AN ABSTRACT OF THE THESIS OF

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(Name of student) (Degree)

in Fisheries and Wildlife presented on June 7, 1974
(Major Department) (Date)

Title: ASPECTS OF MOUNTAIN GOAT ECOLOGY, WALLOWA MOUNTAINS, OREGON

Abstract approved: E. Charles Meslow
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Twenty-six mountain goats (Oreamnos americanus), located between the Lostine River drainage and the East Fork Wallowa River drainage of the Wallowa Mountains, were monitored from June 1972 through June 1973. The age composition of the population was 76.9 percent adults and 11.5 percent each yearlings and kids. The addition of three kids in 1973 with the absence of any detectable mortality altered the age composition to 79.3 percent adults and 10.3 percent each yearlings and kids. Males comprised 34.6 percent of the population.

Mountain goats were dispersed a maximum of 9 airline miles from the point of original release. In summer the population was divided into two female-subadult groups (one each on the Hurricane and Hurwal divides) with males scattered singly or in small groups throughout goat range. Fifty percent of the population

occupied the Hurwal Divide during the summer. In winter at least 77 percent of the population merged into a single group on the Hurwal Divide.

Within the approximate 3440 km^2 study area an intensive use area of 710 km^2 was identified and seven habitat types were defined. High elevation habitat types received the greatest use in summer and winter while low elevation types received the greatest use in spring and fall. In relation to the relative percent composition of each type, ridge top received the greatest annual use.

Population models designed to hypothetically reconstruct the development of the Wallowa Mountains goat population were used to illustrate that low productivity rather than a high rate of mortality may be responsible for the current tenuous status of the population. A 10-20-10 percent mortality schedule for adults, yearlings, and kids respectively combined with alternate year reproduction by females following 15 years of maximum production (one kid per adult female per year) produced a hypothetical population which closely approximated the real population.

Eleven factors were evaluated as potential limiting factors. Insufficient winter range leading to winter nutritional stress and ultimately resulting in in-utero or neonatal losses appeared to be the most likely cause of low mountain goat numbers in the Wallowa Mountains.

Aspects of Mountain Goat Ecology, Wallowa Mountains, Oregon

by

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A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

June 1975

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Date thesis is presented June 7, 1974

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ACKNOWLEDGEMENTS

I was fortunate to have Dr. E. Charles Meslow as my major professor. In addition to his help in setting up this study and his constructive criticism both in the field and in the preparation of this manuscript, he offered continued encouragement and friendship throughout the study. For these things I wish to express my sincere thanks to him.

I am grateful to Larry Hunt who offered suggestions on data analysis and wrote the programs for computer analysis of the data.

I wish to thank Dr. Paul A. Vohs, Jr. for reviewing my research proposal, for advice during manuscript preparation, and for reviewing the manuscript.

Through informal conversations with James E. Tabor and Ronald J. Jameson several problems which arose during manuscript preparation were solved.

I wish to express my thanks to Rex Baxter who worked with me in the field collecting winter activity data. He is also responsible for initial analysis of the winter activity data.

I am grateful to the Oregon Wildlife Commission for supporting this study. Among Commission personnel involved with the study I would like to single out Paul Ebert, Staff Biologist, for his influence in initiating the study; Ronald Bartels and Victor Coggins, Wallowa district biologists, for advice and assistance throughout the field period of the study; Wayne Huff and Kenneth (Spider) Spidel for their expertise in handling packing operations to supply the base camp; and all the personnel of the Wallowa County Fish Hatchery for their friendship and for assistance with the many unexpected problems which arose during the field period of the study.

The U.S. Forest Service, Joseph Ranger District, under the direction of Donald Miller, provided aerial photographs of the study area.

I wish to acknowledge the Oregon Cooperative Wildlife Research Unit for supporting me and the study during my tenure at Oregon State University.

Finally, I wish to thank my wife, Lynn, who endured but enjoyed living under field conditions, acting not only as camp cook but also as a field assistant. She participated in the long tedious climbs to mountain peaks, sat hours in the snow observing mountain goats, and always offered encouragement when encouragement was needed. I commend her patience during the period of manuscript preparation and acknowledge her for typing the preliminary drafts of this manuscript.

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ASPECTS OF MOUNTAIN GOAT ECOLOGY, WALLOWA MOUNTAINS, OREGON

I. INTRODUCTION

This study was designed to determine the status of the mountain goat population in the Wallowa Mountains, Oregon, and to examine their year-long life style with emphasis on the winter period. Special attention was given to evaluating potential limiting factors.

Mountain goats were introduced to the Wallowa Mountains in March 1950. Three adult males, two adult females, and a female kid were transported from Chopaka, Washington, and released on the east slope of Chief Joseph Mountain (Oregon State Game Commission, 1950). One adult female, injured in transport, died the night of release. The remaining five goats moved onto the Hurwal Divide and were infrequently observed over the next several years.

In 1962 the Oregon Wildlife Commission initiated annual aerial surveys to "census" the mountain goat population. Between 1962 and 1971 counts fluctuated between 10 and 29 goats (Bartels, 1971) (Figure 1). Inherent variability in year to year aerial counts, however, renders these data inconclusive but allows the assumption that the total population never exceeded 40 individuals.

Hunting seasons for mountain goats in the Wallowas were held from 1965-1968 (Table 1 and Figure 1). The 4-year harvest was 20

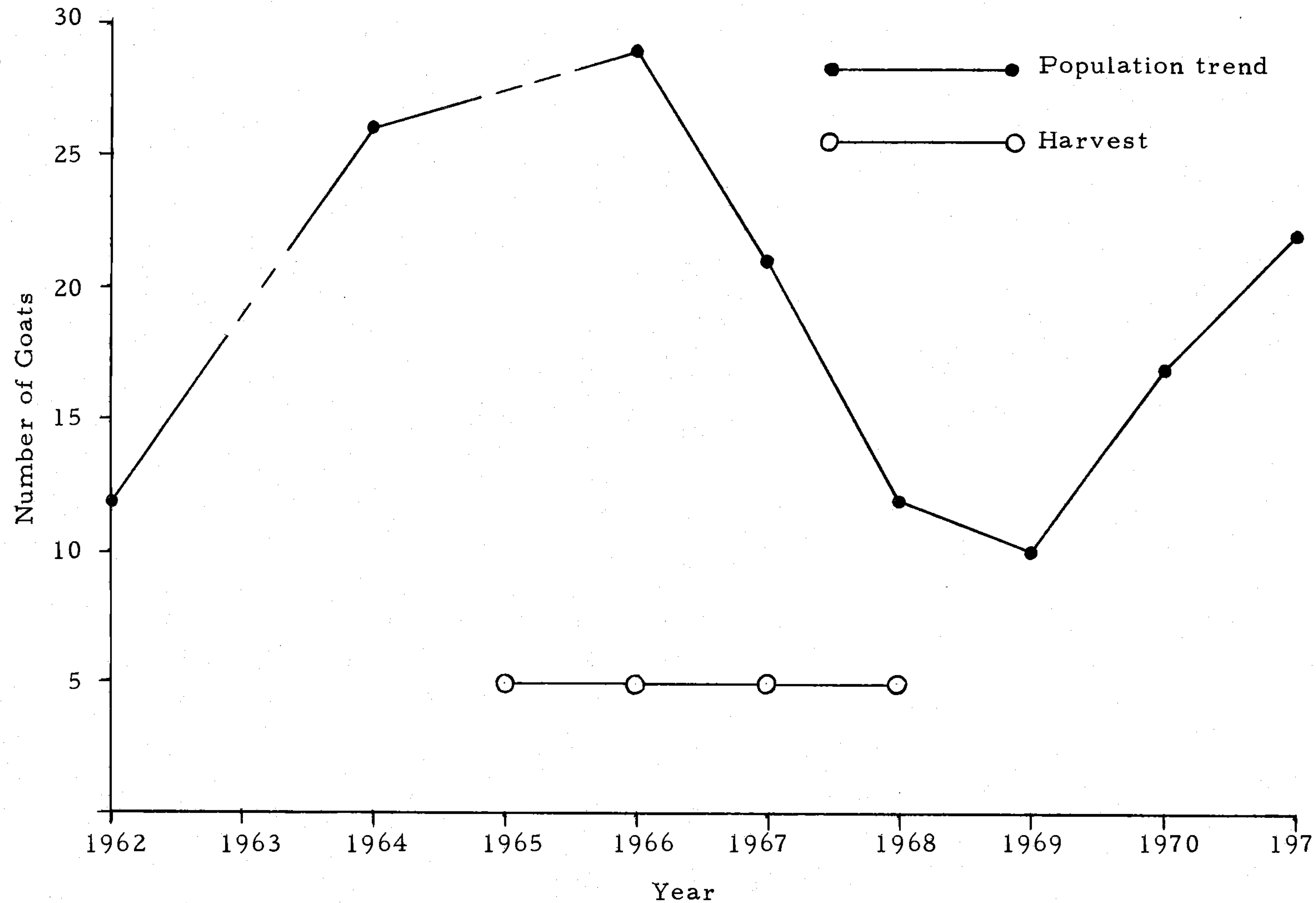

Figure 1. Population trend from aerial survey data (1962-1971) and harvest (1965-1968) of the Wallowa Mountains goat population. Aerial surveys not flown in 1963 and 1965.

Table 1. Harvest of mountain goats in the Wallowa Mountains, Oregon.[a]

Year	Tags Issued	Harvest			Hunter Success (%)
		Males	Females	Total	
1965	5	4	1	5	100
1966	5	3	2	5	100
1967	5	3	2	5	100
1968	8	3	2	5	63
Totals	23	13	7	20	

[a]From the Oregon Game Commission Annual Report, 1969.

goats. Between 1966 and 1969 (survey years corresponding to the hunting seasons) the number of goats counted on aerial surveys dropped from their highest total to their lowest total (Figure 1).

Assuming that the number of goats counted each year was indicative of total numbers it was apparent that some factor or set of factors was limiting the rate of increase of the mountain goat population. Although hunting is implicated (Figure1), the population prior to hunting was low and probably already under the influence of other limiting factors. During the 20 years following release, five mountain goats in South Dakota (Harmon, 1944; Richardson, 1971) and 14 mountain goats in Colorado (Hibbs, 1966; Hibbs et al., 1969) increased to 300-400 and 250-300 goats respectively.

This study constituted the first investigation of mountain goats in the Wallowa Mountains. Specific objectives of the study were to:

1. Provide initial ecological information concerning mountain goats in the Wallowa Mountains.
2. Determine the composition, seasonal distribution, and movement patterns of the mountain goat population.
3. Identify factors limiting the rate of increase of the mountain goat population.

II. DESCRIPTION OF STUDY AREA

The Wallowa Mountains of northeastern Oregon, have as their 118, 921 hectare (293, 735 acre) core the Eagle Cap Wilderness Area. The approximate 34, 413 hectares (85, 000 acres) over which mountain goats range are bounded on the west by the Lostine River, on the east by the East Fork Wallowa River and North Fork Imnaha River, on the south by the South Fork Imnaha River and on the north by the Wallowa Valley (Figure 2). Sacajawea Peak, a center of mountain goat distribution, rises to an elevation of 3, 000 meters (9, 839 ft.) and is the highest peak in the study area. Elevation decreases abruptly eastward and westward to 1, 829 meters (6, 000 ft.). Drainage through the study area is north. Although major exposures are east and west, secondary drainages create minor south and north facing slopes.

The Wallowa Mountains are characterized by U-shaped glaciated valleys, hanging valleys often occupied by lakes, rugged precipitous terrain, and knife edge ridge tops occasionally interrupted by open, gently flowing, ridge tops.

Geology

Diastrophic processes in Tertiary-Quarternary time lifted the Wallowa Mountains to their present heights (Wagner, 1955). Glaciation is evidenced by morainal deposits, hanging valleys, and

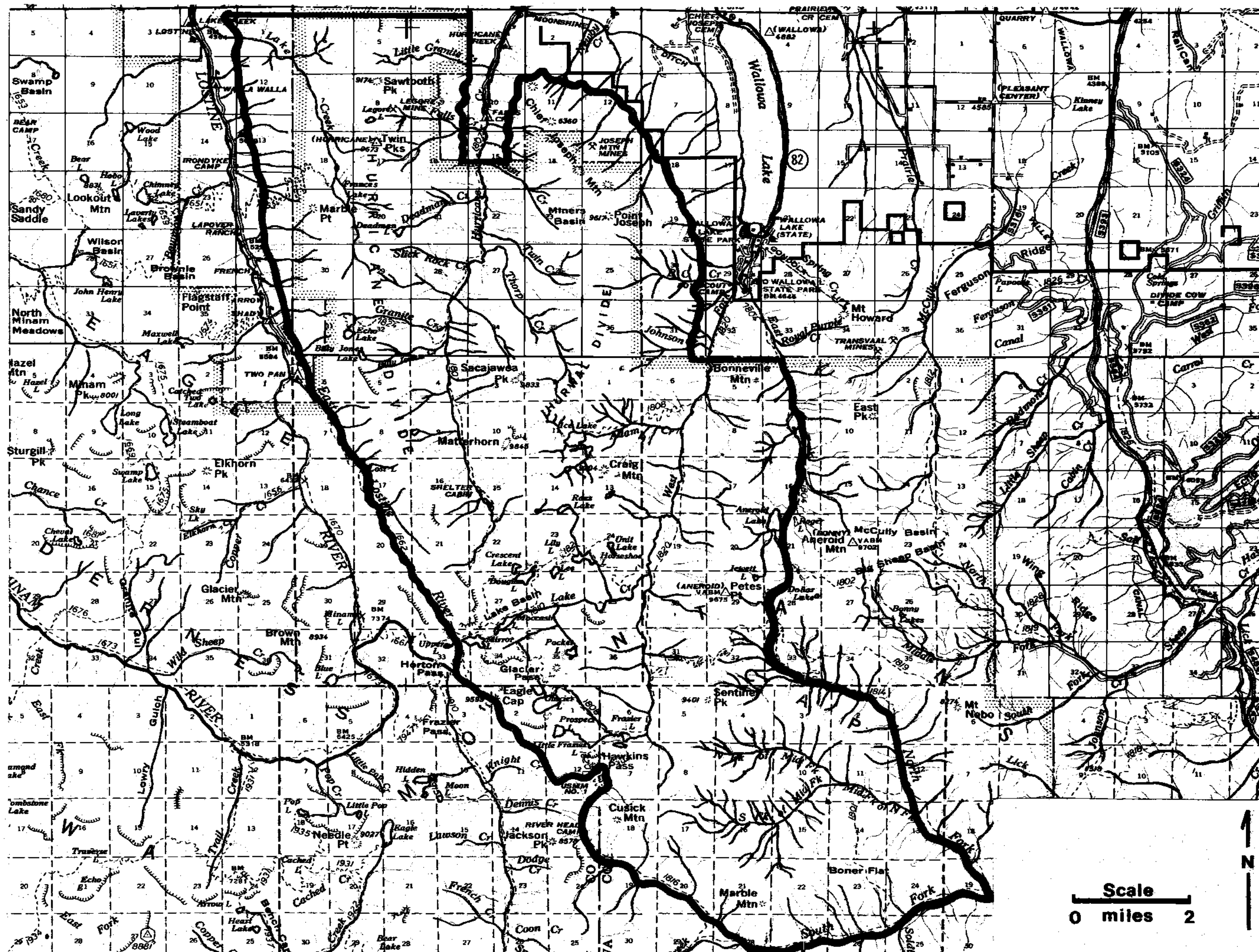

Figure 2. Wallowa Mountains study area.

numerous lakes. Mineral deposits include lavas from Tertiary time, crystaline and sedimentary rock from the Mesozoic era and metamorphosed volcanic and sedimentary rocks from the late Paleozoic era.

Climate

Precipitation, temperature, and snow depth data for 1950-1973 are presented in the Appendix. Temperature and precipitation data were taken in Enterprise, Oregon (elevation 1155 m) 9.6 kilometers north of the Wallowa Mountains.

Snow and sub-freezing temperatures can be expected each month of the year in the Wallowa Mountains (Sternes, 1956). However, snow accumulation is not common until late October and by the end of June only permanent snow fields remain. Mean annual precipitation 1950-1972 was 33.9 centimeters (13.36 in.) Annual maximum and minimum temperatures for 1950-1972 averaged 36.1°C (96.9°F) and -27.3°C (-16.7°F) respectively. Mean annual temperature for the same period was 6.4°C (43.6°F). Winds are predominantly from the west and northwest but are altered by the mountainous terrain.

III. MATERIALS AND METHODS

Personnel of the Oregon State Wildlife Commission assisted me in establishing a base camp in the study area in June 1972. Supplies were carried to the camp on horseback during the summer and by backpack when snow accumulation prevented the use of horses. Travel to the wilderness area boundary during the winter was by snowmobile. Two way radios were used to maintain contact with the district biologist throughout the winter.

Observations were made with 7X35 binoculars and 20X spotting scope. A 30X eye piece, used interchangeably, was often less effective because of atmospheric distortion.

Observation points were not preselected but were determined by movements of the mountain goats. To observe goats between May and October I climbed to their high elevation summer range and established 3-4 day temporary camps. At these high elevations I could observe goats from distances of 50-400 meters. When snow accumulation reduced the practicality of high elevation work observations were made from points along primary drainages, usually at distances greater than 400 meters from the animals.

Each observation was recorded on a form which included date, period of observation, location of goats, number, age class, and sex of goats, sunrise-sunset times, habitat characteristics (habitat type, elevation, aspect, percent slope), and environmental conditions (temperature, wind velocity, precipitation, percent cloud cover, ground conditions). Observations were plotted on maps of the study area using the Universal Transverse Mercator grid system.

Measurements of the physical environment included wind velocity, temperature, barometric pressure, precipitation, snow depth, sunrise-sunset, and topographic measurements (elevation, percent slope, aspect).

Population Characteristics

Mountain goats were assigned to age classes as adults, yearlings, or kids according to Hanson's (1950) description. By midwinter the yearling age class was indistinguishable from the adult class unless observations allowed comparison of horn length with ear length (Hanson, 1950). Sex was determined by one or a combination of the following three methods: urination posture (Hibbs, et al, 1969) (males stretch, females squat), observation of genitalia (summer months only), and horn morphology (Brandborg, 1955). Basal circumference of the horns is greater in the male mountain goat than in the female. In addition the males' horns curve back gradually and are relatively parallel when compared with the horns of the female which tend to curve backward at the tips and diverge from base to tip. Urination posture was the most reliable of the three methods and allowed sex determination at great distances. The other methods required observation from a relatively close distance. In addition, detection of the subtle differences in horn morphology required considerable observer conditioning.

The kid-adult ratio was an indication of productivity. The adult-yearling-kid ratio indicated survival and time of year losses occur. Areas occupied by goats were inspected throughout the year for predator activity and during the winter for avalanches.

Distribution and Movements

Oregon State Wildlife Commission records and data from 10 years (1962-1971) of aerial surveys aided in documenting past distribution of mountain goats. Current distribution was determined by plotting observations, connecting the peripheral points, and projecting the boundary down to the 6,000 foot elevation or the nearest primary drainage.

Home ranges and migration patterns were identified directly and indirectly (Geist, 1971:64). Direct observations of individually recognizable goats (Hanson, 1950; Geist, 1971:68) were made noting location (daily and seasonal) and dates of arrival and departure. Patterns of movement were determined indirectly by comparing numbers and group compositions at various locations throughout the year.

Habitat Analysis

Descriptions of mountain goat habitat in Montana (Foss, 1962; Peck, 1972), Colorado (Hibbs, 1965), and Idaho (Kuck, 1971) were useful guides for identifying habitat types in the Wallowa Mountains. Eight habitat types, based primarily on physical characteristics of the study area rather than plant associations, were identified: (1) timber, (2) open timber, (3) slide rock, (4) cliff-rock, (5) alpine meadow, (6) ridge top, (7) mountain mahogany, (8) water. Each type was easily recognizable from the air or ground.

Relative amounts of each habitat type were determined from aerial photographs of the study area. Combining standard aerial photogrametric interpretation methods (Avery, 1968) with personal knowledge of the study area and color photographs taken during aerial reconnaissance, habitat types were delineated directly on the aerial photographs. Distortion due to relief was corrected to reduce error in final tabulations. A vertical reflecting projector projected the image of a topographic map onto the corresponding aerial photograph. Contour lines at 800 foot intervals were traced directly on the photograph and acreages for each habitat type within each contour interval were calculated. Using the percent slope recorded at each mountain goat observation, slope acre adjustments were made.

Vegetative composition within each habitat type was determined combining methods of Martin (1970) and Daubenmeier (1959). Each species of plant occurring within a specified habitat type was assigned a prominence rating of 1-5 and a cover class of 1-6 (Table 2). Ratings were assigned by ocular estimation. At least three representative sites of each habitat type were inspected before a final description of the habitat type was made.

Aerial Surveys

Aerial surveys were scheduled frequently but irregularly because of unpredictable flying conditions. Thirty-two aerial surveys were flown between January 1972 and August 1973. A 150 hp Supercub piloted by Bud Stangle (Stangle's Flying Service, Enterprise, Oregon) was used in 31 of the surveys and a Bell G-2 helicopter was used for one survey. I was the observer on 30 of the surveys.

Each drainage in the study area was flown at 200-300 foot intervals beginning at valley bottoms. The area traversed remained constant to insure that variation in number of goats counted was due to number present rather than variation in area flown (Geist, 1971:66).

The extent to which mountain goats learned to avoid observation by hiding from the approaching aircraft and how this affected counts is not known. On several occasions goats were located hiding

Table 2. Prominence ratings and cover classes for vegetation analysis in the Wallowa Mountains.

	Prominence Ratings[a]
5	The most prominent species in the stand.
4	Shares equally with one or more others as the most prominent species in the stand.
3	Can be seen easily standing at any point in the stand and looking casually around.
2	Can be seen by intent examination or by moving about in the stand.
1	Must search carefully to find in the stand.

Coverage Classes[b]

Class	Range (%)	Midpoint
1	0-5	2.5
2	5-25	15.0
3	25-50	37.5
4	50-75	62.5
5	75-95	85.0
6	95-100	97.5

[a]From Martin (1970)

[b]From Daubenmire (1959)

under trees or pressed tightly against rocks indicating they did respond to the approaching aircraft. When caught in the open the goats often ran for cover.

IV. RESULTS AND DISCUSSION

Population Structure

The minimum mountain goat population in the Wallowa Mountains, prior to the 1973 kid crop, was 26 individuals (Table 3). The female-subadult segment of the population was divided into two subpopulations occupying the Hurricane and Hurwal divides (Fig. 2). Males were dispersed throughout the study area. Three kids were added to the population in 1973 and no mortalities were recorded during the study period.

Table 3. Age and sex ratios of mountain goats, Wallowa Mountains, Oregon, 1972-73.

	Males (%)	Females (%)	Unknown	Total(%)
Adults	8	10	2	20 (76.9)
Yearlings	1	2	0	3 (11.5)
Kids	0	3	0	3 (11.5)
Total	9 (37.5)	15 (62.5)	2	26

Sex Ratio

The 44 percent adult male and 56 percent adult female sex ratio of mountain goats in the Wallowa Mountains (Table 3) is similar to values found by other observers. Anderson, (1940) in Washington classified 319 adult goats and found 46.1 percent males. Casebeer et al. (1950) found the sex composition of 113 adult goats in Montana to be 53.1 percent male. Cowan (1950) collecting data over a 4-year period in the Rocky Mountain region of Alberta and British Columbia classified 272 adult mountain goats of which 42.6 percent were males. Brandborg (1955) in Idaho classified 118 goats on the Salmon River and 26 goats on the Selway River and found 46.6 percent males and 42.3 percent males on the two rivers respectively.

Sex composition of the 24 goats in the Wallowa Mountains identified to sex was 37.5 percent male and 62.5 percent female. The imbalance favoring females was largely due to the recruitment of five females and only one male in the 1971 and 1972 kidding seasons. I was not able to sex the three kids produced in 1973. The 4-year harvest (1965-1968, Table 1) of 13 males and 7 females may also have contributed to the higher percentage of females.

The current sex ratio in the Wallowa Mountains appears to be satisfactory. The high percentage of females (5:1) produced in 1971 and 1972 and the harvest of predominantly male goats are factors condusive to population increase as long as enough males remain in the population to service all sexually mature females. As noted by Brandborg (1955) mountain goats are polygamous. Thus, from the ratio of 1 male per 1.67 females, it appears that the opportunity exists for each sexually mature female goat in the Wallowa Mountains to breed successfully.

Age Structure

Adults constituted 76.9 percent of the mountain goat population (41.7 percent adult female) and yearlings and kids were 11.5 percent each before the 1973 kid drop. With the three additions in 1973 the age structure changed to 79.3 percent adults, (48.1 percent adult females) and 10.3 percent each kids and yearlings. This is in marked contrast to other mountain goat populations (Table 4). In comparison the Wallowa Mountains goat population had a greater percentage of adults and a smaller percentage of kids than any investigated.

The increase in the percentage of adults in the Wallowa Mountains population between 1971 and 1973 indicates the average age of the population is increasing and that productivity is decreasing. Overall decrease in number of young observed in the 1962-1971 aerial surveys (Table 5) appears to substantiate these trends.

Productivity and Factors Affecting Population Increase

The annual rate of increase of the Wallowa Mountains goat population was 13.0 percent for 1971-1972 and 11.5 percent for 1972-1973. Each addition was a single birth. In addition, the three young produced in 1972 and the three young produced in 1973 were produced

Table 4. Age structure of various mountain goat populations expressed as a percentage.

Study	Location	Adults	Yearlings	Kids	Adults Females	Number Classified
Anderson 1940	Washington	70.3	4.2	25.6	37.9	454
Petrides 1948	Montana	70.5[a]		29.5	-	132
Casebeer et al. 1950	Montana	74.1	11.4	14.5	27.2[b]	317
Hanson 1950	South Dakota	59.2	15.5	25.3	52.1[c]	233
Brandborg 1955	Idaho					
	Selkirk Range	51.1	12.2	36.7	25.6	90
	Selway River	67.0	11.3	21.6	39.2	97
Lentfer 1955	Montana	74.3[a]		25.7	-	1210
Foss 1962	Montana	80.6[a]		19.4	-	643
Holroyd 1967	British Columbia	58.8	8.4	32.7	-	636
Hibbs 1965	Colorado	51.4	22.2	26.4	26.4	83

(Continued on next page)

Table 4. (Continued)

Study	Location	Adults	Yearlings	Kids	Adult Females	Number Classified
Richardson 1971	South Dakota					
	1950	71.1	12.5	16.3	-	104
	1951	66.4	14.9	18.7	-	241
	1964	58.5	19.3	22.2	-	176
	1967	58.1	19.1	22.8	-	136
Kuck 1973	Idaho					
	1970	76.0[a]		24.0	-	868
	1971	83.0[a]		17.0	-	584
Vaughan (this study)	Oregon	76.9	11.5	11.5	41.6	26

[a] Adults and yearlings combined.

[b] Based on 195 goats classified as to sex.

[c] Based on 71 goats classified as to sex.

Table 5. Age composition of goats from annual aerial surveys (1962-1971) in the Wallowa Mountains, Oregon.

Year	Adults		Young		Total
	number	percent	number	percent	
1962	8	67	4	33	12
1963[a]	-	-	-	-	-
1964	18	69	8	31	26
1965[a]	-	-	-	-	-
1966	18	62	11	38	29
1967	17	81	4	19	21
1968	10	83	2	17	12
1969	8	80	2	20	10
1970	12	71	5	29	17
1971	17	77	5	23	22

[a]Survey not flown.

by six different females. This indicates alternate year production at best. The conditions under which alternate year production occurs in mountain goat populations and how commonly it occurs is unclear. Casebeer et al. (1950) in Montana noted that nannies were often followed by a kid and a yearling which suggests every year production. Other observers in Montana (D. Chadwick, C. Rideout personal communication) feel that alternate year production occurs in at least some goat populations.

In attempting to work toward a reasonable explanation of how the Wallowa Mountains goat population developed, I constructed five hypothetical populations based on the actual composition of the 1950 release. The assumption of a 12-year life span for mountain goats is based on data from Seton (1929). The other assumptions concerning how long a female goat is productive, mortality and birth rates, etc., are basically conjecture. However, I feel that these assumptions are in each case reasonably realistic for what they attempt to show.

Table 6 illustrates the reproductive potential of the Wallowa Mountains goat population given the following assumptions (these assumptions generally follow Hanson, 1950):

1. All goats die of old age at 12. The four introduced adults were assumed to be 4 years old when released.
2. Each female gives birth to her first young on her third birthday and each year thereafter until death.

Table 6. Population A. Breeding potential of the Wallowa Mountains goat population based on 12-year life span and other assumptions.

Year	Deaths		Adults		Yearlings		Kids		Total
	Males	Females	Males	Females	Males	Females	Males	Females	Living
1950	-	-	3	1	-	1	1[a]	-	6
1951	-	-	3	2	1	-	-	1	7
1952	-	-	4	2	-	1	1	1	9
1953	-	-	4	3	1	1	1	1	11
1954	-	-	5	4	1	1	2	1	14
1955	-	-	6	5	2	1	2	2	18
1956	-	-	8	6	2	2	2	3	23
1957	-	-	10	8	2	3	3	3	29
1958	3	1	9	10	3	3	4	3	32
1959	-	-	12	13	4	3	5	5	42
1960	-	-	16	16	5	5	6	7	55
1961	-	1	21	20	6	7	8	7	69
1962	1	-	26	27	8	7	10	10	88
1963	-	1	34	33	10	10	13	13	113
1964	1	1	43	42	13	13	16	16	143
1965	1	1	55	54	16	16	20	21	182
1966	2	1	69	69	20	21	27	26	232
1967	2	2	87	88	27	26	33	34	295
1968	2	3	112	111	33	34	43	42	375
1969	3	3	142	142	43	42	54	54	477
1970	4	3	181	181	54	54	69	70	609
1971	5	5	230	230	69	70	88	88	775
1972	6	7	293	293	88	88	112	111	985
1973	8	7	373	374	112	111	143	143	1256

[a] Assumes kid born first year of release.

3. The first born is a male, alternate sexes thereafter.

Under these assumptions the maximum number of goats in 1973 is 1256 (23 percent young of the year). The 26 percent average annual rate of increase for the hypothetical population is 14 percent more than the actual 12 percent claculated between 1971 and 1973. This simply means that there has been a high degree of mortality, or a low rate of productivity (measured from birth)., or more likely a combination of both in the real population.

Reducing productivity by imposing alternate year breeding (population B) markedly effects the hypothetical population (Table 7). Holding other assumptions the same as population A this scheme results in a population in 1973 of 118 goats, a reduction of 91 percent from population A. Young in the population are reduced to 15 percent and average annual rate of increase is reduced to 15 percent. By incorporating in this scheme the actual harvest (Table 1) that occurred between 1965 and 1968 the population number is reduced to 74 (population C) and the average annual rate of increase is reduced to 13 percent, very near the actual 12 percent for 1971-1973 (Table 8). However populations A, B, and C cannot be compared with the actual Wallowa Mountains population for obvious reasons. Rather they indicate the populations' capacity to increase (given initial age and sex data) as affected by the imposition of limiting factors, not considering natural mortality other than death from old age.

Table 7. Population B. Breeding potential of the Wallowa Mountains goat population assuming alternate year production.

Year	Deaths		Adults		Yearlings		Kids		Total
	Males	Females	Males	Females	Males	Females	Males	Females	Living
1950	-	-	3	1	-	1	-	-	5
1951	-	-	3	2	-	-	1	-	6
1952	-	-	3	2	1	-	-	1	7
1953	-	-	4	2	-	1	1	-	8
1954	-	-	4	3	1	-	-	1	9
1955	-	-	5	3	-	1	1	1	11
1956	-	-	5	4	1	1	1	-	12
1957	-	-	6	5	1	-	1	2	15
1958	3	1	4	4	1	2	1	1	13
1959	-	-	5	6	1	1	1	1	15
1960	-	-	6	7	1	1	2	2	19
1961	-	1	7	7	2	2	2	1	21
1962	-	-	9	9	2	1	2	2	25
1963	1	-	10	10	2	2	2	3	29
1964	-	1	12	11	2	3	3	2	33
1965	1	-	13	14	3	2	3	3	38
1966	-	1	16	15	3	3	4	4	45
1967	1	1	18	17	4	4	3	4	50
1968	1	-	21	21	3	4	5	5	59
1969	1	2	23	23	5	5	6	5	67
1970	1	1	27	27	6	5	6	6	77
1971	1	1	32	31	6	6	7	8	90
1972	2	2	36	35	7	8	8	8	102
1973	2	1	41	42	8	8	10	9	118

Table 8. Population C. Added effect of harvest on alternate year production in the Wallowa Mountains goat population. [a]

Year	Deaths		Adults		Yearlings		Kids		Total
	Males	Females	Males	Females	Males	Females	Males	Females	Living
1964	-	1	12	11	2	3	3	2	33
1965	1	-	13	14	3	2	3	3	38
1966	4[b]	2	12	14	3	3	3	4	39
1967	3	3	12	14	3	4	3	3	39
1968	4	2	11	16	3	3	4	3	40
1969	3	3	11	16	4	3	3	4	41
1970	1	1	14	18	3	4	5	4	48
1971	-	1	16	21	5	4	4	5	55
1972	2	1	19	24	4	5	6	5	63
1973	1	-	22	29	6	5	6	6	74

[a] Since the sex composition but not the age composition of the actual harvest is known, goats chosen for harvest were randomly selected from the adults available for harvest. The correct sex composition was applied.

[b] Harvested goats are removed from the population in September and consequently appear the year following harvest.

Since essentially no records exist for the Wallowa Mountains goat population before 1962, and then only limited records, it is impossible to accurately reconstruct the population's 23-year history. It is apparent, however, that the population has a low rate of productivity. A minimum of 10 sexually mature females was in the study area in both 1972 and 1973 yet only six kids are known to have been produced during this period. The potential productivity was thus reduced by al least 70 percent for the 2-year period. The absence of any observed mortality during the period of study further suggests a low rate of mortality.

To suggest patterns that could depict the history of the Wallowa Mountains goat population I have constructed two hypothetical examples with different mortality schedules and recruitment rates. Hypothetical population D (Table 9) assumes: (1) no mortality for the first 5-years, thereafter adults (taken first from the 6 year age class or from the 7 and 5 year age classes if no 6 year olds are available) and kids incur a 10 percent mortality and yearlings 20 percent mortality, (2) every year production per female for the first 15 years after introduction, alternate year production per female thereafter, (3) the actual harvest of 20 was imposed by randomly selecting from the adults available for harvest, (4) no longivity beyond 12 years of age (females die before producing a kid in their

Table 9. Population D. Hypothetical herd development of the Wallowa Mountains goat population under a 10-20-10 percent mortality schedule for adults, yearlings, and kids respectively.

	Year	Death of old age		Age Class (years)																								Other Mortality			Alive
				11-12		10-11		9-10		8-9		7-8		6-7		5-6		4-5		3-4		2-3		1-2		0-1					
				Productive																		Non-productive									
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	Ad.	Yr.	K.	
	1950																	3	1						1	1					6
	1951															3	1						1	1			1				7
	1952													3	1						1	1			1	1	1				9
	1953											3	1						1	1			1	1	1	1	1				11
	1954									3	1						1	1			1	1	1	1	1	2	1				14
	1955							3	1							1			1	1	1	1	1	2	1	1	2	1	-	-	16
	1956					3	1										1	1	1	1	1	2	1	1	1	2	2	1	1	-	18
	1957			3	1											1	1	1	1	2	1	1	1	1	2	2	1	1	1	1	19
	1958	3	1													1	1	2	1	1	1	1	2	2	1	2	1	2	-	-	16
	1959														1	2	1	1	1	1	2	2	1	2		2	3	1	1	-	19
	1960												1	2		1	1	1	2	2	1	2		1	3	2	3	1	1	1	22
	1961										1	2				1	2	2	1	2		1	3	2	2	3	2	2	1	1	24
	1962								1	2					1	2	1	2		1	3	2	2	2	2	3	3	2	1	-	27
	1963						1	2					1	1		2		1	3	2	2	2	2	3	2	3	4	2	1	1	31
	1964				1	2					1	1		1		1	2	2	2	2	2	3	2	2	4	4	3	2	1	1	35
Harvest	1965		1	1					1						1	2	2	1	2	2	1	2	4	3	2	1	1	8	2	-	26
Harvest	1966	1					1						1		1	1	2	1	1	2	3	2	1	1	1	4	5	7	-	1	27
Harvest	1967				1								1	1	1	1	1	1	3		1	1	1	3	4	1	1	7	2	-	22
Harvest	1968		1										1				3		1		1	3	3	1	1	4	3	7	-	1	21
	1969										1				2		1		1	3	3	1	1	3	2	1	2	1	1	1	21
	1970								1				2				1	2	3	1	1	3	2	1	2	4	3	2	-	-	26
	1971						1				2					1	3	1	1	3	2	1	2	3	2	2	2	2	2	1	26
	1972				1				2						2	1	1	3	2	1	2	3	2	2	1	4	3	2	1	-	30
	1973		1				2						2			2	2	1	2	3	2	2	1	3	3	2	3	3	1	1	30

twelfth year), (5) females produce their first kid at age 3 and, (6) sex of goats born and dying alternates.

By 1973 population D consists of 30 individuals compared to the 29 actually present. The age structure of 61 percent adults, 19 percent yearlings, and 16 percent kids suggest that the adult mortality rate may be lower in the real population. The 7 percent average annual rate of increase results from negative rates incurred during years goats were harvested and zero increase in 3 of the last 6 years.

Two factors are noteworthy in this hypothetical population. First is the slow initial increase of the herd. It is likely that this was the case in the actual population because of the inadequate composition of the release (i. e. one adult female and three males). Consecutive production of a number of males or females would have influenced the rate of increase but the one for one probability of a male or female seems a safe assumption. Early catastrophies such as avalanches involving even a few individuals would have slowed the initial numerical increase. However, other goat populations subject to the same hazards have increased at a much faster rate (i. e. herds introduced into Colorado, South Dakota, and Montana). Twinning is one factor not considered in the hypothetical population that could have increased the initial rate of increase. Anderson (1940) in Washington found 14 percent of nannies with young had twins and Lentfer (1955) recorded a 30 percent incidence of twinning for goats in Montana 12 years after release. Hanson (1950) found no twins in the Black Hills. Twins have never been recorded in the Wallowa Mountains although they may have occurred. However, it is likely that had the goat population increased rapidly visitors to the area would have reported numerous sightings and this was not the case.

The second point to note in the hypothetical population is the impact of the combined effects of alternate year production and hunting. Alternate year production was imposed as a stabilizing factor after 15 years of every year production. This might be an expected reaction to social pressure, poor condition of goats or some other factor. As noted by Hanson (1950) goats introduced into parts of Washington and South Dakota increased over a 10-to 15-year period then stabilized. Hunting was applied to relieve these population depressing factors but acted instead as an additional pressure causing further reduction of numbers and slow recovery.

By changing the annual mortality schedule to 5 percent for adults and 10 percent for yearlings and kids and beginning alternate year reproduction after 10 years (Population E) the hypothetical 1973 age ratio (71 percent adults, 15 percent each yearlings and kids) and the annual rate of increase (11 percent) are more in line with the actual population. However, the total number in population E is twice that of the real population. This results because the initial increase

Table 10. Population E. Hypothetical herd development of the Wallowa Mountains goat population under a 5-10-10 percent mortality schedule for adults, yearlings, and kids, respectively.

Year	Death of old age		Age Class (years) 11-12		10-11		9-10		8-9		7-8		6-7		5-6		4-5		3-4		2-3		1-2		0-1		Other Mortality			Alive
			Productive																		Non-productive									
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	Ad.	Yr.	K.	
1950																	3	1						1	1					6
1951															3	1						1	1			1				7
1952													3	1						1	1			1	1	1				9
1953											3	1						1	1			1	1	1	1	1				11
1954									3	1						1	1			1	1	1	1	1	2	1				14
1955							3	1						1	1			1	1	1	1	1	2	1	2	2	-	-	-	18
1956					3	1						1				1	1	1	1	1	2	1	2	2	2	3	1	-	-	22
1957			3	1						1					1	1	1	1	2	1	2	2	1	3	3	1	1	1	1	24
1958	3	1						1					1	1	1	1	2	1	2	2	1	3	3	1	3	3	-	-	-	26
1959						1					1	1		1	2	1	2	2	1	3	3	1	3	2	3	5	1	1	1	32
1960				1					1	1		1	2		2	2	1	3	3	1	3	2	3	5	1		1	-	-	32
1961		1					1	1		1	2		1	1	1	3	3	1	3	2	3	5			4	3	2	1	1	35
1962					1	1		1	2		1	1		3	3	1	3	2	3	5			4	3	2	3	1	-	1	39
1963			1	1		1	2		1	1		3	2		3	2	3	5			4	3	2	2	4	3	2	1	1	43
1964	1	1		1	2		1	1		3	2		2	1	3	5			4	3	2	2	4	3	4	4	2	-	-	47
Harvest 1965		1	2		1	1		3	1		2	1	2	4			3	2	1	2	4	3	3	4	2	4	6	1	1	45
1966	2		1	1		3			2		1	3			2	2	1	2	4	2	2	4	2	3	5	3	7	1	1	43
1967	1	1		3			2		1	3				1	1	2	4	1	2	4		2	4	3	3	5	7	1	1	41
1968		3			1			3				1		2	4	1	2	3		2	3	2	3	5	4	2	6	-	1	38
1969			1			3				1		2	3		2	3		2	3	2	3	5	4	1	3	4	2	1	-	42
1970	1			3				1		2	3		1	2		2	3	2	3	5	4	1	2	4	5	5	2	1	1	48
1971		3				1		2	3		1	2		1	3	2	3	5	4	1	2	4	5	4	3	3	1	1	1	49
1972				1		2	3		1	2		1	2	1	3	5	4	1	2	4	5	4	3	3	5	5	2	-	1	57
1973		1		2	3		1	2		1	2	1	2	4	4	1	2	4	5	4	3	3	4	5	5	4	2	1	1	62

of population E is faster and more adults are in the population, consequently by the time harvest occurs population numbers are at a point to sustain the extra loss and allow a rapid recovery.

The mortality schedule for population E may closely approximate the actual mortality rate of the Wallowa Mountains goat population. Some of the likely causes of mountain goat mortality (parasites, diseases, predation, accidents) do not appear to have much of an effect on the Wallowa Mountains goat population. This may in part justify a low mortality rate for all age classes, adults in particular. If as assumed alternate year production occurs, the offspring are subject to an additional year of protection by their nannies, perhaps increasing their chances of survival through the first 2 years of life.

A number of combinations of mortality and natality schedules that produce herd numbers and compositions comparable to the Wallowa Mountains goat population are possible. However I feel that the assumptions made for populations D and E are entirely realistic and may closely approximate the pattern of development of the Wallowa Mountains goat population.

Seasonal Movements and Distribution

Seasonal distribution of goats on the Hurricane and Hurwal divides is presented in Figure 3. All goat sightings in the Petes

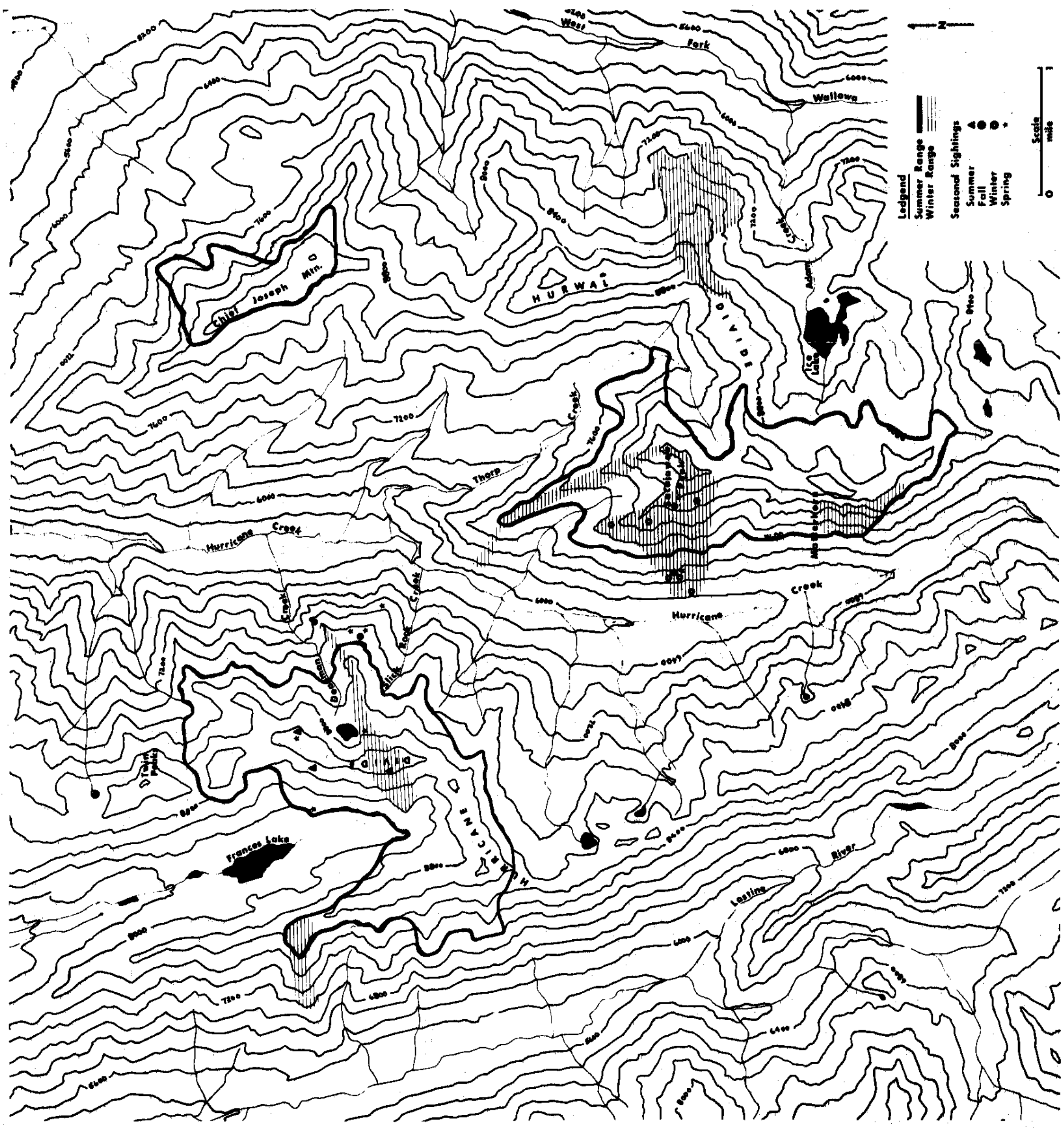

Figure 3. Summer and winter range of mountain goats in the Wallowa Mountains and seasonal movement of an individually recognizable adult female goat in the Wallowa Mountains, Oregon, 1972-73.

Point sector were between Petes Point and the middle fork of the Imnaha River (Figure 2).

In summer 1972, four separate groupings of goats were recognizable. (1) A highly cohesive female-subadult group consisting of six adult females, one yearling of each sex, and one female kid centered around the Francis Lake Basin area of the Hurricane Divide (Figure 3). One adult male traversed the area but remained apart from the group of nine. (2) A less cohesive group of four adult females, one yearling female, and two female kids occupied the Sacajawea Peak-Matterhorn section of the Hurwal Divide. Three males, two south of the Matterhorn and one at the head of Thorp Creek Basin stayed to themselves. (3) Three adult males on Chief Joseph Mountain and (4) three adults (one male, two unknown) in the Petes Point area made up the other two groups. After 4 July 1972, only one goat could be found in the Petes Point area. Between 26 August 1972 and 3 April 1973, no goats were located there. However, after 3 April 1973, one male was regularly seen in the Petes Point area. I believe the other two goats, which I was unable to positively relocate, moved to the Hural Divide. The possibility exists, however, that one or both died.

Other than elevational movements in response to weather conditions each of the four groups remained faithful to its range until late October. In the 19 October aerial survey, mountain goats were scattered throughout their range in small groups. This may have been related to changing weather conditions or the approach of the rutting season. The 19 October aerial survey was also the last time goats were seen on Chief Joseph Mountain until the following spring, with the exception of one male that returned for a short period in January. The last day the lone male at the head of Thorp Creek Basin was seen in that area was 20 October. Because most goats in the Wallowa Mountains were unusually dispersed at this time of the year the movement patterns of the various males is unclear. At least two moved onto the Hurricane Divide, a distance of 3-4 airline miles from either Chief Joseph Mountain or Thorp Creek Basin. Hibbs (1965) in Colorado noted that during the rut some male goats moved similar distances to reach females.

Through November and most of December the goat population was divided into two groups. The group on the Hurricane Divide consisted of three adult males, six adult females, a yearling of each sex, and a female kid. The group on the Hurwal Divide consisted of four adult males, four adult females, a female yearling, and two female kids. The mountain goats that had occupied the Petes Point area during the summer could not be located; tracks on the ridge north of Adam Creek suggest they may have crossed to the Hurwal Divide (Figure 3). The Hurricane Divide goats maintained a relatively tight grouping but, goats on the Hurwal Divide were in two to three subgroups.

In late December goats on the Hurricane Divide moved to the Hurwal Divide, initiating the shift to winter range. This was not regarded as a true migration because it did not entail the use of new range or range used by mountain goats only in the winter. Rather, the majority of the goat population now confined itself to a small part of the Hurwal Divide summer range. Goats in Washington, Idaho, parts of Montana, Alaska, and British Columbia have been found to migrate to separate winter ranges (Anderson, 1940; Brandborg, 1955; Casebeer et al., 1950; Klein, 1953; Kuck, 1973; Holroyd, 1967). In Colorado, South Dakota, and parts of Montana goats used the same range year-round (Casebeer et al., 1950; Hibbs et al., 1969; Richardson, 1971).

In the Wallowa Mountains the shift to winter range was a merger of the Hurricane Divide group with the Hurwal Divide group on the Hurwal Divide (Figure 3). The initial move was made by 11 of the 12 goats on the Hurricane Divide to a low cliff area on the Hurwal Divide. This cliff area apparently served as a transient rest area. One male remained on the Hurricane Divide throughout the winter. After several days on the "transient cliffs" the group of 11 moved to Sacajawea Peak and joined nine goats already using the area. Three adult goats on the Hurwal Divide remained near the Matterhorn through most of the winter.

The center of activity during winter was the west slope of Sacajawea Peak. Occasional ventures south to the Matterhorn and east along the ridge crest above the east end of Thorp Creek Basin were made by small groups of goats. These were not permanent redistributions but short term excursions.

The concentration of 20 goats on the west slope of Sacajawea Peak began breaking up in March. One adult mountain goat moved back to the Hurricane Divide and the remaining goats were spread between the east slope of Sacajawea Peak and the south end of the Matterhorn. Also in March the three nannies with kids and a yearling formed a group which stayed together into June.

In April four more goats moved back to the Hurricane Divide making use of only the east face between Slick Rock Creek and Deadman Creek. Five mountain goats moved to the east face of the Hurwal Divide between Chief Joseph Mountain and Adam Creek and the remaining goats stayed in the Sacajawea-Matterhorn area. This pattern persisted into May with the occasional shifting of the group of nannies and kids between the Hurricane and Hurwal divides. One adult male reappeared in the Petes Point area in early April.

In late May mountain goats were dispersed over both divides, either singularly or in groups of two to five. Two adult females (one on each divide) became sedentary in confined areas until they gave birth to kids in early June. As in the previous summer three males again began to utilize Chief Joseph Mountain.

Most mountain goats appeared to be settled on their summer range by late June. At least nine goats had returned to the Hurricane Divide and two females delivered kids there. Although a comprehensive group composition count was not accomplished, the composition of the group on the Hurricane Divide apparently differed from the previous summer. At least one nannie and her kid (now a yearling) remained on the Hurwal Divide. The two yearlings (now 2-year olds) also failed to move back to the Hurricane Divide.

Other than nannies with their kids only one goat was readily identifiable. An adult female with a broken horn was among the group that summered on the Hurricane Divide and wintered on the Hurwal Divide (Figure 3). Her movements are a good indication of seasonal movement patterns of goats faithful to the Hurricane Divide female-subadult group.

Habitat Analysis

I analyzed the habitats on the Hurricane Divide separating the Lostine River and Hurricane Creek and the Hurwal Divide separating Hurricane Creek and the west fork of the Wallowa River (Figure 2). The Petes Point-Sentinel Peak area separating the west fork Wallowa

River from the east fork Wallowa River and north fork Imnaha River was surveyed exclusively from the air and therefore was not included in the habitat description. Further, each of the Hurricane and Hurwal divides was occupied by relatively large numbers of mountain goats while the Petes Point-Sentinel Peak area supported intermitently only one to three goats.

Excluding the Petes Point-Sentinel Peak area from analysis resulted in the exclusion of approximately 12, 000 hectares (30, 000 acres) that lie within the study area. This area differs from the Hurricane and Hurwal divides in having less broken terrain, less ridge top vegetation possibly as a result of intensive sheep use in the 1930's (Wentworth, 1948:211), and a greater percentage of lush alpine meadows. Parts of the Petes Point-Sentinel Peak area are still grazed by sheep. Thus, the presence of sheep herders and dogs probably have a negative influence on mountain goat utilization of this area.

Description of Types

Eight habitat types were identified on the basis of physiographic characteristics or key plant species (Table 11). A comprehensive description of each type follows:

Timber. Timber is the predominant habitat type in the Wallowa Mountains study area. It is found on all exposures ranging from

Table 11. Description of habitat types in the Wallowa Mountains.[a]

Habitat Type	Elevational Range (ft.)	Most Prominent Species	Range of TPC[b] (%) or canopy closure	Comments
Timber	up to 8000	Douglas-fir Englemann spruce Lodgepole pine	40-95	Grassy meadow and creek bottom inclusions. Forb and shrub understory.
Open Timber	6400-8000	Limber pine White bark pine	25-45	Soil loose, shallow, and rocky.
Slide Rock	6500-9800	Shrubby cinquefoil	Trace-5	Mat-forming forbs and grass inclusions.
Cliff-Rock	5000-9800	Spindly forbs	Trace-5	Includes cliffy areas and open rock areas.
Alpine Meadow	5000-9400	Sedge Alpine buttercup	75-100	Form around moist areas.
Ridge Top	8400-9800	Phlox Ivesia	25-75	Average TPC 40-60 percent
Mountain Mahogany	5000-7500	Mountain mahogany	10-75	Shrub or grass understory.
Water	7600-9000	-	-	High lakes.

[a] Habitat type refers to a physiographic or vegetational type and does not imply a climax community.
[b] TPC - Total plant cover.

valley bottoms to 2434 meters (8, 000 ft.) and from moderate to steep slopes. Douglas fir (Pseudotsuga menziesii) the most abundant tree species, declines in prominence above 2287 meters (7, 500 ft.) and is replaced by subalpine fir (Abies lasiocarpa) as the most prominant species. White fir (Abies concolor) and western larch (Larix occidentalis) are scattered throughout the timber type. Stands of englemann spruce (Picea engelmannii), ponderosa pine (Pinus ponderosa), and lodgepole pine (P. contorta) are found below 2287 meters (7, 500 ft.). Rocky Mountain juniper (Juniperus scopulorum) and mountain common juniper (J. communis) occur primarily on the drier southern and eastern exposures. Quaking aspen (Populus tremuloides), sitka alder (Alnus sinuata), black cottonwood (P. trichocarpa), willow (Salix sp.) red-osier dogwood (Cornus stolonifera) and Rocky Mountain maple (Acer glabrum) are associated with protected basins and stream banks.

Timber understory is primarily shrubs and forbs with prominence shifting from shrubs to forbs along an altitudinal moisture gradient. Grasses (Festuca sp., Poa sp., others, see appendix) are common throughout timber type. Pine grass (Calamagrostis rubescens) is associated with ponderosa pine. Mallow ninebark (Physocarpus malvaceus) and whortleleaf snowberry (Symphoricarpos vaccinioides) are characteristic shrubs. Twin flower (Linnaea borealis) and pipsissiwa (Chimaphila umbellata) are common low elevation forbs while arrow leaf balsamroot (*Balsamorhiza sagittata*) and linanthostrum (*Linanthostrum nuttallii*) are prominent high elevation forbs.

Canopy closure ranges from 40 to 95 percent depending on exposure and type of stand but closure is generally 55 to 75 percent (ocular estimation and aerial photo interpretation). Douglas fir stands on north slopes typically have the greatest percent closure.

Inclusions of cliff-rock, alpine meadow, and slide rock are found in some timbered areas. Interfingering between timber and other habitat types is also common.

Open Timber. Open timber differs from timber in several respects. Limber pine (*P. flexilis*) and white-bark pine (*P. albicaulis*) are the predominant tree species with white-bark pine generally replacing limber pine at elevations above 2317 meters (7, 600 ft.). Spacing between trees is 9 to 15 meters (30 to 50 ft.); krummholz configuration is characteristic. Elevational range is 1951 meters (6, 400 ft.) to 2439 meters (8, 000 ft.). Slope varies from 40 to 55 percent.

Open timber is associated with dry sites. The soil is loose and gravely and composed primarily of erosion deposits from cliffs above. Vegetative understory is sparse (less than 15 percent total plant cover) and composed of spindly forbs and shrubs such as common juniper and bearberry (*Arctostaphylos uva-ursi*). Common forbs are blue flax (_Linum lewisii_), harebell (_Campanula rotundifolia_), yarrow (_Achillea lanulosa_), groundsel (_Senecio integerrimus_), wall-flower (_Erysimum capitatum_), and penstemon (_Penstemon_ spp.). Canopy closure is typically 25 to 45 percent.

Slide Rock. Slide rock is steep talus slopes characteristically occurring between open ridge tops and timberline. Percent slope ranges from 60 to 80 and elevational range is from 1982 meters (6, 500 ft.) to 2988 meters (9, 800 ft.). Because of the paucity of soil, plant growth is sparse; total plant cover is less than 5 percent. Mat forming phlox (_Phlox multiflora_), alpine forget-me-mot (_Eritrichium elongatum_) and whitlow-grass (_Draba densifolia_) occur as inclusions where some soil has accumulated. Shrubby cinquefoil (_Potentilla fruticosa_) is sparsely scattered throughout the slide rock type. Alpine blue grass (_Poa alpina_), Brook and Yellowdot saxifrage (_Saxifrage_ spp.) and a number of other small forbs occassionally grow out of rock crevices.

Cliff-Rock. Cliff-rock is found at elevations between 1524 and 2988 meters (5, 000 and 9, 800 ft.). Two categories of cliff-rock are distinguishable. First are the precipitous jagged cliffs with slopes ranging from 80 percent to vertical (200 percent). Vegetation is thinly distributed if not lacking on cliffs above timberline. In crevices where erosion deposits have accumulated solitary grass plants, yarrow, wild buckwheat (_Eriogonum ovalifolium_) and other small forbs grow. Vegetation on cliffs below timberline is more abundant with mosses, lichens, ferns, and a variety of forbs and grasses growing out of rock crevices. Where soil has accumulated trees may be prominent. In instances where a number of trees occur on cliffs if becomes arbitrary whether the habitat type is cliff-rock or timber.

The second form of cliff rock is open expanses of solid rock. Less precipitous than the first type, this form ranges from 55 to 75 percent slope. Rills and smooth undulations are characteristic formations. Basaltic dikes are also common. Vegetation is sparse and localized. Mountain penstemon, red mountain heath (Phyllodoce empetriformis), common juniper, western wintergreen (Gaultheria humifusa), bearberry, and willow are prominent species.

Alpine Meadow. Alpine meadow, with 75-100 percent total plant cover, is the most densely covered habitat type in the Wallowa Mountains. Alpine meadow can be divided into three categories: in valley bottoms (1524 to 2134 meters) large meadows occur at frequent intervals. These meadows have a variety of grasses, forbs, shrubs, and an occasional englemann spruce, lodgepole pine, or Rocky Mountain juniper. Sedge (Carex sp.) is the most prominent grass like species and shrubby cinquefoil the most prominent species. Common forb species are sagebrush buttercup (Ranunculus glaberrimus), larkspur (Delphinium nelsoni), scarlet gilia (Gilia aggregata), paintbrush (Castilleja sp.) and a number of composites (Erigeron sp. and Aster sp.).

The second type of alpine meadow forms in moist basins at the heads of cirques. The soil is continually damp from melting snow, underground springs, or overflowing lakes. These meadows are in the elevational range of 2195 to 2561 meters (7, 200 to 8, 400 ft.). The most prominent vegetation is sedge. Arnica (Arnica sp.) and Alpine buttercup (R. adoneus) also rank high in prominence.

The final form of alpine meadow, found up to 2866 meters (9, 400 ft.), forms at the base of permanent snowfields, in sinks, and around seepages. These are generally small meadows less than 25 square meters (30 yd^2) in size. Sedge and alpine buttercup are the most prominent species; mosses are also common. Degree of slope for all three meadow types is in the range of 20 to 40 percent.

Ridge Top. Rounded ridgelines interspersed between knife-edge ridges identifies ridge top type. Vegetation is found primarily on the tops of the ridges but may finger down the mountainside 91 meters (100 yds) or more. Total plant cover is generally 40 to 60 percent, with a range of 25 to 75 percent. Elevational range is 2561 to 2988 meters (8, 400 to 9, 800 ft.) and slope ranges from 0 to 55 percent.

Shallow rocky soil combined with the alpine environment causes vegetation to be dwarfed and mat forming. Forbs are the most abundant plant form in ridge top, however, grasses and an occasional shrub can also be found. Vegetational composition and species prominence varies from ridge to ridge however, collectively the most prominent forbs are white phlox, ivesia (Ivesia gordonii), alpine forget-me-not, locoweed (Astragalus purshii), and various composites. Common grasses are sheep fescue (Festuca orvina) and Sandberg's bluegrass (Poa sandbergii). Shrubby cinquefoil, willow (Salix sp.) and western wintergreen are shrubs occasionally found on ridge top type.

Mountain Mahogany. Curlleaf mountain mahogany (Cercocarpus ledifolius) stands always occur below timberline but are separated from timber because of their known importance as a big game forage plant. Most mahogany stands in the Wallowa Mountains are less than 2 hectares (5 a) although some exceed 12 hectares (30 a). The mahogany is typically old growth, reaching heights of 6 meters (20 ft.) and exhibits a distinct browseline at about 2 meters (6 ft.). Elevational range is up to 2287 meters (7, 500 ft.) and percent slope ranges from 20 to 55 percent. Understory varies from high density ninebark and snowberry to grasses and forbs. Canopy closure ranges from 25 to 80 percent.

Water. This category is composed of high mountain lakes. Streams running through meadows or timbered areas were included with those types. Elevational range is 2317 to 2744 meters (7, 600 to 9, 000 ft.). The smallest lakes are less than one hectare and the largest is approximately 18 hectares (45 a).

Intensive Use Area

Much of the available habitat within the Wallowa Mountains study area is not used by mountain goats. Study area boundaries were defined to include not only the portion of a particular divide occupied by goats but also that part of the divide available to the goats for use. Therefore, when it became apparent that the goats used only specific parts of each divide these were defined as an intensive use area. This allowed comparison of areas used by goats and adjacent areas not used by goats.

The intensive use area included all the area between the most southerly and northerly goat sightings on the Hurricane and Hurwal divides. The Hurwal Divide had two groups of goats and thus two intensive use areas (Figure 4).

A comparison of the total study area (Hurricane and Hurwal divides) and the intensive use area (Table 12) illustrates that 68 percent of the total area is not used or infrequently used by goats. Comparison of percent composition of habitat types between the total area and the intensive use area further indicates that the intensive use area has substantially more cliff-rock, slide rock, and ridge top (high elevation types) and less

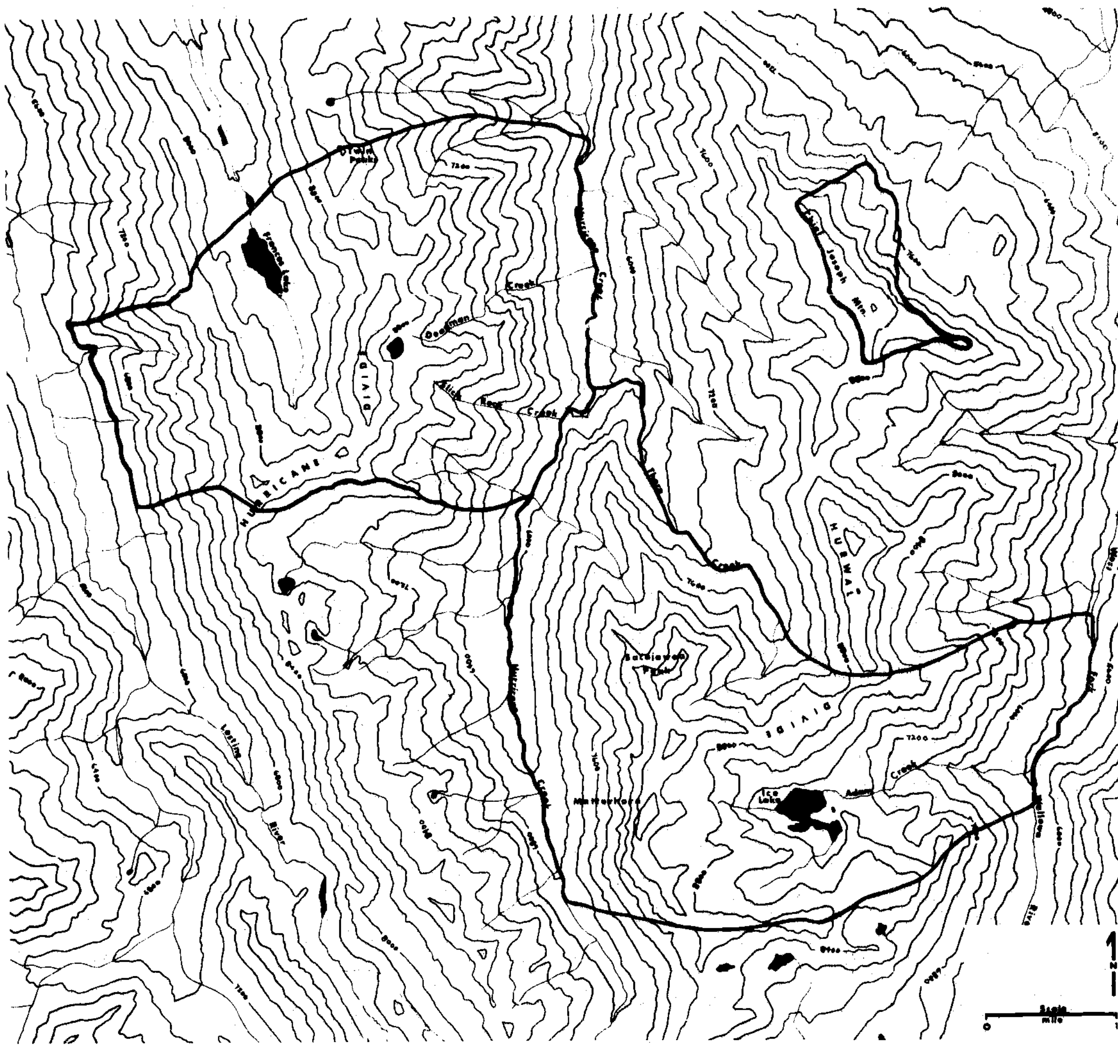

Figure 4. Intensive use area of mountain goats in the Wallowa Mountains, Oregon.

Table 12. Intensive use area vs. total area in the Wallowa Mountains, Oregon.

Habitat Type	Percent Intensive Use Area	Percent Total Area
Timber	31.09	42.04
Open Timber	10.35	13.92
Slide Rock	21.48	17.70
Cliff-Rock	30.46	19.82
Alpine Meadow	4.29	4.24
Ridge Top	1.08	0.94
Mountain Mahogany	0.50	0.48
Water	0.74	0.84
Total Hectares	7,100.54	22,440.50
(Acres)	(17,538.34)	(55,428.04)

timber and open timber (low elevation types) than the study area as a whole. Percent composition of middle elevation types (alpine meadow, mountain mahogany) were not appreciably different. The intensive use area, then, encompasses the highest peaks in the Wallowa Mountains with over 50 percent of the acreage above timber line. It can further be characterized as open and broken terrain.

Habitat Use

Two options were possible in examining habitat use by mountain goats: (1) the goat-minute approach which takes into consideration the amount of time each goat spent in a particular habitat type and (2) the point-in-time approach which is a sample using the habitat type goats were in when first located, thus weighing each observation equally. The latter approach would allow incorporation of aerial survey data since aerial survey observations were point-in-time observations.

Because the goat-minute approach gave a more reliable estimate of relative importance of habitat types (importance based solely on the amount of time spent in a habitat type) than the point-in-time approach, I selected the goat-minute approach as the best approach to use in data analysis. However, before dismissing the point-in-time data I would like to point out a bias involved in this approach (Figures 5 and 6). Point-in-time data (Figure 6 tends to

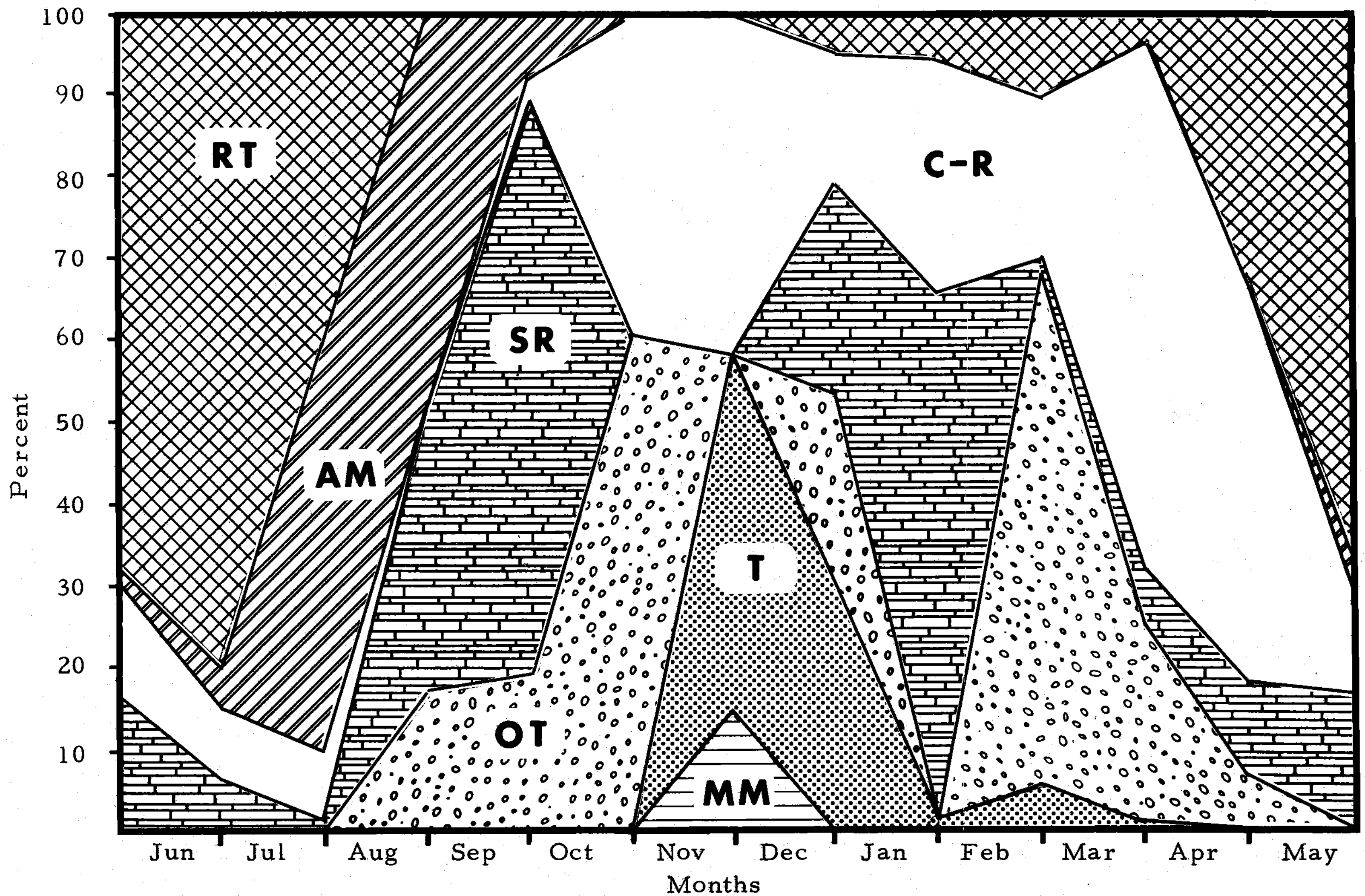

Figure 5. Flow chart of seasonal habitat use by mountain goats in the Wallowa Mountains using goat-minute data.

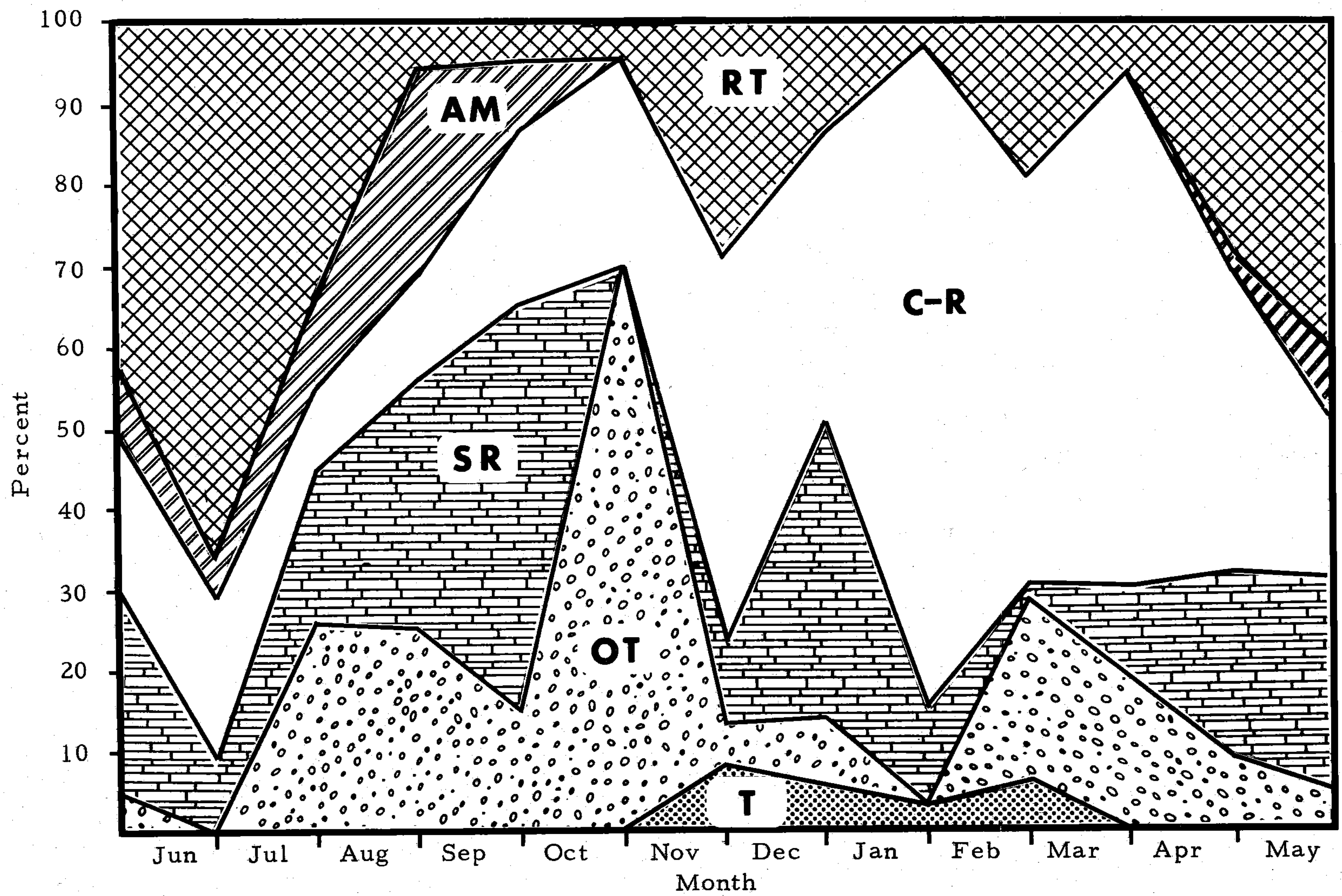

Figure 6. Flow chart of seasonal habitat use by mountain goats in the Wallowa Mountains using point-in-time data.

lessen the importance of alpine meadow in summer and timber in winter. It further exaggerates the importance of cliff-rock throughout the year. The suspected reason for the differences is the tendency of goats to locate the observer and move to high elevations or protective cover (cliff-rock) before the observer locates the goats.

Seasonal Habitat and Elevational Use

Seasonal habitat use by goats in the Wallowa Mountains (Table 13) revealed distinct patterns of preference during different seasons. In winter 59 percent of observed use (diurnal) was divided between open timber (35 percent) and cliff-rock (24 percent). In spring open timber and cliff-rock reversed in importance with cliff-rock receiving 60 percent use and open timber 19 percent. Summer use shifted to ridge top (74 percent) and in the fall slide rock became important with 65 percent use.

In Idaho, Kuck (1971:14, 1973:12) found mountain goats used mahogany-rock (mountain mahogany-cliff-rock association) 72 to 96 percent of the time in winter and ridge top up to 62 percent in summer. Slide rock, limber pine (open timber) and alpine meadow received heaviest use in late summer and early fall. Feeding goats in Montana used grassy slide rock and ridge tops (54 and 17 percent respectively) in spring and summer with greatest use of alpine meadow (16 percent) in August and September (Saunders, 1955).

Table 13. Seasonal habitat use (percent) by mountain goats in the Wallowa Mountains (goat-minute approach).[a]

Season	Habitat Type: Timber	Open Timber	Slide Rock	Cliff Rock	Alpine Meadow	Ridge Top	Mountain Mahogany	Total Hours
Winter (Nov-Mar)	19 (119.4)[b]	35 (217.3)	13 (79.9)	24 (149.0)	0 (0)	6 (39.4)	3 (17.4)	622.4
Spring (Apr-May)	0 (0.9)	19 (47.3)	8 (21.0)	60 (148.2)	0 (0)	12 (29.5)	0 (0)	246.9
Summer (Jun-Aug)	0 (0)	0 (0)	9 (19.7)	9 (19.8)	8 (17.1)	74 (158.6)	0 (0)	215.2
Fall (Sep-Oct)	0 (0.1)	19 (18.8)	65 (64.5)	3 (2.8)	13 (12.5)	0 (0)	0 (0)	98.7

[a]Use defined as the number of hours mountain goats were observed in a particular habitat type.

[b]Figures in parentheses are hours of use.

He found little use of cliff and timber at any time of the year. Peck (1972) also working in Montana, found high use of ledge (cliff-rock) and slide rock in summer (54 and 36 percent respectively). In fall and winter, ledge continued to receive heavy use (59 and 70 percent respectively), and in the spring ridge and ledge received greater than 30 percent use each. Foss (1962), collecting data in Montana from June through September 1960 and 1961, found heavy use of slide rock (54 percent) and cliff-rock (26 percent). Alpine meadow increased in importance from 7 percent in June to 23 percent in September. Geist (1971:271) found 52 percent winter use of cliffs by goats in Alberta.

Summer (June, July, August). The importance of ridge top type throughout the summer is apparent (Table 14). When field work was initiated in late June 1972 goats were already spending most of their time on the ridge tops. In 1973 goats were observed to move to the ridge tops in early June. Observed use of ridge top peaked in July at 80 percent decreasing to 40 percent use in August. The increased use of ridge top through July and subsequent decrease in August is reflected in the average elevation used (Table 15) for the corresponding months.

Nightly freezing temperatures at peak elevations in the Wallowa Mountains persist well into June and delay the maximum vegetative growth until early July. The goats undoubtedly follow the

Table 14. Monthly habitat use (percent) by mountain goats in the Wallowa Mountains, Oregon, 1972-73.

Month	Habitat Type						
	Timber	Open Timber	Slide Rock	Cliff-Rock	Alpine Meadow	Ridge Top	Mountain Mahogany
Jun	0	0	17	13	2	67	0
Jul	0	0	7	8	5	80	0
Aug	0	0	1	9	50	40	0
Sep	0	17	35	0	48	0	0
Oct	0	19	70	3	8	0	0
Nov	0	61	0	39	0	0	0
Dec	43	0	0	42	0	0	15
Jan	31	22	26	16	0	5	0
Feb	2	0	64	28	0	6	0
Mar	6	62	2	19	0	10	0
Apr	1	24	7	65	0	3	0
May	0	7	11	49	0	33	0

Table 15. Seasonal elevational use (meters) by mountain goats in the Wallowa Mountains, 1972-73.

Season	Month	Average Elevation Used			
		Monthly	SD	Seasonally	SD
Summer	Jun	2657	140		
	Jul	2771	100	2719	144
	Aug	2655	243		
Fall	Sep	2477	45	2468	96
	Oct	2466	105		
Winter	Nov	2259	158		
	Dec	1921	0[a]		
	Jan	2473	202	2372	251
	Feb	2601	142		
	Mar	2354	195		
Spring	Apr	2212	227	2323	238
	May	2458	174		

[a]All goats located in December were in one area and sedentary for several days, hence zero standard deviation.

appearance of succulent vegetation to peak elevations. Hjeljord (1971) in Alaska and Kuck (1973) in Idaho noted the greatest use of ridge tops in July and related it to green-up.

Use of ridge top decreased in August and use of alpine meadow increased. Saunders (1955), Foss (1962), and Peck (1972) in Montana, Hjeljord (1971) in Alaska, and Kuck (1973) in Idaho noted the same type of shift and related it to moisture requirements of mountain goats. The same probably applies in the Wallowa Mountains. By mid-August ridge top vegetation was beginning to desiccate as water percolated through the soil. At the same time snowbanks in protected basins receded and the released moisture enhanced the growth of succulent vegetation attractive to the mountain goats. The goats moved to these areas to feed but returned to cliffs at high elevations when not feeding.

Fall (September, October). In September and October goats were seen more frequently in low elevation habitat types (Tables 14 and 15). Alpine meadow received 48 percent use in September and only 8 percent use in October. Slide rock increased from 35 percent to 70 percent use from September to October.

Heavy use of alpine meadow in September was consistent with continued desiccation of ridge top vegetation. In addition snow began to accumulate on the ridge tops early in September making lower elevation types more attractive. Kuck (1973) noted that snow accumulated at peak elevations in October triggering movement of goats to lower winter range. In Alaska, Hjeljord (1971) noted that in late October prior to snow accumulation goats were feeding on steep rocky slopes and sparsely timbered areas (slide rock and open timber). After the first snow in late October goats moved below timberline.

In the Wallowa Mountains the October shift from feeding in alpine meadows to feeding in slide rock type was probably the result of snow accumulation in protected basins. The relatively high elevation of the basins combined with cold air drainage (Loveless, 1967: 94; Geist, 1971:274) and long periods of shading probably led to faster snow accumulation here than in any other type with the possible exception of timbered north slopes.

The average elevation used (Table 15) in September and October indicated that goats were not moving back to high elevations when not feeding as they did in August. Snow accumulation at peak elevations was minimal (less than 15 cm) through October and in itself probably was not responsible for the reluctance of the mountain goats to move back to high elevations. Klein (1953) in Alaska noted that high winds and rain drove goats to protective cover during October. In the Wallowa Mountains rain and wet snow at high elevations were frequent in September and October and perhaps were responsible for the shift away from high elevation types. Open timber, which offered cover from stormy weather, became the third most important habitat type in September (17 percent use) and second in importance in October (19 percent use). Open timber in most cases was adjacent to slide rock thus the food supply was close to protective cover. This further allowed a minimal amount of energy expenditure traveling to the feeding area while utilizing a habitat type (slide rock) with a poor food source.

Winter (November, December, January, February, March): In early winter mountain goats were widely dispersed over several habitat types with no apparent pattern of movement. However, as the winter progressed habitat use and goat movements appeared to be related to snow conditions. The general trend was use of low elevation types early in the winter and use of high elevation types during the most severe winter months. In later winter low elevation types again became important. Overall, open timber and cliff-rock received the greatest amount of use through the winter (Table 13) but, month by month use (Table 14) shifted between types.

Snow depth for the Wallowa Mountains (Table 16) is recorded by the Soil Conservation Service, Cooperative Snow Surveys for February through May only. Personal observations document snow accumulation in the early winter months well enough to allow some assumptions pertaining to the relationship between snow conditions and habitat use.

Table 16. Snow depths in the Wallowa Mountains, 1972-73.[a]

Location	Elevation (m.)	Month	Depth (cm.) 1972	Depth (cm.) 1973
Aneroid Lake (East edge of study area)	2280	Feb	229	165
		Mar	262	178
		Apr	279	206
		May	302	173
T.V. Ridge (NW corner of study area)	2134	Feb	130	86
		Mar	147	86
		Apr	160	130
		May	175	91
Mirror Lake (South end of study area)	2500	Feb	MNV[b]	340
		Mar	MNV	335
		Apr	MNV	343
		May	MNV	333

[a]Extracted from Department of Agriculture, Soil Conservation Service, cooperative snow survey (records located in Portland, Oregon).

[b]Marker not visible--more than 610 centimeters of snow.

In November movements of goats in response to the rut and changing weather conditions made them difficult to locate. The limited hours of observation indicate a division of habitat use between open timber (61 percent) and cliff-rock (39 percent). One aerial survey was flown in November locating nine goats. Eight were in open timber and one was on ridge top.

The presence of snow at high elevations probably accounts for the continued downward movement (2259 meters average) of goats in November and explains the high use of timber and cliff rock. On 9 November I measured 76 centimeters of snow on a ridge crest at 2439 meters (8000 ft). In glassing higher elevations I noted that ridge tops were not wind swept and appeared to have a considerable accumulation of snow. By 22 November there was 30-60 centimeters of snow at 1829 meters (6000 ft) but only 15 centimeters on a ridge crest at 2561 meters (8400 ft). Hjeljord (1971) in Alaska and Peck (1972) in Montana found that low timbered areas were important forage areas when deep snow persisted at high elevations.

Perhaps as a result of snow conditions goats were relatively sedentary in November and could be located several consecutive days in the sample area. This lack of movements may account for the small number of goat observations for the month. Geist (1971:92) noted that sheep observations increased with deep snow conditions at high elevations because the sheep would drop to low elevations. The mechanism was the same in the Wallowa Mountains but the effect was different. Geist was familiar with the sheep wintering area and could readily locate them. I was unfamiliar with the goat wintering area and consequently had difficulty locating goats in early winter.

Habitat use in December was equally divided between timber and cliff-rock (43 and 42 percent respectively). Average elevation used dropped to 1921 meters (the lowest average of the year). However these data are probably somewhat misleading because most of the observations came in late December as the mountain goats on the Hurricane Divide moved to the Hurwal Divide wintering area. Aerial surveys flown on 5 and 11 December located 25 goats with 52 percent on wind swept ridge tops and 32 percent on wind swept slide rock. The average elevation goats occupied on these surveys was 2713 meters (8900 ft).

Snowfall in December was moderate. At 1829 meters (6000 ft) an additional 30 cm accumulated over the November measurement and at peak elevations wind action cleared north and west facing ridge tops. In addition, early in December temperatures were extremely low. Between 5 and 15 December temperatures rarely climbed above -9.5° C (15° F) and ranged down to -32.8° C (-27° F). On 5 December airport (1128 m) temperature in Enterprise was -22.2° C (-8° F) and at 10,000 feet it was -12.2° C (10° F). Geist (1971:274) found temperatures on high slopes as much as 11° C (20° F) warmer than valley bottoms. Thus by moving to high elevations where ridges were free of snow goats were taking advantage of an easily accessible food supply and were experiencing warmer temperatures.

Early in January stormy weather restricted goats to timber and open timber for cover. Later in January and February goats spent more time (diurnal) at elevations above 2439 meters (8000 ft). Because of increasing snow depth in this late winter period (see Table 16, Aneroid Lake for depths comparable to mountain goat wintering area) low elevations (1951 meters) were used only for resting and some feeding on conifers and mountain mahogany. High, wind swept ridges were used almost exclusively for feeding. The goats generally moved to the open ridges by 1000 and descended between 1500 and 1600. This was especially true in late January through February. Geist (1971:262) noted a similar phenomenon for goats in Alberta.

In March a noted shift in habitat use occurred without a significant change in snow conditions. Average elevation used decreased to 2354 meters (7720 ft). Open timber received 62 percent use and slide rock, which had received 64 percent use in February as a major feeding area, dropped to 2 percent use. In late March I climbed to the primary winter feeding area to evaluate the effects of concentrated use and found the range severely overgrazed to the point that practically all vegetative material was removed. Brandborg (1955:85) noted that "forage depletion is often evident where animals concentrate during these periods of limited winter movement and nearby ranges may be utilized very lightly." Thus the shift to open timber apparently resulted from the lack of suitable forage on wind swept ridges.

Patterns of habitat and elevational use throughout the winter followed a general trend not uncommon to other goat populations. Casebeer et al. (1950) in Montana, Brandborg (1955) in Idaho, and Hibbs (1965) in Colorado noted the winter use of wind swept ridges by mountain goats. Hjeljord (1971) found that in winter when snow blanketed all elevations goats preferred habitat types above timberline but in a winter when snow free areas were available at low elevations goats used the snow free areas. Some goat populations in Idaho (Brandborg, 1955; Kuck, 1973) migrated to low cliffy areas and thus avoided areas of deep snow accumulation. Geist (1971:92, 268) found that winter use of low elevations by mountain goats and bighorn sheep (*Ovis canadensis*) was common until wind exposed the upper elevation ridge top type.

In the Wallowa Mountains as snow began to cover the ridge tops goats moved down to the available food supply in cliff-rock, open timber and timber. When snow accumulated at low elevations and wind action concurrently freed high slopes the goats again moved to ridge top and slide rock to feed but retained use of timber and open timber for cover.

Geist (1971:256) recognizing the ability of goats to cope with severe snow conditions stated: "The goat is more specialized rock climber with wider food habits than sheep and appears to be a little better adapted to handle deep snow."

On occasions in the Wallowa Mountains, when snow storms left fresh deposits at high elevations, and in particular during the month of March when the food supply on wind swept ridges was gone, the adaptive ability to forage in deep snow was essential to the goats' survival.

Spring (April, May). The winter of 1971-1972 left a greater accumulation of snow than the winter of 1972-1973 (Table 16). Consequently snow melt in spring 1973 was approximately a month ahead of snow melt in 1972. This probably influenced the time habitat use shifted between years but not the pattern of movement. During the second week of April 1972, prior to initiation of field work, I made a two day reconnaissance of the Wallowa Mountains and located five goats feeding high on a wind swept ridge. This was apparently necessary for the goats because the snow had not visibly begun to recede from low elevations. However, by the second week of April 1973, snow had sluffed off of most of the steeper cliff faces enabling goats to feed on these areas.

In Idaho use of low elevation winter range began to decline in May as goats moved upward to summer range (Kuck, 1973). In Montana use shifted from ledge (cliff rock) in winter (Nov-Apr) to ridge in spring (May-Jun) (Peck, 1972). Hjeljord (1971) noted that the shift to summer range for goats in Alaska takes place in late May and early June. Geist (1971:95) reported a sharp increase in use of cliffs by sheep in March and April.

In the Wallowa Mountains warm temperatures early in April 1973 resulted in rapid sluffing of snow from steep cliff faces and the appearance of new growth around low elevation cliffs. The movement of goats to these open areas was reflected by the concommitant shift in average elevation used to 2212 meters (7255 ft) and habitat used to 65 percent cliff-rock from 19 percent in March. In May as snow continued to recede and new growth appeared at higher elevations average elevation used was 2458 meters (8061 ft). Use of cliff rock decreased to 49 percent and ridge top use increased from 3 to 33 percent.

Data discussed in this section indicate that seasonal movements are related to attractiveness and availability of different habitat types in different seasons. Moisture requirements of mountain goats, desiccation of preferred forage, and snow cover appear to be the primary factors affecting habitat attractiveness and availability. Movements in early winter and late spring can further be related to the rutting and kidding periods respectively although they probably have a lesser influence on the type chosen than the previously mentioned factors. It should be pointed out that seasonal use of particular habitat types represents general trends and does not infer that all goats are faithful to a habitat use pattern. Some goats can be found at all elevations using all habitat types most months of the year. For the majority of the population, however, the pattern is applicable.

Limiting Factors

The assumption that some factor or set of factors is limiting the rate of increase of the Wallowa Mountains goat population is predicated on the small size of the population compared with other populations introduced under similar circumstances and allowed to increase over a similar time period. In the Black Hills of South Dakota, six goats released in 1924 gave rise to a population of over 200 by 1942 (Harmon, 1944). By 1950 this population reached a static level of 300-400 goats (Richardson, 1971). Colorado's Collegiate Range mountain goat herd numbered between 250 and 300 (Hibbs et al., 1969) 20 years after the first releases of eight and six goats in 1948 and 1950 respectively (Hibbs, 1966). In the Crazy Mountains, Montana, releases of 10 goats in 1941 and 11 goats in 1943 gave rise to a minimum population of 278 by 1953 (Lentfer, 1955). In the

Wallowa Mountains only 29 goats are present 24 years after the release of six goats in 1950. In addition, goats in the Wallowa Mountains have dispersed no further than 9 airline miles from the point of original release.

Why has the Wallowa Mountains goat population failed to attain numbers comparable to the aforementioned examples? Obviously this short term study cannot fully answer the question but can suggest possible causes and hypothesize as to the most probable cause.

Factors initially considered potentially limiting to the Wallowa Mountains goat population were (1) accidents, (2) competition, (3) predation, (4) parasites, (5) disease, (6) unfavorable sex ratio, (7) poor survival of kids (after 1 month), (8) poor survival of the yearling age class, (9) in utero or neonatal (within 1 month of birth) losses, (10) winter nutrition, and (11) unsuitable habitat.

Brandborg (1955) and Holroyd (1967) believed accidents accounted for a higher percentage of goat mortalities in Idaho and British Columbia respectively. Casebeer et al. (1950) in Montana, found one goat that apparently died in a fall. Other observers (Lentfer, 1955; Hibbs, 1965) felt accidents were a significant component of overall mountain goat mortality. The adaptation of goats and sheep to snow and rock slides is discussed by Geist (1971:259). He noted that sheep "... react to the loud rumble by jumping to their feet and at once looking uphill." while "...mountain goats head for cover when they hear a loud rumbling which normally signals an avalanche."

Since their introduction in 1950 the remains of four goats have been found in the Wallowa Mountains. There is evidence that at least three of these died in accidental falls. However, during the 12 months of this study no accidental mortalities were recorded. Near accidents did occur. On 11 January an avalanche passed down a slide path dividing the low elevation wintering area of at least 77 percent of the goat population. Mountain goats were resting on both sides of the slide path at the time and within 15 minutes crossed the slide without hesitation. This particular slide path continued to be traversed throughout the winter as a corridor between two regularly used patches of timber. On 12 April several avalanches occurred in a steep area that four goats were attempting to cross. At one point a goat slipped and was covered by snow, starting an avalanche which nearly took two other goats. All, however, scrambled to safety.

The physiography of the Wallowa Mountains is such that rock and snow slides are frequent. However, this is typical of most mountain goat ranges and the probability of accidents occurring to the Wallowa Mountains goats is likely not significantly different than the probability elsewhere. With a population as small as that in the Wallowa Mountsins, however, the loss of a large segment of the population in a single accident becomes a real possibility. The apparent use of traditional areas by goats (Geist, 1971:127 found this for bighorn sheep) and the tendency to group in winter, only adds to this possibility. However, on a long term basis one would not expect this to limit population increase.

Mule deer (Odocoileus hemionus), Rocky Mountain elk (Cervus canadensis), and Rocky Mountain bighorn sheep are potential competitors of mountain goats in the Wallowa Mountains. Deer and elk, however, appear to prefer timbered areas and alpine meadows at elevations at least 305 meters (1000 ft.) below goat range and consequently are not serious competitors. Bighorn sheep (20 reintroduced in 1971) utilize the same summer range as mountain goats but move to lower elevations during the winter and are not competitors at this critical time of the year. At their current population level bighorn sheep are probably not serious competitors on summer range. But, observation of the sheep since their release indicate a high rate of survival and good reproduction (3 lambs in 1972 and 11 lambs in 1973). If this trend continues competition will undoubtably increase and the potential for sheep to limit the size of the goat population will increase. This may come as added pressure on summer range which is also mountain goat winter range. However, competition has not been a factor limiting the rate of increase of the goat population in previous years.

Potential predators of mountain goats in the Wallowa Mountains are coyotes (Canis latrans), bobcats (Lynx rufus), cougars (Felis concolor), and golden eagles (Aquila chrysaetas). Anderson (1940) cited two incidences of attacks on goats by golden eagles and an instance of coyotes chasing a goat. Brandborg (1955) believed cougars and bobcats had the potential to be important predators on goats because of their ability to traverse rugged terrain. He also cites instances of harassment by eagles and one account of a bald eagle (Haliaeetus leucocephalus) taking a kid.

In the Wallowa Mountains sign suggests that cougars follow mule deer concentrations and bobcats frequent areas where snowshoe hares (Lepus americanus) are concentrated. Several coyotes were seen in goat range but never harassing goats. Two apparent attempts by eagles to take goat kids were noted and in each case the kid was protected by its nannie.

There is no current evidence to suggest that predation has an appreciable effect on goats in the Wallowa Mountains. No doubt, instances of predation do occur, but these instances are probably isolated or incidental to the predators activity. Three factors support this theory; (1) the high degree of protection nannies give their offspring (Geist, 1971:249), (2) the ability of goats to inflict mortal wounds (Geist, 1971:249), and (3) the lack of a specialized predator on goats. With regard to the third factor, it would be unprofitable in most cases for a predator to specialize on goats. Predators on large ungulates in Oregon would be more likely to find large concentrations of deer and elk and in much more accessible range.

Kerr and Holmes (1966) in Alberta and Boddicker et al. (1971) in South Dakota reported specifically on the parasites of mountain goats. The former study, which identified two species of ticks, two cestodes, and nine nematodes, found no detrimental effects on goats from parasites but suggested that heavy infestation could cause mortality during a severe winter when goats are in a weakened condition. The latter study, which identified one species of tick, two cestodes, and 11 nematodes suggested that parasitism could account for the static nature of the Black Hills population over the past 20 to 30 years.

Brandborg (1955) and Holroyd (1967) felt that a high incidence of parasitism may account for mortalities during critical winter periods. Although I examined only a minimal number of fecal samples there was no indication of internal parasites in mountain goats in the Wallowa Mountains. Also, no evidence of external parasitism was noted. However, without sufficient data the effect of parasitism as a limiting factor will likely remain undetermined.

Brandborg (1955) found little evidence of disease in goats in Idaho. Because of the isolated habitat used by goats and the small numbers of ungulates in the Wallowa Mountains there is probably little opportunity for transmission of disease. Thus, it is unlikely that disease is limiting the goat population.

The sex ratio of 59 males per 100 females discussed previously appears to be adequate. Observations during the rut indicated that estrous females were receiving attention. Instances of males attempting to mount female yearlings and kids were also noted. In addition males displayed rutting behavior (Geist, 1964; DeBock, 1970) through February even though the normal rutting period is November and December. These observations and the polygamous nature of goats (Brandborg, 1955) discounts an unfavorable sex ratio as a limiting factor.

Poor survival of kids older than 1 month and poor survival of the yearling age class were not problems during this study. All three kids, one of which was markedly smaller than the other two, and all three yearlings survived the winter without apparent difficulty. Anderson (1940) in Washington and Brandborg (1955) in Idaho noted a high percentage of loss in the first 2 years of life. Hanson (1950) in South Dakota and Holroyd (1967) in British Columbia found loss of young to be minor. The severity of the winter appeared to be the governing factor in each of these cases and probably governs survival in the Wallowa Mountains as well. Even though there was no evidence of loss from these two age classes during this study other circumstantial evidence (low numbers of kids) makes poor survival of kids suspect as a limiting factor. Any yearling mortality would compound the effect of kid mortality.

The remaining three potential limiting factors, in utero or neonatal losses, winter nutrition, and unsuitable habitat are interrelated. I feel these three acting in concert are the most likely cause of continued low goat numbers in the Wallowa Mountains. Specifically, I hypothesize that the lack of suitable winter range results in a winter nutritional deficiency which in turn leads to abortions or resorptions by a high percentage of gravid females or those females that do carry their fetuses to term produce small kids with poor chances of survival.

One assumption of this hypothesis is that implantation occurs. Some observers have found that condition prior to the onset of breeding is an important factor controlling implantation. Trainer (1969) felt that fall nutrition was the key factor determining conception in adult female roosevelt elk (Cervus elophus). Teer et al. (1965) working with white-tailed deer (O. virginianus) in Texas felt that the quality of available nutrition was reflected in the implantation rates. In the Wallowa Mountains goats enter the rut in seemingly good condition. Summer range is adequate to support the small.

population and forage does not become scarce until at least November. Thus, there is no reason to suspect that implantation does not occur in estrous females in this population.

Swenson (1973) after a thorough search of the literature on North American ruminants assembled evidence which indicates that once implantation occurs the fetus will survive to parturition unless the female is stricken with an abortion causing disease (brucellosis, listeriosis, vibriosis, leptospirosis). Thorne (1971) working with Rocky Mountain elk, however, concluded that if the female loses more than 10 percent of her body weight during pregnancy, death of the fetus is likely to occur. In addition, some observers have presented data which indicate that in ruminant populations the nutritional quality of forage utilized during pregnancy determines the viability of the newborn (Arnold and Verme, 1963; Murphy and Coates 1966; Thompson and Thompson, 1948; Verme, 1963).

Reviewing some factors pertinent to the hypothesis previously stated, this study has shown that (1) winter range for a higher percentage (at least 77 percent) of the goat population is limited to essentially one small wind-blown ridge top, (2) by late winter the food supply on this exposed ridge top was severely over-grazed, and (3) during the winter goats fed at high elevations (2561 m) and returned at night to low elevations (1951 m). It is obvious that considerable energy is used traversing twice daily between low timbered areas and open ridge tops. Feeding during the winter day is continuous and it is probable that energy return for energy expenditure is negligible. This is certain to have an adverse effect on gravid females. At some degree of nutritional stress gravid females, diverting energy to their embryos at their own expense, would be obliged to sluff off the embryo or die from the added stress. In a more severe winter the stress might be greater or come sooner, not because of a less abundant food supply (wind blown areas would probably be similar regardless of the severity of winter) but because of colder temperatures and deeper snow at low elevations, both of which would require expenditure of more energy.

The ability to successfully carry a fetus to term may in part depend on how recently the nannie has delivered a kid. Under low nutritive or high stress conditions it may take 2 or 3 years to recover after each pregnancy leading to alternate year or every third year production (see Population Structure). Such a reproductive history was exemplified by a one-horned adult female in the Wallowa Mountains (at least 5 years old by horn rings) which did not have a kid in 1972 or 1973.

Observations of abortions or neonatal death or sign of either are not likely to be found and the effect of winter nutrition on population increase will likely remain undetermined for the Wallowa Mountains goat population. However, an instance suggestive of neonatal loss was observed. In July 1972, I observed a yearling nurse for 15 seconds. The fact that a nannie allowed the yearling to suckle may indicate that she had recently lost a kid. One additional factor that may contribute to abortion is the heavy use of conifers in late winter when other available food is scarce. McDonald (1952) found that range cattle in Canada abort or produce weak calves after consuming pine needles and buds. Allen and Kitts (1961) found the same effect in white laboratory mice (*Mus musculus*). However, V. Geist and B. W. O'Gara (personal communication) note that conifers are probably a natural food source for mountain goats and therefore abortion from turpentine in pine and fir needles is not likely.

Finally, in connection with the suitability of winter range, it should be pointed out that the wintering area utilized by goats in the Wallowa Mountains is not necessarily the best wintering area available. Perhaps as a result of tradition or behavior the goats restricted themselves to a small segment of their range during winter. Lower elevations, nearer the northern edge of the mountain range with fewer cliffs but a more abundant food supply are not selected by goats. Bighorn sheep, deer, and elk, however, winter in these areas.

Management Recommendations

An important consideration in organizing a management plan for mountain goats in Oregon is that goats are not native to Oregon. Although transplants in other non-native ranges have been relatively successful (i. e. Colorado and South Dakota) it does not necessarily follow that Oregon can support large numbers of goats. Also to be considered is the priority to be given mountain goats. For instance, Rocky Mountain bighorn sheep recently reintroduced into the Wallowa Mountains, have already demonstrated a potential for success. At some point in time a decision may have to be made as to whether it is more desirable to have large numbers of either sheep or goats in the Wallowas or whether to have smaller numbers of each. Therefore, long range objectives should be kept in mind. With these introductory thoughts the recommendations which follow are based on the assumption that it is desirable to maintain at least some mountain goats in Oregon.

It is probably safe to assume that the Wallowa Mountains goat population would continue to maintain itself near its present level by continuing a hands-off management policy. This is evidenced by the existence of the population today. Despite the introduction of only one adult female, three adult males, and a female kid a population of approximately 35 goats developed within 15 years after release.

Further, the population has apparently recovered to preharvest numbers following the harvest of 1965-68. While a hands-off management policy may not adversely effect the goat population implementation of other management policies may enhance the population.

Two general approaches to big game management are habitat manipulation and population manipulation. Because of the nature of mountain goat range habitat manipulation is impractical in many instances and management will have to rely more on population manipulation. Studies of the habitat are useful, however, for determining the needs of goats and the impact goats have on their range.

Management in the Wallowa Mountains

Aerial Surveys. Population composition counts are necessary to determine trends and population status and should be conducted regularly. The data from this study (Table 17) indicate the best times to fly aerial surveys are mid-summer (June 15-July 15) and mid- to late-winter (January to April). Surveys should be flown when goats are most actively feeding: at daybreak in summer and early afternoon in winter. Summer surveys will provide adult/kid ratios (an indication of productivity) and give some indication of winter losses. Winter surveys will identify wintering areas and indicate first year mortality from changes in

Table 17. Summary of aerial surveys flown in the Wallowa Mountains, 1972-73.

Date	Time	Location				Total
		Hurricane Divide	Sacajawea-Matterhorn	Chief Joseph Mt-Adams Creek	Petes Point-Sentinel Pk.	
1/30/72	0730-0900	1	6	0	-[a]	7
5/03/72	0600-0800	3	7	2	-[a]	12
6/21/72	0530-0730	9	5	4	1	19
7/04/72	0600-0830	9	6	3	2	20
8/04/72	0530-0750	10	4	1	0	15
8/25/72	Daybreak	10	4	3	1	18
10/01/72	0700-0800	6	1	1	-[a]	8[b]
10/19/72	0745-0905	9	3	2	-[a]	14[b]
10/25/72[c]	0700-0820	3	1	-[a]	-[a]	4[b]
11/19/72	0715-1025	8	1	0	0	9
12/05/72	0645-0915	7	3	0	0	10
12/11/72	0710-0930	9	5	1	-[a]	15
1/08/73	1340-1615	0	20	1	0	21
1/21/73	1255-1445	0	10	8	0	18
2/18/73	0830-1035	1	14	1	-[a]	16
3/12/73	1000-1110	2	8	0	-[a]	10[b]
4/03/73	1130-1340	5	16	2	1	24
4/21/73	0800-0840	2	-[a]	-[a]	-[a]	2[b]
4/25/73	0810-1005	6	3	5	-[a]	14
5/06/73	0730-0820	3	5	-[a]	-[a]	8[b]
5/11/73	0530-0835	5	5	5	1	16
5/17/73	0500-0725	6	8	0	-[a]	14[b]
5/27/73	0940-1150	2	4	3	-[a]	9[b]
6/04/73	0825-1115	7	7	6	1	21
6/10/73	0830-1105	6	11	2	1	20
6/19/73	0735-0940	4	4	0	-[a]	8
6/27/73	0550-0805	8	12	1	0	21
7/04/73	0645-0835	10	6	3	1	20
7/10/73	0515-0555	1	-[a]	-[a]	-[a]	1[b]
8/13/73	0525-0755	7	5	3	0	15
9/28/73	0630-0820	5	5	1	0	11

[a]Area not surveyed.

[b]Flight incomplete because of turbulence.

[c]Surveyed in Bell G-2 helicopter.

adult/kid ratios. In addition, goats are more easily located in winter than summer because of tracks. Thus, winter counts offer the opportunity to approach a total count of the population.

Controlled Burning. One potentially useful habitat manipulation practice is controlled burning. The use of fire to the benefit of wildlife has been discussed (Vogl, 1967). Although mountain goats in the Wallowa Mountains rarely use habitat types that lend themselves to burning, burning may stimulate use of new areas. In addition, burning of mountain mahogany stands currently having a browseline out of mountain goat reach, may stimulate growth of new mahogany plants which could be utilized by goats.

Exclosures. The hypothesis that winter range is the ultimate limiting factor of the Wallowa Mountains goat population suggests that it may be unwise to try to increase the population beyond its current level. A test of the hypothesis could be made with exclosures. by establishing and periodically checking exclosures on summer and winter ranges the impact of browsing could be evaluated. On a long term basis comparison of areas used only in summer with areas used summer and winter would identify the effects of additional pressure to winter range and indicate the productive potential of summer and winter ranges. Interpretation of resultant data would help determine if population numbers exceed the carrying capacity of the habitat and aid in selecting sites for future releases.

Trapping and Transplanting. Attempts in other areas to trap mountain goats have proven difficult and time consuming (Kuck, 1971; Brandborg, 1955). The designation of the Wallowa Mountains as a wilderness area only adds to that difficulty. However, trapping and transplanting could prove an effective tool for stimulating productivity and increasing distribution. By removing some goats, density dependent factors should favor increased productivity. The stock removed could be released directly into new areas or held in large enclosures as breeding stock for future releases.

Since the mountain goat population in the Wallowa Mountains consists of distinct geographic groupings, trapping operation efforts should be distributed evenly throughout mountain goat range. No more than two or three females per male should be removed to maintain a balanced sex ratio in the population. All goats captured, whether removed or not, should be clearly marked with a distinguishing collar and eartags so that their future activities can be monitored.

Harvest. Because of the current tenuous status of mountain goats in Oregon harvest at this time is not recommended. By sacrificing a transplant program goats could be harvested at the same rate as proposed for transplant purposes. The advantage of selectivity of animals removed, however, would be lost.

Any harvest plan should include precautionary safeguards. The status of the population should be closely monitored and hunting terminated at the first sign of a trend toward population decrease. The kill should be distributed over the goat range and only adults unaccompanied by young should be taken. With the current population level and reproductive rate no more than three goats every other year should be harvested As long as limited numbers are being taken a representative of the wildlife agency should accompany but not assist hunters. All possible biological data should be taken from kills (weights, measurements, condition, stomach contents, reproductive tracts, tissue samples).

Competition. By competing with goats on summer range which is also mountain goat winter range, bighorn sheep have the potential to exclude the mountain goat population. Sheep numbers should be monitored closely and a balance between the two species maintained to the extent that one species does not exclude the other. This could be accomplished by removing sheep as their numbers increase, either by trapping or hunting. One suggestion is to trap excess sheep between the Wallowa and Lostine rivers (mountain goat range), and hunt excess sheep that spread out of this area. This would allow minimal disturbance of the goat population and reduce the chance of accidental shooting of goats.

Deer and elk are not regarded as serious competitors of mountain goats in the Wallowa Mountains.

General Management

New Introductions. In addition to the Wallowa Mountains, other ranges which may be suitable for mountain goat releases are the Elkhorn Range, the Strawberry Mountains, the Cascade Mountains, and possibly some sections of the Columbia Gorge. While I have taken a critical look at most of these areas I have not investigated them closely enough to confidently comment on their potential as mountain goat habitat except to say that they have some. In the Wallowa Mountains, other sections which appear to be suitable for small numbers of goats are the Cornucopia area of the southeast corner of the Wallowa Mountains and the Huckleberry Mountain area immediately west of the Lostine River. Both of these sections have south facing cliff areas with what appears to be ample vegetation.

All potential release sites should be examined in summer and winter to insure there will be ample range. Goats should be released near the most attractive winter range to insure exposure to this area. Because mountain goats are easily traumatized and susceptible to injury during trapping and transporting operations (Brandborg, 1955; Herbert and Cowan, 1971) precautions should be taken to insure the animals' safety. Brandborg (1955) suggested night transport to reduce heat stress. A refrigerated vehicle is another alternative.

The composition of a release is speculative. The 1941 and

1943 releases of 21 goats in the Crazy Mountains of Montana were highly successful (Brandborg, 1955; Lentfer, 1955). Probably no less than one adult male per three adult females should be released to provide an adequate sex ratio. Yearlings and young would help to stabilize the social structure and provide future breeding stock. With these thoughts in mind, a release of 15 to 20 animals over a 2-3 year period should be adequate. Because of low productivity in many mountain goat populations (Hanson, 1950; Brandborg, 1955; Kuck, 1971) a smaller release would result in smaller initial populations and increase the likelihood of failure. All released animals should be conspicuously marked.

Follow-up Studies. After the introduction of mountain goats to a new area follow-up studies should be initiated. Knowledge of changes in population composition and type and condition of habitat used are important as indicators of population status and the effect the population is having on its range. Aerial surveys can be used to make herd composition counts but should not be used to evaluate habitat preference because of the tendency of goats to react to aircraft and move to escape cover. Also of importance are dispersion patterns.

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APPENDIX

APPENDIX

Introduction to Appendix

The data presented in the appendix are not directly related to the objectives of this study but are in most cases supplemental to the subject matter which has already been discussed in the body of the thesis. Presented here are a partial listing of plants commonly found in the Wallowa Mountains, weather data since 1950 for the Enterprise, Oregon region, results of soil samples from natural mineral licks, and data related to use of exposure, group size, and daily activity patterns of mountain goats in the Wallowa Mountains. In each instance the tables are self explanatory. Also presented is a section on winter activity of goats in the Wallowa Mountains.

Table A. Partial list of plants found in the Wallowa Mountains, Oregon.

TREES AND SHRUBS

Scientific Name	Common Name	Prominence within the various habitat types						
		T	OT	SR	C-R	AM	RT	MM
Abies concolor	White Fir	2						
Abies lasiocarpa	Subalpine Fir	3	2	1	1	1		
Acer glabrum	Rocky Mountain Maple	2				2		
Alnus sinuata	Sitka Alder	3				2		
Amelanchier alnifolia	Saskatoon Serviceberry	2						
Amelanchier cusickii	Cusick Serviceberry	2						
Arctostaphylos nevadenis	Pinemat Manzanita	2	1		1			
Arctostaphylos uva-ursi	Bearberry	2	1		1		2	
Cassiope mertensiana	Mertens Cassiope	1			1	1		
Ceanothus sanguineus	Redstem Ceanothus	2						
Ceanothus veltinus	Snowbrush Ceanothus	3						
Cercocarpus ledifolius	Curlleaf Mountain Mahogany	2						5
Cornus stolonifera	Red-Osier Dogwood	2						
Juniperus communis	Mountain Common Juniper	2	2		1			
Juniperus occidentalis	Western Juniper	2	2		1			
Juniperus scopulorum	Rocky Mountain Juniper	2	2		1			
Kalmia polifolia	Alpine Bog Kalmia	2				1		

Table A. (Continued)

Scientific Name	Common Name	Prominence within the various habitat types						
		T	OT	SR	C-R	AM	RT	MM
Larix occidentalis	Western Larch	3						
Ledum glandulosum	Western Ledum	2						
Mahonia aquifolium	Oregon Grape	1				2		
Menziesia ferruginea	Rusty Menziesia	2						
Phyllodoce empetriformis	Red Mountain Heath	2				2		
Phyllodoce glanduliflora	Cream Mountain Heath	2				2		
Physocarpus malvaceus	Mallow Ninebark	3						3
Picea engelmanii	Engelmann Spruce	3				1		
Pinus albicaulis	Whitebark Pine		3		2			
Pinus contorta	Lodgepole Pine	3				2		
Pinus flexilis	Limber Pine		4		2			
Pinus Ponderosa	Ponderosa Pine	2						
Populus tremuloides	Quaking Aspen	3				1		
Populus trichocarpa	Black Cottonwood	2				1		
Potentilla fruticosa	Bush Cinquefoil			2		3		
Prunus emarginata	Bitter Cherry	2				2		
Pseudotsuga menziesii	Douglas Fir	5			1			
Rhododendron albiflorum	Cascades Azalea	1						
Ribes montigenum	Gooseberry Currant	2			2	1		

Table A. (Continued)

Scientific Name	Common Name	Prominence within the various habitat types						
		T	OT	SR	C-R	AM	RT	MM
Ribes petiolare	Western Black Currant	2			2	1		
Ribes viscosissimum	Sticky Currant	2			2	1	1	
Salix barclayi	Barclay Willow	2				2		
Salix commutata	Undergreen Willow	2		1		2	1	
Sambucus melanocarpa	Blackbead Elder	2						
Shepherdia canadensis	Russet Buffaloberry	2	2	1	1		1	
Sorbus scopulina	Greenes Mountain-Ash	1				1		
Spiraea densiflora	Subalpine Spiraea	2			1			
Symphoricarpos vaccinioides	Whortleleaf Snowberry	3						2
	FORBS							
Achillea lanulosa	Yarrow	1	1	1	2	2	2	
Anemone patens	Pasque Flower					2		
Antennaria rosea	Pussytoes		1	1	1	1	2	
Arenaria obtusiloba	Sandwort						2	
Arnica cordifolia	Arnica	1				3	1	
Aster integrifolius	Thickstem Aster	1				2	2	
Astragalus purshii	Locoweed						3	
Balsamorhiza sagittata	Arrowleaf Balsamroot	2				1		

Table A. (Continued)

Scientific Name	Common Name	Prominence within the various habitat types						
		T	OT	SR	C-R	AM	RT	MM
Campanula rotundifolia	Harebell	2	1	1	2	1	1	
Castilleja spp.	Paintbrush	1			1	2	2	
Chaenactis alpina	Dusty Maiden						1	
Chimaphila umbellata	Western Pipsissewa	3						
Clematis columbiana	Columbia Rock Clematis	2						
Clematis hirsutissima	Sugarbowl	1						
Delphinium nelsoni	Larkspur	1				3		
Dodecatheon pauciflorum	Shootingstar	1				2		
Draba densifolia	Whitlow-Grass			1			2	
Dryas drummondii	Mountain-Avens	1			1			
Dryas hookeriana	Dryad	1			2			
Erigeron compositus	Cutleaf Daisy			1	1	2	2	
Erigeron speciosus	Showy Daisy			1	1	2	2	
Eriogonum flavum	Sulphur flower		1		1	2	2	
Eriogonum ovalifolium	Wild Buckwheat			1			2	
Eritrichium elongatum	Alpine Forget-me-not					3		
Erysimum capitatum	Wallflower		2	1	1		1	
Frasera speciosa	Green Gentian					2		
Fritillaria pudica	Yellow Fritillary	1				1		
Gaultheria humifusa	Western Wintergreen						1	

Table A. (Continued)

Scientific Name	Common Name	Prominence within the various habitat types						
		T	OT	SR	C-R	AM	RT	MM
Geranium viscosissimum	Sticky Geranium	1				2		
Gilia aggregata	Scarlet Gilia		1		1	2		
Hydrophyllum capitatum	Waterleaf				1	1	1	
Ivesia gordonii	Ivesia						4	
Linanthostrum nuttallii	Linanthostrum	2	1		1		2	
Linnaea borealis	Twinflower	3						
Linum lewisii	Blue Flax		2	1	2		2	
Lomatium macrocarpum	Biscuitroot		1	1	1		1	
Myosotis alpestris	Forget-me-not					2		
Oxyria digyna	Mountain-Sorrel						1	
Penstemon cyaneus	Penstemon					2	1	
Penstemon fruticosus	Bush Penstemon		1		1			
Penstemon montanus	Mountain Penstemon		2		1			
Phyllodoce empetriformis	Mountain Heath	1				1	1	
Phlox multiflora	White Phlox			2	1	2	4	
Ranunculus adoenus	Alpine Buttercup					3	2	
Ranunculus glaberrimus	Sagebrush Buttercup					3		
Saxifraga arguta	Brook Saxifrage		1	1	2		2	
Saxifraga bronchialis	Yellowdot Saxifrage		1	1	2		2	
Saxifraga oppositifolia	Purple Saxifrage		1	1	2		2	

Table A. (Continued)

Scientific Name	Common Name	Prominence within the various habitat types						
		T	OT	SR	C-R	AM	RT	MM
Sedum stenopetalum	Stonecrop	1	2	1	2		3	1
Selaginella watsonii	Little Club-Moss					2		
Senecio integerrimus	Groundsel		2	1	1		2	
Silene acaulis	Moss Campion						2	
Vicia americana	American Vetch	2			1	2	2	
Viola adunca	Violet	2						
Viola nuttallii	Yellow Violet	2						
	GRASSES							
Carex spp.	Sedge	2				5	3	
Festuca ovina	Sheep Fescue	2	1	1	1	2	2	2
Bromus tectorum	Downy Chess Brome	2			1	2		
Phleum alpinum	Alpine Timothy	1				1	1	
Koeleria cristata	Junegrass	2				1		
Agropyron spicatum	Bluebunch Wheatgrass	2			1	2	1	
Poa pratensis	Kentucky Bluegrass	2	1	1	1	2	1	
Poa sandbergii	Sandberg's Bluegrass	2	1	1	1	2		
Poa compressa	Canada Bluegrass	2	1	1	1	2	1	

Table B. Monthly and annual precipitation, Enterprise, Oregon

Year	Month: Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total	Departure from Normal
1950	1.84	0.42	0.97	0.95	0.57	2.75	0.94	0.51	0.54	1.42	0.88	0.72	12.51	-0.69
1951	0.69	0.78	1.27	0.13	1.31	0.96	--	0.59	0.06	1.44	0.77	0.91	---	---
1952	0.28	0.97	0.57	1.34	2.43	5.93	0.46	0.20	0.88	0.18	0.23	0.49	13.96	0.76
1953	1.46	1.23	1.46	1.60	2.62	2.16	T[a]	1.62	0.01	0.46	0.77	0.41	13.80	0.60
1954	1.00	0.42	0.49	1.12	1.53	1.59	0.67	1.51	0.81	0.31	0.47	0.34	10.26	-2.94
1955	0.44	0.64	1.73	1.37	1.06	1.36	2.15	0.00	1.60	1.19	2.18	2.08	15.80	2.60
1956	1.71	1.82	0.63	0.44	3.17	2.31	1.63	1.80	0.46	1.92	0.64	1.37	17.90	4.70
1957	0.98	0.71	1.31	1.07	3.47	0.89	0.43	0.42	0.08	1.50	0.46	1.79	13.11	-0.15
1958	0.59	0.56	0.94	1.50	1.10	5.21	0.53	0.44	0.91	0.77	2.06	1.67	16.28	3.02
1959	1.29	0.61	0.94	0.61	3.26	0.88	0.26	0.48	3.43	0.99	0.35	0.27	13.37	0.11
1960	0.61	1.02	1.18	1.41	2.74	0.29	0.52	1.78	1.22	0.50	1.41	0.28	12.96	-0.30
1961	0.37	0.67	1.61	0.84	2.34	0.21	0.32	1.33	0.76	1.50	2.00	0.67	12.62	-0.64
1962	1.19	0.44	0.93	0.41	2.62	0.42	0.11	0.56	0.72	2.24	1.13	0.87	11.64	-1.90
1963	0.65	1.57	0.73	1.14	1.62	1.43	0.62	1.41	0.80	0.69	1.04	1.09	12.79	-0.75
1964	0.95	0.24	0.57	1.71	1.08	3.15	0.42	1.48	1.12	0.79	0.42	3.90	15.83	2.29
1965	1.64	0.46	0.40	1.12	1.54	2.20	1.93	2.25	0.62	0.19	0.70	0.14	13.19	-0.35
1966	0.71	0.83	1.34	0.15	0.25	2.14	0.12	0.59	1.11	0.99	0.56	1.51	10.30	-3.24
1967	0.55	0.14	1.95	1.43	1.06	3.90	0.39	0.51	0.89	1.88	0.41	0.99	14.10	0.56
1968	0.52	0.67	0.87	0.42	1.96	2.49	0.35	2.32	0.82	1.21	1.78	1.10	14.49	0.95
1969	1.18	0.30	0.17	1.11	1.39	2.99	0.26	0.00	1.54	0.95	0.08	1.27	11.24	-2.30
1970	2.15	0.36	1.33	1.04	2.14	1.73	1.39	0.03	2.17	1.50	1.05	0.94	15.83	2.29
1971	1.19	0.37	0.91	0.38	1.96	2.49	0.53	0.47	1.07	0.54	1.28	1.21	12.40	-1.14
1972	0.88	0.53	0.78	1.33	1.33	1.13	0.90	0.62	1.48	0.64	0.87	0.49	10.98	-2.56
1973	0.58	0.27	0.82	0.50	0.86	1.11	0.15	0.28						
1950/59	1.03	0.82	1.03	1.01	2.05	2.40	0.79	0.76	0.88	1.02	0.88	1.01	14.11	
1960/69	0.84	0.63	0.98	0.97	1.66	1.92	0.50	1.22	0.96	1.09	0.95	1.18	12.92	
1970/72	1.41	0.42	1.01	0.92	1.81	1.78	0.94	0.37	1.57	0.89	1.07	0.88	13.07	

[a]T = trace

Table C. Average temperatures (degrees farenheit), Enterprise, Oregon (3280' elevation) 1950-1973.

Year	Month: Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Max	Date	Min	Date	Departure from Normal	Annual Avg
1950	17.5	27.1	34.4	40.7	46.8	55.4	61.9	61.8	53.8	47.5	35.8	33.2	98	9/02	-26	1/31	-0.8	43.0
1951	23.3	29.2	30.9	43.1	50.7	54.0	64.7	60.7	55.1	43.0	32.2	23.1	97	7/17	-20	1/29	-1.3	42.5
1952	19.5	23.3	30.6	45.9	50.9	55.7	61.9	61.2	56.9	48.9	28.5	26.7	95	7/30	-15	2/22	-1.3	42.5
1953	36.4	29.9	35.8	40.7	45.9	51.5	61.9	60.7	57.1	46.1	38.3	29.2	99	7/12	-5	2/20	0.7	44.5
1954	29.4	35.2	33.0	43.1	50.9	52.1	62.2	56.8	52.3	43.3	38.0	24.2	93	7/04	-14	1/20	-0.4	43.4
1955	M[a]	22.7	25.7	39.1	46.6	57.6	61.9	60.8	52.8	45.9	28.4	27.3	95	6/21	-22	11/15	-	-
1956	24.1	22.4	32.8	44.5	52.3	54.1	63.7	59.8	54.9	43.4	31.6	26.9	94	7/09	-22	2/01	-1.3	42.5
1957	13.4	27.6	36.9	43.2	52.5	58.0	61.3	58.8	56.6	44.1	30.6	28.6	92	9/06	-26	1/26	-0.8	42.6
1958	26.5	35.3	34.1	41.4	56.1	59.0	64.4	64.7	52.9	46.7	32.8	32.7	95	8/25	3	1/01	2.2	45.6
1959	29.5	31.1	36.2	43.7	45.8	57.5	62.6	58.6	52.7	44.7	33.0	26.1	103	7/23	-27	1/04	0.1	43.5
1960	18.0	26.0	34.1	43.4	47.2	56.1	66.7	59.1	56.8	46.3	34.3	27.2	103	7/18	-22	2/29	-0.5	42.9
1961	28.6	36.8	38.0	42.2	50.0	61.2	65.4	67.4	49.4	42.5	30.7	25.5	105	8/04	-19	12/11	1.4	44.8
1962	21.3	27.7	34.3	46.6	47.9	55.7	60.4	60.0	55.1	46.1	36.1	28.2	94	7/23	-27	1/21	-0.1	43.3
1963	18.6	39.5	37.1	40.3	51.9	55.8	60.4	61.1	59.5	48.6	36.3	23.2	94	9/28	-21	1/11	1.0	44.4
1964	23.2	24.3	31.3	39.1	49.1	55.7	63.6	58.8	52.3	47.1	33.3	25.6	97	7/12	-30	12/17	-1.4	42.0
1965	28.1	32.0	33.4	45.0	46.8	55.1	62.4	60.9	49.4	48.9	36.8	26.0	95	8/08	-6	12/23	0.3	43.7
1966	29.1	27.1	35.4	42.7	52.7	54.7	61.3	61.3	57.9	44.8	36.6	28.9	99	8/24	-5	3/02	1.0	44.4
1967	32.0	34.2	35.0	37.9	48.8	57.7	64.1	66.0	58.8	44.7	35.1	26.3	100	7/12	-6	12/15	1.7	45.1
1968	24.6	36.5	39.8	39.9	48.9	56.4	63.8	55.9	55.9	44.3	34.1	26.0	97	7/27	-20	12/30	0.4	43.8
1969	24.4	25.2	34.6	43.9	53.2	58.2	61.6	61.9	56.2	41.1	35.3	30.5	98	8/23	-17	1/24	0.4	43.8
1970	30.3	35.1	34.2	35.6	49.2	61.5	65.1	64.3	49.7	41.9	34.2	22.2	96	8/23	-3	12/13	0.2	43.6
1971	28.9	31.4	32.2	40.4	50.1	53.2	63.2	67.1	48.8	41.6	32.2	23.9	96	8/01	-10	12/28	-0.6	42.8
1972	23.3	29.3	40.7	38.8	51.0	57.9	61.9	63.9	50.1	44.7	34.3	19.7	98	8/08	-23	12/09	-0.4	43.0
1973	22.0	28.6	36.0	42.0	52.2	57.0	64.5	61.6										
1950/59	24.4	28.4	33.0	42.5	49.9	55.5	62.7	60.4	54.5	45.4	32.9	27.8	96.1		-17,4			43.3
1960/69	24.8	30.9	35.3	42.1	49.7	56.7	63.0	61.2	55.1	45.4	31.6	26.7	98.2		-17.3			43.8
1970/72	27.5	31.9	35.7	38.3	50.1	57.5	63.4	65.1	49.5	42.7	33.6	21.9	96.6		-12.0			43.1

[a]M - signifies that more than 10 days of records are missing for the month.

Table D. Snow depth and water content (inches) from the Aneroid Lake[a] snow course, 1950-1973.

	February		March		April		May	
Year	Depth	Content	Depth	Content	Depth	Content	Depth	Content
1950	82	25.6	92	35.9	113	45.2	102	46.8
1951	76	23.8	105	30.0	106	42.4	88	38.3
1952	114	41.4	113	42.8	116	44.6	83	46.3
1953	88	30.9	102	37.6	111	45.7	--	----
1954	88	28.9	97	35.5	110	39.2	78	41.6
1955	45	12.4	71	15.9	92	27.2	89	36.4
1956	102	34.0	135	53.6	127	58.8	94	48.0
1957	67	17.8	86	27.0	96	33.1	75	35.8
1958	73	21.6	82	30.6	103	37.2	113	44.2
1959	82	24.6	97	32.2	96	36.6	--	----
1960	39	10.6	58	16.4	54	20.6	65	26.0
1961	50	19.5	82	28.2	92	32.4	79	34.6
1962	72	27.2	96	33.5	105	41.7	83	40.9
1963	51	15.6	62	21.7	100	27.2	102	35.4
1964	80	21.9	74	25.4	90	30.8	86	36.6
1965	118	42.1	125	48.0	123	50.2	108	53.6
1966	66	21.2	78	26.6	81	32.0	63	30.8
1967	99	31.7	93	35.8	115	45.2	130	52.0
1968	62	21.8	86	32.0	90	34.4	89	39.4
1969	102	32.8	109	37.2	107	44.8	88	39.8
1970	87	23.8	83	29.8	98	34.4	121	44.8
1971	97	35.6	105	35.4	127	51.2	112	49.2
1972	90	31.0	103	38.4	110	46.2	119	48.2
1973	65	18.6	70	23.6	81	27.4	68	27.8

[a]Aneroid Lake - elevation 7480 feet, is located on the east edge of the study area.

Table E. Results of soil analysis from four natural licks in the Wallowa Mountains, Oregon.

	Extractable cations				
Sample Number[a]	K (ppm)	Ca (meq/100g)	Mg (meq/100g)	Na (meq/100g)	Salts (mmhos/cm)
1	190	27.8	7.25	0.27	0.45
2	78	11.7	4.0	0.16	0.22
3	117	32.1	7.3	0.10	0.16
4	213	13.3	3.8	0.18	0.29
5	97	35.3	5.6	0.10	0.15
6	117	22.5	6.9	0.12	0.13
7	88	32.9	5.3	0.18	0.24
8[b]	16	11960	52	10	

[a]Location of samples:

1) Main lick on Chief Joseph Mountain.
2) Secondary lick on Chief Joseph Mountain.
3) Adjacent to secondary lick on Chief Joseph Mountain.
4) 30 yds. from secondary lick on Chief Joseph Mountain.
5) Lick on Hurricane Divide above Deadman Lake.
6) Adjacent to lick on Hurricane Divide.
7) 30 yds. from lick on Hurricane Divide.
8) Rock sample from east ridge of Sacajawea Peak.

[b]Sample eight is from a rock often licked by goats. All values for sample eight are in ppm.

Table F. Average monthly group size of mountain goats in the Wallowa Mountains, Oregon 1972-73.

Month	Ground Observations		Aerial Observations	
	Group Size	S.D.	Group Size	S.D.
Jan.	6.95	6.62	5.75	4.71
Feb.	3.17	2.40	3.20	3.83
Mar.	6.38	4.46	2.50	3.00
Apr.	2.23	1.85	2.44	2.42
May	1.97	1.38	1.97	1.56
Jun.	2.61	1.79	2.02	1.68
Jul.	3.74	2.56	2.28	2.14
Aug.	2.00	1.67	2.23	2.27
Sep.	2.67	1.53	1.14	0.38
Oct.	3.10	1.85	1.86	1.51
Nov.	1.57	0.53	4.50	4.95
Dec.	5.50	1.76	3.41	3.06

Table G. Exposures utilized (percent) by mountain goats in the Wallowa Mountains, Oregon 1972-1973[a].

Season	Aspect				Number of Observations
	North	East	South	West	
Summer	19.8	20.8	7.3	51.9	312
Fall	11.1	36.1	44.4	8.3	72
Winter	0.0	7.2	5.8	86.8	442
Spring	2.3	32.4	12.5	52.7	256

[a]Combines aerial and ground observations.

Table H. Daily patterns in habitat use (percent) by season for mountain goats in the Wallowa Mountains, Oregon 1972-1973.

Season	Time Period	Type: Timber	Open Timber	Slide Rock	Cliff Rock	Alpine Meadow	Ridge Top	Mountain Mahogany	Hours of Observation
	Sunrise-0900	0	0	4	0	0	96	0	38.4
Summer	0901-1200	0	0	1	13	0	87	0	38.3
(Jun-Aug)	1201-1500	0	0	20	7	17	56	0	61.6
	1501-Sunset	0	0	8	14	9	70	0	76.9
									215.2
	Sunrise-0900	0	26	64	5	5	0	0	14.7
Fall	0901-1200	0	24	66	1	9	0	0	42.1
(Sep-Oct)	1201-1500	1	2	91	7	0	0	0	16.6
	1501-Sunset	0	18	49	1	32	0	0	25.1
									98.5
	Sunrise-0900	22	6	3	69	0	0	0	28.2
Winter	0901-1200	8	46	6	28	0	6	6	171.1
(Nov-Mar)	1201-1500	24	27	22	17	0	8	2	300.4
	1501-Sunset	23	46	3	24	0	3	0	123.0
									622.7
	Sunrise-0900	0	6	7	80	0	7	0	33.2
Spring	0901-1200	0	32	8	51	0	10	0	100.7
(Apr-May)	1201-1500	0	20	9	60	0	11	0	59.0
	1501-Sunset	2	2	11	66	0	20	0	54.2
									247.1
	Sunrise-0900	6	7	12	41	1	34	0	114.4
Annual	0901-1200	4	34	13	30	1	15	3	352.2
	1201-1500	17	21	22	21	2	15	2	437.6
	1501-Sunset	10	22	10	27	5	25	0	279.1
									1183.3

Winter Activity

Activity data were gathered in January, February, and March 1973. Activities recorded were feeding, bedding, moving, and standing. Other recognized activities (agressive activity and comfort activity) accounted for an insignificant portion of the time. Upon first observing a goat the activity engaged in was determined and timed with a stop watch. At the completion of the activity the elapsed time was recorded. The number of repetitions of the observation-timing cycle and the time spent sampling varied among samples. I recordedonly adult goat activity. Activity patterns for the remainder of the year were determined from the activity recorded at the beginning and end of each observation period.

Feeding and bedding are the most important late winter activities of mountain goats in the Wallowa Mountains (Table I). Comparable data (Table J) suggest a similarity for other ungulates.

Goats concentrated feeding activity in late morning and early afternoon, resting mornings and evenings (Table I). Moving was relatively insignificant during all periods of the day while standing was an important activity throughout the day. The function of these activities is obvious with the exception of standing. Harmon (1944) noted goats standing in one spot for periods in excess of an hour. A conjectural explanation of this activity is that during these

Table I. Late winter activity budget of mountain goats in the Wallowa Mountains, Oregon, 1973.

	Percentage of each time period devoted to various activities.				
Activity	Early Morning (0600-0900)	Late Morning (0901-1200)	Early Afternoon (1201-1500)	Late Afternoon (1501-1800)	Daily Total
a) Bedding	67 (4980)[a]	26 (3932)	0 (-0-)	57 (11610)	37.5
b) Feeding	12 (864)	44 (6712)	83 (6804)	26 (5309)	41.3
c) Moving	1 (62)	5 (707)	6 (471)	2 (506)	3.5
d) Standing	20 (1497)	25 (3745)	11 (910)	15 (3124)	17.7
Total b-c-d	33	74	100	43	

[a]Figures in parentheses indicate sample time in seconds.

Table J. Comparison of diurnal activity budget for various large ungulates in winter.

Activity	*Oreamnos americanus*	*Ovis dalli stonei*	*Cervus canadensis*	*Antilocarpra americana*	*Odocoileus hemionus*	*Bos* sp.
	Approximate percentage of daylight devoted to major activities by various species.					
a) Bedding	37.5[a] (37)[b]	28[c]	41.0[d]	14.9[e]	---	---
b) Feeding	41.3 (45)	57	51.4	77.8	45.9[f]	37.6[g]
c) Moving	3.5 (-)	---	5.1	2.5	---	---
d) Standing	17.7 (-)	---	2.5	4.6	---	---
Total of (b)-(c)-(d)	62.5 (63)	72	59.0	84.9	---	---

[a]Figures in the upper position are from the present study.

[b]Figures in parentheses are from Geist (1971:272). Data apply to females only.

[c]Source: Geist (1971:272). Females only.

[d]Source: Craighead et al. (1973:32). Females only.

[e]Source: Buechner (1950:303). Short-distance movements while foraging were classed as feeding. the net time was "considerably less" than the 77.8 percent figure.

[f]Source: Mackie (1970:31).

[g]Source: Mackie (1970:47).

standing periods goats are surveying the area for possible danger; standing may afford rest as well. Ritzman and Benedict (1931) noted that heat produced while standing was 15 percent greater for domestic sheep and 17 percent greater for cattle than heat produced while lying down. Thus, standing may also function to maintain body temperature.

The daily activity pattern of goats in late winter, which is the antithesis of summer activity (Btandborg, 1955; Geist, 1971:262; Hibbs, 1965; Saunders, 1955), is apparently a behavioral characteristic adapted to conserve heat and reduce energy expenditure (Geist, 1971:95, 262). This is evidenced by the practice of centering activity in the warmest part of the day and resting during the cooler parts of the day. Moen (1973:287) noted that "The effectiveness of bedding posture as a heat conservation mechanism in the total thermal regime is relatively greater at higher wind velocities and colder temperatures." This seems to confirm that more energy is saved by bedding in the colder winter mornings and evenings than would be by feeding during this period.

Bedding was the most prevalent activity during the early morning time period; this was apparently temperature related. Most goats spent winter nights at low elevation on a west slope which was not hit by the sun until late morning. Consequently, temperatures remained low here longer than most other areas.

Standing and incidental feeding were preparatory to moving to higher elevations.

Feeding and standing increased and bedding decreased in late morning. As temperatures warmed activity increased and there was a general movement upward to exposed feeding areas. The small percent of time spent moving reflects the directness with which goats moved to and from their feeding area, not the distance involved.

The height of feeding activity (83 percent) occurred in early afternoon. Geist (1971:262) noted a similar pattern for goats and Stone's sheep (Ovis dalli) in Canada verifying Blood's (1963) earlier findings for California bighorn sheep. Brandborg (1955) found goats in Idaho were most active on winter afternoons. In winter, penned white-tailed deer (O. virginianus) (Ozoga and Verme, 1970) and domestic sheep (Arnold, 1960) were most active in the afternoon. Because early afternoon is usually the warmest part of the winter day in the Wallowa Mountains, concentrating feeding effort during this period minimized heat loss from energy expenditures.

Bedding in early afternoon was not observed although it probably occurred. Standing and moving were also minimal. Reducing these latter activities allowed maximum time for feeding. This was particularly critical in winter when increased energy was needed and the energy source was most limited.

In late afternoon as temperatures cooled, feeding gradually decreased. Shortly after sunset goats spontaneously moved to low elevations. Once at low elevations the goats generally fed for a short period then bedded. Geist (1971:262) speculated that the cessation of goat activity in the evening might be due to poor night vision which would make moving hazardous.

The winter activity budget of goats in the Wallowa Mountains also appears to be related to winter habitat use (Table K). Use of low elevation cliff rock and timber (89 percent) in early morning reflects the high incidence of bedding during the same time period. The later morning switch to open timber (46 percent), a type used for feeding and cover (standing or bedding activity), is evidenced in the increased feeding activity. Early afternoon use of slide rock (22 percent) and ridge top (8 percent), both high elevation feeding types, is in part attributable to the high incidence of feeding at this time. Heavy use of timber and open timber in early afternoon is a measure of early descents or the failure of goats to move to high elevations, often in response to severe weather conditions. Increased bedding activity in late afternoon is again reflected in the use of timber and cliff rock during this period. Also, use of open timber is an indication that goats spend time feeding and standing after moving to low elevations.

Goats obviously do not perform a given activity because they are in a certain habitat type. They do, however, appear to select certain habitat types for particular activities; i.e., timber for bedding and open ridges (slide rock and ridge top) for feeding. Arnold (1960) showed an inverse relationship between percentage of time domestic sheep spent feeding and the amount of pasture available. This relationship probably applies to mountain goats as well. Therefore, the composition of the area selected for wintering may determine how much of the goats' daily activity must be devoted to energy uptake. Thus, percentage of time spent feeding in winter, especially on marginal range, may provide an index to mountain goat survival.

Table K. Daily use of habitat types in winter (percent) by mountain goats in the Wallowa Mountains, Oregon, 1973.

	Types						
Time Period	T	OT	SR	CR	AM	RT	MM
Sunrise-0900	22	6	3	69	-	-	-
0901-1200	8	46	6	28	-	6	6
1201-1500	24	27	22	17	-	8	2
1501-Sunset	23	46	3	24	-	3	-

APPENDIX LITERATURE CITED

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