ALASKA DEPARTMENT OF FISH AND GAME

JUNEAU, ALASKA

HABITAT USE BY MOUNTAIN GOATS IN SOUTHEAST ALASKA

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Final Report
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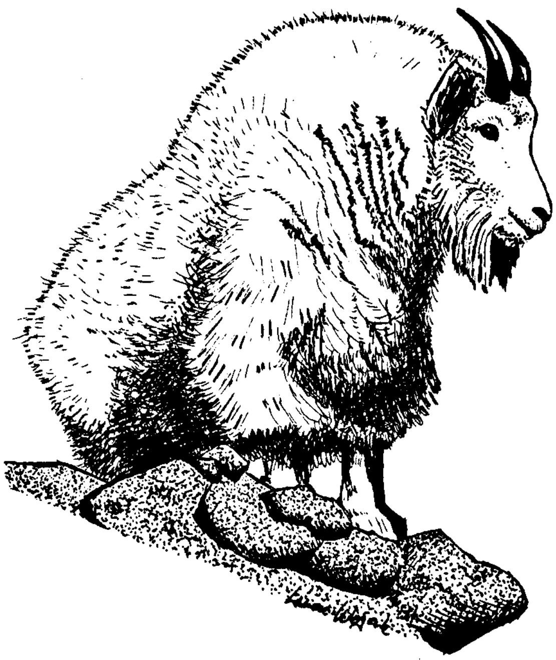

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FINAL REPORT (RESEARCH)

State: Alaska

Cooperators: John W. Schoen, Matthew D. Kirchhoff, O. C. Wallmo, Joseph L. Fox, and Richard D. Taber

Project Nos: W-17-10, W-17-11, W-21-1 and W-21-2

Project Title: Big Game Investigations

Job Title: Habitat Use by Mountain Goats in Southeast Alaska

Job No.: 12.4R

Period Covered: July 1, 1977 through June 30, 1981

SUMMARY

A field investigation of the home range patterns, movements, and seasonal habitat preferences of mountain goats northwest of Juneau, Alaska was initiated in July 1977 and completed in March 1981. Several capture techniques were evaluated. Drug immobilization from a helicopter was found to be an efficient capture technique. The immobilizing agent M-99 was utilized effectively in dosages of 3.5 mg per adult. Twenty goats were captured with no mortalities and 662 observations of these goats were subsequently recorded.

Female goats generally displayed strong winter home range fidelity while males were more likely to inhabit different winter home ranges from one year to the next. The greatest airline distance moved by any goat during this study was only 9 miles (14.4 km). Goats observed in the study showed no tendency to migrate into or out of the relatively small study area.

Seasonal habitat preference was measured and described in terms of elevation, slope, aspect, distance to nearest cliff, and habitat type. Distance to nearest cliff was the single most important attribute in defining preferred goat habitat throughout the year. Significant seasonal differences as well as differences between sexes occurred in goat use of many landscape attributes. These are discussed and several hypotheses proposed. During fall, winter, and spring some goats made substantial use of old-growth forest while others used predominately alpine and rock habitats. Steep, broken terrain was characteristic of goat habitat regardless of vegetative cover. Predation was suggested as a major factor influencing habitat preference. The loss of goat habitat by logging is expected to be minimal and localized since technology for harvesting most timber in forested goat habitat is currently unavailable. However, indirect impacts as a result of increased access and disturbance may be substantial.

CONTENTS

BACKGROUND

Mountain goats *(Oreamnos americanus)* are indigenous to the coastal mountains of the southeast Alaska mainland and also occur on Baranof Island where they were successfully introduced in 1923. Although the mountain goat is considered an important and distinctive member of the wildlife fauna of southeast Alaska, only recently has information become available on its seasonal habitat requirements.

In February 1977, the First International Mountain Goat Symposium was held in Kalispell, Montana. The Proceedings of this Symposium are the most recent and complete set of papers dealing with this species. In the Proceedings, both Ballard (1977*a*) and Eastman (1977) emphasized that goats were the least understood North American ungulate and that substantially more research is needed before our knowledge of mountain goats is equivalent to that of other big game species. The most recent mountain goat studies outside Alaska which address habitat requirements include those of Chadwick (1973), Rideout (1974, 1977), and Smith (1976) from Montana, Hibbs (1965) from Colorado, Kuck (1977) from Idaho, Stevens (1980) from Washington, and Hebert and Turnbull (1977) from British Columbia.

Within Alaska Klein (1952, 1953*a*, *b*) investigated the habitat requirements and population dynamics of goats on the Kenai Peninsula as well as conducted a general reconnaissance study of goats in Alaska. Merriam (1960, 1965) evaluated goat distribution and population status in southeast Alaska. Hjeljord (1971, 1973) studied goat feeding ecology and habitat preference in Alaska. Ballard (1975) evaluated various survey techniques for goats in southeast Alaska and reported on the status and management of goats in Alaska (1977*b*). Nichols (1978, 1980*a*) also evaluated aerial survey techniques and described criteria for differentiating various sex and age classes. Fox (1977, 1978) investigated weather as a determining factor in summer goat activity and habitat use. Fox has also reported (1978, 1979*b*, 1981) on site selection by goats wintering in forested habitat in southeast Alaska. Nichols (1980*b*) is currently investigating seasonal movements and range fidelity of goats on the Kenai Peninsula, and Smith (1982) has just begun a study of seasonal habitat use by goats on the mainland near Ketchikan.

In light of an apparent statewide decline in goat populations (Merriam 1965, Ballard 1977*b*, ADF&G 1975, 1976), an assessment of basic goat habitat requirements is urgently needed. Once this is completed, subsequent investigations can determine how patterns of goat habitat use are affected by such factors as increased human access, hunting, weather, predation, and habitat alteration. In southeast Alaska, most mountain goat range is located on National Forest land. Here one of the greatest potential impacts on wildlife is from habitat loss due to clearcut logging. Although most goat investigations elsewhere (Brandborg 1955, Chadwick 1973, Smith 1976) have indicated little goat use of forested habitat, Hebert and Turnbull (1977) reported extensive forest use by goats in coastal British Columbia. Area game biologists of the Alaska Department of Fish and Game and Forest Service biologists have also suspected substantial forest use by goats during some winter periods in southeast Alaska.

This study was a cooperative effort of the Alaska Department of Fish and Game, the Forest Sciences Laboratory (Pacific Northwest Forest and Range Experiment Station, USDA Forest Service, Juneau), and later the College of Forest Resources, University of Washington, Seattle. Interim results can be found in Schoen (1978, 1979), Schoen et al. (1981), and Fox (1978, 1979*a*, *b*, 1981).

OBJECTIVES

To develop capture and telemetry procedures suitable for monitoring mountain goat movements and to determine habitat use by mountain goats in southeast Alaska.

STUDY AREA

The general study area for this investigation begins approximately 12 miles (19 km) northwest of Juneau, Alaska (58° 17'N., 134° 24'W) and continues in a northwesterly direction for about 30 miles (48 km). This area is generally characteristic of the northern southeast Alaska mainland coast.

The vegetation of this area is dominated by two major habitat types - temperate rain forest and alpine tundra. Interspersed throughout the forest are poorly drained muskeg areas. Forests of this region are typically western hemlock - Sitka spruce (*Tsuga heterophylla - Picea sitchensis*). An extensive discussion of forest ecology and timber management in southeast Alaska is given by Harris and Farr (1974).

The study area is divided into 2 study sites: the Herbert - Mendenhall site and the Echo Cove site (Fig. 1). The Herbert - Mendenhall site encompasses about 56 mi^2 (145 km^2) while Echo Cove is about 70 mi^2 (181 km^2).

Both sites posess a variety of topographic conditions. Herbert - Mendenhall is a more interior site with elevations ranging from 200 (61 m) to 5,180 ft (1,579 m). Approximately half the area is below 2,000 ft (610 m); only 3% is above 4,000 ft (1,220 m). One-third of the area slopes between 10 and 30°, while 7% of the area has slopes steeper than 50°. The predominant exposure is southwesterly.

Echo Cove is a coastal site with about 10 m (16 km) of saltwater shoreline. Elevations here range from sea level to 5,883 ft (1,794 m). This is generally a steeper, more rugged area than Herbert - Mendenhall. About 1/3 of the area lies below 2,000 ft (610 m); 17% is above 4,000 ft (1,220 m). Forty percent of this area slopes between 10 and 30°, while 17% has slopes greater than 50°. Westerly exposures predominate.

Both sites are dominated by forest, rock, or ice. Echo Cove has more forested land, 66 compared to 59%. Most of this forested area is composed of old-growth hemlock-spruce stands. Less than half of the forested habitat in each area is classified as commercial forest (8,000 board ft per acre or greater) by the U. S. Forest Service. About half the commercial forest area is low volume (8,000 - 20,000 board ft per acre) and about 10% is high volume (greater than 30,000 board ft per acre). The major difference between sites is that Herbert - Mendenhall has more ice (27%) and less rock (17%) compared to Echo Cove (14 and 26%, respectively). Other habitat types which occur include alpine and subalpine areas, brush and slide zones, deciduous stands, second-growth conifer stands, and muskeg.

A cool maritime climate prevails in the study area. Average minimum and maximum temperatures for the Juneau airfield (6 mi [9.6 km] south of the Herbert - Mendenhall site and at an elevation of 12 ft [4 m]) are: summer, 44 and 64° F and winter, 18 and 34° F with temperature extremes of -22 and 89° F (Selkregg 1975). Average annual precipitation is 55 in (140 cm) including 107 in (272 cm) of snow. On both study sites the upper elevations are usually snow covered for 7 to 9 months of the year.

The entire area from Mendenhall Glacier to Berners Bay supported between 150 and 250 goats during the study period. The Herbert-Mendenhall population was about 50 to 75 animals while the Echo

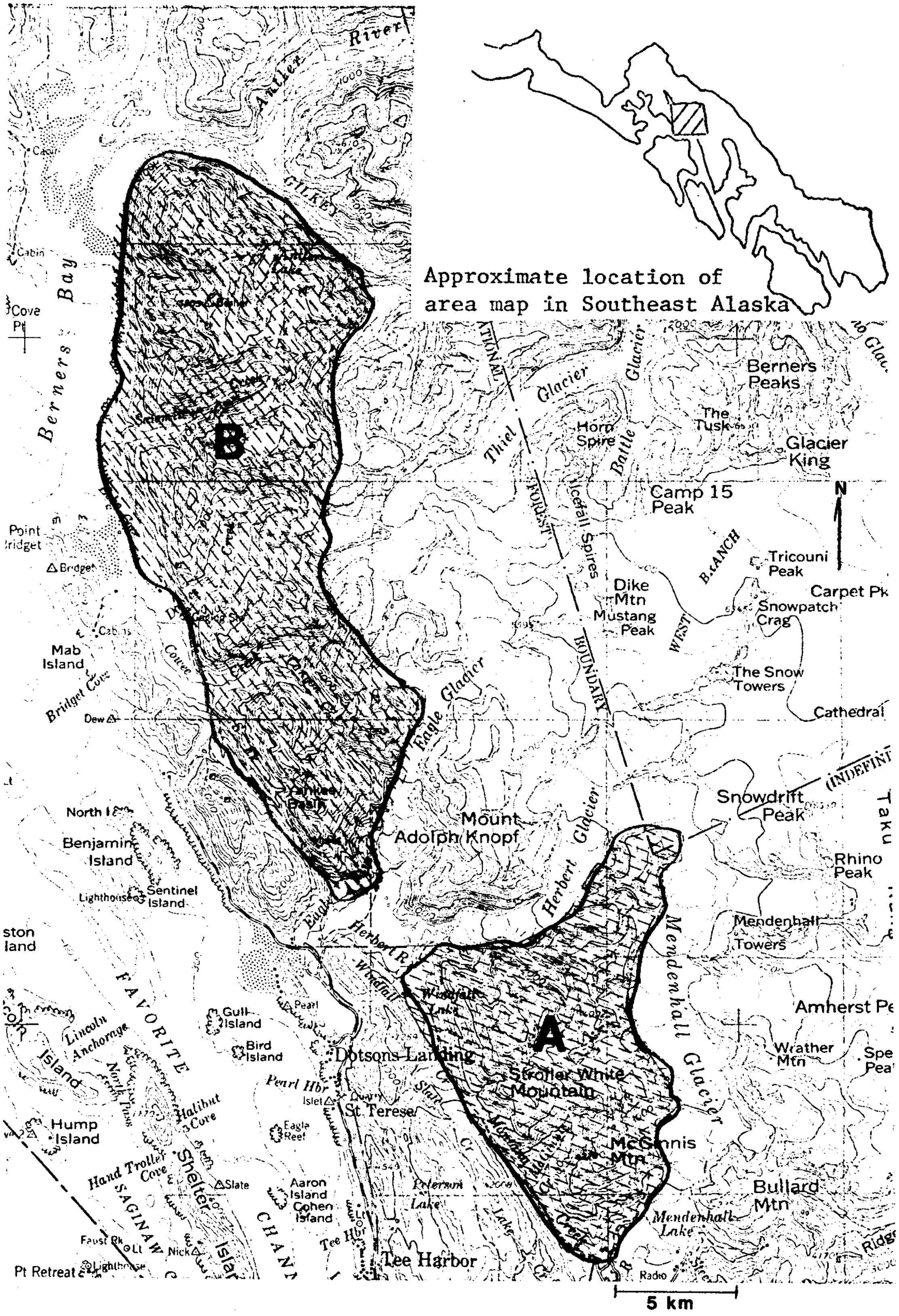


Fig. 1. Location of study areas. A. Herbert-Mendenhall, B. Berners Bay

Cove population was about 60 to 100 animals. Hunting is permitted from October 1 through November 30 with a 1 goat limit. Generally, hunting pressure is relatively light because of inclement fall weather.

Mountain goats are the most common ungulate within the study area, with Sitka black-tailed deer *(Odocoileus hemionus sitkensis)* occurring only occasionally and in low numbers. Moose *(Alces alces)* occur to the north of the study area in Berners Bay. Wolves *(Canis lupus)*, brown bears *(Ursus arctos)*, and black bears *(Ursus americanus)* also occur in the study area. Wolves are likely a significant predator of goats, but their impact on population levels is unknown at this time.

Presently, both study sites are relatively undisturbed. However, the Forest Service plans a major timber sale in the Echo Cove site. About 35 million board ft of timber is expected to be harvested over the next 5-year period in the first of 3 entries over the next 100 years. This activity will be concentrated in the Davies, Cowee, and Sawmill Creek drainages.

PROCEDURES

Capture Techniques

A variety of techniques for capturing goats has been assessed elsewhere, including traps, dropnets, snares, and darting (Rogers 1960, Richardson 1971, Hebert and Cowan 1971, Rideout 1974, Rudge and Joblin 1976, Clarke and Henderson 1979). The techniques tested in this study included baiting and snaring, drop nets, and darting from a helicopter.

Baiting and Snaring: Bait used for snaring included ground apple mash and salt blocks placed in areas frequented by goats. Snares were modified Aldrich leg-hold snares set along frequently used goat trails and bait stations. Snares were checked daily.

Drop Nets: A drop net was manufactured from a 10x20 ft (3-6 m) purse seine web. This was attached to a PVC pipe at the front and weighted on the other three edges to form a belly in the center. A bridle assembly was rigged to attach to a drop hook on an Allouett helicopter. The net flared out behind the helicopter while in flight and dropped with a forward motion when released.

Darting from a Helicopter: The immobilizing drug M-99 (etorphine) was delivered utilizing a Palmer Cap-Chur gun. A Hiller 12E aircraft was used for this operation with the gunner sitting at an open door on the right side of the aircraft. Goats were first located and their vulnerability and safety assessed. If they were on flat to moderate topography and near deep snow, the helicopter would be slowly flown towards them. Generally at about 25 to 50 ft (8-15 m) from the goat, the helicopter would flare and the shot was taken. If the shot was successful, we would move from the vicinity and wait for the animal to go down. Once the animal was immobilized, a radio collar was attached, it was ear-tagged with a numbered plastic roto tag, its age and sex determined, and standard body measurements recorded. At completion of handling, the antagonist M50-50 (diprenorphine) was administered.

Most goats were captured during the winter (December - April). However, during the latter stage of the project, 6 goats were captured between June and August. Two goats were captured by stalking from the ground.

Telemetry Techniques

Initially, telemetry equipment was purchased from A.V.M. Instrument Company, Champaign, IL and consisted of a 12-channel receiver and 12 radio collars transmitting on the frequencies 150.700 through 150.975 MHz. Our antenna system consisted of a single 3-element yagi antenna taped to the belly of the aircraft pointed in the direction of flight.

Later, telemetry equipment was purchased from Telonics Company (Mesa, AZ) and consisted of a TR-2 telemetry receiver and scanner operating in the 150.0 to 152.0 MHz range and capable of monitoring 200 separate frequencies. Ten additional transmitters were acquired for instrumenting animals in both sites. Location and habitat data were obtained using fixed-wing aircraft. Our upgraded antenna system consisted of 2 twin-element yagi antennas, 1 mounted on each wing perpendicular to the aircraft fuselage and connected to a right/left switchbox located in the cockpit. Pilot and observer wore boom mike headsets connected to the receiver through a Sigtronic intercom system enabling a free exchange of communication while monitoring the transmitter's signal. Most aerial telemetry work was done in a 250-hp Helio Courier on wheels.

Although we planned to conduct telemetry flights once per week in each study site, inclement weather reduced the frequency of flights to once every 10 to 20 days (Table 1). Most flights occurred between 0800 and 1800 hours depending on light and weather conditions. All telemetry flights were conducted in reasonable flying weather (visibility greater than 3 mi [4.8 km], ceilings greater than 5,000 ft [1524 m], and winds less than 20 kn). After reaching the study site the operating frequencies were scanned. Once a signal was isolated, diminishing circles were flown over the site until a fix was obtained. During field trials in forested habitat, location accuracy was determined to be generally within a 20 to 50 yard (18-46 m) radius. After an animal was located, its position was plotted on 1:63,360 scale topographic maps, and specific landscape attributes such as elevation, habitat type, canopy, terrain, and snow cover were recorded. When a goat was observed, the habitat described was that within approximately a 16 ft (5 m) radius of the animal. Data for each relocation also included the goat's number, date,

Table 1. Number of mountain goat survey flights by year and season.

Year	No. of Flights	Season	No. of Flights
1977	3	winter	26
1978	36	spring	34
1979	28	summer	19
1980	18	fall	10
1981	4		

time, weather, and a subjective assessment of the accuracy of that particular fix.

Elevation was recorded to the nearest 100 ft (30 m) by reference to the aircraft altimeter. Slope and aspect were determined from topographic maps. Slope was recorded to the nearest 5° and aspect was recorded as flat, north, northeast, east, southeast, south, southwest, west, northwest, or ridge top. Distance to nearest cliff was calculated from grid coordinates of goat locations and cliff locations. Cliffs were arbitrarily defined as slopes greater than 50° and were identified from topographic maps. Eight major habitat types were recognized (Table 2).

Overstory canopy coverage was estimated from the air and recorded to the nearest 5%. The character of the terrain was recorded as either smooth or broken. Percent snow cover was estimated from the air.

Location accuracy was estimated as follows: position accurate to within 25 a (10.4 ha) and landscape attributes accurate; position accurate but landscape attributes uncertain; and position accurate only to within 100 a (40 ha) and all landscape attributes uncertain.

Seasonal Distribution, Habitat Utilization, and Home Range

A map of the 2 study sites was overlaid by a grid coordinate system. Grid size was 25 a (10.4 ha) which coincided with the accuracy with which the instrumented animals could be located considering both the accuracy of the antenna system and accuracy of transferring the location to 1:63,360 scale maps.

Telemetry data were entered into the University of Alaska's Honeywell computer which was accessed by a terminal located in the Juneau office. Using a home range plotting program, adapted from Koepple et al. (1975), 2-dimensional plots of goat movements were produced on a tektronix desk-top plotter. Home ranges were defined by connecting the outer points of relocation to form convex polygons (Mohr 1947). Because of the extreme 3-dimensional nature of the study site, home range area calculations based on 2-dimensional convex polygons would grossly underestimate actual home range area. For this reason, home ranges were not computed.

In order to evaluate habitat preferences, it was necessary to determine the availability of habitat attributes within the study area. Habitat availability in terms of elevation, slope, distance to cliffs, aspect, and habitat type was determined from 884 randomly located points. Topographic features were recorded from U.S.G.S. topographic maps and habitat types were recorded from U.S.F.S. timber type maps.

We were able to describe patterns of goat habitat utilization in terms of 8 parameters: elevation, slope, aspect, distance to

Table 2. Habitat types defined for the Juneau mountain goat study area.

Habitat Type	Description
1 rock outcrop/cliff:	smooth or broken terrain, predominately rock.
2 alpine:	well drained slopes above timberline characterized by forbs, subshrubs, and krummholz generally above 2,500 feet (762m).
3 subalpine:	open forest and meadow from about 2,000 feet (610m) to alpine characterized by an abundant forb/shrub community.
4 brush/slide:	decidous brush and avalanche slide zones.
5 old growth:	uneven-aged, silviculturally overmature forests with dominant trees over 300 years.
6 second growth:	young, even-aged conifer forests.
7 muskeg:	wet, poorly drained bog meadows.
8 ice:	permanent snow fields and glaciers.

nearest cliff, terrain class, habitat type, percent canopy cover and percent snow cover. We identified 5 separate factors which, at least potentially, may show a systematic relationship with patterns of habitat use. These factors were: study site (n=2), year (n=3), season (n=4), sex (n=2), and individual (n=20). In theory, it is possible to evaluate the effects of one of these factors on a specific habitat parameter, and control for the other factors by selecting different subsets of the total sample and performing repeated chi-square tests (e.g. to test for effects of year, compare each habitat parameter, by year, for a given study site, a given season, a given sex, and a given individual). The number of possible chi-square comparisons using this number of factors and habitat parameters, however, runs into the hundreds. To select such minute subsets of our data and still avoid the problems associated with having empty cells in our contingency table, would require much more data than we presently have. Realistically, this approach is impractical.

To simplify the analysis, we made some subjective decisions about which factors are most important in terms of explaining variability in the data. Although some variability obviously existed between individual goats (of the same sex, in a given study area at a given point in time) we had difficulty evaluating our data for such differences.

Finally, recognizing that goats may respond to their environment differently from one year to the next, largely in response to annual changes in weather patterns or predation, we assumed that year-to-year variability in observed goat habitat relationships was relatively minor during this study (Dec. 1977-Mar. 1981). Weather patterns during this period were average to mild and there was no evidence that wolf population levels varied substantially during this period. To simplify our analyses, we therefore lumped observations on individuals (of the same sex) from different study areas and different years. We were then left with the factors of season and sex to explain the variability in our observations.

Differences between sexes were most obvious when analyzed on a seasonal basis. Seasonal differences in habitat selection were analyzed for all goats (males and females combined).

Habitat preference was expressed by using Ivlev's (1961) Electivity Coefficient, $E=(r_i-p_i)/(r_i+p_i)$, where E equals the coefficient of electivity or preference index, r_i equals the proportion of the variable which was utilized and p_i equals the proportion of the variable occurring within the environment or study area. Negative values (-1) indicate avoidance, positive values (+1) indicate preference.

A statistical analysis of habitat preferences was also performed for each season. A chi-square goodness of fit test was used to test the null hypothesis that goat locations occur in each habitat in proportion to its availability. An Adjusted Residual (Everitt 1977) was calculated to determine whether the selection or avoidance was significant. The sign of the residual indicated the direction of departure of the expected value from the observed value.

Goats use rather specific types of habitat, the characteristics of which can be simply represented by reporting mean elevation, slope, snow cover, etc. of all goat observations. We recognize, however, that certain habitat parameters are likely more important than others in determining goat habitat selection and it would be of interest to identify those. Our approach to this question was to use discriminant analysis (Nie et al. 1975) to identify parameters which best distinguish between the habitat available to goats and what they actually use. What they use is reflected in data on actual goat observations; what they have available is reflected in data collected at random from topographic and timber type maps covering the entire study area. The habitat parameters used in this analysis were limited to interval-level measurements (elevation, slope, and distance to cliff), rather than discrete variables such as habitat and aspect. A discriminant function was calculated for data from 8 goats chosen at random. The reliability of our function was validated by classifying observations on 10 additional goats and seeing what percentage were correctly classified as actual goat locations versus random locations.

Because this discriminant analysis is based on multiple observations of relatively few goats, the assumption of random, independent observations is not strictly satisfied. However, because observations on individual goats were made at greater than 1 week intervals the likelihood of a current observation being dependent on a previous observation is reduced. Relationships which are significant at higher levels ($P<.05$) should probably be accepted with some caution.

RESULTS AND DISCUSSION

Capture Techniques

Baiting and Snaring: Bait stations and salt blocks set out in summer and fall of 1977 were not used by goats. Snares, which were checked daily for a week, failed to capture any goats. This technique was considered inefficient in terms of time, manpower and success, and was subsequently abandoned.

Drop Nets: On 31 August 1977, after several practice sessions, a test was made using a drop net cast from a helicopter. Four drops were made on small groups of goats. Although several attempts were nearly successful, no goats were captured using this technique. With considerable improvement, this technique could be successful; however, it was considered too dangerous for the terrain we were working in and was abandoned.

Darting From a Helicopter: After testing on stationary objects, this technique was put to use during December 1977. Capture results utilizing this technique are summarized in Table 3. Thirty-four shots were attempted, and 23 (68%) were hits. Four goats which were hit never became immobile. Eighteen goats (78% of those actually hit) were successfully captured and instrumented. After being hit, 1 goat moved into an inaccessible area where she became immobile and remained for 1.5 to 2 days before she fully recovered and left the area. One goat slid down an avalanche chute after being immobilized, but was unhurt. No known mortality occurred as a result of any of our capture efforts.

Eleven helicopter trips were taken to capture 18 goats. The number of goats captured per trip ranged from 0 to 4 and averaged 1.6. Flight time per goat was estimated at about 1.25 hours including ferry time from Juneau.

Eleven of the goats were captured in alpine habitat during the winter, and seven were captured on spring or summer ranges. Our success was higher during winter when the goats could be moved into deep snow. However, this biased our sample toward goats which wintered in open alpine habitats. For this reason it would have been preferable to concentrate the capture effort on the summer range.

Two goats were captured at lower elevations by stalking. This technique is much more difficult than helicopter darting and less time efficient.

Helicopter darting of goats can be a highly successful and efficient technique if an appropriate aircraft and experienced pilot are utilized. During the work reported here a Hiller 12E was used. However, later experience with deer and goats elsewhere indicated that a larger aircraft with more power, such as a Hughes 500 or an Allouette, are far superior to the smaller aircraft even at several hundred dollars an hour more in cost. Even more important to the success of this technique than aircraft, however, is pilot experience. During 1979, we were forced to use inexperienced pilots and our success was greatly reduced. Once a qualified pilot is found and trained, it is most efficient to retain that individual.

Capture and Immobilization

A summary of age and sex of captured goats and immobilization results using M-99 is presented in Table 4. Fourteen females and 6 males were captured. Ages of females ranged from 1 to 11 years and averaged 6 years and those of males from 3 to 8 years with an average of 6 years. Throughout our capture effort shots were not attempted on young-of-the-year and shots at yearlings were attempted less frequently than adults. In general, we considered our sample of goats to represent a reasonable cross section of the adult population although young adults from 2 to 4 years were

Table 3. Mountain goat capture attempts and success from December 1978 to August 1979.

Date	Shot	Hit	Captured
12-13-77	5	3	3
12-21-77	5	4	1
12-22-77	1	1	1
12-26-78	4	4	4
12-27-78	4	2	2
4-10-79	2	1	1
4-11-79	no shots	-	-
6-15-79	4	2	2
6-22-79	2	1	1
7-25-79	5	4	2
8-21-79	2	1	1
Totals	34	23	18

Table 4. Age, sex, location, and current status of captured mountain goats and immobilization results using M99.

Goat	Area	Date	(years)	Sex	(minutes)	(minutes)	(mg)	Status
1	Herbert	12-13-77	1	female	10	30	2.5	radio failure
2	Herbert	12-13-77	6	female	20	45	2.5	dead
3	Herbert	12-13-77	3	male	20	90+	3	radio failure
4	Herbert	12-21-77	6	male	13	58	3	hunter kill
5	Herbert	12-22-77	5	female	13	40	2.5	dead
78	Herbert	12-26-78	6	female	10	65	3.5	radio failure
81	Herbert	12-26-78	1	female	13	40	3.5	radio failure
11	Herbert	12-26-78	5	male	10	27	3.5	hunter kill
26	Herbert	12-26-78	5	female	12	54	3.5	?
7	Berners	12-27-78	9+	female	7	32	3.5	hunter kill
79	Berners	12-27-78	7	male	8	80	3.5	dead
16	Herbert	3-27-79	7	female	?	?	3.5	hunter kill
65	Herbert	4-01-79	8	female	?	?	3.5	transmitting
83	Berners	4-10-79	8	male	10	65	3.5	transmitting
32	Berners	6-15-79	9	female	10	?	3.5	transmitting
86	Berners	6-16-79	7	male	15	28	7.0[1]	transmitting
82	Herbert	6-22-79	2	female	10	60	3.5	transmitting
9	Berners	7-25-79	7	female	20	40	3.5	transmitting
31	Berners	7-25-79	11	female	15	45	7.0[1]	?
33	Berners	8-21-79	8	female	19	30	3.5	?

[1] shot twice

not well represented. Perhaps the structure of this population tended toward older age classes.

In 1977 we began immobilizing goats with 2.5 mg of M-99, later increasing this to a standard dosage of 3.5 mg for yearling and adult animals. Induction time from injection to immobilization for 11 goats using 3.5 mg ranged from 7 to 20 minutes and averaged 11.7 minutes (Table 4). During 1977 when we used dosages of 2.5 to 3 mg the average induction time for 5 goats was more than 15 minutes. Our recommendation for future capture work is that a minimum dose of 3.5 mg be used on adult animals and that 4.0 mg be considered as an optimal dose. Chris Smith (pers. commun.) has reported using 4.0 mg on adult animals in Ketchikan with induction times averaging about 9 minutes.

When using M-99 it is generally better to overdose than underdose since the antagonist M50-50 is available for rapid reversal of the immobilizing agent. If underdosed or hit with a partial injection goats became very excited, uncoordinated, and underwent excessive stress. During this phase they were very vulnerable to falls and injury in steep, broken terrain. When under the complete influence of M-99, goats were entirely subdued with eyes closed and a low, steady respiration. Our recommendation is to select a goat in reasonably safe terrain, dose heavily, and move away from the goat if it is unable to move into dangerous terrain, or stay with it and herd it away from such terrain until it becomes immobile. Duration of paralysis ranged from 27 to over 90 minutes and averaged 49 minutes. This, of course, depended on when we injected the antagonist, which in turn depended on how accessible the goat was for efficient handling.

Location Telemetry

From December 1977 through March 1981, 662 observations were recorded for 20 radio-instrumented goats. The number of relocations per individual ranged from 4 to 61 with an average of 33. About 70% of the relocations resulted in a visual observation. Ninety-six percent (613) of these relocations were of sufficient accuracy to be used in our analysis of goat habitat use.

As of March 1981, radios on 6 instrumented goats were still transmitting, the batteries were depleted on 4 goats, 4 had been killed by hunters, 3 mortalities of unknown cause had occurred, and 3 goats were unaccounted for.

Throughout our telemetry surveys, general observation on group size and composition and productivity were recorded. A summary of these observations is presented in Appendix I.

Movements and Home Range

Movements and seasonal home ranges for 19 radio-instrumented mountain goats have been plotted (data on file, ADF&G Juneau).

During the period December 1977 through March 1981, the airline distance between any 2 points of relocation for individual goats ranged from 2 mi (3.2 km) to 9 mi (14.4 km) and averaged 4.4 mi (7 km).

Several home range patterns emerged from our plots of summer and winter goat relocations (Table 5). Two males used summer and winter ranges, 2 males with data from 2 consecutive years displayed overlaps one year but not the next, and 1 male used overlapping ranges. Five instrumented females occupied overlapping summer and winter ranges, 3 females used summer ranges distinct from their winter ranges, and 1 female had overlapping ranges one year but not the next. Although our sample is small, it appears females more often inhabit overlapping summer and winter ranges than do males.

The mean distances between the centers of summer and winter ranges for males and females, respectively, were 1.8 mi (2.9 km) and 1.2 mi (2.2 km). These distances are considerably less than those reported from the Kenai Peninsula in Alaska (Nichols 1980*a*, *b*; pers. commun.) and from the Northwest (Brandborg 1955, Lentfer 1955, Chadwick 1973, Smith 1976). Some investigators, however, considered goats nonmigratory (Hibbs 1966, Hjeljord 1971). The relatively short movements observed in this study probably reflect the lack of extensive suitable goat habitat in this study area.

Data from consecutive years for 12 instrumented goats provided us an opportunity to evaluate fidelity to winter home range. Eight individual goats (67%) had overlapping winter ranges during consecutive years. Winter home range fidelity varied substantially between sexes, however, with only 2 males (40%) compared to 6 females (86%) using the same winter range from one year to the next. Males are more apt to inhabit different winter ranges, due, in part, to their extensive movements associated with the rut just prior to the onset of winter. The average airline distance between winter home range centers for individual goats was only 1.8 mi (2.9 km). Five goats provided consecutive years' data on summer home ranges. Both males and 2 of 3 females used overlapping summer ranges.

We suspect that early experience is important in home range establishment and once home ranges are established, especially for females, they are maintained for several years or more. Geist (1971) found that a young female mountain sheep will adopt the home range of the female group of which she is a member. Howard (1960) suggested 2 distinct patterns of juvenile dispersal: environmental and innate. The first involves dispersal of young into a region within or adjacent to the mother's home range while the second involves dispersal a considerable distance from the origin. Most female goats probably follow the former pattern. Stronger home range fidelity in females than males also has been observed in goats from Idaho (Kuck 1977) and Montana (Rideout 1977). An individual should

Table 5. Overlap between winter and summer home ranges of 14 instrumented mountain goats.

Sex	Overlap	No. of Years
Male	Yes/No[1]	2
Male	Yes/No[1]	2
Male	No	1
Male	No	1
Male	Yes	1
Female	Yes/No[1]	2
Female	No	1
Female	Yes	2
Female	No	1
Female	Yes	1
Female	Yes	1
Female	Yes	2
Female	Yes	1
Female	No	1

[1] overlap one year but not the next.

incur a selective advantage by learning an area and its resources well and selectively utilizing the area to maximize benefits gained for costs expended.

Throughout the course of this investigation, none of our instrumented goats moved out of either study site. We suspect that dispersal of coastal goat populations, such as those observed at Echo Cove and between the Herbert and Mendenhall Glaciers, may be restricted by natural barriers.

Habitat Utilization and Preference

Following an initial analysis of goat distribution relative to elevation, slope, aspect, and habitat type, by month, we felt maximum information could be obtained by separating the goat observations into 4 groups based on calendar seasons. During summer (21 Jun-20 Sept), forage resources are unlimited and goats are widely distributed. During fall (21 Sept-20 Dec), snow begins to accumulate in higher elevations, annual plants disappear and, in November and December, goats become actively involved in the rut. Winter (21 Dec-20 Mar) is the most restrictive period of the year, often with heavy snow accumulation and low forage availability and quality. Spring (21 Mar-20 Jun) is a transition period. Goats begin to move in response to early green-up and nannies become more solitary in preparation for parturition in late May and early June.

Six hundred and twenty locations were used in our analysis of seasonal habitat use by 20 instrumented goats. These locations were distributed by season as follows: winter 24%, spring 39%, summer 27%, and fall 10%. In addition to evaluating seasonal habitat use, habitat preference was determined for those attributes where availability could be measured. These included elevation, slope, aspect, distance to nearest cliffs, and habitat type.

A chi-square analysis of the significant differences in seasonal habitat use between sexes is summarized in Table 6. During winter, females were distributed at higher elevations, on steeper, more broken, rockier slopes, and closer to cliffs than were males. We suspect that females may be more selective than males for areas of greater security from predation and areas of greater forage availability.

In winter, kids are still closely associated with their nannies and the pair (especially the kid) would be more vulnerable to predation than a lone billie. Steep slopes have a greater surface area and therefore reduced snow accumulation per unit of horizontal distance than a flat or moderate slope. Steeper slopes on all but northerly exposures would also receive more solar insolation than less steep slopes. Kuck (1977) reported that the primary determinant in selecting winter ranges in Idaho appeared to be physical snow shedding characteristics.

Table 6. Significant differences between sexes in mountain goat seasonal habitat use.

Habitat Attribute	Season		
	Winter[1]	Spring	Summer
Elevation	.00[1]	N.S.	.00[1]
Slope	.03[1]	.00	N.S.
Aspect	N.S.[1]	.01	.00
Terrain	.00	.00	N.S.
Distance to cliffs	.00	N.S.	.00
Habitat type	.00[1]	.00	N.S.

[1] These chi-square comparisons do not satisfy the requirement that no expected frequency be less than 1.0 and no more than 20% of the expected frequency be less than 5.0. Since this rule of thumb may be conservative at significance levels .05 (Zar 1974) the results are presented.

Sex-related differences in habitat use during spring were similar to those for winter except that there were no significant differences with respect to elevation or distance to cliffs. Since the strong bond between nannies and kids generally breaks down at this time, the security of cliffs may be of lesser importance to females compared to other seasons. During summer, females occupied lower elevations and were closer to cliffs (perhaps for security with young kids at their sides) than males. Throughout the year, females occupied more northerly exposures than males. We have no explanation for this. Small fall sample size precluded using chi-square analysis.

Even though we recognized that significant differences in habitat use occur between sexes, for simplification, we combined data for both sexes and looked at habitat use by mountain goats in general. Significant differences ($p<.01$) in habitat use between seasons were observed with respect to elevation, slope, aspect, habitat types, and snow cover. Instrumented goats utilized their habitat similarly throughout the year with regard to terrain, distance to nearest cliffs and canopy cover.

Seasonal use and preference relative to elevation: The mean elevations of radio-instrumented goat locations from winter through fall are presented in Table 7. During all seasons, elevation distribution of our sample of mountain goats was significantly ($p<.01$) different than the availability of ranges within the study sites. A summary (from Appendix II) of seasonal selectivity for elevation is presented in Fig. 2.

Goats displayed the narrowest range of elevational preference and use during winter. Elevations above 4,000 ft (1,220 m) and below 1,500 ft (457 m) were avoided while preferred use occurred between 3,000 and 4,000 ft (918-1,220 m). During winter, goats were frequently observed on higher slopes which were heavily windswept. These slopes often had lower snow accumulations than middle elevations more protected from the wind. The relationship between elevation, wind, and snow accumulation probably varies greatly with local topographic situations and weather conditions.

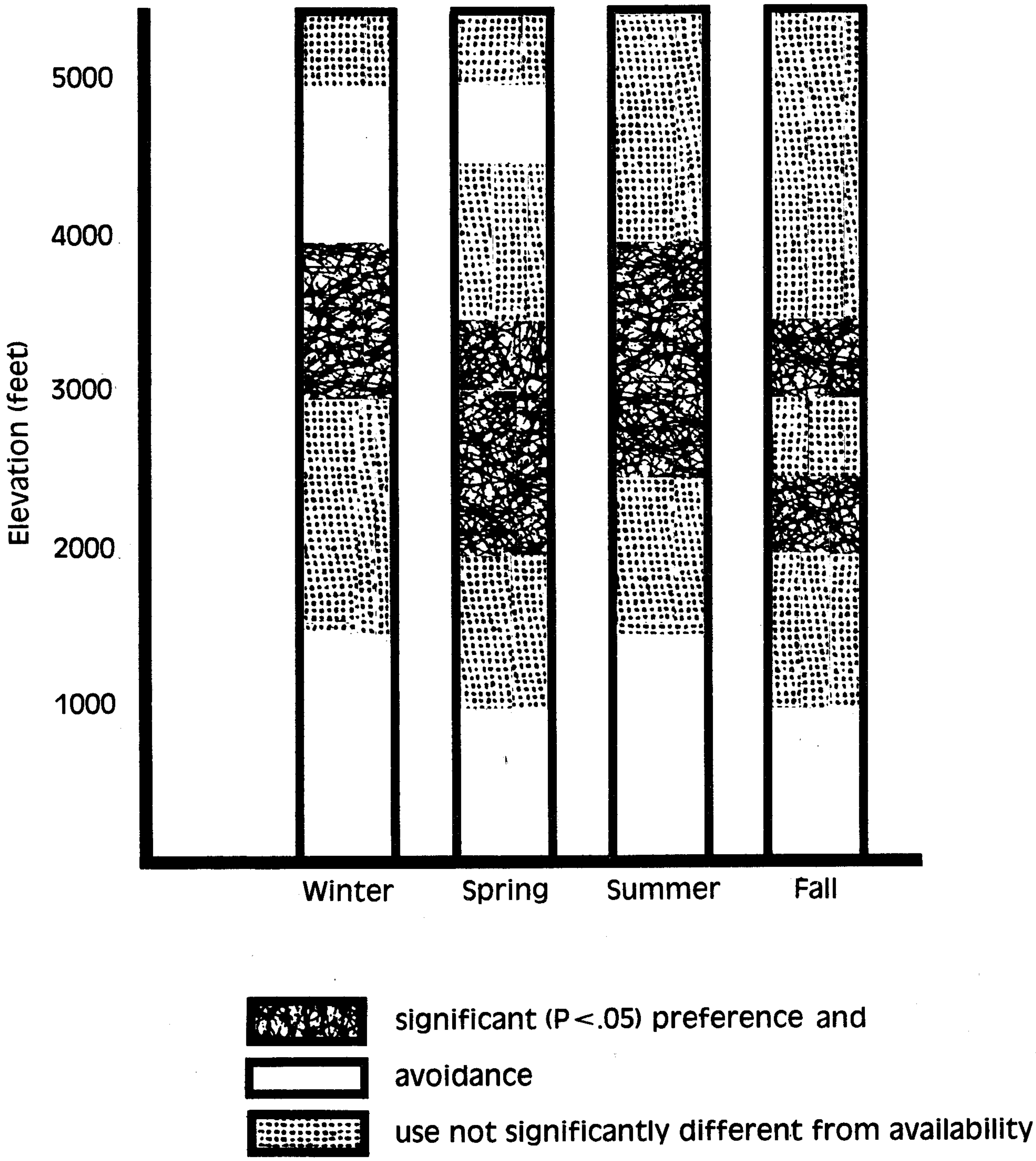
During spring, both the range of preference and use expanded. At this time, goats preferred lower elevations between 2,000 and 3,500 ft (610-1,067 m) and avoided areas below 1,000 ft (305 m) and above 4,500 ft (1,372 m). We observed a downward trend in goat distribution primarily during April and May. This, we presumed, was in response to early green-up of spring vegetation, particularly on steep southerly exposures. This elevational response to new spring plant growth has also been reported by McCrory et al. (1977) in British Columbia.

In summer, goats dispersed upward from spring ranges as snow receded. Significant preference was observed for elevations between 2,500 and 4,000 ft (762-1,220 m). Elevations below 1,500 ft (457 m) were avoided. Summer is the least restrictive season in terms of snow accumulation and this is when goats are most widely distributed in elevation.

Table 7. Mean and standard deviation of seasonal mountain goat locations relative to elevation.

	Elevation in feet (m)		
Season	Mean	Standard Deviation	n
Winter	3,047 (929)	796	171
Spring	2,612 (796)	904	254
Summer	3,026 (923)	835	168
Fall	2,503 (763)	756	67
Year	2,819 (859)	873	660

Fig. 2. Radio-instrumented mountain goat seasonal selectivity for elevation.



During fall, goats again used lower elevations as snow began to accumulate in the high country. They preferred elevations between 2,000 and 3,500 ft (610-1,067 m) and avoided elevations below 1,000 ft (305 m).

Seasonal use and preference relative to slope: The mean slope associated with radio-instrumented goat locations from winter through fall is displayed in Table 8. Throughout the year, the mean slope associated with goat locations was 35°.

Seasonal selectivity relative to slope is summarized (from Appendix III) in Fig. 3. During all seasons, goat use of slope was significantly ($p<.01$) different than availability of those slopes within the study area. During winter instrumented goats preferred slopes between 25 and 50° and avoided all others. In spring, goats preferred steeper slopes from 30 to over 50°. This may have been in response to increased solar insolation on steep slopes resulting in earlier snow melt and spring green-up. As in winter, slopes less than 20° were avoided.

During summer, goats preferred slopes between 20 and 30° and avoided slopes less than 10°. Goats again preferred steeper slopes between 30 and 50° during fall while avoiding slopes above 50° and below 10°.

Steep slopes have more effective snow shedding characteristics than do flat ground and moderate slopes. Areas of least snow accumulation provide for easier movement and more available forage resources during fall, winter, and spring. Additionally, it is during that period that predation from wolves is assumed to be most critical. Steep slopes should provide goats with better opportunities to escape or avoid such predators. Fox (1981) has suggested, from his winter investigations in the same study area, that predator avoidance is the major factor in goat habitat selection followed by food acquisition and then thermoregulation. Kuck (1977) indicated the primary determinant for selection of winter ranges by goats in Idaho appeared to be snow shedding characteristics and not available food supply. We suggest that in northern southeast Alaska both predation and forage availability are important factors in habitat selection and both are impacted by snow accumulation. Thus the preference for steep slopes is probably a response to both of these forces and may be more important than elevational preference under most conditions. During summer, goats were widely distributed, forage was abundant and snow was not a significant factor in habitat selection. Although goats used gentler slopes at this time, they seldom occurred far from cliffs.

Seasonal use and preference relative to distance to nearest cliffs: A summary (from Appendix IV) of goat preference relative to distance from nearest cliffs is presented in Fig. 4. Selectivity of this attribute was similar in all seasons and varied significantly ($p<.01$) from availability. Instrumented goats preferred areas with cliffs and avoided areas away from

Table 8. Mean and standard deviation of seasonal mountain goat locations relative to slope.

Season	Slope in Degrees		
	Mean	Standard Deviation	n
Winter	34	12	171
Spring	38	16	247
Summer	31	14	168
Fall	33	12	67
Year	35	14	653

Fig. 3. Radio-instrumented mountain goat seasonal selectivity for slope.

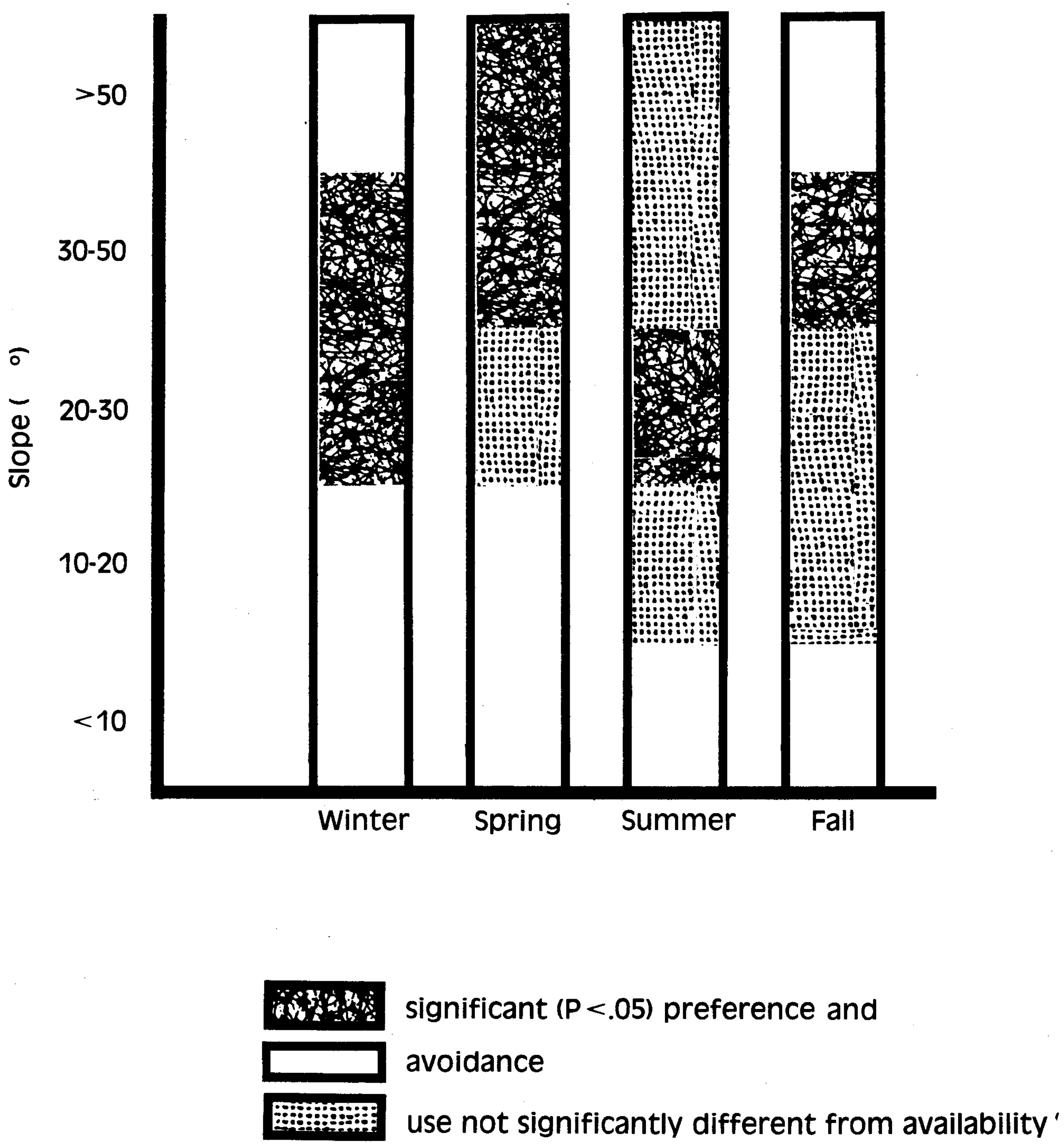
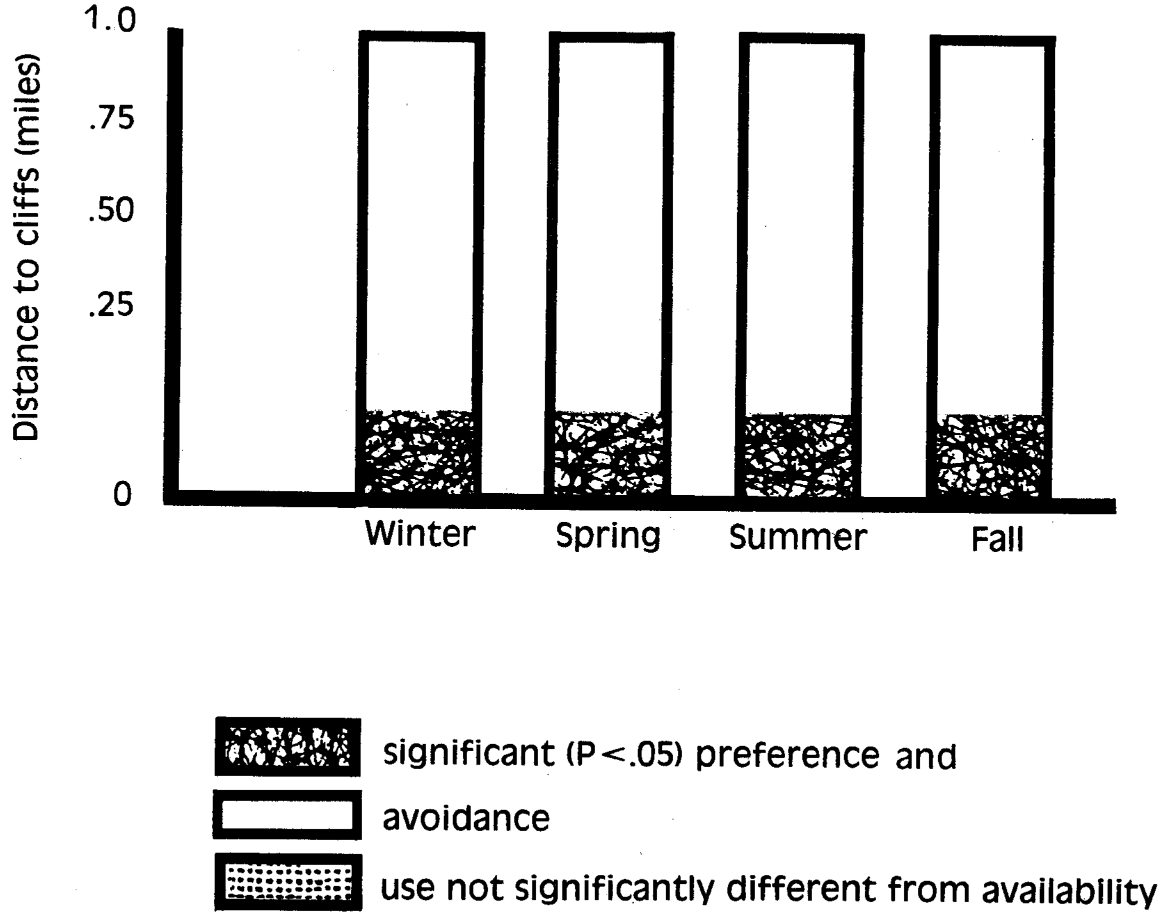


Fig. 4. Radio-instrumented mountain goat seasonal selectivity for distance to nearest cliff.



cliffs. Throughout the year between 63 and 75% of all goat locations were within cliff habitat. Such areas should be similar to steep slopes in terms of snow shedding characteristics. The fact that cliff habitat was preferred throughout the year (even in the absence of snow accumulation) suggests that these areas are important primarily as escape terrain as opposed to foraging areas. During the summer and early fall, forage is more abundant in alpine and subalpine meadows away from cliffs. Although goats were often observed in such areas, these forage sites were usually within 0.25 mi (0.4 km) of cliffs and escape terrain. During winter 1979, in the same study area, Fox (1981) observed low goat use of areas greater than 328 yd (300 m) from steep broken terrain.

Seasonal use and preference relative to aspect: Goat preference relative to aspect is summarized (from Appendix V) in Table 9. During winter and spring, northerly exposures were avoided. Southwest exposures were preferred in winter and all southerly exposures were preferred in spring. During summer, goats avoided south exposures and utilized all others nearly in proportion to their availability. There was no significant preference or avoidance relative to aspect during fall.

Throughout the winter and spring seasons, mountain goat selection for aspects can most likely be explained by differences in solar insolation and its effect on snow melt and perhaps thermoregulation. Southerly exposures receive more insolation, are warmer, have a higher snow line, and less accumulated snow than the other exposures. Consequently, forage is more readily available during the winter-spring period and travel less restricted on southerly aspects. During late spring, steep, low elevation, southerly slopes are also the first to produce new plant growth.

Snow is not a limiting factor during summer and is less limiting during fall than winter and spring. Consequently, during this period of the year, we observed little selection relative to aspect except avoidance of southerly exposures. It must be recognized, however, that most of our sampling was conducted during periods of clear skies or high ceilings when summer temperatures were highest. Perhaps southerly exposures were avoided at this time due to thermoregulatory behavior.

Seasonal use and preference relative to habitat type: Seasonal selection for habitat type is summarized (from Appendix VI) in Table 10. During every season, use of habitat types was significantly ($p<.05$) different than the availability of those types within the study area. Rock was the most frequently used habitat type throughout the year receiving between 32 and 50% of instrumented goat use. This type was preferred during every season except fall when it was used in proportion to availability. The 2nd most utilized habitat type was alpine which received between 16 and 28% of the recorded use and was preferred during all seasons. Subalpine habitat use ranged from 5% in winter to 25% in fall when it was preferred. Brush slopes and slide areas

Table 9. Radio-instrumented mountain goat seasonal selectivity relative to aspect (December 1977 through March 1981).

Aspect	Season: Winter	Spring	Summer	Fall
NW	-	-	0	0
N	-	-	0	0
NE	-	-	0	0
E	-	0	0	0
SE	0	+	0	0
S	0	+	+	0
SW	+	+	0	0
W	-	-	0	0

Significant (P<.05) preference (+), avoidance (-), and use not significantly different from availability (0).

Table 10. Radio-instrumented mountain goat seasonal selectivity relative to habitat type (December 1977 through March 1981).

Habitat type	Season: Winter	Spring	Summer	Fall
Rock	+	+	+	0
Alpine	+	+	+	+
Subalpine	0	0	0	+
Old-growth	-	-	-	-
Second-growth	-	-	-	0
Brush	0	+	+	0
Ice	-	-	-	-
Muskeg	-	-	0	0

Significant (P<.05) preference (+), avoidance (-), and use not significantly different from availability (0).

received from 1 to 10% of recorded use and were preferred during spring and summer. Muskegs, forests, and ice were generally avoided throughout the year relative to availability. Ice and permanent snow fields were utilized most (8%) in summer as bedding or resting sites during warm days.

Rocky habitat was the most heavily utilized and was generally preferred throughout the year. It's attractiveness to goats is probably related primarily to its value as escape terrain. Other areas such as alpine and subalpine slopes and brush slide areas may produce more potential forage. However, animals using these habitats are probably more vulnerable to predation. Fox (1981) reported that 73% of his winter observations of goats in this area occurred in the best predation avoidance areas and only 18% in the best forage acquisition areas. Alpine and subalpine areas are important forage producing areas and were most utilized when in close proximity to steep rock areas.

Fox (1981) found a high correlation between goat use and available forage biomass based on observations of goats which were adjacent to steep, broken terrain. However, less than 20% of all his winter goat observations were in alpine plant communities with the most available forage. He concluded that the importance of forage availability is subordinate to predator avoidance in habitat selection.

Results of various studies (Casebeer 1948, Brandborg 1955, Hibbs 1967, Hjeljord 1973, Kuck 1977, Fox 1981) suggest that goats are capable of utilizing a variety of forage species. In southeast Alaska, Fox (1981) found goats consumed a wide variety of forage species, with conifers being the highest component of the winter diet. Geist (1971) has interpreted wide forage acceptance by goats to be a compensation for narrow habitat preference.

Because of the extensive logging currently taking place in southeast Alaska, we are especially interested in seasonal use of forested habitat by mountain goats. Although throughout the year goat use of old-growth forest was significantly less than availability within the study area, during fall, winter, and spring old-growth received between 14 and 18% of total use. Recognizing the heterogeneity of old-growth forests (Wallmo and Schoen 1980, Schoen et al. 1981), it would be reasonable to assume that goats probably prefer some forest communities over others. For those winter and spring goat locations which occurred in old-growth forest, we calculated goat use versus availability for the variables: elevation, slope, aspect, and distance to cliffs (Appendix VII). In every case, goat use of those variables was significantly ($p<.01$) different than their availability. Within the broad category of old-growth forest, they preferred areas above 1,500 ft (457 m), slopes greater than 30°, southerly exposures, and areas within or adjacent to cliff habitat. Thus, although goats displayed no preference for old-growth forest in general, they made substantial use of particular portions of it during some periods of the year. In the same study area, Fox

(1979*a*, *b*, 1981) also reported extensive winter goat use of old-growth forest habitat, especially in areas with ready access to steep, broken terrain. Smith (1982) reported extensive use of forested habitat by goats on the Cleveland Peninsula north of Ketchikan, Alaska. This forest use was also associated with steep, broken terrain. Hjeljord (1973) reported goats in southeast Alaska moving into snow-free areas under mountain hemlock stands following fall snows. Future goat research should look at forest habitat on a much finer scale in order to better refine our understanding of goat-forest relationships.

Although telemetry was considered the best approach for evaluating forest use by goats, sample bias probably clouded our results. Twelve of 20 instrumented goats were captured by helicopter on alpine winter ranges. It was not until the 2nd year of our study that we attempted to capture goats on summer range. Although more difficult to obtain, these goats may be more representative of the population as a whole, relative to determining winter habitat use.

Most of our sample of instrumented goats spent little time in forested habitat. However, 5 of 20 goats were located at least 20% of the time in old-growth forest during winter, spring, or fall and 1 of these utilized old-growth forest exclusively during winter 1980. Three of those 5 individuals were captured either from the ground or on summer ranges. In order to more accurately assess what proportion of the population utilizes forested habitat, it would be necessary to capture and instrument a large sample of goats on their summer range. In addition, bias associated with weather conditions necessary to safe aerial surveys may reduce relocations in forested habitats in that goat use of old-growth forest may be greater during inclement weather when flying is impractical.

We know that some goats winter in part or exclusively in old-growth forest. Presumably the amont of forest use varies between areas and with winter conditions (the winters encountered during this study were light to average snow years). Based on results reported here and by others (Hebert and Turnbull 1977, Fox 1981), old-growth forest habitat characterized by steep, broken terrain should be considered important winter goat habitat.

Seasonal use relative to terrain: There were no significant ($p<.05$) seasonal differences in mountain goat distribution relative to terrain. Throughout the year, goat use of broken terrain ranged from 65 to 77% of their total habitat use. The high proportion of goat locations in broken versus smooth terrain suggests that steepness of slope and proximity to cliffs are not in themselves the only indications of good goat habitat. Steep, broken terrain should be considered an important factor in identifying optimal goat habitat.

Seasonal use relative to canopy cover and snow cover: There were no significant ($p<.05$) seasonal differences in mountain goat occurrence relative to canopy coverage. About 70 to 80% of all goat locations occurred in areas with less than 20% canopy cover. Goat use relative to percent snow cover varied significantly ($p<.05$) between seasons. Goats were located most frequently in snow free areas during summer and fall. During spring goats occurred in a wide variety of snow cover conditions while during winter, most locations (75%) were recorded in areas with greater than 75% snow cover.

Key variables for defining goat habitat: A discriminant analysis was run to determine which of the continuous variables (elevation, slope, or distance to nearest cliff) is most important in terms of defining preferred goat habitat. This was done by comparing attributes of actual goat locations (all seasons and years combined) with random locations. The results indicate that distance to nearest cliff is the single most important attribute for identifying preferred goat habitat. The mean distance to nearest cliff for all goat locations was 370 ft (0.11 km). Although goats selected higher elevations and steeper slopes than were generally available in the study site, these variables were not significant ($p<.01$) once distance to nearest cliff was accounted for.

We validated this relationship by classifying data from 10 goats (independent of those from which the discriminant function was calculated) and comparing predicted group membership (either goat location or random location) with actual group membership (goat location). On the basis of distance to nearest cliff, 100% of our observations were correctly classified as actual goat locations. We concluded that distance to nearest cliff is an important criterion in goat habitat selection, and may be invaluable when evaluating habitat and predicting consequences of specific development plans.

Along the northern southeast Alaska mainland, radio-instrumented mountain goats displayed a strong preference for a narrow band of steep, rugged country between the coast and the major ice fields. Although seasonal variations occurred in their preference for particular habitat variables, they occurred within this narrow band throughout the year. This strong preference for steep, precipitous, broken country has been reported by numerous investigators from geographically diverse areas (Brandborg 1955, Geist 1971, Chadwick 1976, Smith 1976, Kuck 1977, Fox 1981 and others).

Within this narrow range of goat habitat, seasonal patterns in habitat preference occur as individual goats respond to a changing seasonal environment. Factors such as aspect, elevation, slope, and forest overstory interact to alter patterns of snow accumulation which, in turn, influence mobility and forage availability. Given immediate access to escape terrain, those habitats which provide adequate forage, such as steep southerly slopes, appear to be preferred winter-spring habitat. Summer-early fall habitat selection is much broader than winter-spring since resources are comparatively unlimited at that time.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Immobilization of mountain goats from helicopters is a highly successful and efficient capture technique. High performance aircraft and pilot proficiency are important keys to the success of this technique. Etorphine (M-99) is a desirable immobilization drug used in dosages of 3.5-4.0 mg per adult goat.

Movements and distance between summer and winter home ranges were less than many of those reported in the literature. Home range fidelity was higher for nannies than billies on winter range. There was no immigration or emigration observed within our 2 study sites during the investigations. If local populations are reduced below threshold levels, it may take many years before such areas are repopulated.

Rocky outcrops, alpine, and subalpine were the most utilized and preferred habitat types throughout the year, especially those with broken terrain and in close proximity to cliffs (slopes >50°). Substantial use of old-growth habitat occurred from fall through spring. Although this habitat was statistically not selected for by mountain goats relative to its availability, some goats utilized old-growth habitat substantially or exclusively. Winter conditions throughout the period of study were average to mild. It appears likely that some forested areas which were not utilized during this study may be used under more severe snow conditions. Specific portions of old-growth were utilized in greater proportion than availability (eg. southerly, high elevation slopes within or near cliffs). Sampling bias prevented us from determining what proportion of the population utilized old-growth forest habitat during fall, winter, and spring. However, old-growth sites on slopes with southern exposures steeper than 30°, and within close proximity (less than 1,500 ft [457 m]) to cliffs should be considered potentially valuable winter goat habitat.

It is unlikely that clearcut logging would pose a direct threat to forested goat habitat because such steep areas are currently classified as unharvestable and the timber is often of marginal value economically. However, as harvest methods change (eg. helicopter logging) conflicts in these areas may develop. We have evidence of substantial goat use in small "islands" of habitat. Extensive logging between "islands" of preferred goat habitat could create barriers to dispersal.

In northern southeast Alaska, the loss of winter mountain goat habitat as a result of logging will probably be minimal and localized in occurrence compared to impacts on winter deer habitat. However, the indirect impacts on goat populations following logging may be substantial. Improved access into many drainages has the potential for concentrating legal hunting pressure, poaching, and disturbances. These problems are not restricted to logging activities but could also result from mining, hydro projects, and other land development activities.

As areas are developed, the Department of Fish and Game will have to increase the intensity of monitoring programs in these areas in order to maintain viable populations. Because of minimal dispersal in many areas, local populations may be especially vulnerable to overuse and disturbance.

To best protect goat habitat over a wide range of conditions, we suggest maintaining entire drainages and ridge complexes that have identifiable goat populations. If it becomes necessary to enter any of these drainages for development activities considered detrimental to maintaining optimal goat habitat, we suggest the following: All cliff areas within that drainage with slopes greater than 50° should be identified. These areas likely are the focal point of most goat use regardless of vegetative cover. Broken terrain should be accorded higher value than smooth terrain. Southerly exposures are important during winter and spring and should be given special consideration. Development activities should not occur within at least a 0.5 mi (0.8 km) radius of these areas. Once an area becomes easily accessible, it may be necessary to monitor its population more intensively and/or reduce seasons or bag limits.

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LITERATURE CITED

Alaska Dept. of Fish and Game. 1975. Annual Report of Survey-Inventory Activities. Vol. 5, Part III. Alaska Fed. Aid in Wildl. Rest. Rep. Proj. W-17-6, Job No. 12.

Alaska Dept. of Fish and Game. 1976. Annual Report of Survey-Inventory Activities. Vol. 6, Part III. Alaska Fed. Aid in Wildl. Rest. Rep. Proj. W-17-7, Job No. 12.

Ballard, W. 1975. Mountain goat survey techniques evaluation. Alaska Dept. of Fish and Game, P-R Proj. Rep. W-17-7, Juneau, Alaska 21pp.

__________. 1977*a*. Foreward. *In* W. Samuel and W. Macgregor, eds. Proc. of the First International Mountain Goat Symposium.

__________. 1977*b*. Status and management of the mountain goat in Alaska. *In* W. Samuel and W. Macgregor, eds. Proc. of the First International Mountain Goat Symposium.

Brandborg, S. M. 1955. Life history and management of the mountain goat in Idaho. Idaho Dept. of Fish and Game Wildl. Bull. 2. 142pp.

Casebeer, R. L. 1948. Food habits of mountain goats in western Montana. Proc. Montana Acad. Sci. 788:69.

Chadwick, D. H. 1973. Mountain goat ecology-logging relationships in the Bunker Creek Drainage of Western Montana. Montana Fish and Game Dept. P-R Proj. Rep. N-120-R-3, 4. M.S. Thesis, Helena, Montana. 262pp.

__________. 1976. Ecological relationships of mountain goats, *Oreamnos americanus*, in Glacier National Park. *In* Proceedings of the First Conference on Scientific Research in the National Parks, New Orleans.

__________. 1977. The influence of mountain goat social relationships on population size and distribution. pp. 74-91. *In* W. Samuel and W. Macgregor, eds. Proc. of the First International Mountain Goat Symposium.

Clarke, C. M. H. and R. A. Henderson. 1979. Evaluation of a helicopter/dart-gun technique for capturing chamois and attaching radio telemetry collars. New Zealand J. Zoo. 6:493-498.

Eastman, D. A. 1977. Research needs for mountain goat management. pp 160-168. *In* W. Samuel and W. Macgregor, eds. Proc. of the First International Mountain Goat Symposium.

Everitt, B. A. 1977. The analysis of contingency tables. John Wiley and Sons Inc. New York. 128pp.

Fox, J. 1977. Summer mountain goat activity and habitat preference in Coastal Alaska as a basis for assessment of survey techniques. pp 190-199 *In* W. Samuel and W. Macgregor, eds. Proc. of the First International Mountain Goat Symposium.

__________. 1978. Weather as a determinant factor in summer mountain goat activity and habitat use. M.S. Thesis Univ. of Alaska, Fairbanks. 64pp.

__________. 1979*a*. Factors determining use of forest as mountain goat habitat in winter. Final Rep. Coop. Agreement No. 151 between USDA Forest Service (Pacific Northwest Forest and Range Experiment Station) and College of Forest Resources, University of Wash. 25pp.

__________. 1979*b*. Site selection by mountain goats wintering in forest habitat. Final Rept. Coop. Agreement No. 153 between USDA Forest Service (Pacific Northwest Forest and Range Experiment Station) and College of Forest Resources, University of Wash. 16pp.

__________. 1981. Site selection by mountain goats winter in forest habitat. Final Rept. Coop. Agreement No. 153 between USDA Forest Service (Pacific Northwest Forest and Range Experiment Station) and College of Forest Resources, University of Wash. 55pp.

Geist, V. 1971. Mountain sheep - a study in behavior and evolution. University of Chicago Press, Chicago, Ill. 383pp.

Harris, A. S. and W. A. Farr. 1974. The forest ecosystem of southeast Alaska. Forest ecology and timber management. USDA Forest Serv. Gen. Tech. Rep. PNW-25, 109pp.

__________. and I. McT. Cowan. 1971. White muscle disease in the mountain goat. J. Wildl. Manage. 35(4):752-756.

Hebert, D. and W. Turnbull. 1977. A description of southern interior and coastal mountain goat ecotypes in British Columbia. pp 126-146 *In* W. Samuel and W. Macgregor, eds. Proc. of the First International Mountain Goat Symposium.

Hibbs, L. D. 1965. The mountain goat of Colorado. M.S. Thesis, Colorado State University, Fort Collins, Colo. 152pp.

__________. 1966. Bighorn sheep and mountain goat investigations. Colorado Div. Wildl. P-R Proj. Rep., W-041-R-15. 101pp.

__________. 1967. Food habits of the mountain goat in Colorado. J. Mammal. 48(2):242-248.

Hjeljord, O. G. 1971. Feeding ecology and habitat preference of the mountain goat in Alaska. M.S. Thesis, Univ. of Alaska, Fairbanks. 126pp.

__________. 1973. Mountain goat forage and habitat preference in Alaska. J. Wildl. Manage. 37(3):353-362.

Howard, W. 1960. Innate and environmental dispersal of individual vertebrates. Am. Midland Nat. 63(1):152-161.

Ivlev, V. S. 1961. Experimental feeding of fishes. Yale Univ. Press. 302pp.

Klein, D. R. 1952, 1953. Habitat requirements and population dynamics of the mountain goat; Seward-Kenai area, Alaska. Alaska Coop. Wildl. Res. Unit. Q. Reps. 3(3):9-10, 4(1):69, 4(4):3-4.

__________. 1953. A reconnaissance study of the mountain goat in Alaska. M.S. Thesis, Univ. of Alaska, College. 121pp.

Koepple, J., N. Slade, and R. Hoffmann. 1975. A bivariate home range model with possible application to ethological data analysis. J. Mammal. 56(1):81-90.

Kuck, L. 1977. The impacts of hunting on Idaho's Pashimeroi mountain goat herd. pp 114-125. *In* W. Samuel and W. Macgregor, eds. Proc. of the First International Mountain Goat Symposium.

Lentfer, J. W. 1955. A two-year study of the Rock Mountain goat in the Crazy Mountains, Montana. J. Wildl. Manage. 19(4):417-429.

McCrory, W. P., D. A. Blood, D. Portman, and D. Harwood. 1977. Mountain goat surveys in Zoho National Park, British Columbia. pp 69-73. *In* W. Samuel and W. Macgregor, eds. Proc. of the First International Mountain Goat Symposium.

Merriam, H. R. 1960. Alaska wildlife investigations - goat distribution and population status. Alaska Dept. of Fish and Game, P-R Proj. Rep., W-006-R-01. 10pp.

__________. 1965. Goat distribution and population status, southeast Alaska. Alaska Dept. of Fish and Game, P-R Proj. Rep., W-6-2.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Am. Midland. Nat. 37:223-249.

McFetridge, R. J. 1977. Strategy of resource use by mountain goat nursery groups. pp 169-173. *In* W. Samuel and W. Macgregor, eds. Proc. of the First International Mountain Goat Symposium.

Nichols, L. 1978. Mountain goat aerial survey technique evaluation. Alaska Dept. of Fish and Game, P-R Proj. Rep., W-17-9-12.2R and W-17-10-12.3R. 31pp.

__________. 1980*a*. Mountain goat management technique studies. Alaska Dept. of Fish and Game, P-R Proj. Rep., W-17-9, W-17-10, and W-17-11. 51pp.

__________. 1980*b*. Mountain goat movement studies. Alaska Dept. of Fish and Game. P-R Proj. Rep. W-21-1. 9pp.

Nie, H., C. Hull, J. Jenkins, K. Steinbrenner, and D. Bent. 1975. Statistical package for the social sciences. McGraw-Hill, New York. 675pp.

Richardson, A. 1971. The Rocky Mountain goat in the Black Hills, South Dakota, Dept. Game, Fish and Parks. Bull 2. 25pp.

Rideout, C. B. 1974. A comparison of techniques for capturing mountain goats. J. Wildl. Manage. 38(3):573-575.

__________. 1977. Mountain goat home ranges in the Sapline Mountains of Montana. pp 201-211. *In* W. Samuel and W. Macgregor, eds. Proc. of the First International Mountain Goat Symposium.

Rogers, R. 1960. Idaho mountain goats moved to new homes. Idaho Wildl. Rev. 13(3):6-7.

Rudge, M. R. and R. J. Joblin. 1976. Comparison of some methods of capturing and marking final goats *(Capra hircus)*. New Zealand Journ. of Zoology, 3:51-55.

Schoen, J. 1978. Winter habitat use by mountain goats. Alaska Dept. of Fish and Game P-R Progress Rept. W-17-10, Job 12.4R. 36pp.

__________. 1979. Winter habitat use by mountain goats. Alaska Dept. of Fish and Game P-R Progress Rept. 52pp.

__________., M. D. Kirchhoff, and O. C. Wallmo. 1981. Winter habitat use by mountain goats. Alaska Dept. of Fish and Game, P-R Proj. Rept. W-21-1. 13pp.

Selkregg, L. 1975. Alaska Regional Profiles, Vol. IV Southeast Region. Univ. of Alaska, Arctic Environmental Information and Data Center, Anchorage. 233pp.

Smith, B. 1976. Ecology of Rocky Mountain goats in the Bitterroot Mountains, Montana. M.S. Thesis, University of Montana, Missoula. 203pp.

Smith, C. 1982. Habitat use by mountain goats in Southeast Alaska. Alaska Dept. of Fish and Game P-R Proj. Rept. W-21-2.

Stevens, V. 1980. Terrestrial baseline surveys, non-native mountain goat studies of the Olympic National Park. Final Rept. USDI Park Service Contract No. CX-9000-7-0065. 144pp.

Wallmo, O. C. and J. W. Schoen. 1980. Response of deer to secondary forest succession in southeast Alaska. Forest Sci. 26(3):448-462.

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APPENDIX I. General observations of mountain goats north of Juneau, December 1977 through March 1981.

From December through July of the first year of this study, observations on all marked and unmarked goats were recorded. In succeeding years with additional animals to monitor, only data on marked goats and their associated groups were recorded. Group size by season from December 1977 through July 1978 and for the entire study period are presented in Tables 1 and 2. The largest group sizes occurred during summer and winter while the greatest number of single individuals were observed in spring. This corresponds to the period just prior to, and including, parturition when the females become solitary.

Adult:kid ratios are presented by season for 1978 in Table 3. These data suggest about a 2-fold decline in the number of kids observed from winter to spring. Such a trend, if representative, may also help explain the older age structure observed in our sample of captured animals.

Parturition took place from mid-May through mid-June with the peak during the last week of May and the first week of June. The first young-of-the-year were observed on 23 May 1978, 21 May 1979, and 27 May 1980.

Table 1. Group size by season of all goats observed on telemetry surveys 1978.

Season	Group Size 1	2	3	4	5	6-10	11-20	21+
	(% observed)							
Winter (n groups = 80)	30	25	13	5	11	14	1	0
Spring (n groups = 88)	43	23	10	9	2	7	6	0
June - July (n groups = 74)	13	32	12	14	5	18	1	0

Table 2. Group size by season of radio-instrumented goats observed from December 1978 through March 1981.

Season	Group Size 1	2	3	4	5	6-10	11-20	21+
	(% observed)							
Winter (n groups = 113)	28	27	12	10	4	16	3	0
Spring (n groups = 155)	52	16	12	9	3	8	0	0
Summer (n groups = 136)	28	24	10	7	8	17	6	1
Fall (n groups = 37)	41	35	11	3	8	3	0	0

Table 3. Average adult:kid ratios for mountain goats, December 1977 through July 1978.

Season	Average Adult:Kid ratio	No. of Surveys
Winter	100:31.3[1]	12
Spring	100:16.5[1]	6
June - July	100:27.3[2]	6

[1] represents young-of-the-year 1977
[2] represents young-of-the-year 1978

APPENDIX II. Seasonal use, availability, and preference for elevation.

Table 1. Winter habitat use, availability, and preference of 18 radio-instrumented mountain goats north of Juneau (n = 166 locations).

Elevation (feet)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
0-500	0	15.2	-1.0	***
600-1,000	1.2	10.5	-0.79	***
1,100-1,500	6.0	12.7	-0.36	**
1,600-2,000	6.6	9.8	-0.20	N.S.
2,100-2,500	12.0	10.0	+0.09	N.S.
2,600-3,000	15.1	11.0	+0.16	N.S.
3,100-3,500	33.7	10.7	+0.52	***
3,600-4,000	22.3	9.5	+0.40	***
4,100-4,500	2.4	6.4	-0.45	**
4,600-5,000	0.6	3.8	-0.73	**
5,100-5,500	0	0.3	-1.0	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 2. Spring habitat use, availability, and preference of 19 radio-instrumented mountain goats north of Juneau, 1978-1980 (n = 240 locations).

Elevation (feet)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
0-500	0.4	15.2	-0.95	***
600-1,000	2.9	10.5	-0.57	***
1,100-1,500	11.3	12.7	-0.06	N.S.
1,600-2,000	14.2	9.8	+0.18	*
2,100-2,500	22.9	10.0	+0.39	***
2,600-3,000	16.3	11.0	+0.19	**
3,100-3,500	15.4	10.7	+0.18	**
3,600-4,000	12.1	9.5	+0.12	N.S.
4,100-4,500	4.6	6.4	-0.16	N.S.
4,600-5,000	0	3.8	-1.0	***
5,100-5,500	0	0.3	-1.0	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 3. Summer habitat use, availability, and preference of 20 radio-instrumented mountain goats north of Juneau (n = 167 locations).

Elevation (feet)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
0-500	0	15.2	-1.0	***
600-1,000	0.6	10.5	-0.89	***
1,100-1,500	5.4	12.7	-0.40	***
1,600-2,000	8.4	9.8	-0.08	N.S.
2,100-2,500	13.8	10.0	+0.16	N.S.
2,600-3,000	24.6	11.0	+0.38	***
3,100-3,500	21.0	10.7	+0.32	***
3,600-4,000	15.6	9.5	+0.24	**
4,100-4,500	9.0	6.4	+0.17	N.S.
4,600-5,000	1.8	3.8	-0.36	N.S.
5,100-5,500	0	0.3	-1.0	N.S.

1 x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

2 N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 4. Fall habitat use, availability, and preference of 19 radio-instrumented mountain goats north of Juneau (n = 60 locations).

Elevation (feet)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
0-500	0	15.2	-1.0	***
600-1,000	1.7	10.5	-0.72	**
1,100-1,500	15.0	12.7	+0.08	N.S.
1,600-2,000	11.7	9.8	+0.09	N.S.
2,100-2,500	26.7	10.0	+0.46	***
2,600-3,000	15.0	11.0	+0.15	N.S.
3,100-3,500	20.0	10.7	+0.30	**
3,600-4,000	8.3	9.5	-0.07	N.S.
4,100-4,500	1.7	6.4	-0.58	N.S.
4,600-5,000	0	3.8	-1.0	N.S.
5,100-5,500	0	0.3	-1.0	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected ($P<.01$).

[2] N.S. = Not Significant, * = $P<.1$, ** = $P<.05$, *** - $P<.01$, based on analysis of residuals.

APPENDIX III. Seasonal use, availability, and preference for slope.

Table 1. Winter habitat use, availability, and preference of 18 radio-instrumented mountain goats north of Juneau (n = 166 locations).

Slope (°)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
10	4.8	22.2	-0.64	***
10-20	2.4	15.7	-0.73	***
20-30	29.5	21.3	+0.16	***
30-50	60.8	30.9	+0.33	***
50	2.4	10.0	-0.61	***

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 2. Spring habitat use, availability, and preference of 19 radio-instrumented mountain goats north of Juneau, 1978-1980 (n = 240 locations).

Slope (°)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
10	3.3	22.2	-0.74	***
10-20	6.7	15.7	-0.40	***
20-30	20.0	21.3	-0.03	N.S.
30-50	53.3	30.9	+0.27	***
50	16.7	10.0	+0.25	***

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 3. Summer habitat use, availability, and preference of 20 radio-instrumented mountain goats north of Juneau (n = 167 locations).

Slope (°)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
10	6.0	22.2	-0.57	***
10-20	18.0	15.7	+0.07	N.S.
20-30	30.5	21.3	+0.18	***
30-50	36.5	30.9	+0.08	N.S.
50	9.0	10.0	-0.05	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 4. Fall habitat use, availability, and preference of 20 radio-instrumented mountain goats north of Juneau (n = 60 locations).

Slope (°)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
10	6.7	22.2	-0.54	***
10-20	6.7	15.7	-0.40	*
20-30	30.0	21.3	+0.17	N.S.
30-50	55.0	30.9	+0.28	***
50	1.7	10.0	-0.71	**

1 x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

2 N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

APPENDIX IV. Seasonal use, availability, and preference for distance to nearest cliff.

Table 1. Winter habitat use, availability, and preference of 18 radio-instrumented mountain goats north of Juneau (n = 166 locations).

Distance from Cliffs (mi.)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
0	66.9	10.0	+0.74	***
0-.25	25.6	45.7	-0.28	***
.25-.50	7.5	24.9	-0.54	***
.50-.75	0	10.0	-1.0	***
.75-1.0	0	4.2	-1.0	**
1.0-1.25	0	1.6	-1.0	N.S.
1.25-1.50	0	1.1	-1.0	N.S.
1.50-1.75	0	0.9	-1.0	N.S.
1.75-2.0	0	1.1	-1.0	N.S.
2.0-2.50	0	0.6	-1.0	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 2. Spring habitat use, availability, and preference of 19 radio-instrumented mountain goats north of Juneau, 1978-1980 (n = 240 locations).

Distance from Cliffs (mi.)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
0	67.9	10.0	+0.74	***
0-.25	29.6	45.7	-0.21	***
.25-.50	2.5	24.9	-0.82	***
.50-.75	0	10.0	-1.0	***
.75-1.0	0	4.2	-1.0	***
1.0-1.25	0	1.6	-1.0	*
1.25-1.50	0	1.1	-1.0	N.S.
1.50-1.75	0	0.9	-1.0	N.S.
1.75-2.0	0	1.1	-1.0	N.S.
2.0-2.50	0	0.6	-1.0	N.S.

1 x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

2 N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 3. Summer habitat use, availability, and preference of 20 radio-instrumented mountain goats north of Juneau, (n = 167 locations).

Distance from Cliffs (mi.)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
0	62.9	10.0	+0.73	***
0-.25	35.8	45.7	-0.12	**
.25-.50	1.3	24.9	-0.90	***
.50-.75	0	10.0	-1	***
.75-1.0	0	4.2	-1	**
1.0-1.25	0	1.6	-1	N.S.
1.25-1.50	0	1.1	-1	N.S.
1.50-1.75	0	0.9	-1	N.S.
1.75-2.0	0	1.1	-1	N.S.
2.0-2.50	0	0.6	-1	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 4. Fall habitat use, availability, and preference of 19 radio-instrumented mountain goats north of Juneau, (n = 60 locations).

Distance from Cliffs (mi.)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
0	74.6	10.0	+0.76	***
0-.25	20.3	45.7	-0.38	***
.25-.50	5.1	24.9	-0.66	***
.50-.75	0	10.0	-1.0	**
.75-1.0	0	4.2	-1.0	N.S.
1.0-1.25	0	1.6	-1.0	N.S.
1.25-1.50	0	1.1	-1.0	N.S.
1.50-1.75	0	0.9	-1.0	N.S.
1.75-2.0	0	1.1	-1.0	N.S.
2.0-2.50	0	0.6	-1.0	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

APPENDIX V. Seasonal use, availability, and preference for aspect.

Table 1. Winter habitat use, availability, and preference of 18 radio-instrumented mountain goats north of Juneau (n = 166 locations).

Aspect	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
N	1.9	5.9	-0.51	**
NE	3.7	12.2	-0.53	***
E	1.2	7.1	-0.71	***
SE	8.1	9.8	-0.09	N.S.
S	14.9	11.3	+0.14	N.S.
SW	52.2	19.0	+0.45	***
W	13.7	20.7	-0.20	**
NW	4.3	13.9	-0.53	***

1 x^2 Test of null hypothesis that use is proportional to availability was rejected ($P<.01$).

2 N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 2. Spring habitat use, availability, and preference of 19 radio-instrumented mountain goats north of Juneau, 1978-1980 (n = 240 locations).

Aspect	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
N	2.6	5.9	-0.39	**
NE	5.1	12.2	-0.41	***
E	5.1	7.1	-0.16	N.S.
SE	18.4	9.8	+0.30	***
S	12.0	11.3	+0.03	***
SW	41.5	19.0	+0.37	***
W	12.0	20.7	-0.27	***
NW	3.4	13.9	-0.61	***

1 x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

2 N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 3. Summer habitat use, availability, and preference of 20 radio-instrumented mountain goats north of Juneau, (n = 167 locations).

Aspect	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
N	7.4	5.9	+0.11	N.S.
NE	10.4	12.2	-0.07	***
E	4.3	7.1	-0.25	N.S.
SE	11.7	9.8	+0.09	N.S.
S	5.5	11.3	-0.35	**
SW	23.9	19.0	+0.11	N.S.
W	19.0	20.7	-0.04	N.S.
NW	17.8	13.9	+0.12	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected ($P<.01$).

[2] N.S. = Not Significant, * = $P<.1$, ** = $P<.05$, *** - $P<.01$, based on analysis of residuals.

Table 4. Fall habitat use, availability, and preference of 19 radio-instrumented mountain goats north of Juneau, (n = 60 locations).

Aspect	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
N	8.8	5.9	+0.20	N.S.
NE	21.0	12.2	+0.27	*
E	3.8	7.1	-0.34	N.S.
SE	14.0	9.8	+0.18	N.S.
S	8.8	11.3	-0.12	N.S.
SW	19.3	19.0	+0.01	N.S.
W	12.3	20.7	-0.25	*
NW	12.3	13.9	-0.06	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

APPENDIX VI. Seasonal use, availability, and preference for habitat type.

Table 1. Winter habitat use, availability, and preference of 18 radio-instrumented mountain goats north of Juneau (n = 166 locations).

Habitat Type	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
Rock	49.4	23.3	+0.36	***
Alpine	28.3	6.2	+0.76	***
Subalpine	5.4	7.6	-0.17	N.S.
Old-growth	15.1	33.0	-0.37	***
Second-growth	0	2.9	-1.0	**
Brush	1.2	3.1	-0.44	N.S.
Ice	0.6	20.6	-0.94	***
Muskeg	0	3.4	-1.0	**

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 2. Spring habitat use, availability, and preference of 19 radio-instrumented mountain goats north of Juneau, 1978-1980 (n = 240 locations).

Habitat Type	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
Rock	50.4	23.3	+0.37	***
Alpine	16.3	6.2	+0.45	***
Subalpine	8.8	7.6	+0.07	N.S.
Old-growth	14.2	33.0	-0.40	***
Second-growth	0.4	2.9	-0.76	**
Brush	9.2	3.1	+0.50	***
Ice	0.8	20.6	-0.93	***
Muskeg	0	3.4	-1.0	***

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 3. Summer habitat use, availability, and preference of 20 radio-instrumented mountain goats north of Juneau, (n = 167 locations).

Habitat Type	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
Rock	42.5	23.3	+0.29	***
Alpine	21.0	6.2	+0.44	***
Subalpine	11.4	7.6	+0.20	N.S.
Old-growth	3.0	33.0	-0.83	***
Second-growth	0.6	2.9	-0.66	**
Brush	10.2	3.1	+0.53	***
Ice	7.8	20.6	-0.45	***
Muskeg	1.2	3.4	-0.48	N.S.

1 x^2 Test of null hypothesis that use is proportional to availability was rejected ($P<.01$).

2 N.S. = Not Significant, * = $P<.1$, ** = $P<.05$, *** - $P<.01$, based on analysis of residuals.

Table 4. Fall habitat use, availability, and preference of 19 radio-instrumented mountain goats north of Juneau, (n = 60 locations).

Habitat Type	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
Rock	31.7	23.3	+0.15	N.S.
Alpine	21.7	6.2	+0.56	***
Subalpine	25.0	7.6	+0.44	***
Old-growth	18.3	33.0	-0.27	**
Second-growth	0	2.9	-1.0	N.S.
Brush	3.3	3.1	+0.03	N.S.
Ice	0	20.6	-1.0	***
Muskeg	0	3.4	-1.0	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected ($P<.01$).

[2] N.S. = Not Significant, * = $P<.1$, ** = $P<.05$, *** - $P<.01$, based on analysis of residuals.

APPENDIX VII. Forest habitat use of mountain goats relative to elevation, slope, aspect, and distance to cliffs.

Table 1. Winter-spring habitat use, availability, and preference relative to elevations within old-growth forest for 19 radio-instrumented mountain goats north of Juneau (n = 59 locations).

Elevation (feet)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
0-500	1.7	26.2	-0.88	***
600-1,000	8.5	24.0	-0.48	***
1,100-1,500	28.8	28.7	0.0	N.S.
1,600-2,000	33.9	12.4	+0.46	***
2,100-2,500	18.6	5.8	+0.52	***
2,600-3,000	6.8	2.9	+0.40	**
3,100-3,500	1.7	0	+1.0	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

[2] N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 2. Winter-spring habitat use, availability, and preference relative to slope within old-growth forest for 19 radio-instrumented mountain goats north of Juneau (n = 59 locations).

Slope (°)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
10	0	16.7	-1.0	***
10-20	5.1	25.8	-0.67	***
20-30	30.5	22.2	+0.16	N.S.
30-50	52.5	30.2	+0.27	***
50	11.9	5.1	+0.40	***

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected ($P<.01$).

[2] N.S. = Not Significant, * = $P<.1$, ** = $P<.05$, *** - $P<.01$, based on analysis of residuals.

Table 3. Winter-spring habitat use, availability, and preference relative to aspect within old-growth forest for 19 radio-instrumented mountain goats north of Juneau (n = 59 locations).

Aspect	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
N	0	4.0	-1.0	N.S.
NE	3.4	10.2	-0.50	
E	1.7	4.0	-0.40	N.S.
SE	23.7	12.7	+0.30	**
S	13.6	10.9	+0.11	N.S.
SW	30.5	15.6	+0.32	**
W	22.0	30.9	-0.17	N.S.
NW	5.1	11.6	-0.39	N.S.

1 x^2 Test of null hypothesis that use is proportional to availability was rejected (P<.01).

2 N.S. = Not Significant, * = P<.1, ** = P<.05, *** - P<.01, based on analysis of residuals.

Table 4. Winter-spring habitat use, availability, and preference relative to distance to nearest cliff within old-growth forest for 19 radio-instrumented mountain goats north of Juneau (n = 59 locations).

Distance From Cliffs (mi.)	Goat Locations[1] %	Availability[1] %	Preference Index	Significance Level[2]
0	58	5.1	+0.84	***
.25	42	33.8	+0.12	N.S.
.25-.50	0	29.5	-1.0	***
.50-.75	0	17.5	-1.0	***
.75-1.0	0	7.3	-1.0	*
1.0-1.25	0	1.5	-1.0	N.S.
1.25-1.50	0	2.5	-1.0	N.S.
1.50-1.75	0	1.1	-1.0	N.S.
1.75-2.0	0	1.8	-1.0	N.S.

[1] x^2 Test of null hypothesis that use is proportional to availability was rejected ($P<.01$).

[2] N.S. = Not Significant, * = $P<.1$, ** = $P<.05$, *** - $P<.01$, based on analysis of residuals.