



The ecology of the Rocky Mountain goat in the Spanish Peaks area of southwestern Montana
by Stanley Vernon Peck

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
MASTER OF SCIENCE in Fish and Wildlife Management

Montana State University

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Abstract:

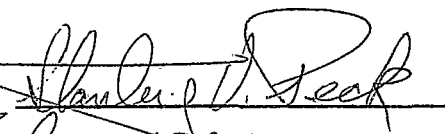
An ecological study of the Rocky Mountain goat (*Oreamnos americanus missoulae*) was conducted in the Spanish Peaks area of southwestern Montana from April, 1970 to November of 1971. Aerial surveys revealed three areas of goat concentration in winter; Spanish Peaks, Bear Trap, and Jack Creek. The Spanish Peaks and Bear Trap were used by goats in summer. The segment of the population that used the Jack Creek area in winter migrated to the Spanish Peaks area in late spring or early summer. Four habitat types including timber, sliderock, ledge, and ridge were delineated on the basis of usage by goats. Ledge received the greatest use during all seasons. The presence of succulent vegetation in conjunction with residual snowdrifts appeared to directly influence the use of habitat types and exposures during summer. Snow cover influenced the use of exposures during all seasons. During summer goats preferred shaded areas for all activities. A change in proportionate use of forage classes between summers was revealed from feeding site examination. This was related to the type of habitat used and availability of residual snowdrifts. Forbs were the most used forage class during summer. Examination of rumen contents indicated that grasses, sedges, and rushes were more heavily used than any other forage class during fall. Curl-leaf mountain mahogany (*Cercocarpus ledifolius*) was the primary forage in winter for both Jack Creek and Bear Trap areas. No data on food habits in winter were available for the Spanish Peaks area, but the examination of alpine fir (*Abies lasiocarpa*) in summer indicated use of this plant. Examination of reproductive organs from hunter killed goats indicated the breeding season is probably later than October and females breed for the first time as 2 1/2 year olds. Kid/adult ratios were higher in the Jack Creek and Bear Trap areas than in the Spanish Peaks. Ratios were 42/100, 43/100, and 21/100 respectively. Age class composition of a sample of goats killed by hunters during 1971 was lower than for a sample from 1970. This plus the relatively small harvest in relation to the total population suggested that Jack Creek segment was sustaining a disproportionate share of the kill of goats by hunters. Hunter success was only moderately high in both seasons with 60 and 65 percent respectively of the permit holders killing a goat. Most of the animals were killed during the first week of the mid-September to late-November season.

An earlier season would possibly provide for greater hunter harvest, more desirable hunting conditions, and distribute the kill more evenly over all segments.

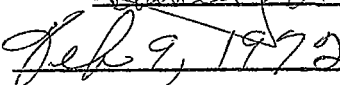
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THE ECOLOGY OF THE ROCKY MOUNTAIN GOAT IN THE
SPANISH PEAKS AREA OF SOUTHWESTERN MONTANA

by

STANLEY VERNON PECK

A thesis submitted to the Graduate Faculty in partial
fulfillment of the requirements for the degree

of

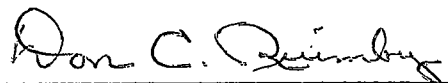
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ABSTRACT

An ecological study of the Rocky Mountain goat (*Oreamnos americanus missoulæ*) was conducted in the Spanish Peaks area of southwestern Montana from April, 1970 to November of 1971. Aerial surveys revealed three areas of goat concentration in winter; Spanish Peaks, Bear Trap, and Jack Creek. The Spanish Peaks and Bear Trap were used by goats in summer. The segment of the population that used the Jack Creek area in winter migrated to the Spanish Peaks area in late spring or early summer. Four habitat types including timber, sliderock, ledge, and ridge were delineated on the basis of usage by goats. Ledge received the greatest use during all seasons. The presence of succulent vegetation in conjunction with residual snowdrifts appeared to directly influence the use of habitat types and exposures during summer. Snow cover influenced the use of exposures during all seasons. During summer goats preferred shaded areas for all activities. A change in proportionate use of forage classes between summers was revealed from feeding site examination. This was related to the type of habitat used and availability of residual snowdrifts. Forbs were the most used forage class during summer. Examination of rumen contents indicated that grasses, sedges, and rushes were more heavily used than any other forage class during fall. Curl-leaf mountain mahogany (*Cercocarpus ledifolius*) was the primary forage in winter for both Jack Creek and Bear Trap areas. No data on food habits in winter were available for the Spanish Peaks area, but the examination of alpine fir (*Abies lasiocarpa*) in summer indicated use of this plant. Examination of reproductive organs from hunter killed goats indicated the breeding season is probably later than October and females breed for the first time as 2½ year olds. Kid/adult ratios were higher in the Jack Creek and Bear Trap areas than in the Spanish Peaks. Ratios were 42/100, 43/100, and 21/100 respectively. Age class composition of a sample of goats killed by hunters during 1971 was lower than for a sample from 1970. This plus the relatively small harvest in relation to the total population suggested that Jack Creek segment was sustaining a disproportionate share of the kill of goats by hunters. Hunter success was only moderately high in both seasons with 60 and 65 percent respectively of the permit holders killing a goat. Most of the animals were killed during the first week of the mid-September to late-November season. An earlier season would possibly provide for greater hunter harvest, more desirable hunting conditions, and distribute the kill more evenly over all segments.

INTRODUCTION

The Spanish Peaks Wilderness area, approximately 32 miles southwest of Bozeman, Montana, is one of the areas into which the Rocky Mountain goat (*Oreamnos americanus missoulae*) was introduced by the Montana Fish and Game Department. A total of 35 was trapped in the Deep Creek area west of Choteau in northcentral Montana and transplanted into areas of the Spanish Peaks as follows: May of 1947--two adult males, two adult females, and one yearling male into the West Fork; May and June of 1950--six adult males into the West Fork and 16 adult males, three adult females, two male kids, and three female kids into the "Bear Trap" area adjacent to the Madison River dam (Fig. 1). No intensive studies were conducted on this population after the initial introductions. Mountain goat numbers increased and in 1964 the first hunting season was held with five either sex permits being issued. In 1967 and 1970 the number of permits was raised to 10 and 20 respectively in an attempt to secure greater harvests. In 1970 and 1971 an intensive study of the ecology of the Rocky Mountain goat was conducted in the Spanish Peaks Wilderness and surrounding area by the author under the auspices of the Montana Fish and Game Department in conjunction with Montana State University. The need for more specific information to more intensively manage this herd and the increased use by people of the Spanish Peaks Wilderness area were motivating factors in the initiation of this study. The main

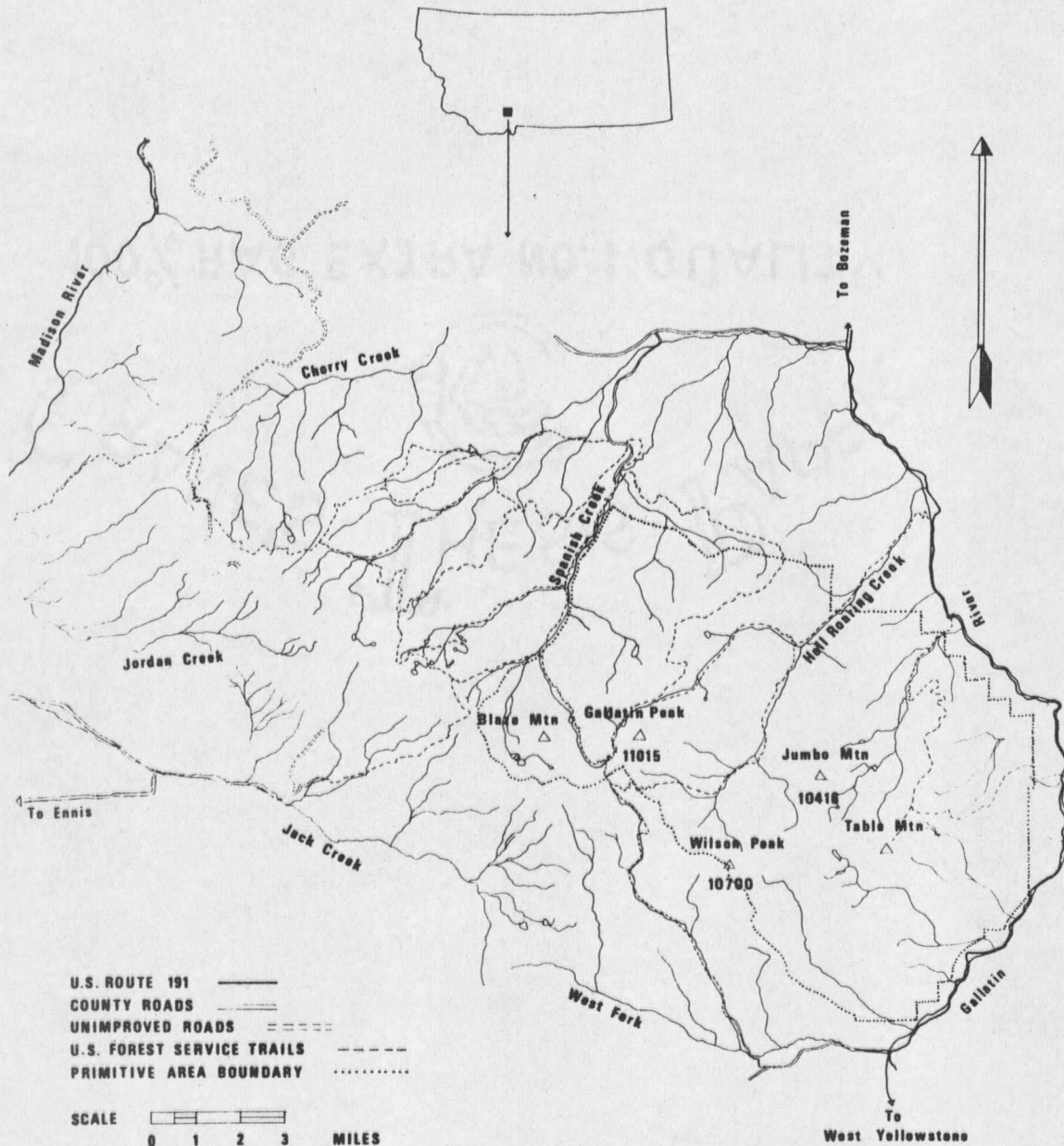


Figure 1. Map of Study Area.

objectives were: (1) to describe quantitatively the major vegetation types utilized by mountain goats; (2) to describe mountain goat seasonal distribution, movements, food habits, production, age class composition, and behavior patterns; (3) to determine range conditions and trends; and (4) to obtain hunter harvest information and biological samples from mountain goats killed by hunters.

DESCRIPTION OF STUDY AREA

The Spanish Peaks study area (Fig. 1) of approximately 215 square miles is irregular in shape, being elongated in a northwest-southeast direction. It lies in the Gallatin and Beaverhead National Forests of Gallatin and Madison Counties. The Spanish Peaks are characterized by rugged topography. Gallatin Peak, with an elevation of 11,015 feet above sea level, is the highest point. Elevation decreases abruptly to 6,000 and 5,000 feet at the Gallatin and Madison River Canyons to the east and west, respectively. This area is bordered by lower mountains of the Madison Range to the north and south. Drainage eastward and westward is by tributaries of the Gallatin and Madison Rivers, respectively. Most of these streams flow in broad glaciated valleys with steep walls extending to the ridge crests, 1,000 to 3,000 feet above the valley floors. Alpine glaciation has produced a topography with many knife-edge ridges and cirques (Fig. 2). All of the many lakes in the area occupy cirques. Near the eastern and western boundaries of the area, glacial erosion was not as severe, and traces of the preglacial topography remain. Most of the area consists of precambrian metamorphic rock which along the southwestern boundary of the area, is in fault contact with folded mesozoic sedimentary rocks. Information on the geology and climate was obtained from Becraft (1966). Timberline is near 9,000 feet. Slopes below are forested with various species of conifers. Predominant conifers listed according to



Figure 2. View in the Spanish Peaks showing knife-edge ridges and snow filled cirques.

occurrence from higher to lower elevations include alpine fir (*Abies lasiocarpa*), limber pine (*Pinus flexilis*) or whitebark pine (*Pinus albicaulis*), Engelmann spruce (*Picea engelmanni*), Douglas fir (*Pseudotsuga menziesii*), and lodgepole pine (*Pinus contorta*). Understory is similar in all of these conifer types consisting mainly of dwarf huckleberry (*Vaccinium scoparium*), and Arnica (*Arnica* sp.). Several species of deciduous trees grow along stream beds, with quaking aspen (*Populus tremuloides*) being the most abundant. The south slopes of some ridges at lower altitudes are bare except for big sagebrush (*Artemisia tridentata*), curl-leaf mountain mahogany (*Cercocarpus ledifolius*), and bluebunch wheatgrass (*Agropyron spicatum*).

The climate in the basin surrounding the area is semiarid, but the mountains have considerably more precipitation. Snow covers the area from October into July with depths of 2-6 feet being common. There are wide variations in daily and seasonal temperatures. Summers are mild with temperatures seldom above 90 degrees F. Winters are severe, with considerable subzero temperatures.

METHODS

Representatives of the major plant species were collected during the summers of 1970 and 1971. My identifications of plants were verified by Dr. W. E. Booth. Scientific and common names followed Booth (1959), and Wright and Booth (1954).

During the summer and fall of 1970 and 1971, vegetational composition and habitat types of areas used by mountain goats were determined. To determine vegetational composition for low growing plants, a method similar to Daubenmire's (1959) was used to estimate canopy coverage and frequency within plots and stands. For shrub and timber types a method similar to Canfield (1941), with slight modifications, was used. In timber areas a 100 foot line was stretched through a stand to be sampled. Basal diameter was recorded for each tree within six inches of the line. All shrubs and other low growing plants that contacted the line were recorded as to inches of canopy intercept by species to the nearest 1/10 inch. An estimation of canopy coverage of conifers was made on each stand sampled.

An abney level was used to determine percent of slope.

Feeding sites were examined after mountain goats had departed from a feeding area. Use on each plant species was recorded following a system similar to that reported by Brazda (1953). When practical, the vegetation within each of 20 2x5 dcm. plots was examined on a feeding site to determine vegetational composition. To supplement data from

feeding sites, a rumen sample from each of 11 hunter-killed goats was analyzed in the laboratory. Samples were washed on a 4 mm. screen, and the plant parts were separated and identified to species if possible but in many instances only major categories of classification were recognizable. Each item was then measured as to volume by the water displacement method.

Ground observations of mountain goats were conducted during both summers with the aid of 7x35 binoculars and a 15-60 power spotting scope. Locations of animals observed were plotted within a 1/8 section area on a base map. Other data recorded for each observation site included approximate elevation, habitat type, and whether in shade or in sunlight. Activities of mountain goats such as moving, resting, or feeding were noted. Composition of groups to adults and kids were recorded. No attempt was made to determine sex.

Aerial surveys from a 150 hp. Super Cub were conducted throughout the period of study. Roger Stradley was the pilot during most of the flights with the writer as observer on all trips. Procedures were similar to Lentfer (1955). Data collected during these flights were the same as for ground observations. Due to inclement weather and high winds aloft, no complete censuses of the entire area were possible during midwinter of 1970 and 1971.

In the spring of 1971 an attempt was made to trap mountain goats on the Jack Creek winter range so that individuals could be marked for

identification. No animals were trapped and an alternate method was instituted. Six glass balls filled with orange or blue sheep branding paint were dropped from the Super Cub on each of five individual animals. Areas of the body marked were recorded. This allowed identification of individuals. One marked animal was reobserved on July 8th. Shedding of hair in late July probably prevented other observations.

Biological specimens from hunter-killed-goats were obtained during the 1970 and 1971 hunting seasons. Eight animals were taken in October and five in September. Eleven reproductive tracts, 11 rumen samples, and 13 mandibles were obtained. The gonads from two male and nine female mountain goats were sectioned and examined to determine the presence of mature spermatozoa or corpora lutea and corpora albicantia, respectively. Age of specimens was estimated by the examination of mandibular dentition (Lentfer, 1955).

Representatives of the major forage species were collected from winter ranges in the Spanish Peaks and Jack Creek areas for chemical analyses by chemists at the Chemistry Station at Montana State University. Needles and smaller twigs of alpine fir, leaders and leaves of curl-leaf mountain mahogany, and seedheads and leaves of sedges, rushes, and grasses were the parts collected for testing. These tests provided a basis for comparing nutrient values of forage on the different ranges. An attempt was made to equate these samples by collecting them at about the same time with reference to phenology.

Curl-leaf mountain mahogany was collected in Jack Creek when the first green blades of downy chess brome (*Bromus tectorum*) began to appear in the late winter. Alpine fir, sedges, rushes, and grasses were collected in the Spanish Peaks when the first green blades of spreading wheatgrass (*Agropyron scribneri*) began to appear in spring.

RESULTS

Distribution of Mountain Goats

Aerial observations revealed three areas of concentration; Spanish Peaks, Jack Creek, and Bear Trap (Figs. 3, 4). Mountain goats were observed in the Spanish Peaks during all seasons. Numbers of goats counted in winter were approximately two-thirds of those in summer which revealed a minimum of 58 goats for the latter season. About 20 goats were observed in the Jack Creek area, but only in winter. One goat marked on Jack Creek in May of 1971 was observed on a ridge equidistant between Jack Creek and the Spanish Peaks in July of the same year. On this same ridge, a recognizable group of four yearlings and one adult was observed on three different occasions between May 23 and June 22, 1971. These observations suggest that the goats wintering on Jack Creek were a part of the Spanish Peaks summer population. The Bear Trap area was used by about 10 goats during all seasons in 1970 and 1971. No movement from this area was apparent.

Habitat Types

Four major habitat types based on physiography, vegetation, and usage by mountain goats for resting and/or feeding were recognized. These were timber (Fig. 5), sliderock (Fig. 6), ledge (Fig. 7), and ridge (Fig. 8).

Timber type: This type was characterized by mature stands of evergreen conifers ranging from approximately 10 to 30 feet in height.

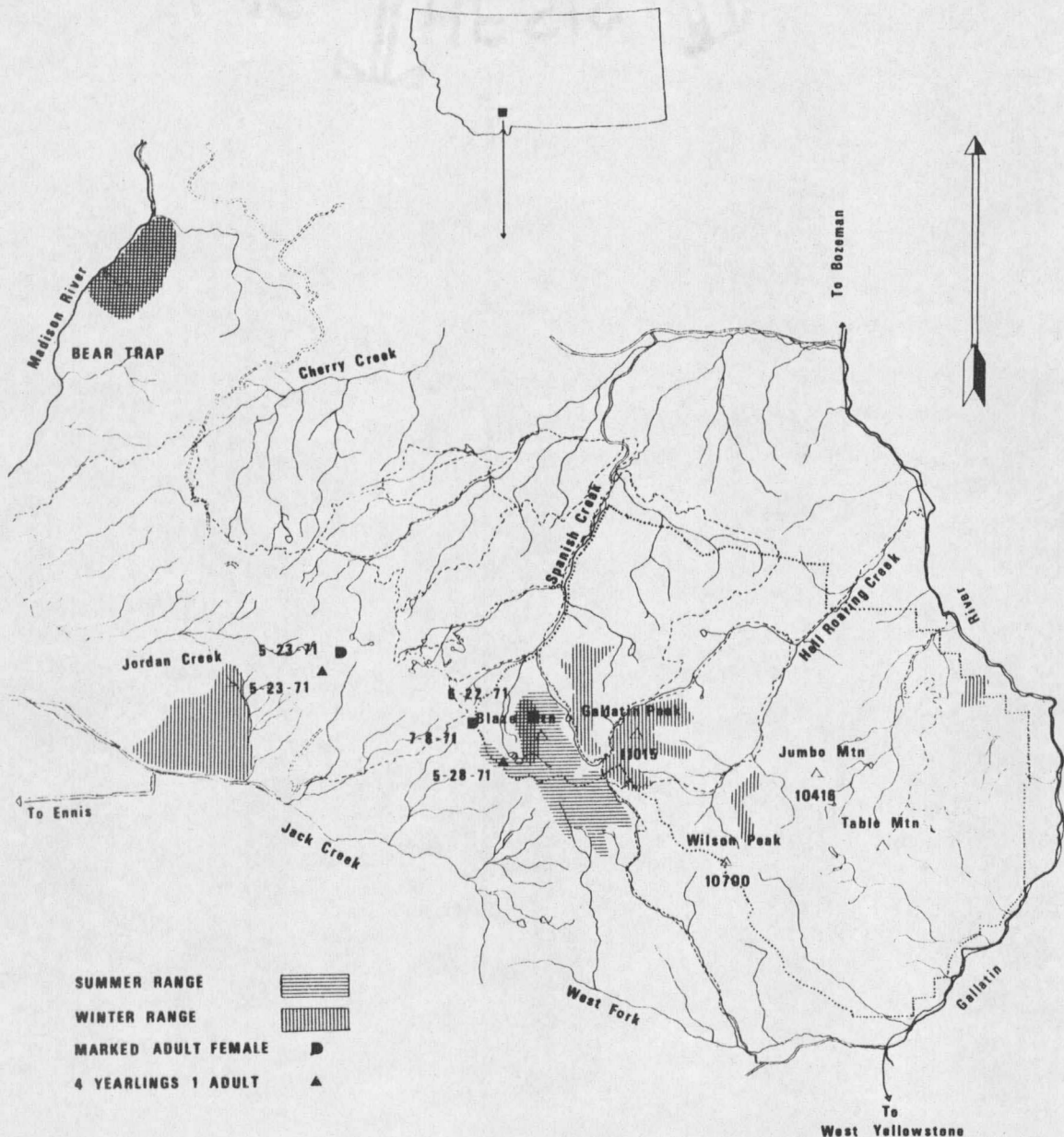


Figure 3. Summer and winter distribution of mountain goats and movements of identifiable animals as determined from aerial surveys.

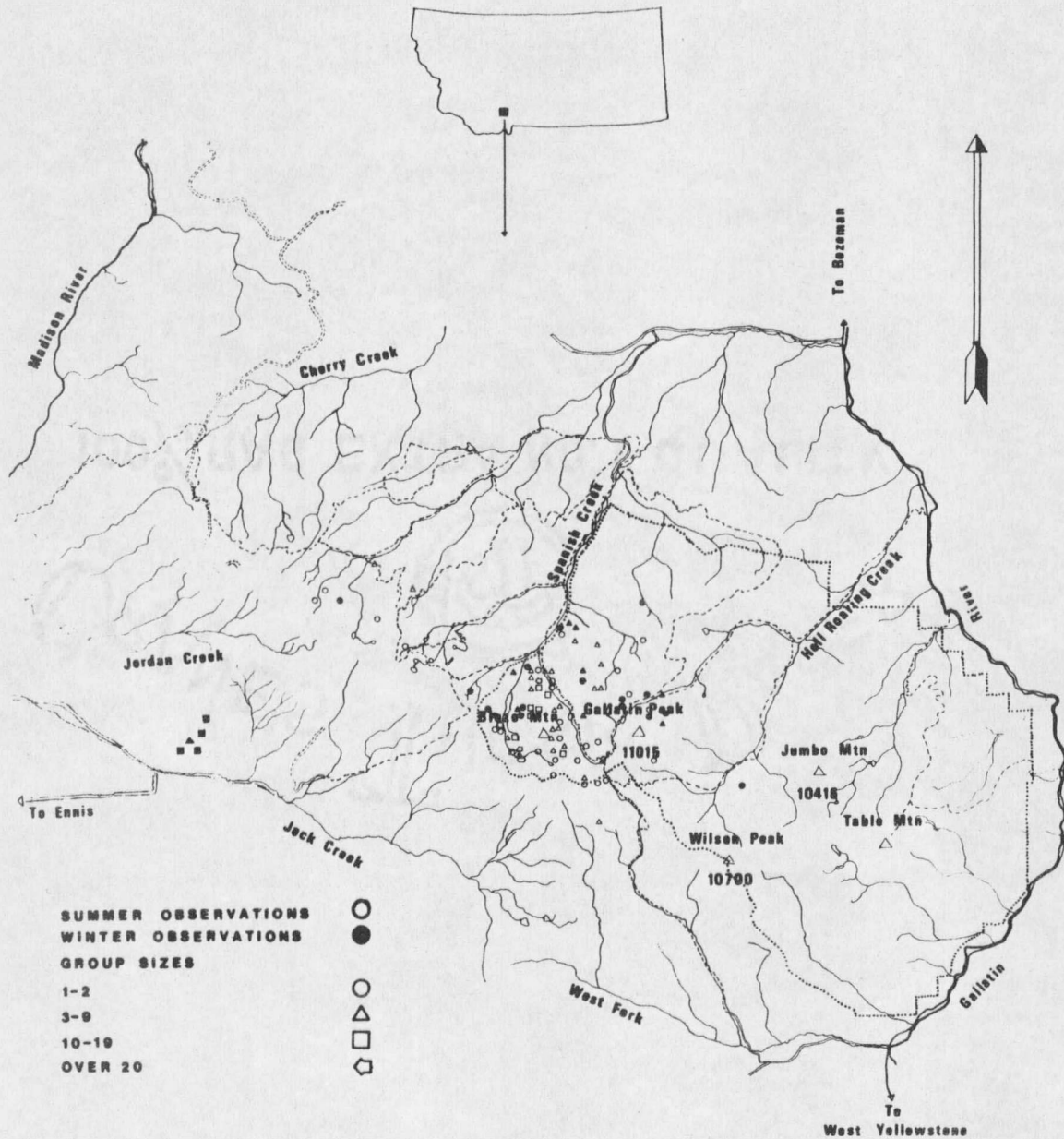


Figure 4. Quantitative distribution of mountain goats in summer and winter as determined from aerial surveys.

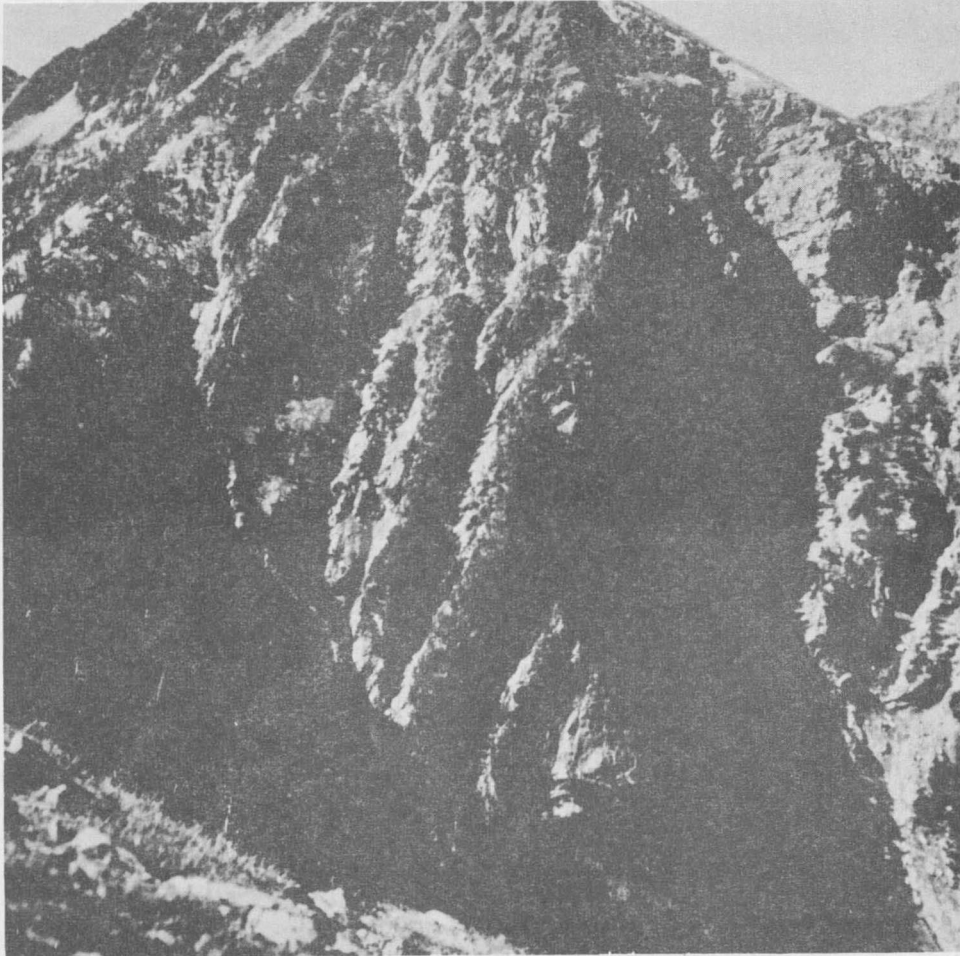


Figure 5. A. View in the Spanish Peaks showing timber type, at a distance.



Figure 5. B. View in the Spanish Peaks showing timber type, close up.



Figure 6. A. View in the Spanish Peaks showing sliderock type, at a distance.

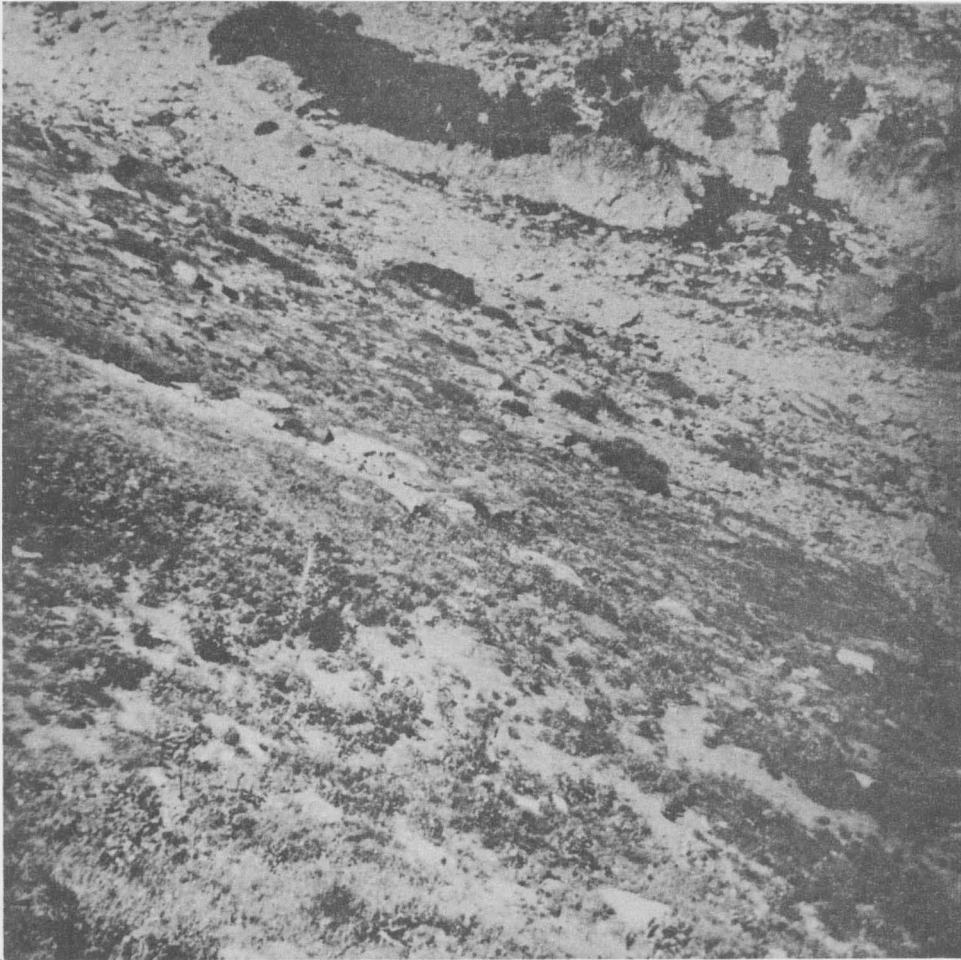


Figure 6. B. View in the Spanish Peaks showing sliderock type, close up.



Figure 7. A. View in the Spanish Peaks showing ledge type, at a distance.



Figure 7. B. View in the Spanish Peaks showing ledge type, close up.



Figure 8. A. View in the Spanish Peaks showing ridge type, at a distance.

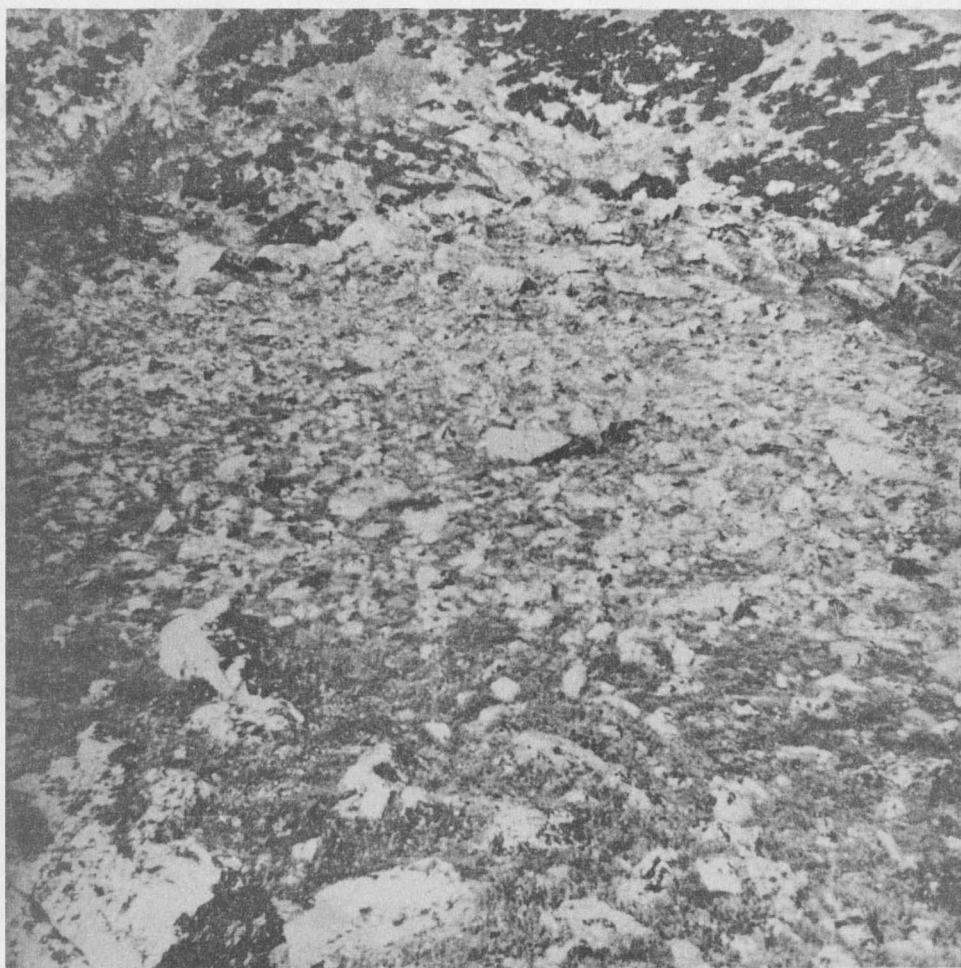


Figure 8. B. View in the Spanish Peaks showing ridge type, close up.

It was found mainly on north exposures with slopes ranging from 25 to 90 percent, with most being in the 80 to 90 percent range. Soils in this type were four to five inches in depth. Major species were alpine fir, white bark pine or limber pine, Engelmann spruce, and a scattering of Douglas fir. Characteristics of the tree species are shown in Table 1. Understory vegetation was dominated by dwarf huckleberry (Table 2).

Sliderock type: Sliderock type was situated in areas of stabilized rockslides with the beginning of soil formation and very little movement of the substrate. "Fingers" of this type were observed to extend downward into the timber type, but this type was usually found above 9,000 feet. Slopes in the area ranged from 60 to 80 percent, with most falling in the 65 percent category. Soils were very shallow, in most areas being less than two inches in depth. Vegetation consisted mainly of plants less than 10 inches in height with sheep cinquefoil (*Potentilla ovina*), Hayden clover (*Trifolium haydenii*), sedges (*Carex* sp.), and yarrow (*Achillea millefolium*) being the major plants present (Table 2).

Ledge type: Ledge type occurred mainly at elevations above 9,500 feet in broken areas of the topography, but this type was also observed intermingled with the timber type. Slope ranged from 45 to 85 percent, with a wide variation being apparent. Soil depths were usually two inches or less. Major plants were sedge, Hayden clover, Arnica

Table 1. Average basal diameter for individuals and total canopy coverage for all tree species encountered along a 100-foot transect at each of three elevations.

Trees	Elevation		
	7,600 ft.	9,000 ft.	9,200 ft.
<i>Abies lasiocarpa</i>	3.8/1 ¹	2.45/4	6.6/6
<i>Picea engelmanni</i>		32.8/2	
<i>Pinus flexilis</i> or <i>Pinus albicaulis</i>		1.6/3	4.25/10
<i>Pseudotsuga menziesii</i>	6.3/4		
<i>Pinus contorta</i>	9.0/2		
Approximate canopy coverage, in percent	75	35	90

¹Average basal diameter in inches/number of trees sampled.

Table 2. Vegetational composition of low growing plants in each habitat type as determined by evaluation of 20 2x5 dcm. plots in each of two stands for each habitat type.

Plants	Habitat Type			
	Timber	Sliderock	Ledge	Ridge
Grasses ¹	1.2/35	3.1/70 ²	3.0/68	8.3/93
Sedges ³	1.4/40	11.3/85	34.2/100	15.7/100
Rushes ⁴		5.3/70	9.1/53	12.8/100
Forbs	32.8 ⁵	77.2	48.3	57.9
<i>Achillea millefolium</i>		9.3/40	1.2/18	0.5/20
<i>Agoseris</i> sp.		1.2/20		
<i>Antennaria alpina</i>	0.5/15	Tr./3.0 ⁶	3.0/35	
<i>Arenaria congesta</i>				3.4/65
<i>Arnica cordifolia</i>	6.0/75			
<i>Arnica rydbergii</i>	7.8/95	7.2/40	13.4/75	
<i>Campanula rotundifolia</i>		Tr./8		
<i>Castilleja pulchella</i>		0.7/13		
<i>Castilleja rhexifolia</i>	1.1/30			
<i>Cerastium beeringianum</i>		3.5/25		Tr./10
<i>Epilobium glandulosum</i>	2.6/30		Tr./5	
<i>Erigeron compositus</i>	3.4/70	4.9/65	0.5/15	1.6/40
<i>Eritrichium nanum</i>		4.4/40	4.1/50	14.5/100
<i>Gentiana algida</i>		Tr./3		
<i>Mertensia alpina</i>		0.5/15	0.5/13	3.2/30
<i>Pedicularis</i> sp.	2.6/25	0.9/23	1.4/10	
<i>Phlox</i> sp.		5.3/45		8.4/95
<i>Polygonum bistortoides</i>		2.3/50		Tr./5
<i>Potentilla ovina</i>	2.6/25	16.8/65	0.7/5	19.2/95
<i>Sedum stenopetalum</i>		Tr./3	Tr./5	1.0/40
<i>Senecio triangularis</i>	6.2/30	4.0/15	1.7/13	
<i>Smelowskia calycina</i>		1.7/33		Tr./5
<i>Trifolium haydenii</i>		13.1/93	21.8/100	6.1/75
Forbs; Unidentified		1.4/8		

Table 2. Continued.

Plants	Habitat Type			
	Timber	Sliderock	Ledge	Ridge
Shrubs				
<i>Vaccinium caespitosum</i>	63.6/80	2.5/18	4.1/35	
Lichens			1.3/23	5.3/95
Mosses	0.9/25	1.3/5		

¹Includes *Deschampsia caespitosa*, *Festuca ovina*, *Phleum alpinum*, and *Poa alpina*.

²Percent canopy coverage/frequency of occurrence.

³Includes *Carex concinnoides*, and *Carex podocarpa*.

⁴Includes *Juncus drummondii*, *Luzula spicata*, and *Luzula parviflora*.

⁵Total canopy coverage of all forbs.

⁶Tr. indicate less than 0.5%.

(*Arnica rydbergii*), and rushes (Table 2).

Ridge type: Ridge type occupied the highest elevation of all the types with most occurring over 9,500 feet. Slope was not established for this type. Soil was variable, ranging from less than one inch in some areas to as deep as three inches in others. Vegetation was mainly composed of sheep cinquefoil, sedges, alpine-forget-me-not (*Eritrichium nanum*), and rushes (Table 2).

Use of Habitat Types

Summer (July, August): During the summers of 1970 and 1971, 1,774 observations of mountain goats were recorded by habitat type (Table 3). Use of timber type as compared to use of other types was relatively low during July and August of both summers. During July of 1971 no use of this type by goats was observed. This was possibly related to retention of snow from the near record snowfall of the previous winter (Table 4). Use of the timber in summer was mainly during or immediately before a storm. In early May, goats were observed to move off the winter range in Jack Creek into timbered areas. About mid-June some mountain goats were seen leaving timbered areas accompanied by new-born kids, suggesting kidding occurred here as reported by Saunders (1955). Saunders (1955) reported light use of the timbered type by goats during summer and Foss (1962) reported use during inclement weather.

Use of the sliderock type appeared to be related to the abundance of residual snowdrifts on the ledge type. During July of 1970 use of

Table 3. Use of habitat types by mountain goats in summer as observed during ground and aerial observations (includes repeated observations of the same animals).

Habitat Type	July 1970	July 1971	August 1970	August 1971	Summer 1970 and 1971
Timber	43/8 ¹	0/0	20/4	16/4	79/4
Sliderock	172/32	160/45	225/49	77/18	634/36
Ledge	244/46	175/49	197/43	332/78	948/54
Ridge	73/14	19/6	20/4	1/0.1	113/6
Total	532/100	354/100	462/100	426/100	1774/100

¹Number of observations of goats/percent of total.

Table 4. Snow depths and water content of snow at two elevations in areas immediately adjacent to the study area in late winter of 1970 and 1971. U. S. Dept. of Agriculture, Soil Conservation Service, Montana.

Location	Date	Snow Depth	Water Content
Bear Basin (8150 feet)	3/27/70	85 ¹	26.4 (20.2) ²
	4/1/71	90	31.8 (20.2)
Jack Creek (7400 feet)	3/31/70	30	7.2 (6.0) ³
	3/30/71	28	9.1 (6.0)

¹All measurements in inches.

²Nine year average water content.

³Six year average water content.

sliderock was lower than use of the ledge type, but in August of that year use of the sliderock was greater than use of the ledge type. This was apparently related to the disappearance of snowdrifts and the subsequent drying of the ledge and ridge types. Sliderock type remained mesic throughout the summer of 1970. In July of 1971 use of ledge and sliderock was approximately equal. In August of 1971 use of the ledge was four times as high as use of sliderock. Many of the ledge areas retained snowdrifts throughout the summer and into the fall. This was apparently related to a near record snowfall the previous winter (Table 4), but other climatic factors may have been significant.

Ridge type was used mainly for movements by mountain goats. Animals moving off the Jack Creek winter range used this type to move to the summer range in the Spanish Peaks. One female mountain goat marked on the winter range was observed moving into the Spanish Peaks via this type. Greater use of this type in July of 1970 as compared to July of 1971 was possibly due to the later movement of mountain goats from the Jack Creek winter range in 1971, because of higher snowfall during the preceding winter, and slower snow melt. Greater use of ridges in 1970 as compared to use in 1971 was indicated by the data for August. The decreased use of ledges and increased use of sliderock from July to August of 1970 may have caused extensive movement by goats and hence use of the ridge type as goats moved from one area to another to get to areas of sliderock where mesic conditions prevailed

longer than on other types. In July and August of 1971 all types remained more or less mesic. Goats were not obligated to engage in extensive movements to find favorable feeding sites. This possibly accounted for the low use of ridges.

Fall (September, October): Use of habitat types in fall was similar to use of these types in summer (Tables 3 and 5). The small increase in use of ledge in fall was possibly due to activity during the hunting season. Most goats were observed on ledge type during this season (Table 5). This was probably due to the high threshold value of this type.

Winter (November, December, January, February, March, April): Highest use of a single habitat type during any season occurred on ledge type in winter. Saunders (1955) reported that grasses, sedges, and rushes received higher use than any other type of vegetation during the winter. Ledges supported more of this type of vegetation than any other type (Table 2). Use of all habitat types increased as compared to both summer and fall, except sliderock which was not used.

Spring (May, June): The habitat type most used during spring was ridge. This was apparently related to movements. Mountain goats began moving into timbered areas to kid and off the winter range in some instances to summer range via ridges. As compared to all other seasons, spring use of the habitat types showed a more equal distribution.

Table 5. Use of habitat types in fall, winter and spring of 1970-71 as determined from aerial observations (includes repeated observations of the same animals).

Habitat Type	Fall	Winter	Spring
Timber	4/4 ¹	16/16	23/20
Sliderock	34/37		16/14
Ledge	55/59	71/70	37/32
Ridge		15/14	41/35

¹Number of observations of goats/percent of total.

Ridges received significantly more use than in any other season.

Use of Exposures

Summer: Northern exposures received greater use in this season than at any other time (Table 6). The lush vegetation in connection with the abundant residual snowdrifts was probably the main factor.

Fall: Exposure use changed from summer to fall with most mountain goats using southern exposures during the latter season. Heavy use of the southern exposure was probably due to the snowfall period which began in mid-September. While southern exposures were characterized by melting snow and bare slopes, most other slopes remained snow covered.

Winter: Exposure use during the winter was mainly confined to southern and western exposures. Prevailing winds in the study area are from the southwest. Thus some of the ledges on southern and western exposures were blown free of snow. No use was made of northern exposures during this season although they were used in all other seasons.

Spring: A change of order was noted from winter to spring with the western exposure becoming the most important. Some of the timbered areas used for kidding were situated on western exposures and probably were a middle ground between the bright southern exposures and the snow choked northern exposures.

Table 6. Seasonal use of exposures by goats as recorded from aerial observations (includes repeated observations of the same animals).

	Northern	Eastern	Southern	Western
Summer	181/50 ¹	35/9	86/24	62/17
Fall	14/30	1/2	24/51	8/17
Winter		1/7	8/53	6/40
Spring	22/13	13/7	52/30	87/50

¹Number of observations of goats/percentage of total.

Daily Activities in Summer

Hourly activities of mountain goats are shown in Table 7. Goats were observed to feed during all daylight hours. During any hour at least 22 percent of the goats observed were feeding. The greatest peak of feeding activity occurred between 6:00 and 6:59 a.m. A lesser peak was indicated for 8:00 to 8:59 p.m. Non-feeding goats were recorded as resting or moving. Some goats were recorded as engaged in one or the other of these activities during all hours except for 6:00 to 6:59 a.m. The highest percentage for resting among the goats was for 1:00 to 1:59 p.m. The highest percentage recorded for moving goats was for 10:00 to 10:59 a.m. This coincides with the time when most feeding sites became fully illuminated by sunlight. Mountain goats preferred shaded area during all activities (Table 8). This was more marked in August than in July when snowdrifts were more numerous.

Food Habits

Summer (Spanish Peaks): During the summer of 1970 forbs made up 95 percent of the total instances of use at feeding sites and 61.7 percent of the total canopy coverage on habitat types used by goats for feeding (Table 9). Arrowleaf groundsel (*Senecio triangularis*), lanceleaf bluebell (*Mertensia* sp.), bluebell (*Mertensia* sp.), and Arnica (*Arnica rydbergii*) made up over 90 percent of the total instances of use. All were more common in the diet than in the plant community suggesting preference. Grasses, sedges, and rushes made up

Table 7. Hourly activities of mountain goats for the summers of 1970 and 1971 as determined by ground observations (includes repeated observations of the same animals).

Time Intervals	Feeding	Resting	Moving
6:00-6:59 a.m.	23/92 ¹	2/8	0/0
7:00-7:59 a.m.	52/57	36/40	3/3
8:00-8:59 a.m.	12/34	16/46	7/20
9:00-9:59 a.m.	45/38	61/51	14/11
10:00-10:59 a.m.	47/40	22/19	48/41
11:00-11:59 a.m.	42/39	60/55	6/6
12:00-12:59 p.m.	31/38	31/38	20/24
1:00-1:59 p.m.	10/22	30/65	6/13
2:00-2:59 p.m.	20/59	3/9	11/32
3:00-3:59 p.m.	52/57	29/32	10/11
4:00-4:59 p.m.	107/44	84/34	53/22
5:00-5:59 p.m.	117/58	35/17	50/25
6:00-6:59 p.m.	104/67	20/12	32/21
7:00-7:59 p.m.	73/52	22/16	46/32
8:00-8:59 p.m.	38/69	10/18	7/13

¹Number of observations of goats/percent of total.

Table 8. Activities of mountain goats in shaded and sunlit areas during July and August 1970-71 as determined by ground observations (includes repeated observations of the same animals).

Activities	July 1970-71		August 1970-71	
	Shade	Sunlight	Shade	Sunlight
Feeding	264/85 ¹	47/15	409/95	23/5
Resting	132/71	54/29	251/82	56/18
Moving	82/59	56/41	143/85	25/15

¹Number of observations of goats/percent of total.

Table 9. Summer and fall food habits as determined by feeding site examinations and rumen analyses.

Plants ¹	Summer Composition		Instances of Use		Samples from 11 rumens in the fall of 1970 & 1971
	4 sites, 160 plots ²	3 sites, 120 plots ³	1970 16 sites	1971 11 sites	
Grasses, sedges, rushes	26.4/74 ⁴	37.8/88	72/5 ⁵	364/39	90/525.9 ⁶
Unidentified					82/473.5
Gramineae	3.0/67	4.3/77	39/3	10/1	Tr./2.4 ⁷
<i>Agropyron scribneri</i>					Tr./0.2
<i>Phleum alpinum</i>	0.9/16	1.2/21			
<i>Carex</i> sp.	14.0/81	20.4/95	15/1	64/7	7/40.8
<i>Carex concinnoides</i>	1.7/32	2.3/43		5/1	Tr./0.1
<i>Carex podocarpa</i>	Tr./21	0.5/28		277/29	Tr./0.1
Rushes	6.8/56	9.1/74	18/1	8/1	1/7.9
<i>Luzula parviflora</i>					Tr./1.1
Forbs	53.7/21	61.7/25	1472/95	581/61	6/33.2
<i>Achillea millefolium</i>	2.8/26	3.7/26			Tr./1.1
<i>Agoseris</i> sp.	Tr./7	0.4/7	7/Tr.		
<i>Antennaria alpina</i>	1.0/13	1.2/13			Tr./0.6
<i>Aquilegia flavescens</i>					Tr./0.2
<i>Arenaria congesta</i>	0.8/16	1.1/22			Tr./0.8
<i>Arnica longifolia</i>	0.6/9	Tr./10	40/3	26/3	Tr./0.2
<i>Arnica rydbergii</i>	7.1/54	6.9/38	255/17	209/22	Tr./1.7
<i>Castilleja pulchella</i>	Tr./3	Tr./4		2/Tr.	
<i>Cerastium berringianum</i>	1.0/9	1.3/12	10/1		Tr./1.6
<i>Erigeron compositus</i>	2.6/48	2.3/47	18/1	2/Tr.	
<i>Eriogonum flavum</i>					Tr./0.1
<i>Eritrichium nanum</i>	5.7/65	7.7/63			
<i>Heracleum lanatum</i>					Tr./1.6
<i>Heuchera cylindrica</i>					Tr./0.3
<i>Lupinus sericeus</i>					Tr./3.2
<i>Mertensia alpina</i>	1.0/15	1.4/19		54/6	
<i>Mertensia lanceolata</i>	1.8/28	Tr./Tr.	327/21		Tr./Tr.
<i>Mertensia</i> sp.	Tr./5	Tr./6	321/21		
<i>Pedicularis</i> sp.	1.2/15	0.8/11			

Table 9. Continued.

Plants	Summer Composition		Instances of Use		Samples of 11 rumens in the fall of 1970 & 1971
	4 sites, 160 plots	3 sites, 120 plots	1970 16 sites	1971 11 sites	
Forbs, continued					
<i>Phlox</i> sp.	3.4/35	4.6/47			
<i>Polemonium viscosum</i>					Tr./0.1
<i>Polygonum bistortoides</i>	0.7/14	0.9/18		2/Tr.	Tr./0.4
<i>Potentilla ovina</i>	9.8/48	12.2/55		18/2	Tr./2.3
<i>Saxifraga bronchialis</i>					Tr./0.4
<i>Sedum stenopetalum</i>	Tr./12	0.7/16			Tr./3.0
<i>Senecio triangularis</i>	3.0/15	1.9/9	489/32	250/26	3/15
<i>Smelowskia calycina</i>	0.6/10	0.7/13			
<i>Trifolium haydenii</i>	10.3/67	13.7/89	5/Tr.	18/2	Tr./0.6
Forbs, Unidentified	Tr./8	0.5/8			
Shrubs	17.5/33				1/3.9
<i>Alnus</i> sp.					Tr./2.4
<i>Phyllodoce glanduliflora</i>					Tr./0.1
<i>Salix</i> sp.					Tr./0.1
<i>Vaccinium caespitosum</i>	17.5/33				Tr./1.1
Conifers					3/11.2
<i>Abies lasiocarpa</i>					2/9.9
<i>Juniperus scopulorum</i>					Tr./0.1
<i>Pinus albicaulis</i> or <i>Pinus flexilis</i>					Tr./1.2

¹Only those plants with values of 0.1% or more of volume for rumens, for total instances of use, and/or vegetation composition are included.

²One site in each habitat type (see Table 2) for comparison with contents of rumen samples.

³The three sites were represented by sliderock, ledge, and ridge for comparison with feeding site data which are restricted to these types.

⁴Average percent canopy coverage/average frequency of occurrence.

⁵Number of instances of use/percent of total.

⁶Percent of total/volume in cc's.

⁷Trace is less than 0.1.

only five percent of the total usage, and 37.8 percent of the canopy coverage.

In the summer of 1971 forbs made up 61 percent of the total instances of use which approximated their abundance. Arrowleaf groundsel, and Arnica made up about 50 percent of the total usage. Arrowleaf groundsel was the most preferred species, with 26 percent of the total usage and 1.9 percent of the canopy coverage. Grasses, sedges, and rushes made up 39 percent of the total usage. Sedge (*Carex podocarpa*) appeared to be the most preferred of all plant species with 29 percent of the total usage and 0.5 percent of the canopy coverage. The heavy use of this plant in 1971 as compared to 1970 was probably due to the high water content of the residual snowdrifts for the former year (Table 4). This helped to maintain a lush vegetation on all areas, throughout the summer, especially on ledges where this and similar plants were abundant.

Fall (Spanish Peaks): Ninety percent of the total volume of plants from 11 rumen samples was grasses, sedges, and rushes, with *Carex* sp. being the most commonly recognized plant (Table 9). Forbs made up about six percent of the total volume with arrowleaf groundsel being the most important making up about two-fifths of the total forb volume. Conifers comprised about three percent of the total volume with alpine fir making up about nine-tenths of the total volume of conifers. The first noted seasonal use of shrubs occurred in the fall when this forage class made up about one percent of the total volume

of rumens. Alder (*Alnus* sp.) made up about two-thirds of the total shrub volume. A definite increase in the use of grasses, sedges, and rushes was apparent from summer to fall.

Winter (Spanish Peaks): No feeding sites were examined in the Spanish Peaks during winter. During the winter of 1971 goats were observed several times in alpine fir stands and examination of these stands later showed heavy use on available branches.

Winter (Jack Creek and Bear Trap): Browse was the most important forage source on both Jack Creek and Bear Trap winter ranges (Table 10) (Fig. 3). Browse made up 85 and 64 percent of the observed use on these two areas, respectively. The browse species receiving the heaviest use on both areas was curl-leaf mountain mahogany with 71 and 58 percent of the total use for Jack Creek and Bear Trap, respectively. No use of forbs was observed. Bluebunch wheatgrass, and Idaho fescue were commonly used grasses. Downy chess brome was used mainly in late winter when greenup began. Although alpine fir was present in the Jack Creek area, no use of this species was apparent.

Comparison of Chemical Composition of Forage Plants

During the late winter of 1971 samples of available winter forage were obtained from both the Spanish Peaks (Fig. 9) and Jack Creek (Fig. 10) winter ranges. Curl-leaf mountain mahogany from Jack Creek and alpine fir and grass-like plants from the Spanish Peaks were chemically analyzed (Table 11). Curl-leaf mountain mahogany was highest in

Table 10. Vegetation composition on Jack Creek and Bear Trap winter ranges and instances of use on various species.

Plants	Canopy Intercept 2-100 foot transects		Winter Feeding Sites Instances of use	
	Jack Creek	Bear Trap	Jack Creek	Bear Trap
Grasses	113.1/32 ¹	76/11	59/15 ²	55/36
<i>Agropyron spicatum</i>	68.3/19	42/6	37/9	23/15
<i>Bromus tectorum</i>	44.8/13	5/1	22/6	11/7
<i>Festuca idahoensis</i>		29/4		21/14
Forbs	33.5/9	85/11		
<i>Artemisia frigida</i>	23.5/7			
<i>Artemisia michauxiana</i>	8.0/2			
Cruciferae	1.0/Tr. ³			
<i>Tragopogon dubius</i>	1.0/Tr.			
Unidentified		85/11		
Shrubs	205.0/59	551.0/78	338/85	96/64
<i>Artemisia tridentata</i>	58.0/17		8/2	
<i>Cercocarpus ledifolius</i>	147.0/42	386.6/55	282/71	87/58
<i>Chrysothamnus nauseosus</i>	*		48/12	
<i>Philadelphus lewsi</i>		125.0/18		
<i>Prunus virginiana</i>		34.0/5		9/6
<i>Ribes</i> sp.		5.0/1		
Conifers				
<i>Pseudotsuga taxifolia</i>	*	19/2 ⁴		

¹Canopy intercept in inches/percent of total.

²Instances of use/percent of total.

³Trace is less than 0.5%.

⁴Average basal diameter/number of trees.

*Present in area but not encountered along transect.



Figure 9. View in the Spanish Peaks showing a portion of the mountain goat winter range.



Figure 10. View in Jack Creek of a portion of the mountain goat winter range.

Table 11. Comparison of food value for major forage species on two different winter ranges.

Area	Plants	Moisture %	Protein %	Ether Extract %	Ash %	Crude Fiber %	Phos- phorous %	Calcium %	Date Collected
Jack Cr. 7,000 ft.	Curl-leaf Mt. Mahogany	36.2	9.9	6.84	2.44	24.52	.09	.84	4/23/71
Spanish Peaks 9,200 ft.	Alpine fir	51.8	6.3	2.56	3.52	19.20	.18	.78	6/25/71
	Sedges, rushes & grasses	6.9	4.7	2.39	9.80	33.15	.86	.40	6/25/71

content of protein, ether extract, and calcium as compared to the other plants whereas grasses, sedges, and rushes were highest in phosphorous. Over all, alpine fir was second to curl-leaf mountain mahogany while grasses, sedges, and rushes were lowest of all, in nutrient value. Verme (1962) indicated that female white-tailed deer on a winter and spring diet with high calorie content and 12 percent protein had a fawn loss of only seven percent whereas females on a low calorie and protein diet for these seasons had a fawn loss of 90 percent. The differences between the nutritive values of forage on the Jack Creek and Spanish Peaks winter ranges may account for the higher kid/adult ratios on Jack Creek (Table 12).

Condition of Browse

A browse transect was established on the Jack Creek winter range in a stand of curl-leaf mountain mahogany in the spring of 1970. An examination was made in the fall of 1970 to measure the annual growth of the leaders (Table 13). Re-examination of the selected leaders in the spring of 1971 revealed that 75 percent of the leader growth and 80 percent of the leaders were used. I compared the results of qualitative estimates of browse usage, which are based on visual impressions, with the results of the quantitative method where measurements are utilized. The results were quite similar as regards the percent of total numbers of leaders used.

Table 12. Kid/adult ratios of mountain goats as determined during aerial surveys in June and July of 1970 and April of 1971.

Area	Date	Kids	Adults	Kids/100 Adults
Spanish Peaks Area	6/23/1970	7	34	21
	4/4/1971	6	24	25
Jack Creek Area	6/18/1970	5	12	42
	4/1/1971	5	7	71
Bear Trap Area	7/1/1970	3	7	43
	4/21/1971	3	7	43

Table 13. Results of qualitative and quantitative methods used to determine use of curl-leaf mountain mahogany on a browse transect in Jack Creek.

Methods	Ave. Leader Length in Fall 1970	Ave. Leader Length in Spring 1971	Percent of Leaders Used	Percent of Annual Growth Used
Qualitative	-	-	74% ¹	-
Quantitative	6.25 cm. ²	1.45 cm.	80% ³	75% ⁴

¹Estimated percent of total numbers of leaders used during the winter of 1970-71.

²Length of annual growth as determined from 10 marked leaders from each of 20 plants.

³Percent of the total number of marked leaders used.

⁴Percent of leader length used from marked leaders.

Reproduction

Reproductive organs: The ovaries of nine females collected during the fall of 1970 and 1971 were sectioned and examined according to the gross technique of Cheatum (1949). No corpora lutea or rupture sites were identified (Table 14). Corpora albicantia were not found in two and one-half year olds, but were present in all older animals. Developing Graffian follicles were present in all ovaries examined. The largest covered about three-fourths of the greatest diameter of a sectioned ovary. These data suggest that mountain goats do not breed as yearlings, which agrees with Brandborg (1955) and Lentfer (1955), but possibly breed as two-year-olds as indicated by these same authors. These data also suggest a breeding season later than October, possibly in November and December as indicated by Brandborg (1955).

The contents of the epididymides of two males collected in September of 1970 were stained and examined microscopically. They contained mature spermatozoa. Both animals were in the 4½+ age class.

Kids/100 adults: Aerial counts during June and July of 1970 and April of 1971 provided the most complete data for determining kid/adult ratios (Table 12). Survival of kids from early summer to late winter appeared to be high in all segments of the goat population. Survival of adults differed between areas which was probably related to differences in hunting pressure and related mortality. The Jack

Table 14. Ovarian structures present in nine mountain goats collected in September and October of 1970 and 1971.

Age	No.	Corpora lutea	Corpora albicantia		Largest Diameter of Ovary	Graffian follicles		Rupture site on Ovary
			Ave. No.	Size ¹		Ave. No.	Size ²	
2½ ³	2	0	0	-	10(9-11) ⁴	7.5(6-9)	4(4)	None
3½	2	0	1.5(1-2)	4.5(4-5)	11(11)	9.5(8-11)	6.5(6-7)	None
4½+ ⁵	5	0	3.0(1-4)	4.6(4-5)	12.6(12-14)	11(7-14)	7.0(6-8)	None

¹Greatest diameter in any direction in mm for largest in each pair of ovaries.

²Diameter of largest follicle in each pair of ovaries.

³Only one ovary available for one specimen.

⁴Mean value (range of sizes) all in mm.

⁵Goats classified as 4½+ are at least 4½ and may range upwards to 9 years of age.

Creek segment showed the greatest loss of adults followed by the Spanish Peaks. The Bear Trap herd remained constant with no hunting mortality apparent. One 8½+ male was found dead in the Spanish Peaks during the summer of 1971.

Sex and Age Composition of Hunter Killed Goats

From examination of the mandibular dentition ages were estimated for a sample of goats killed by hunters (Table 15). The average age of animals killed in 1971 was lower than in 1970. This possibly substantiates the earlier conclusion that one segment of the population, Jack Creek, is subject to higher mortality from hunting. This latter statement is made in view of the fact that relatively few goats were harvested from the total population; 13 in 1970 and 12 in 1971. This magnitude of kill could not influence the age structure between years to the extent indicated if it were distributed equally among the estimated total population of 75 to 125 animals. More females than males were killed each year. This may have been due to a higher proportion of females in the population as indicated by Cowan (1950) for mountain goats in Jasper, Banff and Yoho National Parks. The fact that females are more gregarious than males as indicated by Brandborg (1955) and are thus more likely to be observed by hunters may account for the greater kill of females.

Table 15. Age and sex composition of hunter killed goats for the fall of 1970 and 1971.

Year	Female			Male		
	No.	Age ¹	Ave. Age	No.	Age	Ave. Age
1970	4	3½-7½	5.5	3	4.5-8.5+	7.0
1971	5	2½-6½	3.9	1	3½	3.5

¹Range of ages.

Hunting Season

The hunting season was mid-September to late November for both years. Hunter success was determined from a telephone survey of the permit holders. In the falls of 1970 and 1971 13 and 12 goats were harvested by 20 permit holders each year. Thus giving 65 and 60 percent success, respectively. In the fall of 1971 50 percent of the goats were harvested in the first week of the season. An earlier season, which would avoid inclement weather, would probably result in higher hunter success and a more desirable condition for hunters. In addition, it may alleviate the disproportionate harvest of one segment of the population by distributing the kill more evenly over all segments.

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