green rhizomes	14.5	3.8	9.1	2.5	445	70.1

Table 18. Weight estimates of principal forage species on three winter ranges on Kodiak; figures in g/m^2 and dry weight at 85°C

	Habitat G		Habitat L		Habitat C	
Species	Coverage	g/m^2	Coverage	g/m^2	No. roots/m^2	g/m^2*
Athyrium filix-femina						
Rhizomes	--	--	--	--	2.6	20
Festuca altaica	3	--	5	--	--	--
Dry leaves	--	8.2	--	6.0	--	--
Green leaves	--	.7	--	.5	--	--
Carex circinnata	--	--	10	--	--	--
Dry leaves	--	--	--	4.5	--	--
Green leaves	--	--	--	1.2	--	--
Carex microchaeta	--	--	7	--	--	--
Dry leaves	--	--	--	3.0	--	--

* 1/3 of each rhizome available to the goats
Coverage according to vegetation analysis

The humid and mild winters on Kodiak would appear to foster degradation of dry exposed vegetation and consequently reduction of its forage value. However, both the percentage of nitrogen-free extract (mainly sugar, starch, and hemi-cellulose) and the caloric content of the dry leaves indicate that total energy is similar to that of green plants (Table 16). Therefore, in spite of the maritime climate on Kodiak, the winter temperatures are apparently too low for fungal and bacterial decomposition of the dead vegetation.

Changes in the digestibility of the plants associated with higher percentages of crude fiber apparently occurs with maturity. The decrease in protein may be attributed to an increase in fiber content and nitrogen-free extract as well as a redistribution of protein throughout the plant with senescence (Pate, 1967). The carrying capacity of big game ranges depends on both quality and quantity of the forage. Therefore, the most accurate way of determining range value would be to compute the amounts of available nutrients per unit of land. An example is shown in Tables 18 and 19 for three winter ranges on Kodiak: the ridge habitat (G), the rock outcrop habitat (L), and the subalpine habitat. Due to the small sample sizes and inherent variability the figures should be interpreted with caution. Rather than emphasizing exact values, attention should be directed towards the trends expressed

Table 19. Approximate nutrient value in g/m^2 for principal forage species on three winter ranges on Kodiak

Species	Habitat G			Habitat L			Habitat C		
	Protein	Fat	NFE	Protein	Fat	NFE	Protein	Fat	NFE
Athyrium filix-femina									
Rhizomes	--	--	--	--	--	--	2.9	.8	14.0
Festuca altaica									
Dry leaves	.3	.2	4.5	.2	.1	3.3	--	--	--
Green leaves	.1	--	.4	.1	--	.3	--	--	--
Carex circinnata									
Dry leaves	--	--	--	.2	.1	2.9	--	--	--
Green leaves	--	--	--	.2	--	.7	--	--	--
Carex microchaeta									
Dry leaves	--	--	--	.1	--	1.7	--	--	--
Total	.4	.2	4.9	.8	.2	8.9	2.9	.8	14.0*

NFE: nitrogen free extract
* the habitat also offers a significant amount of browse

by gross differences between the values. The weight estimates are based upon the species coverage from the vegetation analysis. Corresponding to the estimated coverage by each species, samples were collected. For a period of 20 hours samples were oven dried at 85°C, then weighed on a Mettler analytical balance to the nearest tenth of a gram. By multiplying the figures in Tables 17 and 18 one will arrive at an approximate value for nutrients per square meter (Table 19).

Besides offering the greatest amount of nutrients per square meter, the subalpine habitat also extends over the largest area. In view of the relatively small goat population its forage is virtually inexhaustible. The degree of utilization depends upon how far the animals venture from the steep broken ravines. In spite of the fact that habitat L also possesses a relatively large amount of nutrients per square meter, it belongs to the high altitude rock outcrop type and is rather limited in extent. The growth area is restricted to narrow ledges and cracks in the rock and the range will only support a limited number of animals for a limited time.

Although the leaves of F. altaica and C. circinnata which remain green in winter comprise only a small part of the total tussock (Table 18), they add significant amounts of protein to the diet. This contribution is of particular importance in late winter and early spring

when the increased growth rate and reproductive demand of goats put greater requirements on nutritional quality.

Most investigators agree that mountain goat winter range usually is located where snow cover is sparse or absent and the general requirement for broken, refuge terrain can be met. In most areas, the winter range is located in the same mountain complex as, but at lower altitude than, the summer range (Anderson, 1940; Holroyd, 1967; Brandborg, 1955; Klein, 1953). In some areas, however, goats appear to use the high windswept ridges and rock outcrops extensively. Lentfer (1955), on the basis of studies in Montana, states that goats present in areas of deep snow during the winter were located at higher elevations than during the summer. In Montana, Casebeer (1948) found that in winter a majority of the goat population remained on the same ranges that were used in summer and took advantage of the exposed vegetation on the bald, windswept ridges. In northern British Columbia, Geist (1962) reported that goats stayed on the same mountain and at the same elevation throughout the year.

Table 19 shows some quantitative data related to feeding habits of goats on ranges in different parts of North America. Other data which have not been quantified are those of Geist (1962) who states that alpine fir (Abies lasiocarpa) formed the major "filler" of the rumen, and was important as a food source on the winter ranges

in northern British Columbia. Another record of significant feeding on conifers (Saunders, 1955; Table 20) also involves alpine fir. Cowan (1944), from his observations in Banff and Jasper National Parks, rates balsam fir (Abies balsamea, Sargent) as being of high palatability during winter. Brandborg (1955), on the other hand, on the basis of stomach samples from animals found dead on winter ranges in Idaho, states that alpine fir and white bark pine (Pinus albicaulis, Munz) are apparently used as emergency forage in this area. He also believes that these species are important sources of food on many high wintering areas.

Hanson (1950), investigating the mountain goats in the Black Hills of Idaho, reported that Arctostaphylos uva-ursi, although not eaten when the ground was snow free, was readily pawed out and eaten after the first snowfall. Throughout the winter, this plant constituted a staple food item in the daily diet. He also stated that the importance of arboreal lichens was striking both from the standpoint of preference and the quantity eaten.

Grasses and grass-like plants appear to form the bulk of the goats' winter diet in most areas, but the animal also utilizes a wide spectrum of other plant categories.

Geist (1962), commenting upon differences in adaption between mountain goats and mountain sheep, suggested that the plasticity of mountain goat food habits is a

Table 20. Forage utilization in per cent by mountain goats on various winter ranges in North America (approximate values)

Investigator		Location	Forage utilization, per cent: Sedges, grasses, and rushes	Herbs	Ferns	Conif. trees	Decid. trees	Winter green shrubs
Saunders	1955	Montana	59	10	--	30	1	--
Hibbs	1967	Colorado	88	--	--	--	12	--
Anderson	1940	Washington	90*	--	--	1	6	3
Casebeer	1948	Montana	63	2	--	--	35	--
Brandenborg	1955	Idaho	54	--	--	--	42	4
Klein	1953**	Alaska	13	--	72	1	--	14
	Alp. hab.***		98	2	--	--	--	--
This study		Alaska						
	Subalp. habitat		--	--	90	--	10	--

* Referring to a winter with sparse snow cover. When bunch grasses are not available due to deep snow, Anderson states that goats are exclusively browsers.

** From analyses of rumen samples of two animals killed by snow slides. From field investigations Klein concludes that bearberry, grasses, and several species of browse are also used to some extent.

***Data from the single alpine range on Kenai indicate that the animals may utilize dwarf evergreen shrubs such as Phyllodoce glanduliflora and Luetkea pectinata.

compensation for disadvantages related to its narrow habitat preference.

SPRING INVESTIGATIONS

In May, the principal goat ranges on both Kodiak and Kenai are the lower alder slopes. These ranges are identical in location with the subalpine winter habitats, but as the season progresses the animals become more dispersed and show an increasing tendency toward upward migration.

Throughout late April and early May foraging on the lower slopes changes gradually from primarily fern rhizomes and browse to the new growth of grasses, ferns, and other herbs. Tables 21 and 22 show utilization and species composition of the first growth on Kenai and Kodiak, respectively. The data were recorded in mid-May.

As seen from Tables 21 and 22, Calamagrostis canadensis, which is not used in other seasons, is the principal forage plant in the subalpine spring habitat. Also, the very young leaves of Athyrium filix-femina are eaten to some extent, while forbs and the first shoots of browse are only slightly utilized and not intensively grazed in any spot.

The ridges just above timberline (described as Type 1 under winter range) are also regularly used throughout spring. Goats feed here on the rapidly growing F. altaica as well as on the same forbs utilized at lower altitudes.

In mid-May, when there is relatively lush and abun-

Table 21. Sample of spring range, Kenai Peninsula

Species		Feeding site 1	2	3	Accumulative utilization C x CR
Calamagrostis canadensis					178.2
	C	3.7	0.1	0.4	
	CR	45	52	55	
	TR	57	45	43	
Athyrium filix-femina					88.9
	C	0.1	1.5	0.7	
	CR	25	52	12	
	TR	50	70	10	
Sambucus racemosa					60.0
	C	2.4	--	--	
	CR	25	--	--	
	TR	70	--	--	
Veratrum viride					11.5
	C	--	2.3	--	
	CR	--	5	--	
	TR	--	5	--	
Heuchera glabra					3.0
	C	--	0.1	0.1	
	CR	--	20	10	
	TR	--	5	30	
Angelica lucida					2.5
	C	0.5	--	--	
	CR	5	--	--	
	TR	15	--	--	
Thelypteris phegopteris					--
	C	0.1	0.1	0.1	
	CR	0	0	0	
	TR	--	--	--	
Gymnocarpium dryopteris					--
	C	--	0.1	0.1	
	CR	--	0	0	
	TR	--	--	--	

C: coverage, per cent
CR: coverage removed, per cent
TR: tissue removed, per cent

Table 22. Sample of spring range, Hidden Basin, Kodiak

Species		Feeding site 1	2	3	4	Accumulative utilization C x CR
Calamagrostis canadensis						275.0
	C	5.5	4.0	1.0	2.1	
	CR	15	25	40	25	
	TR	25	30	30	15	
Athyrium filix-femina						115.0
	C	1.0	1.5	5.5	2.0	
	CR	5	5	15	10	
	TR	10	15	5	10	
Angelica lucida						62.5
	C	0.5	--	--	4.0	
	CR	5	--	--	15	
	TR	15	--	--	15	
Sambucus racemosa						37.5
	C	1.5	--	--	--	
	CR	25	--	--	--	
	TR	40				
Veratrum viride						25.0
	C	4.5	--	--	5.0	
	CR	0	--	--	5	
	TR	--	--	--	10	
Heracleum lanatum	C	0.5	2.3	--	3.5	10.2
	CR	2	4	--	0	
	TR	10	10	--	--	
Streptopus amplexifolius						5.0
	C	2.0	1.0	1.0	1.0	
	CR	0	0	5	0	
	TR	--	--	10	--	
Cochlearia officinalis						--
	C	1.0	2.0	--	--	
	CR	0	0	--	--	
	TR	--	--	--	--	
Fritillaria sp.						--
	C	--	2.0	--	1.5	
	CR	--	0	--	0	
	TR	--	--	--	--	
Epilobium angustifolium						--
	C	0.5	--	--	--	
	CR	0	--	--	--	
	TR	--	--	--	--	

C: coverage, per cent
CR: coverage removed, per cent
TR: tissue removed, per cent

dant growth on the lower alder slopes, growth of new vegetation on the high windblown ridges and rock outcrops has not yet started. Still the goats are spotted in increasing numbers above timberline by this time. They travel extensively, along barren ridges as well as over large continuous snow fields. As the vegetation on the alpine habitat appears poor both in quality and quantity at this time of year, this early migration appears to be more the result of their affinity for the high, rough terrain rather than a search for better forage. As a rule goats do not remain at high elevations during these early days of spring but return frequently to the habitats at lower altitude.

The permanent shift to the alpine summer habitat takes place towards the end of May and in the early part of June. By this time, the larger part of the summer range is still covered with snow, and only ridges and south-facing rock outcrops can offer the goats a limited amount of new vegetation.

On the high ridges in spring the goats select the first growth of the same plants that are preferred later in summer. But also a winter forage plant like F. altaica already in an advanced state of growth is still heavily grazed at high altitudes. Later in summer no feeding is recorded on this species.

Most investigators agree upon the importance of grasses and forbs in the goats' spring diet. On the basis

of studies in Idaho, Brandborg (1955) states that in April and early May, goats move lower than at any time throughout the winter. He found that they descend the slopes for the new growth of forbs and grasses. In Washington, where goats generally browse more than they graze, various grasses are important in spring (Anderson, 1940). In South Dakota, where browse and lichens form a major part of the yearly diet of the goats, grasses are heavily utilized in spring (Hanson, 1950). In May, Klein (1953) observed goats feeding almost exclusively on the new growth of Artemisia arctica. The coiled fronds of ferns, Athyrium spp., were eaten to a lesser extent. Therefore, in spite of variability in the pattern of seasonal feeding habits, the goats appear to be primarily grazers in spring.

POPULATION DYNAMICS

The Physiography of Habitat as a Factor in Controlling Population Size

There are no records of mountain goats ever having exceeded the carrying capacity of their range. Brandborg (1955) showed in a literature survey that mountain goats exhibit low rates of increase and have stable populations on most of the ranges where they have been studied. The mountain goat study in Washington cited earlier (Anderson, 1940) was initiated because of dissatisfaction with the rate of increase in the goat population during 15 years of complete hunting closure; Anderson states (Ibid., 1):

> The first step is to study the life history of the animals, and the knowledge so derived is to be used in proceeding step by step on the basis of known facts to the final solution of the unknown limiting factors which are influencing any notable increase of the mountain goat population in this state.

As mentioned previously, mountain goats were introduced to Kodiak Island during 1952 and 1953. The transplanted stock consisted of seven males and eleven females. The population has increased relatively slowly. The average yearly rate of increase during the 18 years since introduction has been 9%, and today the herd probably numbers around 100 animals and has not spread out from the original site of introduction. Reproductive success, however, has been good with kid/adult ratios in late

summer averaging 57% for the years 1962 through 1968 (Table 23). Assuming a sex ratio of 75/100 in favor of females (Hibbs, 1966) and a certain number of sexually immature females in the population, this would mean close to one kid for every fecund female. According to field notes, one out of ten females with kids had twins in the summer of 1969, but the frequency of twins may have been greater in earlier years as there are reasons to believe that the goats reproduced poorly in 1969 (see following chapter).

In Fig. 12 the actual rate of increase of the goat herd introduced to Kodiak Island is compared to potential rate of increase. The computation of potential rate of increase is based on the following assumptions:

1. Four males and five females of the introduced stock survived to reproduce.

2. Starting with the second year after introduction, one male and one female of the original stock died each year.

3. Females bear their first young at three years of age.

4. Every fecund female has one kid every year.

5. The adult sex ratio was 75/100 in favor of females.

6. The animals die at an age of eight years.

As is seen from Fig. 12 there is considerable differ-

Table 23. Population levels and kid/adult ratios of mountain goats introduced to Kodiak Island as 7 males and 11 females during 1952 and 1953. The figures are based on aerial counts conducted in late summer by Alaska Department of Fish and Game personnel.

	Number of animals			
Year*	Adult	Kid	Total	Kid/Adult x 100
1956	--	--	5	--
1957	2	2	4	--
1958	4	2	6	--
1959	--	--	7	--
1962	14	8	22	57
1963	18	8	26	44
1964	13	13	26	100
1965	22	13	35	60
1966	38	16	54	42
1967	39	19	58	48
August 1968	31	16	47	51
December 1968	57	14	71	24
1969	73	15	88	20
1970**	61	20	81	33

* Data for the years 1954, 1955, 1960, and 1961 are lacking.
**Number of goats was probably under-estimated in 1970 because of unfavorable counting conditions.

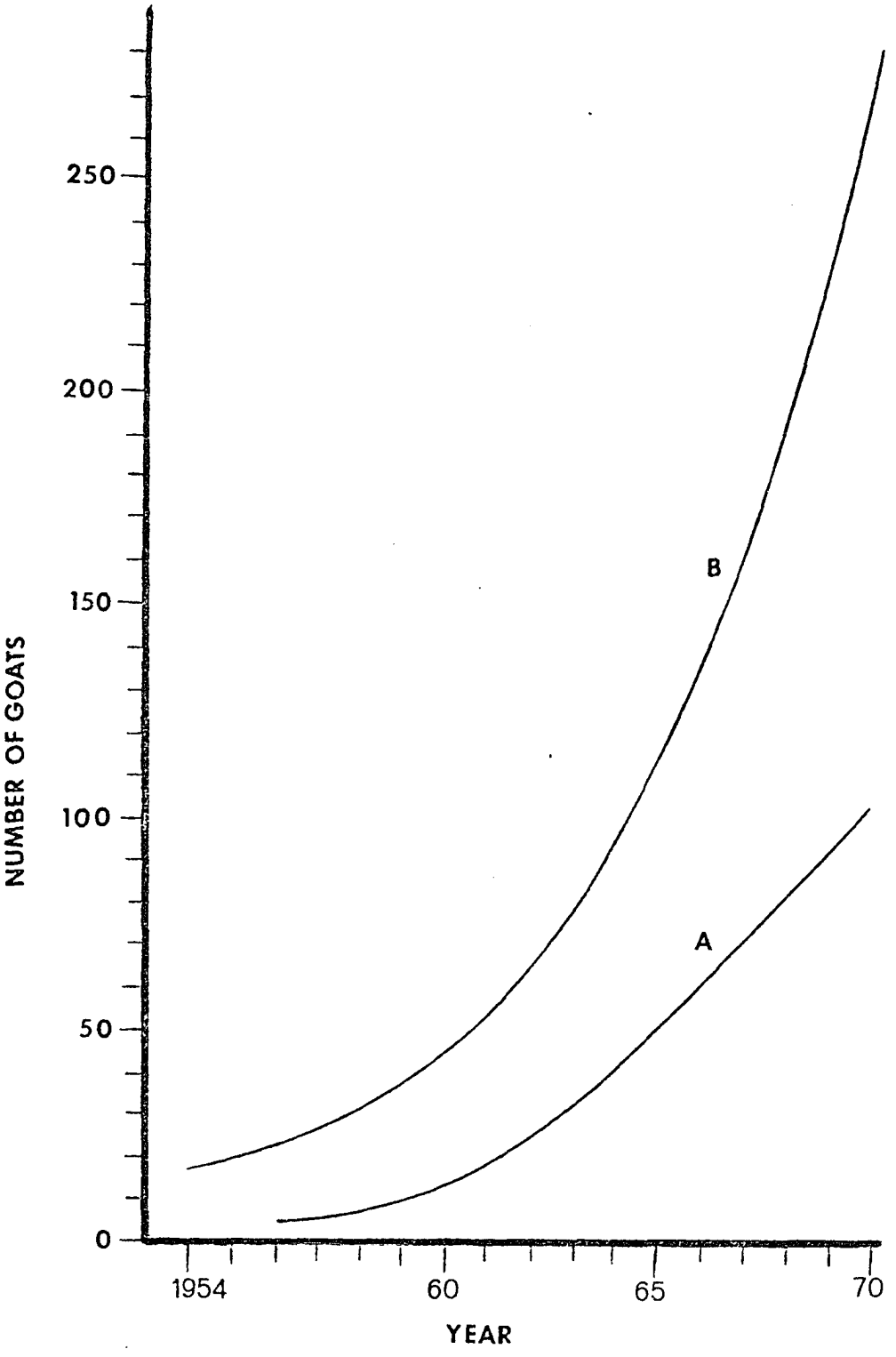


Fig. 12. Actual rate of increase (A) compared to potential rate of increase (B) in the mountain goat population on Kodiak Island since its introduction

ence between actual and potential rate of increase. According to the computations there should have been 273 goats in the herd in 1970 if potential rate of growth had been realized, whereas actually there is less than one third of this number. There is no evidence that this lower population level was caused by predators. On Kodiak, the only predators capable of killing a goat are brown bears and eagles. Brown bears on Kodiak have traditionally subsisted almost exclusively on salmon and plant material. With the introduction of cattle to the island they also proved capable of turning into formidable cattle killers. It is, however, doubtful that they are able to catch healthy goats. Brandborg (1955) concluded from studies in Idaho that grizzly bears were probably insignificant as predators on goats, and there is no reason to believe that this should be different on Kodiak.

Both the golden eagle and bald eagle are regular breeders in the area. Eagles were often seen circling over goats, but no incidents of predation were recorded during the study. Nor were goat remains found in the two bald eagle nests located in the vicinity of the study area. Several investigators report that eagles occasionally prey upon goats, but there is no information to establish that this is an important mortality factor in any goat population.

Several investigators have pointed to accidents as

an important cause of death among mountain goats, with the heaviest losses occurring during winter when snow and ice cover ledges and rock outcrops. Snow slides were found by Klein (1953) to account for seven of a total of ten recorded cases of mortality in his study areas on Kenai, and Brandborg (1955) states that snow slides throughout the late winter and early spring probably are responsible for more accidental deaths than any other natural cause.

On Kodiak snow slides occur particularly in barren fractures or faults on the mountain slopes. In these depressions, accumulations of snow generate snow slides several times during the winter, the frequency being greater towards late winter and spring. In the feeding sites, however, on the elevated ridges and rock outcrops where snow is sparse or absent, or below timberline where the snow is stabilized by dense growth of alder, the risk of snow slides is almost entirely absent. On March 21, 1970, an earthquake triggered numerous snow slides on Kodiak, but as far as could be established these caused no fatalities among the goats. When traveling, on the other hand, goats show no hesitation in crossing dangerous slopes and under certain conditions they may trigger snow slides which, given sufficient snow accumulation, may prove fatal. Walking on overhanging snow cornices as well as loss of footing on snow and ice covered ledges also

add to the hazards in a goat's life time.

The goat population on Kodiak has shown a high rate of reproduction during most of the years since introduction. Failure of the herd to increase at its potential rate in spite of lack of major predators, indicates a high loss to other environmental hazards. Although no supporting evidence was found during the present study, it is believed that accidents, particularly during the winter time, were the main factor responsible for the slow build up of the goat population in this area.

Range Conditions on Kodiak as Reflected Through Reproductive Success in the Goat Herd

Numerous studies both of domestic and wild ruminants have shown that quantity and quality of nutrition can exert profound effects on the oestrus cycle, ovulation and fertilization rates, and survival of the young. Among wild ruminants such relationships have been demonstrated for species of deer (Cheatum and Severinghaus, 1950). Brandborg (1955) states that production of young goats varies with conditions which females encounter during the winter previous to parturition. Adverse wintering conditions, resulting in lowered availability of foods and use of those of poor nutritional quality, were reflected in lower kid production.

The figures in Table 25 indicate that kid/adult ratios have been decreasing during recent years on Kodiak.

While the average kid/adult ratio for the years 1962 to 1968 was 57%, the average for the last two years is 26%. The low ratio for 1969 appears to have been caused at least partly by unfavorable weather during the previous winter (see below), but the continued lowered rate of reproduction in 1970 may indicate that the goat population on Kodiak is approaching the carrying capacity of the range, implying increasing competition for forage. However, the mechanisms at work are not clearly apparent. No evidence of overgrazing on the subalpine winter range was detected in 1969/1970, and yet the aerial summer survey revealed a comparatively low kid/adult ratio of 33%. Other population regulating factors related to animal density may also be at work. It is surprising that the goat population on Kodiak has not dispersed out from the original site of introduction. The mountains in the vicinity as well as on the island as a whole offer an abundance of goat habitat, but apparently the goat population needs to build up to maximal density in one area before dispersion takes place to other ranges.

The kid/adult ratio in 1969 (Table 23) is the lowest recorded during the 12 years of goat survey on Kodiak. It appears logical to relate this low reproductive success partly to the increasing density of goats as discussed above, and partly to the severity of the winter of 1968/69. As described in earlier chapters, in that winter

deep snows at low altitudes forced the goats to utilize high, windblown ranges. These habitats offer the goats only sparse and scattered forage (Table 20); furthermore, they suffer greater stress from exposure to weather here than in the more sheltered subalpine habitat. Both these factors probably lower the physiological condition of the goats and thereby have a negative influence upon reproduction.

A Comparison of Goat Density Between the Ranges in the Kenai and Kodiak Study Areas

Mountain goats, because of their particular habitat preference, will utilize only a relatively small part of the ranges where they are generally distributed. The extent of actual goat habitat may vary greatly from one mountain complex to another, and it therefore would be meaningless to compute density figures for entire mountain ranges without at the same time considering the size of the area that is regularly utilized by the goats. Because of movement to summer and winter ranges, it is also necessary to consider seasonal habitats separately.

The area of summer range on Kenai and Kodiak was calculated from the sketches in Figs. 1 and 3. The approximate boundaries of the summer ranges were established in the field from tracks, pellets, and shed wool, etc. The area computation gives 4.4 square miles of summer range in the study area on Kodiak and 12.5 square

miles on Kenai. The numbers of animals counted within the study areas on Kodiak and Kenai are 84 and 83, respectively. These figures are based upon aerial surveys conducted by Alaska Department of Fish and Game personnel, and therefore represent minimum numbers, but they should suffice for comparisons as long as survey efficiency can be regarded as being the same for the two areas. The density of goats calculated from the above figures is 20 animals per square mile on Kodiak and 6.8 per square mile on Kenai. These are average values (and not representative for any particular area) because the goats are rather unevenly distributed over the ranges. As described in earlier chapters the goats on Kodiak are concentrated in the bowls along the southern extension of Crown Mountain (Fig. 1), making the density figure here two or three times higher than for the range as a whole. In the study area on Kenai the highest density of goats, 9.2 animals per square mile, occurs on the southernmost mountain facing Seward and Resurrection Bay. While the summer range on Kodiak is more or less continuous, the goat population on Kenai occurs on four separate mountains or mountain complexes. These mountains are divided by rather deep and partly forested valleys which, to a certain extent, appear to restrict goat movement from one range to the other.

Due to the great variation in snow cover both during the winter and among different years, no attempts have

been made to calculate total area of the winter range. It was, however, possible to establish the approximate extent of four of the subalpine habitats utilized in the late winter of 1970 and calculate animal density for each habitat. This was done for the range composed of habitats A and B and separately for habitat C on Kodiak and for habitats A and B on Kenai and gave the approximate estimates of 150, 180, 90, and 130 animals per square mile for the respective winter ranges and habitats.

It is evident, therefore, that the ranges on Kodiak support a far higher density of goats than do those in the study area on Kenai. There may be several reasons for this:

1. Difference in hunting pressure. While on Kodiak there has been only a limited permit hunt on goats, there is a regular hunting season on Kenai with a bag limit of one goat and with the season extending from August 10 to November 15. The hunting pressure in the Kenai Mountains, however, is thought to be moderate. Goat hunters from the closest town, Seward, usually go across Resurrection Bay where goats can be found in greater numbers than in the study area and reached with less climbing. Hunters from the Anchorage area usually do their goat hunting in the mountains farther to the north. The difference in hunting pressure, therefore, seems unlikely to be the only factor responsible for the lower goat density on Kenai.

2. Lack of broken topography on Kenai. The goat

ranges on Kodiak are of a rugged and precipitous nature offering goats an abundance of their preferred habitat. On Kenai, on the other hand, the mountains are more rounded and smooth. This is particularly the case in the northern part of the study area where the ranges probably are less than optimal as goat habitat, a conclusion also reached by Klein (1953). The southernmost mountains which possess a highly broken and rugged topography also have the highest density of goats within the study area (see introduction to the chapter). However, the goat density here is still four or five times less than that in the areas of highest density on Kodiak, indicating that other factors also may be of importance in lowering goat abundance on the Kenai ranges.

3. Difference in the carrying capacity of the winter ranges. Studies by Cowan (1955), Klein (1965), and other workers indicate that, while the summer range governs the growth rate of individual animals in an ungulate population, the quality and quantity of winter forage are critical in determining the number of animals to be found on a given range. Applying this to the goat ranges on Kenai and Kodiak appears to offer some explanation for the lower animal density on Kenai. As already mentioned, the important winter forage plant, Carex circinnata, is absent from the alpine ridges on Kenai, thus lowering the winter range value of these habitats. But probably of greater impor-

tance is the difference in the extent of snow coverage between the subalpine winter ranges of the two study areas. While these ranges offer roughly the same amount of forage, the area of snow-free ground over the winter appears to be considerably larger on Kodiak than on Kenai (compare Fig. 4 and Fig. 8). This is a consequence of the more maritime climate on Kodiak Island: the snow line is higher on the slopes, and snow stays on the ground for a shorter period of the year. From Tables 9 and 10 it is seen that the snow in the winter of 1969/70 covered the ground for 62 days at Kodiak compared to 92 days at Seward. On Kenai, this would obviously restrict the goats' access to the abundant and nutritious forage on the subalpine habitat, and, to a greater extent than on Kodiak, force the animals to utilize areas of relatively poor range value.

4. Difference in the carrying capacity of the summer range. Feeding habits of goats on their summer ranges were discussed earlier. Apparently the animals select certain plant tissues and remove only an insignificant part of the total vegetation cover. Sparse growth will restrict this possibility for selection and force the animals to utilize less palatable and probably less nutritious forage.

For the study areas on Kodiak and Kenai the abundance and richness of the vegetation on the feeding sites were evaluated by comparing the figures from the vegetation

analyses in Tables B 29 through B 37. Average values for plant coverage from all feeding sites in each of the two study areas were calculated for total vegetation (except lichens and mosses) and for the forage species separately. The mean value for per cent coverage of higher plants on the 21 feeding sites on Kodiak is 47% and the mean value for the forage species is 35%; the figures calculated from the 19 feeding sites on Kenai are 35% and 17%, respectively. In other words, the vegetation is less luxuriant on Kenai. These differences in plant coverage between the two study areas are significant at the 95% confidence level for total plant coverage and at the 99% level for forage species.

Probably the main reason for the less luxuriant vegetation on Kenai is the higher elevation of the summer ranges in this study area. While the average altitude of the feeding sites on Kodiak is 2600 ft, the figure for Kenai is 3600 ft (Table 2). Besides becoming more sparse, the vegetation also changes composition with increasing altitude, bunch grasses and "bunch" sedges becoming more dominant; as these are not eaten on the summer range the per cent of forage species will decrease with increasing altitude. While forage species represent 2/3 of the total vegetation coverage on Kodiak, the figure is only 1/2 for Kenai.

As both total amount of vegetation and relative percentage of forage plants are less on Kenai than on Kodiak,

it appears likely that this also may be one of the factors responsible for the lower goat density on Kenai.

SUMMARY

The object of this study has been to investigate the feeding ecology and habitat preference of the mountain goat in selected areas along the south coast of Alaska. Two main study areas were chosen: one in the Crown Mountains on Kodiak Island where goats were introduced in 1952 and 1953, and other in the Kenai Mountains north of Seward on the Kenai Peninsula.

The goat populations in the two study areas show common features in their range and habitat adaptation.

Different ranges are utilized in different seasons, but the preference for broken and rugged terrain is evident throughout the year.

Summer ranges of the goats are located towards the summits of the mountains and commonly the goats will feed on south-facing slopes, apparently because of better conditions for plant growth on these sites. The vegetation type preferred on Kodiak is the forb-sedge meadow common in bowls along the southeast extension of Crown Mountain. On Kenai, where the vegetation is less luxuriant, the animals also spend a considerable amount of time feeding on the prostrate vegetation on the high ridges. During the summer the bulk of the forage consists of forbs while broad-leaved sedges are used to a lesser extent, and

grasses are hardly used at all. The utilized and preferred plant species make up at least half of the total vegetative cover on the summer range, but the goats rarely remove as much as 1% of the above-ground biomass on the feeding sites. They are frequently seen with their noses close to the ground for long periods of time, apparently searching for certain plant tissue. The selection of forage and the use of different vegetation types are at least to some extent governed by the occurrence of new growth or the presence of particularly succulent plant species. The heavy use of Carex microchaeta along snow patches at high altitudes on Kodiak is obviously the result of preference for young plant tissue. At Crown Mountain on Kodiak, the high density of goats in the bowls along the south ridge also is believed to be a result of the preference for young plant tissue; due to the late melt of snow in these bowls, some of the vegetation will be in an early stage of growth throughout the summer. A preference for flowers is evident on Kodiak but not on Kenai, probably because of a lack of rich forb meadows on the summer range on Kenai.

Field work was not carried out in the study areas on Kodiak and Kenai during fall and early winter, but during late October five days were spent studying goats in the mountains to the north of Port Houghton, in southeastern Alaska. While the ground was still free of snow the goats

were concentrated at timberline in this area, feeding mainly on sedges. The first snow of the winter arrived during the study period and this markedly influenced the goat distribution. Following the snowfall goats were found almost entirely below timberline, eating evergreen dwarf shrubs and ferns on snow free areas under mountain hemlock.

Along the south coast of Alaska, the winter of 1969 was colder than usual. The temperatures at Kodiak and Seward, respectively, averaged .5 and 1.4°F below the normal for the months of November through April. In contrast, the winter of 1970 was exceptionally mild with the same temperatures varying, respectively, 2.0 and 4.2°F above the normal. These differences in temperature had a pronounced influence upon the extent of the snow cover. Throughout the whole winter of 1968/69, there was a permanent snow cover from sea level to the tops of the mountains on both Kodiak and Kenai. During the winter of 1969/70 the conditions were entirely different. At lower altitudes most of the precipitation fell as rain or sleet. Throughout most of the winter there was no permanent snow cover below 100-400 ft on Kenai and below 300-800 ft on Kodiak, depending on exposure.

On Kodiak in March 1969, goats were found almost entirely above timberline, at an altitude varying from 1000 to 2500 ft. They were feeding on windblown ridges

and on south-facing rock outcrops. In February and March 1970, on the other hand, more than 90% of the goat population remained below timberline, feeding on the partly snow-free alder slopes. On this subalpine habitat they would generally stay adjacent to ravines.

On the high ridges, the animals fed mainly on bunch grasses and "bunch sedges"; foremost among these were Festuca altaica and Carex circinnata. These species show similarity in having stiff filiform leaves which enable the plants to withstand snow pressure and maintain an upright position throughout the winter. They also both possess considerable amounts of green tissue. On the habitat below alderline, the goats did some browsing but mainly fed on rhizomes and petioles of Athyrium filix-femina. The growth form of the alder on the slopes prevents snow accumulation on the ground and thereby leaves fern rhizomes more easily accessible.

Analysis of forage samples from the winter range indicates a high level of protein in fern rhizomes and in the green tissue of F. altaica and C. circinnata. The fern rhizomes also show a high percentage of carbohydrates and a low fiber content. Evidence of degradation of forage value in dry exposed vegetation was not indicated from the analyses. On a per square unit of range basis the analyses revealed that the forage on the subalpine habitat was highest in nutrients.

The spring range of goats on Kenai and Kodiak is identical in location with the subalpine winter range. During spring forage changes from fern rhizomes and browse to the new growth of grasses and forbs; Calamagrostis canadensis is the principal forage species in May. At times during spring goats move to the high ridges which normally are part of the summer range, and feed on the same plants which are preferred later in summer. The permanent shift to the summer range takes place in late May and early June.

The goat population on Kodiak has increased relatively slowly since its introduction in 1952-53, numbering only around 100 animals today. This equals a yearly rate of increase of 9%. Reproduction, on the other hand, has been good, with an average kid/adult ratio of 57% for the years 1964 to 1967. Accidents are thought to be the main reason for the slow build up of the population.

Reproduction was relatively poor on Kodiak in 1969 and 1970. In 1969, this is believed to have been caused partly by the severity of the previous winter, but the continuing low kid/adult ratio in 1970 may indicate that the herd is approaching the carrying capacity of the range.

The density of goats is considerably lower in the study area on Kenai than on Kodiak. Differences between the two areas in topography, extent of snow cover over the winter, and abundance of vegetation on the summer ranges

are believed to be the main causes for this.

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APPENDIX A

VEGETATION ANALYSES OF MOUNTAIN GOAT WINTER RANGES IN THE KENAI AND KODIAK MOUNTAINS

SYMBOL EXPLANATION

Figures in per cent expressing values as described under Study Approach.

Frequency is the number of squares out of 100 in which species are present.

Frequency	
No./100	Rank
100 - 81	1
80 - 61	2
60 - 41	3
40 - 21	4
20 - 11	5
10 - 6	6
5 - 1	7

t = trace (less than one per cent)

Table A 24. Species coverage and frequency ranking of vegetation in alpine winter habitats on Kodiak, Type 1 (Table 13), Habitats G and N (Table 12, Fig. 1)

Species	G		N	
	Coverage	Frequency Rank	Coverage	Frequency Rank
Geranium erianthum	24	2	34	1
Sanguisorba stipulata	12	2	17	3
Angelica lucida	12	2	3	4
Athyrium filix-femina	11	3	--	--
Epilobium angustifolium	9	3	t	6
Solidago sp.	7	3	--	--
Festuca altaica	3	4	6	3
Vaccinium ovalifolium	--	--	6	5
Calamagrostis canadensis	5	2	1	3
Heracleum lanatum	5	4	--	--
Carex macrochaeta	3	3	5	1
Achillea borealis	5	2	4	1
Erigeron peregrinus	--	--	4	3
Bryophyta	--	--	5	4
Senecio triangularis	4	3	--	--
Galium sp.	4	2	--	--
Rhododendron camtschaticum	--	--	3	4
Salix phlebophylla	--	--	3	5
Thelypteris phegopteris	2	4	3	3
Arctostaphylos uva-ursi	--	--	2	3
Trientalis arctica	1	4	2	3
Geum macrophyllum	--	--	2	5
Coptis trifolia	2	2	1	3
Poa leptocoma	3	3	--	--
Lupinus nootkatensis	2	3	t	6
Stellaria sp.	t	4	1	2
Conioselinium chinense	1	5	--	--
Carex sp.	1	5	--	--
Aconitum delphinifolium	t	5	t	5
Fritillaria camschatcensis	t	6	--	--
Silene sp.	t	7	--	--
Aquilegia formosa	--	--	t	6
Phleum commutatum	--	--	t	6
Castilleja unalaschcensis	t	6	t	6
Rhinanthus minor	t	6	t	4
Anemone narcissiflora	--	--	t	6
Epilobium sp.	--	--	t	4
Botrychium lunaria	t	6	--	--
Festuca rubra	t	7	--	--
Viola Langsdorfii	t	5	--	--

Table A 25. Species coverage and frequency ranking of vegetation in alpine winter habitats on Kodiak, Type 2 (Table 13), habitats J and K (Table 12, Fig. 1)

Species	J		K	
	Coverage	Frequency Rank	Coverage	Frequency Rank
Bryophyta	14	1	6	2
Geranium erianthum	12	2	t	5
Artemisia arctica	7	3	3	4
Festuca altaica	6	4	t	6
Arctostaphylos alpina	6	5	--	--
Luzula parviflora	--	--	5	4
Carex macrochaeta	3	3	3	2
Salix phlebophylla	t	6	3	4
Lupinus nootkatensis	4	2	1	5
Achillea borealis	4	1	--	--
Rhododendron camtschaticum	4	4	t	5
Campanula lasiocarpa	t	5	2	1
Sanguisorba stipulata	3	5	--	--
Polygonum viviparum	2	4	2	3
Anemone narcissiflora	2	4	2	4
Antennaria monocephala	--	--	2	3
Carex microchaeta	2	3	1	3
Vaccinium ovalifolium	2	5	--	--
Solidago sp.	2	5	--	--
Arctostaphylos uva-ursi	2	4	2	4
Erigeron peregrinus	2	5	t	7
Carex circinnata	1	4	t	5
Stellaria sp.	1	3	--	--
Antennaria pallida	t	7	t	4
Fritillaria camschatcensis	1	4	--	--
Cassiope Stelleriana	--	--	1	5
Angelica lucida	1	4	--	--
Festuca ovina	--	--	t	4
Solidago multiradiata	--	--	1	4
Euphrasia mollis	1	3	t	6
Rhinanthus minor	1	3	t	6
Galium sp.	1	4	--	--
Trientalis sp.	1	4	--	--
Loiseleuria procumbens	1	7	t	7
Luzula multiflora	1	4	--	--
Poa sp.	t	4	--	--
Epilobium angustifolium	t	7	--	--
Cladonia sp.	--	--	t	7
Salix sp.	--	--	t	6

Table A 26. Species coverage and frequency ranking of vegetation in alpine winter habitat on Kodiak, Type 3 (Table 12)

Species	Coverage	Frequency Rank
Bryophyta	14	1
Salix phlebophylla	7	4
Campanula lasiocarpa	3	1
Stereocaulon sp.	3	3
Carex microchaeta	3	3
Rhododendron camtschaticum	3	4
Carex circinnata	3	3
Polygonum viviparum	2	3
Vaccinium ovalifolium	2	4
Cladonia sp.	2	5
Diapensia lapponica	1	5
Antennaria pallida	1	4
Hierochloe alpina	1	4
Artemisia arctica	t	4
Anemone narcissiflora	t	5
Festuca sp.	t	4
Arctostaphylos uva-ursi	t	4
Poa alpigena	t	5
Calamagrostis canadensis	t	5
Astragalus a. alpinus	t	6
Luzula spicata	t	7
Festuca altaica	t	7
Sibbaldia procumbens	t	7
Lycopodium alpinum	t	7

Table A 27. Species coverage and frequency ranking of vegetation in alpine winter habitats on Kodiak, Type 4 (Table 13), habitats L and O (Table 11, Fig. 2)

Species	L		O	
	Coverage	Frequency Rank	Coverage	Frequency Rank
Bryophyta	15	2	25	1
Carex circinnata	10	3	2	3
Festuca altaica	5	2	5	3
Carex microchaeta	7	1	3	1
Solidago multiradiata	4	4	3	4
Antennaria pallida	4	2	3	2
Campanula lasiocarpa	4	2	2	3
Rhododendron camtschaticum	t	--	2	4
Epilobium angustifolium	t	6	3	4
Achillea borealis	2	3	1	2
Potentilla villosa	2	4	2	3
Erigeron peregrinus	--	--	1	6
Anemone narcissiflora	1	6	t	6
Artemisia arctica	1	5	1	4
Saxifraga ferruginea	t	6	1	6
Festuca sp.	t	7	t	6
Senecio resedifolius	t	7	t	6
Luzula spicata	t	5	t	5
Geranium erianthum	t	7	t	5
Lupinus nootkatensis	t	6	t	6
Festuca rubra	t	--	t	5
Coptis trifolia	t	5	--	--
Silene acaulis	--	--	t	5
Veronica Wormskjoldii	1	4	t	5
Fritillaria camschatcensis	t	--	t	7
Viola Langsdorfii	t	6	t	4
Cladonia sp.	t	7	t	6
Stereocaulon sp.	--	--	t	6
Trisetum spicatum	t	7	t	6
Equisetum arvense	t	7	--	--
Arabis divaricarpa	--	--	t	6
Trisetum spicatum	t	7	--	--
Poa alpigena	t	7	t	7
Astragalus umbellatus	t	7	--	--
Sibaldia procumbens	t	7	t	7
Galium sp.	t	7	--	--

Table A 28. Species coverage and frequency ranking of vegetation of the alpine ridge society at 3200 ft in the Kenai Mountains

Species	Coverage	Frequency Rank
Bryophyta	25	1
Arctostaphylos alpina	1	4
Carex microchaeta	4	3
Diapensia lapponica	4	4
Salix rotundifolia	2	3
Sedum rosea	2	3
Silene acaulis	2	5
Campanula lasiocarpa	1	3
Saxifraga bronchialis	1	4
Antennaria monocephala	1	4
Thamnolia vermicularis	1	4
Stereocaulon sp.	1	3
Pedicularis capitata	1	4
Arctostaphylos uva-ursi	1	5
Festuca altaica	t	5
Artemisia arctica	t	5
Luzula Wahlenbergii	t	5
Poa stenantha	t	5
Festuca ovina	t	5
Anemone narcissiflora	t	5
Primula cuneifolia	t	5
Phlox sibirica	t	6
Arnica Lessingii	t	6
Cassiope Stelleriana	t	6
Lloydia serotina	t	7

APPENDIX B

VEGETATION ANALYSES AND RECORDS OF PLANT TISSUE REMOVED BY GOATS ON FEEDING SITES IN SUMMER RANGES IN THE KODIAK AND KENAI MOUNTAINS.

Terminology used in the Tables is described under Study Approach.

Table B 29. Species coverage, frequency ranking, and utilization of vegetation by goats in Carex meadows on summer range at Kodiak

Species	Site 1, 1500 ft, Exp S, Slope 70%				Site 2, 2000 ft, Exp SE, Slope 75%				Site 3, 2400 ft, Exp SE, Slope 75%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Carex macrochaeta	32	1	1	70	44	1	--	--	51	1	--	--
Geranium erianthum	5	4	3	3	--	--	--	--	--	--	--	--
Calamagrostis canadensis	3	2	--	--	3	2	--	--	11	2	--	--
Arnica latifolia	--	--	--	--	5	3	3	4	2	4	1	2
Artemisia arctica	2	3	10	50	3	4	3	30	3	4	8	18
Bryophyta	2	4	--	--	t	6	--	--	--	--	--	--
Erigeron peregrinus	2	4	3	4	9	3	3	10	5	3	2	4
Viola Langsdorfii	--	--	--	--	4	2	--	--	2	3	--	--
Lupinus nootkatensis	2	4	2	40	--	--	--	--	2	5	1	4
Epilobium angustifolium	1	3	22	50	--	--	--	--	--	--	--	--
Festuca altaica	--	--	--	--	2	4	--	--	--	--	--	--
Campanula lasiocarpa	1	4	--	--	--	--	--	--	--	--	--	--
Sanguisorba stipulata	1	4	--	--	--	--	--	--	--	--	--	--
Anemone narcissiflora	1	5	--	--	--	--	--	--	--	--	--	--
Myosotis alpestris	1	5										
Hieracium triste	t	4	--	--	--	--	--	--	1	5	--	--
Petasites hyperboreus	t	5	--	--	--	--	--	--	1	5		
Epilobium sp.	t	4	--	--	2	2	--	--	1	4	--	--
Luzula parviflora	t	5	--	--	--	--	--	--	1	4	--	--
Coptis trifolia	t	5	--	--	t	6	--	--	t	6	--	--
Luzula multiflora	t	5	--	--	--	--	--	--	t	6	--	--
Cladonia sp.	t	5	--	--	--	--	--	--	--	--	--	--
Angelica lucida	t	6	--	--	--	--	--	--	1	5	--	--
Stellaria sp.	t	6	--	--	--	--	--	--	t	5	--	--
Aconitum delphinifolium	t	6	--	--	--	--	--	--	--	--	--	--
Castilleja unalaschcensis	--	--	--	--	t	6	2	3	--	--	--	--
Sibbaldia procumbens	--	--	--	--	t	6	--	--	t	6	--	--

Table B 29. Contd.

Species	Site 4, 2500 ft, Exp S, Slope 75%				Site 5, 2200 ft, Exp S, Slope 80%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Carex macrochaeta	42	1	--	--	30	1	2	3
Erigeron peregrinus	13	1	3	4	10	3	--	--
Calamagrostis canadensis	17	1	--	--	7	2	--	--
Geranium erianthum	--	--	--	--	4	3	--	--
Artemisia arctica	--	--	--	--	4	4	10	15
Epilobium angustifolium	--	--	--	--	3	4	15	50
Sanguisorba stipulata	6	1	--	--	2	4	--	--
Anemone narcissiflora	--	--	--	--	2	4	--	--
Campanula lasiocarpa	--	--	--	--	1	2	--	--
Lupinus nootkatensis	--	--	--	--	1	4	6	10
Myosotis alpestris	--	--	--	--	1	4	--	--
Hieracium triste	--	--	--	--	1	5	--	--
Coptis trifolia	t	6	--	--	t	5	--	--
Epilobium sp.	9	1	--	--	t	5	--	--
Petasites hyperboreus	--	--	--	--	t	5	--	--
Angelica lucida	--	--	--	--	t	5	--	--
Arnica latifolia	2	5	1	2	--	--	--	--
Prenanthes alata	2	5	--	--	--	--	--	--
Castilleja unalaschcensis	t	7	--	--	--	--	--	--
Sibbaldia procumbens	1	6	--	--	--	--	--	--

Table B 30. Species coverage, frequency ranking, and utilization of vegetation by goats on Erigeron slop[illegible] on summer range at Kodiak

Species	Site 1, 3200 ft, Exp SE, Slope 65%				Site 2, 3000 ft, Exp S, Slope 85%				Site 3, 2700 ft, Exp S, Slope 70%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Erigeron peregrinus	2	4	1	2	3	3	2	3	6	3	2	4
Carex macrochaeta	20	1	3	40	10	1	--	--	3	1	1	70
Arnica latifolia	--	--	--	--	--	--	--	--	25	1	2	3
Lupinus nootkatensis	13	2	--	--	7	1	8	15	4	2	--	--
Bryophyta	21	1	--	--	15	--	--	--	21	2	--	--
Luetkea pectinata	--	--	--	--	--	--	--	--	8	3	--	--
Artemisia arctica	7	1	6	18	8	1	2	5	t	4	--	--
Salix phlebophylla	4	5	--	--	2	4	--	--	--	--	--	--
Anemone narcissiflora	2	4	--	--	1	3	--	--	4	3	--	--
Veronica Wormskjoldii	3	2	--	--	4	3	--	--	2	4	--	--
Achillea borealis	3	4	--	--	--	--	--	--	--	--	--	--
Hieracium triste	1	4	--	--	t	4	--	--	4	3	3	4
Campanula lasiocarpa	2	3	--	--	2	5	--	--	t	5	--	--
Sibbaldia procumbens	2	3	--	--	--	--	--	--	--	--	--	--
Polygonum viviparum	2	4	--	--	1	4	--	--	t	4	--	--
Castilleja unalaschcensis	2	4	--	--	--	--	--	--	3	3	--	--
Viola Langsdorfii	--	--	--	--	--	--	--	--	3	3	--	--
Poa leptocoma	1	3	2	3	--	--	--	--	--	--	--	--
Trisetum spicatum	1	4	--	--	t	4	--	--	--	--	--	--
Epilobium angustifolium	t	2	--	--	1	3	--	--	--	--	--	--
Poa stenantha	t	5	2	3	t	5	--	--	--	--	--	--
Pedicularis sp.	t	5	--	--	t	5	--	--	--	--	--	--
Festuca ovina	t	5	--	--	t	5	--	--	--	--	--	--
Thamnolia vermicularis	t	5	--	--	t	5	--	--	--	--	--	--
Myosotis a. asiatica	t	5	--	--	--	--	--	--	--	--	--	--
Poa alpigena	t	5	--	--	--	--	--	--	--	--	--	--
Stellaria sp.	t	6	--	--	t	5	--	--	--	--	--	--
Luzula multiflora	t	6	--	--	t	6	--	--	--	--	--	--
Calamagrostis canadensis	t	6	--	--	t	6	--	--	6	1	--	--
Peltigera sp.	t	6	--	--	t	6	--	--	--	--	--	--
Euphrasia mollis	--	--	--	--	t	6	--	--	t	6	--	--

Table B 30. Contd.

Species	Site 4, 2700 ft, Exp S, Slope 65%				Site 5, 2400 ft, Exp SV, Slope 70%				Site 6, 2500 ft, Exp S, Slope 80%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Erigeron peregrinus	8	1	1	3	7	3	--	--	9	1	3	4
Carex macrochaeta	15	1	--	--	4	1	--	--	5	1	2	50
Arnica latifolia	4	1	1	4	31	1	1	3	7	3	--	--
Lupinus nootkatensis	t	6	--	--	5	2	t	1	4	3	4	10
Bryophyta	3	3	--	--	7	3	--	--	1	4	--	--
Luetkea pectinata	6	3	--	--	9	2	--	--	48	1	--	--
Artemisia arctica	4	2	10	30	2	4	--	--	7	2	6	23
Anemone narcissiflora	3	3	--	--	4	3	2	2	--	--	--	--
Veronica Wormskjoldii	3	2	--	--	t	4	--	--	3	1	--	--
Hieracium triste	3	4	--	--	7	2	t	t	4	2	--	--
Campanula lasiocarpa	t	3	--	--	--	--	--	--	t	6	--	--
Polygonum viviparum	1	5	--	--	t	4	--	--	1	3	--	--
Castilleja unalaschcensis	--	--	--	--	4	3	1	1	--	--	--	--
Viola Langsdorfii	--	--	--	--	5	2	--	--	--	--	--	--
Luzula parviflora	--	--	--	--	3	1	--	--	2	3	--	--
Festuca sp.	--	--	--	--	3	3	--	--	--	--	--	--
Calamagrostis canadensis	1	3	--	--	1	2	--	--	1	1	--	--
Carex scirpoidea	--	--	--	--	t	4	--	--	3	3	--	--
Carex microchaeta	--	--	--	--	t	6	--	--	--	--	--	--
Coptis trifolia	--	--	--	--	t	6	--	--	--	--	--	--
Vaccinium ovalifolium	--	--	--	--	t	6	--	--	--	--	--	--
Epilobium sp.	--	--	--	--	t	6	--	--	3	3	--	--
Rubus pedatus	t	6	--	--	--	--	--	--	1	3	--	--
Lycopodium alpinum	--	--	--	--	--	--	--	--	t	6	--	--
Salix phlebophylla	--	--	--	--	--	--	--	--	t	6	--	--
Sibbaldia procumbens	t	4	--	--	--	--	--	--	--	--	--	--
Epilobium angustifolium	t	5	--	--	--	--	--	--	--	--	--	--
Myosotis a. asiatica	2	4	--	--	--	--	--	--	--	--	--	--

Table B 30. Contd.

Species	Site 7, 2400 ft, Exp SV, Slope 95%				Site 8, 2700 ft, Exp SE, Slope 95%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Erigeron peregrinus	7	1	--	--	11	1	3	5
Carex macrochaeta	10	6	2	50	--	6	1	18
Arnica latifolia	8	1	--	--	5	2	2	3
Lupinus nootkatensis	20	1	2	5	1	6	2	3
Bryophyta	5	3	--	--	7	4	--	--
Luetkea pectinata	16	5	--	--	38	1	--	--
Artemisia arctica	9	1	--	--	3	2	3	10
Anemone narcissiflora	5	2	1	2	6	2	--	--
Veronica Wormskjoldii	3	3	--	--	1	4	--	--
Hieracium triste	3	4	--	--	4	3	--	--
Sibbaldia procumbens	1	4	--	--	--	--	--	--
Polygonum viviparum	--	--	--	--	t	6	--	--
Viola Langsdorfii	--	--	--	--	t	6	--	--
Calamagrostis canadensis	1	4	--	--	3	1	--	--
Carex scirpoidea	--	--	--	--	1	4	--	--
Epilobium sp.	2	3	--	--	--	--	--	--
Sanguisorba stipulata	3	4	1	2	--	--	--	--
Myosotis alpestris	1	4	--	--	--	--	--	--
Epilobium angustifolium	t	5	8	30	--	--	--	--

Table B 31. Species coverage, frequency ranking, and utilization of vegetation by goats on Lupinus ridges on summer range at Kodiak

Species	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Cassiope Stelleriana	8	5	--	--	10	1	--	--	--	--	--	--	5	5	--	--
Luetkea pectinata	7	5	5	10	7	4	--	--	10	4	--	--	6	4	--	--
Sibbaldia procumbens	6	1	--	--	7	1	--	--	--	--	--	--	5	1	--	--
Hieracium triste	6	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carex microchaeta	6	2	--	--	3	4	5	40	7	2	1	20	3	2	--	--
Bryophyta	10	2	--	--	8	1	--	--	4	4	--	--	7	2	--	--
Luzula Wahlenbergii	3	1	--	--	3	1	--	--	--	--	--	--	--	--	--	--
Lupinus nootkatensis	3	3	20	50	5	2	25	30	2	4	20	18	8	2	15	35
Campanula lasiocarpa	1	3	--	--	1	5	--	--	t	6	--	--	1	5	--	--
Artemisia arctica	1	5	--	--	3	7	--	--	3	4	--	--	t	5	--	--
Astragalus alpinus	1	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arnica Lessingii	t	7	--	--	t	6	--	--	--	--	--	--	--	--	--	--
Poa alpigena	t	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Calamagrostis canadensis	t	6	--	--	t	6	--	--	4	3	--	--	1	3	--	--
Trisetum spicatum	t	6	--	--	t	6	--	--	--	--	--	--	--	--	--	--
Carex scirpoidea	--	--	--	--	--	--	--	--	3	2	--	--	--	--	--	--
Erigeron peregrinus	--	--	--	--	--	--	--	--	2	4	--	--	--	--	--	--
Polygonum viviparum	--	--	--	--	--	--	--	--	1	6	--	--	--	--	--	--
Hieracium triste	--	--	--	--	--	--	--	--	t	5	--	--	--	--	--	--
Vaccinium ovalifolium	--	--	--	--	--	--	--	--	t	6	--	--	--	--	--	--
Salix phlebophylla	--	--	--	--	--	--	--	--	t	5	--	--	--	--	--	--
Carex macrochaeta	--	--	--	--	--	--	--	--	--	--	--	--	3	3	--	--

Table B 32. Species coverage, frequency ranking, and utilization of vegetation by goats on Carex Ridges on summer range at Kodiak

Species	Site 1, 3000 ft, Exp V, Slope 30%				Site 2, 3200 ft, Exp E, Slope 25%				Site 3, 3000 ft, Exp S, Slope 40%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Lichen sp.	37	1	--	--	28	1	--	--	--	--	--	--
Carex microchaeta	11	1	5	50	8	2	5	40	11	2	1	30
Bryophyta	7	1	--	--	7	1	--	--	15	2	--	--
Luzula Wahlenbergii	3	1	--	--	5	2	--	--	4	2	--	--
Carex lachenalii	1	6	--	--	--	--	--	--	--	--	--	--
Dryas Drummondii	--	--	--	--	1	6	--	--	--	--	--	--
Sibbaldia procumbens	--	--	--	--	t	5	--	--	6	1	--	--
Carex pyrenaica	--	--	--	--	t	6	--	--	--	--	--	--
Carex circinnata	--	--	--	--	t	6	--	--	--	--	--	--
Campanula lasiocarpa	--	--	--	--	t	6	--	--	--	--	--	--
Salix rotundifolia	--	--	--	--	t	6	--	--	--	--	--	--
Cladonia sp.	--	--	--	--	--	--	--	--	20	2	--	--
Artemisia arctica	--	--	--	--	--	--	--	--	2	4	15	35
Sedum rosea	--	--	--	--	--	--	--	--	1	2	25	60
Trisetum spicatum	--	--	--	--	--	--	--	--	t	4	--	--
Arnica Lessingii	--	--	--	--	--	--	--	--	t	5	--	--

Table B 33. Species coverage, frequency ranking, and utilization of vegetation by goats on snow beds on summer range at Kodiak

Species	Site 1, 3400 ft, Exp NV, Slope 30%				Site 2, 3200 ft, Exp NV, Slope 25%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Lichen sp.	32	1	--	--	15	1	--	--
Carex microchaeta	4	4	20	50	3	5	30	60
Luzula Wahlenbergii	2	5	--	--	1	5	--	--

Table B 34. Species coverage, frequency ranking, and utilization of vegetation by goats on *Artemisia* slopes on summer range in the Kenai Mountains

Species	Site 1, 3500 ft, Exp E, Slope 70%				Site 2, 3100 ft, Exp SE, Slope 70%				Site 3, 3600 ft, Exp S, Slope 80%				Site 4, 3800 ft, Exp SE, Slope 90%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Bryophyta	44	1	--	--	25	1	--	--	38	1	--	--	39	1	--	--
Salix phlebophylla	--	--	--	--	15	5	--	--	15	4	--	--	--	--	--	--
Artemisia arctica	10	1	4	30	6	1	7	35	6	2	6	25	6	3	5	15
Peltigera sp.	8	1	--	--	7	2	--	--	1	6	--	--	t	5	--	--
Luetkea pectinata	7	2	--	--	7	3	--	--	1	5	--	--	1	3	--	--
Luzula Wahlenbergii	6	3	--	--	t	3	--	--	2	3	--	--	t	5	--	--
Epilobium latifolium	2	4	5	15	3	4	4	10	7	2	7	15	3	5	6	15
Carex macrochaeta	5	1	2	40	4	1	4	50	4	1	6	40	6	1	2	30
Geranium erianthum	4	3	--	--	3	3	--	--	t	6	--	--	1	3	--	--
Veronica Wormskjoldii	3	1	--	--	2	2	--	--	t	3	--	--	1	2	--	--
Empetrum nigrum	3	4	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trisetum spicatum	2	2	--	--	1	2	--	--	1	2	--	--	--	--	--	--
Campanula lasiocarpa	2	3	--	--	t	2	--	--	t	4	--	--	1	2	--	--
Sibbaldia procumbens	2	3	--	--	1	2	--	--	t	3	--	--	2	2	--	--
Poa leptocoma	2	4	--	--	1	3	--	--	t	2	--	--	t	2	--	--
Lycopodium selago	--	--	--	--	7	2	--	--	--	--	--	--	1	3	--	--
Solidago multiradiata	--	--	--	--	3	3	2	7	3	4	--	--	3	1	--	--
Thamnolia vermicularis	--	--	--	--	--	--	--	--	t	4	--	--	--	--	--	--
Rubus pedatus	--	--	--	--	--	--	--	--	--	--	--	--	5	2	--	--

Table B 35. Species coverage, frequency ranking, and utilization of vegetation by goats on Carex slopes on summer range in the Kenai Mountains

Species	Site 1, 3200 ft, Exp S, Slope 80%				Site 2, 3000 ft, Exp NV, Slope 76%				Site 3, 3700 ft, Exp S, Slope 75%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Carex macrochaeta	28	1	--	--	3	1	1	50	2	4	2	60
Festuca altaica	--	--	--	--	20	1	--	--	25	1	--	--
Artemisia arctica	13	2	--	--	4	1	2	15	9	1	5	44
Calamagrostis canadensis	7	4	--	--	--	--	--	--	--	--	--	--
Geranium erianthum	3	2	--	--	3	1	--	--	5	1	--	--
Bryophyta	5	2	--	--	1	4	--	--	4	2	--	--
Salix phlebophylla	--	7	--	--	4	2	--	--	4	4	--	--
Solidago multiradiata	2	4	--	--	5	2	--	--	7	2	2	7
Astragalus alpinus	1	3	--	--	1	2	--	--	3	2	--	--
Peltigera sp.	--	--	--	--	1	5	--	--	5	3	--	--
Epilobium latifolium	1	5	--	--	1	3	3	15	t	6	2	18
Epilobium angustifolium	1	6	5	40	--	--	--	--	--	--	--	--
Lupinus nootkatensis	--	5	2	15	--	--	--	--	--	--	--	--
Anemone narcissiflora	--	6	--	--	t	6	--	--	t	6	--	--
Achillea borealis	--	6	--	--	--	--	--	--	--	--	--	--
Campanula lasiocarpa	--	2	--	--	t	2	--	--	2	4	--	--
Aconitum delphinifol.	--	7	--	--	1	6	--	--	1	4	--	--
Botrychium lunaria	--	7	--	--	--	--	--	--	--	--	--	--
Stellaria sitchana	--	--	--	--	1	3	--	--	1	3	--	--
Cassiope Stelleriana	--	--	--	--	t	5	--	--	--	--	--	--
Myosotis alpestris	--	--	--	--	t	6	--	--	t	6	--	--
Phyllodoce aleutica	--	--	--	--	t	6	--	--	--	--	--	--
Cladonia sp.	--	--	--	--	7	4	--	--	7	4	--	--
Antennaria monocephala	--	--	--	--	--	--	--	--	2	4	--	--

Table B 35. Contd.

Species	Site 4, 3500 ft, Exp SE, Slope 65%				Site 5, 3700 ft, Exp V, Slope 70%				Site 6, 3300 ft, Exp S, Slope 80%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Carex macrochaeta	20	1	2	50	4	2	3	40	4	1	1	50
Festuca altaica	12	1	--	--	2	2	--	--	20	1	--	--
Artemisia arctica	6	5	2	10	6	2	3	20	6	1	3	12
Geranium erianthum	1	2	1	2	1	3	--	--	6	1	1	2
Bryophyta	16	1	--	--	30	1	--	--	9	1	--	--
Salix phlebophylla	t	5	--	--	5	4	--	--	--	--	--	--
Solidago multiradiata	8	1	1	10	5	2	1	1	2	5	--	--
Astragalus alpinus	--	--	--	--	--	--	--	--	1	5	--	--
Peltigera sp.	--	--	--	--	15	3	--	--	5	5	--	--
Epilobium latifolium	2	4	4	15	2	4	2	30	2	5	--	--
Sibbaldia procumbens	--	--	--	--	1	3	--	--	--	--	--	--
Antennaria monocephala	1	4	--	--	1	5	--	--	--	--	--	--
Stellaria sitchana	3	4	--	--	1	6	--	--	--	--	--	--
Cassiope Stelleriana	--	--	--	--	1	7	--	--	--	--	--	--
Campanula lasiocarpa	1	2	--	--	t	7	--	--	t	4	--	--
Lupinus nootkatensis	t	4	--	--	--	--	--	--	2	4	--	--
Aconitum delphinifolium	1	3	1	2	--	--	--	--	1	5	--	--
Petasites hyperboreus	--	--	--	--	--	--	--	--	1	7	--	--
Myosotis alpestris	--	--	--	--	--	--	--	--	1	3	--	--
Sanguisorba stipulata	--	--	--	--	--	--	--	--	1	3	--	--
Anemone narcissiflora	t	7	--	--	--	--	--	--	1	3	--	--
Veronica Wormskjoldii	t	5	--	--	--	--	--	--	--	--	--	--
Poa leptocoma	t	5	--	--	--	--	--	--	--	--	--	--
Epilobium angustifolium	t	7	--	--	--	--	--	--	--	--	--	--

Table B 36. Species coverage, frequency ranking, and utilization of vegetation by goats on Sedum ridges on summer range in the Kenai Mountains

Species	Site 1, 3700 ft, Exp S, Slope 75%				Site 2, 4300 ft, Exp S, Slope 50%				Site 3, 4000 ft, Exp NE, Slope 40%				Site 4, 4400 ft, Exp S, Slope 75%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Artemisia arctica	11	1	2	25	6	1	3	30	5	1	2	15	1	2	--	--
Cetraria sp.	11	3	--	--	10	3	--	--	5	3	--	--	15	3	--	--
Carex microchaeta	10	1	3	50	15	1	2	50	4	1	3	60	20	1	2	40
Cladonia sp.	10	3	--	--	1	4	--	--	10	3	--	--	10	3	--	--
Bryophyta	15	1	--	--	7	2	--	--	28	1	--	--	18	1	--	--
Peltigera sp.	6	3	--	--	6	3	--	--	10	2	--	--	2	4	--	--
Sibbaldia procumbens	2	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Campanula lasiocarpa	2	3	--	--	t	3	--	--	1	1	--	--	t	1	--	--
Luzula Wahlenbergii	1	5	--	--	t	6	--	--	1	3	--	--	1	4	--	--
Salix rotundifolia	1	5	--	--	5	4	--	--	1	2	--	--	3	2	--	--
Trisetum spicatum	1	6	--	--	t	7	--	--	t	7	--	--	--	--	--	--
Gentiana glauca	1	6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lloydia serotina	1	5	--	--	--	--	--	--	1	2	--	--	t	5	--	--
Poa leptocoma	t	6	--	--	--	--	--	--	t	7	--	--	--	--	--	--
Sedum rosea	t	6	25	50	1	2	25	60	--	--	--	--	3	1	15	40
Geranium erianthum	--	--	--	--	1	4	--	--	--	--	--	--	1	4	--	--
Thamnolia vermicularis	--	--	--	--	1	3	--	--	1	3	--	--	t	4	--	--
Antennaria monocephala	--	--	--	--	t	5	--	--	t	5	--	--	--	--	--	--
Hierochloe alpina	--	--	--	--	t	6	--	--	1	2	1	3	1	4	--	--
Polygonum viviparum	--	--	--	--	t	6	--	--	t	5	--	--	t	6	--	--
Epilobium latifolium	--	--	--	--	t	7	--	--	t	7	3	15	--	--	--	--
Primula cuneifolia	--	--	--	--	--	--	--	--	t	4	--	--	--	--	--	--
Festuca ovina	--	--	--	--	--	--	--	--	t	5	--	--	t	6	--	--
Arctostaphylos uva-ursi	--	--	--	--	--	--	--	--	t	5	--	--	t	6	--	--
Pedicularis sp.	--	--	--	--	--	--	--	--	t	5	--	--	--	--	--	--
Cassiope Stelleriana	--	--	--	--	--	--	--	--	--	--	--	--	1	5	--	--

Table B 36. Contd.

Species	Site 5, 4100 ft, Exp V, Slope 35%				Site 6, 4100 ft, Exp V, Slope 30%				Site 7, 4500 ft, Exp E, Slope 55%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Artemisia arctica	8	1	1	80	9	1	--	--	3	2	4	10
Bryophyta	27	1	--	--	24	1	--	--	10	2	--	--
Cetraria sp.	13	1	--	--	11	4	--	--	24	2	--	--
Carex microchaeta	22	1	6	55	6	1	--	--	6	1	3	30
Cladonia sp.	15	2	--	--	11	4	--	--	10	2	--	--
Sedum rosea	4	1	23	50	1	2	--	--	1	2	10	30
Peltigera sp.	4	4	--	--	10	2	--	--	--	--	--	--
Salix rotundifolia	3	2	--	--	4	5	--	--	1	5	--	--
Hierochloe alpina	2	2	1	70	t	5	--	--	1	4	--	--
Thamnolia vermicularis	2	3	--	--	1	4	--	--	--	--	--	--
Lloydia serotina	1	3	--	--	--	--	--	--	--	--	--	--
Luzula Wahlenbergii	1	4	--	--	--	--	--	--	t	6	--	--
Campanula lasiocarpa	1	2	--	--	t	4	--	--	1	1	--	--
Antennaria monocephala	1	7	--	--	2	5	--	--	2	5	--	--
Polygonum viviparum	t	5	--	--	--	--	--	--	--	--	--	--
Primula cuneifolia	t	6	--	--	--	--	--	--	--	--	--	--
Arctostaphylos uva-ursi	t	7	--	--	1	5	--	--	t	5	--	--
Festuca ovina	t	7	--	--	--	--	--	--	t	6	--	--
Festuca altaica	--	--	--	--	3	4	--	--	--	--	--	--
Geranium erianthum	--	--	--	--	3	5	--	--	1	2	--	--
Cassiope Stelleriana	--	--	--	--	2	5	--	--	2	4	--	--
Vaccinium ovalifolium	--	--	--	--	1	6	--	--	t	5	--	--
Epilobium angustifolium	--	--	--	--	1	5	--	--	--	--	--	--
Solidago multiradiata	--	--	--	--	1	5	--	--	t	5	--	--
Myosotis alpestris	--	--	--	--	t	5	--	--	--	--	--	--
Pedicularis sp.	--	--	--	--	t	6	--	--	--	--	--	--
Luzula spicata	--	--	--	--	t	6	--	--	t	5	--	--
Epilobium latifolium	--	--	--	--	t	6	--	--	2	3	1	20
Trisetum spicatum	--	--	--	--	t	6	--	--	--	--	--	--
Poa leptocoma	--	--	--	--	t	6	--	--	--	--	--	--

Table B 37. Species coverage, frequency ranking, and utilization of vegetation by goats on Stellaria ridges on summer range in the Kenai Mountain

Species	Site 1, 2600 ft, Exp NV, Slope 75%				Site 2, 2400 ft, Exp V, Slope 75%			
	Coverage	Frequency	Coverage Removed	Tissue Removed	Coverage	Frequency	Coverage Removed	Tissue Removed
Stellaria sp.	20	1	--	--	10	1	--	--
Lupinus nootkatensis	2	4	--	--	30	2	1	20
Polemonium acutiflorum	15	1	3	6	5	2	3	15
Bryophyta	10	3	--	--	10	3	--	--
Poa stenantha	5	1	10	50	2	4	4	60
Veronica Wormskjoldii	4	2	--	--	1	4	--	--
Draba cinera	4	3	5	30	3	3	2	20
Stellaria sitchana	2	4	--	--	t	6	--	--
Peltigera sp.	1	5	--	--	t	5	--	--
Carex macrochaeta	1	6	--	--	1	2	--	--
Calamagrostis canadensis	t	6	--	--	1	4	--	--
Aquilegia formosa	t	7	--	--	t	5	--	--
Solidago multiradiata	--	--	--	--	t	7	--	--
Hieracium triste	--	--	--	--	t	7	--	--
Epilobium latifolium	--	--	--	--	t	7	--	--