Spring 1970

Subalpine Cover Ecology of Eutamias amoenus, Eutamias townsendii and other small Mammals in Huckleberry Park, Mount Rainier National Park

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SUBALPINE COVER ECOLOGY OF EUTAMIAS AMOENUS, EUTAMIAS TOWNSENDII AND OTHER SMALL MAMMALS IN HUCKLEBERRY PARK, MOUNT RAINIER NATIONAL PARK

A Thesis

Presented to

the Graduate Faculty

Central Washington State College

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

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May, 1970

APPROVED FOR THE GRADUATE FACULTY

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ACKNOWLEDGMENTS

I am indebted to the chairman of my graduate committee, Mr. Sheldon R. Johnson of the Department of Biological Sciences, Central Washington State College, for his valuable guidance, advice, and criticism throughout this study. I also thank Dr. Philip C. Dumas and Mr. Curt A. Wiberg, members of my graduate committee, who offered additional guidance and advice. I am indebted to Mr. Max W. Holden, Wildlife Staff Ranger, Mount Rainier National Park, for his encouragement and aid in obtaining permission from the National Park Service to do this study. I thank the National Park Service for permission to trap small mammals and collect plants in Huckleberry Park. I wish to further acknowledge Miss Marcia Hamonn of Bellevue, Washington, for her help in identifying plants; Mr. Gary Wolfe of Albuquerque, New Mexico, and Mr. Randal Risser of Altadena, California, for their assistance in the field. I am indebted to the Mazamas of Portland, Oregon, for their financial assistance, under their mountain research grant.

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INTRODUCTION

Little work has been done on the ecology of alpine and subalpine small mammals. They are included in faunal surveys (Pattie and Verbeek, 1967; Brown, 1967), but little is known of their habits.

In Mount Rainier National Park the first faunal survey was made in 1897 by a U. S. Biological Survey team led by C. Hart Merriam. A follow-up survey was made in 1919 by the National Park Service, the Bureau of the Biological Survey (U. S. Department of Agriculture), and the State College of Washington, Pullman. The results of these two surveys were published by Taylor (1922) and Taylor and Shaw (1927).

From 1919 to 1966 little more than observational data were gathered on the mammals (on file at library, Longmire, Washington). Potts and Grater (1949) summarized some of these data.

From 1966 to 1968 Shamberger of Oregon State University conducted a qualitative study of the small mammals of the park for his doctoral research (Shamberger, 1968, unpublished progress report to Mount Rainier National Park, Washington). The author ran trap-lines for Shamberger during the summers of 1966 and 1967 as an employee of the National Park Service. This initial experience with alpine and subalpine small mammals fostered the impetus for this study in Huckleberry Park, Mount Rainier National Park.

To understand the ecology of small mammals it is necessary to know something about their environment. The alpine and subalpine environment has been described by only a few ecologists. Griggs (1946) described the environmental factors affecting timberline. Billings and Bliss (1959), Van Vechten (1960), Marr (1961), Bliss (1963), and Shetler (1964) described various alpine and subalpine plant communities. Franklin (1966a, 1966b) and Franklin and Mitchell (1967) described the subalpine communities of the Cascade Mountains.

Hollister's chipmunk, Eutamias amoenus ludibundus Hollister, and Cooper's chipmunk, Eutamias townsendii cooperi Baird, have been observed feeding together in the subalpine parklands along the Cascade crest (Dalquest, 1948; Shamberger, 1969, personal communication). The two species, E. amoenus (Allen) and E. townsendii (Bachman), overlap in range in the northern Sierra Nevada Mountains of California, the Cascade Mountains of Oregon and Washington, and the Olympic Mountains of Washington (Hall and Kelson, 1959). Since they appear to be associated with the same habitat in Washington, they offer an opportunity to study the ecological relationships of two similar species living together.

Considering their wide geographic range and their conspicuous diurnal habits, it is surprising that chipmunks have received little ecological study. Forbes (1966) did a detailed study of the ecology of Tamias striatus and Eutamias minimus in Minnesota, where the ranges of these two genera overlap. He found that cover was an important factor separating the two forms. Broadbooks (1949) did a comprehensive study on the biology of Eutamias amoenus on the east slope of the Cascades of Washington. Walker (1923), Svihla (1936), Holdenried (1940), Aldous (1941), Gordon (1943), Shaw (1944), Larrison (1947), Tevis (1952, 1953, 1955), Gashwiler (1959, 1963, 1965), and Hall (1969) have contributed additional information on the field biology of *Eutamias*.

In the summer of 1969 this study was undertaken in subalpine Huckleberry Park, Mount Rainier National Park, to determine the species of small mammals in the area and some of their relationships with the environment and each other. The relationships between *E. amoenus* and *E. townsendii* were of special interest.

METHODS AND MATERIALS

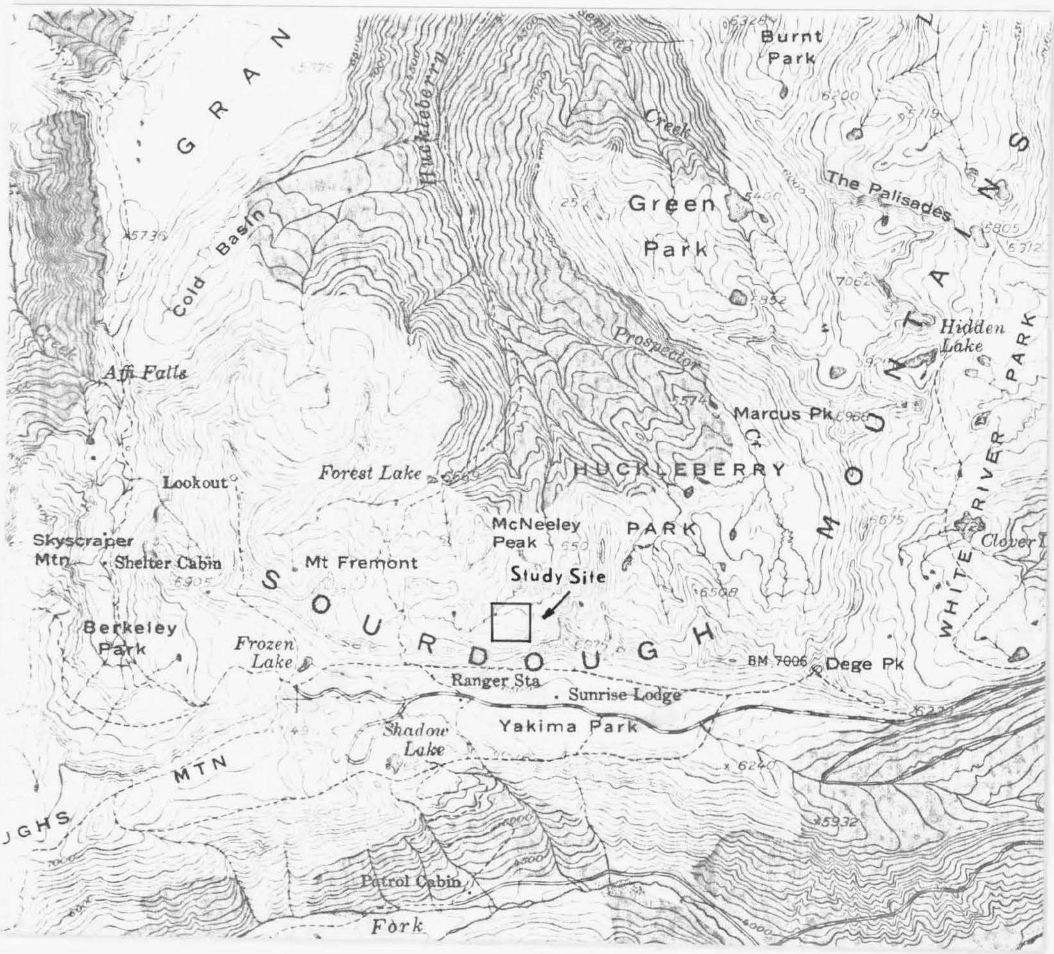
Study Site Description

Mount Rainier National Park is located on the west slope of the Cascade Mountains in central Washington. The Park includes 378 square miles of rugged topography, dominated by the glacier-clad volcano, Mount Rainier, rising 14,410 feet above sea level.

This study was conducted from June 30 to September 4, 1969, in Huckleberry Park, at an elevation of 6,000 feet. Huckleberry Park is a subalpine area on the north slope of the Sourdough Mountains in the northeast section of the Park. The study site was reached from Sunrise by following the Wonderland Trail to its junction with the Dege Peak Trail and crossing the saddle in the east-west crest of the Sourdoughs. The site was located in the forest-meadow mosaic between the alpine meadows on the slopes of Mount Fremont and the mountain hemlock, *Tsuga mertensiana*, forest zone (Franklin and Dyrness, 1969) of the Huckleberry Creek drainage (Figure 1 and Plate I, Figure 1).

Snow remains on the north slope until early July, with some remaining all summer in the protected ravines. In June long glissades were made down the snow-covered Sourdough slope to transport equipment into the area. July and August are the only relatively snow-free months. By early September, snow storms are quite common. Time to investigate the spring and summer biology of this region's inhabitants is at a premium.

Figure 1. Study Site Location Map, Huckleberry Park, photocopy from Mount Rainier National Park Quadrangle, Washington, 1955, U. S. Geological Survey, Denver, Col.



In late June a 5.06 hectare (225 x 225 meter) (12.5 acre) grid was staked out (Figure 2). The grid was composed of 256 trap stations, staked at 15 meter intervals. The southern boundary was set at the foot of the steep talus-heather slope of the Sourdoughs on a line due west from the summit of Antlers Peak. The grid included many meadow and tree island communities common to Merriam's upper-Hudsonian life-zone (Taylor, 1922).

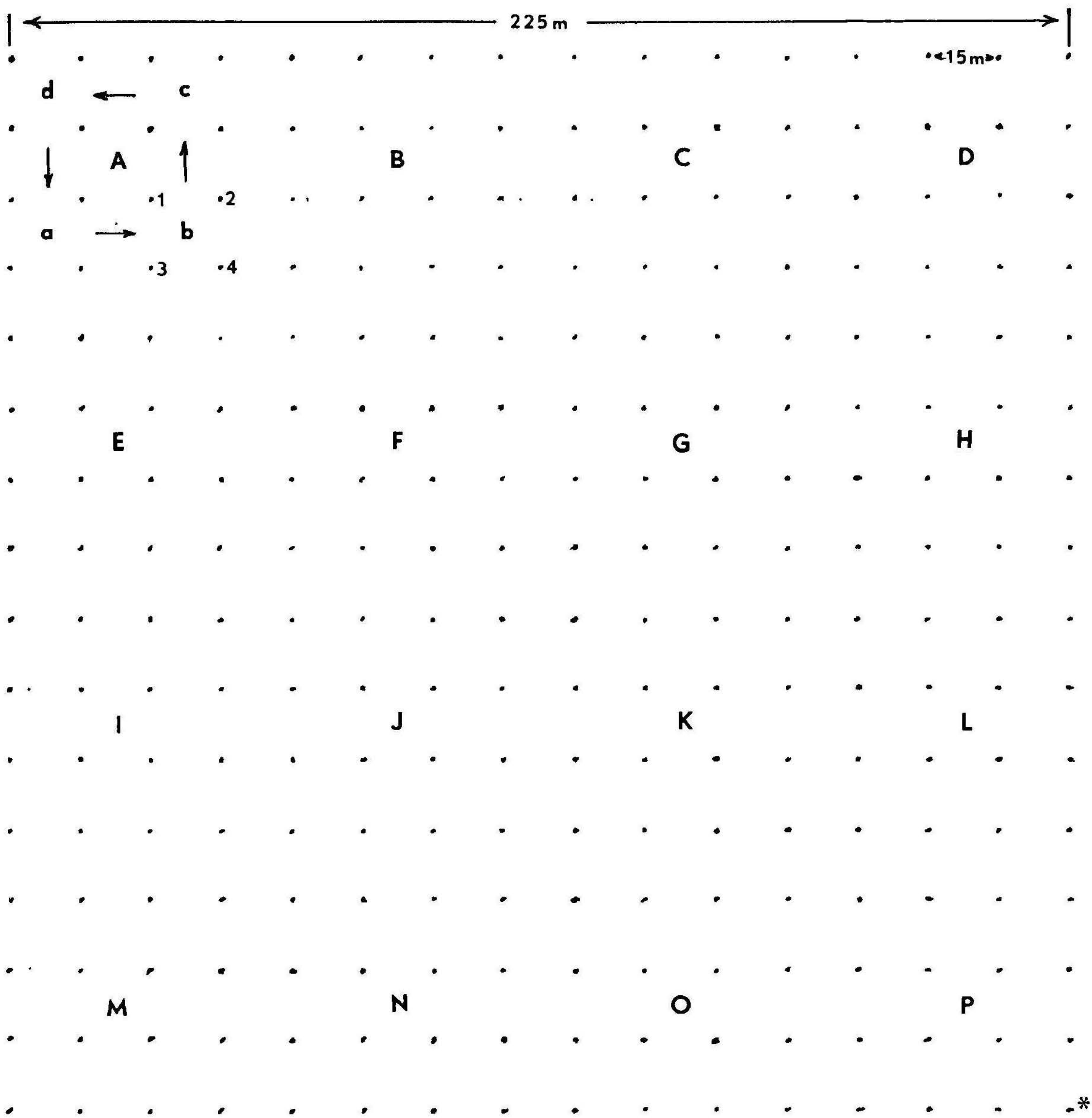
Trapping Method

A modification of Brant's (1962) grid live-trap method was used in this study (Figure 2). The 16 station x 16 station grid was divided into sixteen 4 station x 4 station sectors, A--P. In each sector traps were set at the four stations of only one of the four subsectors, a--d. The traps were rotated (a to b, one day; b to c, the next day; etc.) every trapping day for the first week. The second through the fifth week, because of the time involved (three to four hours each morning), the traps were rotated every second day of trapping. This allowed more time to complete other projects in the study area and it is believed that it lessened the disruptive influence created by spending considerable time in the area.

Two Sherman live-traps (3 x 3 x 10 inches) and one modified Maser (1967) microtine trap were placed within one meter of each station trapped. The traps were set out, closed, and prebaited a week before the trapping began. Oats were used as bait.

The Maser traps were made of ¼ inch hardware cloth, 2½ x 2½ x 10 inches, with the doors opening on one end. These traps were to be

Figure 2. Trap Station Grid in Huckleberry Park. A--P, 16 station sectors; a--d, 4 station subsectors; 1--4, station numbers. Trap rotation pattern within each sector indicated by arrows: traps set at a first day, moved to b third day, b to c two trapping days later, etc.



*McNeely Peak 325±5° and Antlers Peak 90±5°.

placed in microtine runways unbaited, being triggered by voles passing along the runways. Use of these traps was discontinued after the first week. Actual vole runways were few and far between, and no captures of voles were made in these traps. This sharply contrasted with the results of pilot studies using these traps on Microtus montanus in the Columbia Basin where microtine runways were more prevalent.

The grid was trapped for three consecutive days each week, for five weeks, July 21 to August 19. The traps were checked twice daily, at dawn (4:30 to 6:30 a.m., depending on day length) and at dusk (6:00 to 8:00 p.m.). On the first day of the three day trapping period, the traps were set and baited early in the morning. On the morning of the last day, the traps were closed and the back doors opened. In this manner, all stations were trapped an equal number of times; and all stations had traps closed with free access to the bait an equal number of times.

When an animal was caught, the trap was placed inside the mouth of a cotton collecting bag. The back door of the trap was opened and the occupant shaken into the bag. The animal was grasped by the nape through the bag and the bag turned inside out, exposing the animal.

If the animal had been caught for the first time, it was marked and numbered as an individual by a system of toe clips (Mosby, 1963). No more than the first digit of two toes was clipped from each animal.

Each animal was recorded as to species, individual number, trap number, sex, age, and measurements. The age was recorded as either mature or immature. An immature animal was one in which the testes had not descended or the vaginal opening was not noticeable. Determining the sex of the immatures in the field is, therefore, difficult. The two individuals described as immature were not sexed.

Measurements were taken using a metric ruler tacked on the back of a clipboard. The animal was laid along the ruler and its tail and total length measured to the nearest millimeter. The animal was then released at the station captured.

Plant Analysis

Meadow

A plant analysis was made of each meadow community, using Daubenmire's (1959) canopy-coverage method. A community was selected in an area of maximum soil, topographic, and vegetational homogeneity. Ecotones were considered to be narrow blendings of two or more communities and were not analyzed.

In each community a metric tape was extended between two stakes 25 meters apart. The tape was placed along a north-south or east-west line using a trap station stake as a base point. Care was taken in selecting the base point to keep the tape within the community to be analyzed.

A 20 x 50 centimeter (inside dimension) plot frame, made of welded 3/16 inch steel rods, was placed at each meter on the tape. The percent coverage of each species of plant was estimated by placing the frame on the ground and noting the fraction of plot area that was covered by the canopies of the species. The percentages were subdivided and recorded in 6 classes (Table I). The range midpoints of each class were used to calculate the overall coverage for the sample (Daubenmire, 1959).

Table I. Plant Coverage Classes

Class	Percent Coverage
1	0-5
2	5-25
3	25-50
4	50-75
5	75-95
6	95-100

Tree Island

The tree islands in sector P were considered to be representative of the study area and were selected for analysis. They were analyzed by counting the number of individuals of each species of tree in each island. The circumference of each mature tree was measured at breast height (4 feet) using a metric tape. Any tree less than breast height was counted separately from the mature trees. An estimate was made of the area of each tree island, by comparing it with the known area of each grid subsector (225 square meters) it was in.

Cover Analysis

A cover analysis was made of each plant community using a light meter (Kahl Scientific Corp., El Cajon, Calif.). The meter measured light intensities in foot candles with a range of 0-10,000 f.c. In each community five readings were taken at five different trap stations. All observations were made on September 1, under clear skies. The sensor was placed on the ground, in the shade, with the sensitive side facing up. Direct sunlight readings were also taken at the same time, in each community. The under cover values were expressed as percentages of direct sunlight.

Temperature

Two recording thermographs (Model 1000, Marshalltown Manufacturing Inc., Iowa) were set out at the beginning of the study, one in the meadow near station Nb2 and the other in the tree island near station Pd2 (Figure 2). Each sensor was placed 3 centimeters above the ground in a three-sided housing (Figure 3). This protected the sensor from any direct sunlight, while allowing for adequate air circulation. The temperatures were recorded on a circular graph (No. 7-533, -10 to 60°C, Marshalltown) which was changed every week.

Mapping

A map was sketched of the study site, showing the position of the various plant communities in relation to the grid stations (Figure 8). Each trap station was described as to the type of community or ecotone it had been placed in.

Observations

Observations, to determine the movements of predators in and about the area, were made from the crest of Sourdough ridge, about ¼ mile south of the study site. The observations were made for about one to two hours, after each morning visit to the area and before the afternoon visit, weather permitting. Binoculars, 7 x 35, were used to scan the area.

Statistical Analysis

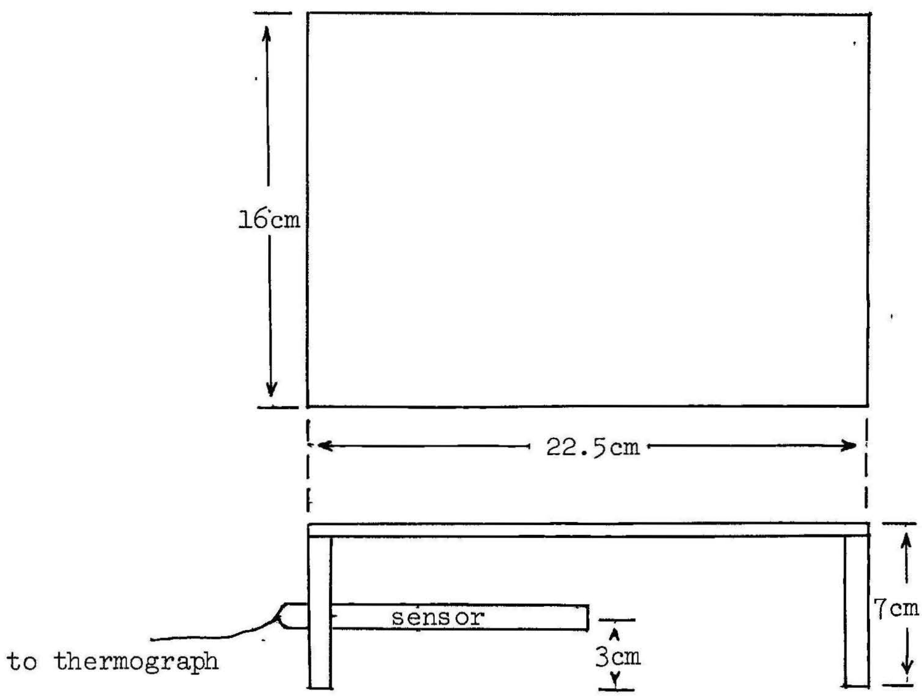
The statistical procedures followed were those of Mendenhall (1967). The level of significance used for all tests was 95 percent.

Home Range

The two species of chipmunks, *Eutamias amoenus* and *Eutamias townsendii*, were the only animals that gave sufficient data to analyze home range. Because the two were living sympatrically, the home ranges of each were compared to determine if there were any significant differences between them.

Brant (1962) compared home ranges of small mammals on the basis of average M, average maximum distance between captures; average D, average distance between successive captures; and average T, average time between successive captures. This was used with the chipmunks and analyzed using the Mann-Whitney U Test for nonparametric data.

Figure 3. Temperature Sensor Housing



Cover Data

The mean and variance of each cover type's light penetration data were computed. Each cover type's mean was compared with the means of the other cover types using the t-Test. Each cover type's variance was compared with the variances of the other cover types using the F-Test.

The type of cover frequented by each species of small mammal was compared using Chi-square Contingency Tables. In the case of the two species of chipmunk, there were sufficient data to also compare the sexes.

RESULTS

Trapping Success

There were twelve 24-hour days of trapping. Since the traps were checked twice daily and 128 traps set, there were 3,072 trap units (one trap unit = one trap/12-hour trapping period). Out of these trap units, there were 235 captures, or 7.6 percent success.

Table II describes the trapping success by species. There were 213 captures of 65 known individuals. There were 22 captures of individuals which escaped before identification could be made.

Eutamias dominated the results. Of the total individuals, 43.1 percent were chipmunks which comprised 77.9 percent of the captures. *Eutamias amoenus* averaged 7.7 captures per individual, while *Eutamias townsendii* averaged 4.8 captures per individual. Using the t-Test, the capture per individual ratio of *E. amoenus* was found to be significantly larger than that of *E. townsendii* (t = 6.0, 26 degrees of freedom, d.f.).

These data were broken down by sex. *E. amoenus* males averaged 4.6 captures per individual, and the females averaged 13.3 captures per individual. *E. townsendii* males averaged 5.3 captures per individual, and the females averaged 3.6 captures per individual. When analyzed using the t-Test, *E. townsendii* males showed a significantly higher capture per individual ratio than the females (t = 2.1, 15 d.f.). *E. amoenus* males and females were not significantly different from themselves (t = 0.7, 9 d.f.). *E. amoenus* females showed a significantly higher capture per individual ratio than E. townsendii females ($t = 5.4$, 7 d.f.). No significant difference was found between the males of the two species ($t = 0.9$, 17 d.f.).

Field differentiation between the Oregon meadow mouse, Microtus oregoni (Bachman), and the heather vole, Phenacomys intermedius Merriam, was extremely difficult. For this reason the data for these two possible species were combined.

Nocturnal versus diurnal activity was clearly shown in several species. The deer mouse, Peromyscus maniculatus (Wagner), and the Pacific jumping mouse, Zapus trinotatus (Rhoads), were captured during the night or early morning. The Cascades golden-mantled ground squirrel, Citellus saturatus (Rhoads), was captured during the day. E. amoenus and E. townsendii were captured during both periods, but it is believed that many of the nocturnal captures were actually early morning captures. Those individuals recorded during the morning trap check were active and showed no signs of trap fatigue, i.e., wet pelts, shivering, etc.

Home Range

The individual home ranges of the two species of chipmunk were mapped according to sex (Figures 4, 5, 6, and 7), using the exclusive boundary strip method (Stickel, 1954). A boundary line was drawn half-way between the trap stations where an individual was captured and those where it was not. All captures were included within the boundary. In this way the area of the home range was kept at a minimum while allowing for all known movements.

Table II. Capture by Species

Species		No. of Indiv.	Captures night	Captures day	Total Captures
Eutamias amoenus		11	24	61	85
	♂	7	7	25	32
	♀	4	17	36	53
Eutamias townsendii		17	18	63	81
	♂	12	17	46	63
	♀	5	1	17	18
Peromyscus maniculatus		7	10	0	10
	♂	2	3	0	3
	♀	5	7	0	7
Clethrionomys gapperi		8	5	4	9
	♂	5	4	2	6
	♀	3	1	2	3
Citellus saturatus		3	0	8	8
	♂	1	0	2	2
	♀	2	0	6	6
Microtus oregoni and/or Phenacomys intermedius		7	5	3	8
	♂	2	2	1	3
	♀	4	3	1	4
	immature	1	0	1	1
Sorex cinereus		5	4	1	5
Zapus trinotatus		4	4	0	4
	♂	1	1	0	1
	♀	3	3	0	3
Microtus richardsoni		3	2	1	3
	♂	1	0	1	1
	♀	1	1	0	1
	immature	1	1	0	1

Table III lists the individual home range areas of the two chipmunk species. Only individuals with three or more captures are shown. Three captures were considered to be minimum to delineate home range. Those individuals which were captured at boundary stations are marked. These data were not sufficient to establish significant correlations or trends. Likewise, no significant differences were found between the chipmunk sexes or species when Brant's (1962) average M, D, and T were analyzed using the Mann-Whitney U nonparametric test.

Plant Communities

Figure 8 is a map of the plant communities on the grid. The tree islands are distinguished from the meadow communities as enclosed solid lines.

Meadow

Franklin and Dyrness (1969) described the meadow communities according to the species they found dominating them. The communities in Huckleberry Park have been classified using the same scheme. Similar species compositions were found although the dominating forms varied from those found by Franklin.

There were three basic meadow communities: *Phyllodoce empetriformis-Cassiope mertensiana*, *Valeriana sitchensis*, and *Carex nigricans*. Appendix I is a list of the plant species of each of these communities, their percent coverage and their percent frequency (number of plots occurred/total plots). The samples were chosen subjectively

Figure 4. Male Eutamias amoenus home ranges. Diamonds indicate capture locations.

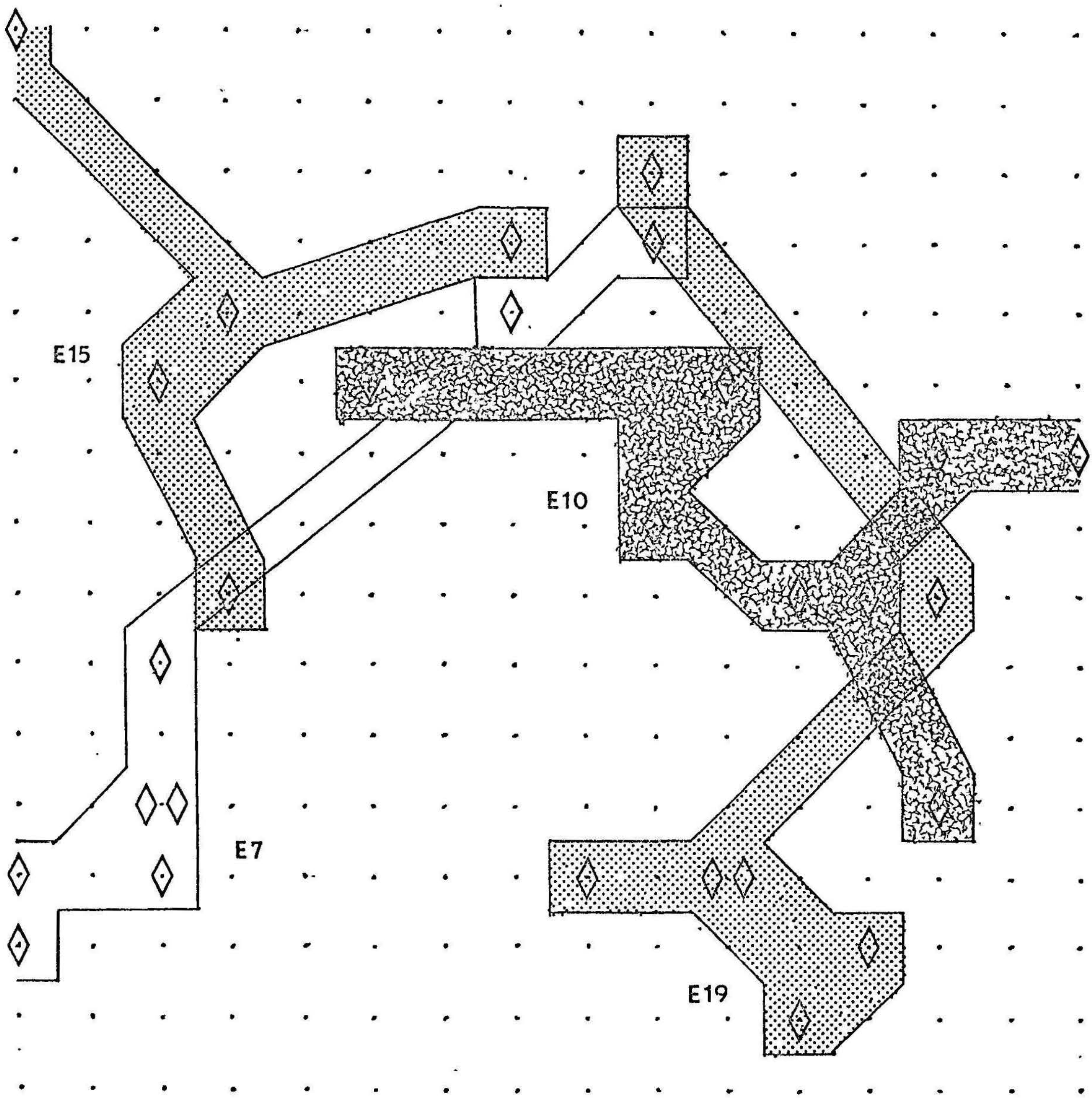


Figure 5. Female <u>Eutamias amoenus</u> home ranges. Diamonds indicate capture locations.

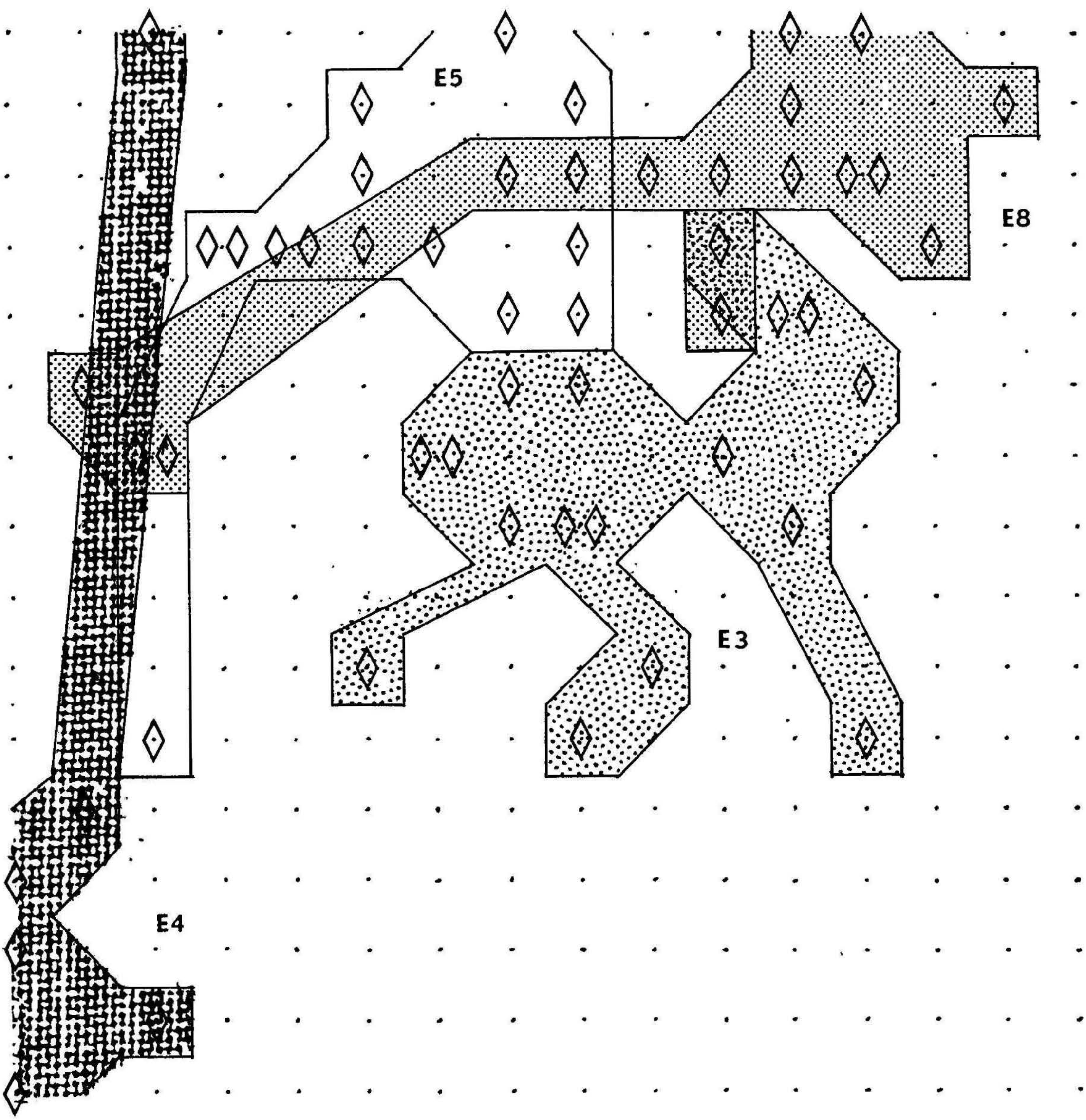


Figure 6. Male Eutamias townsendii home ranges. Diamonds indicate capture locations.

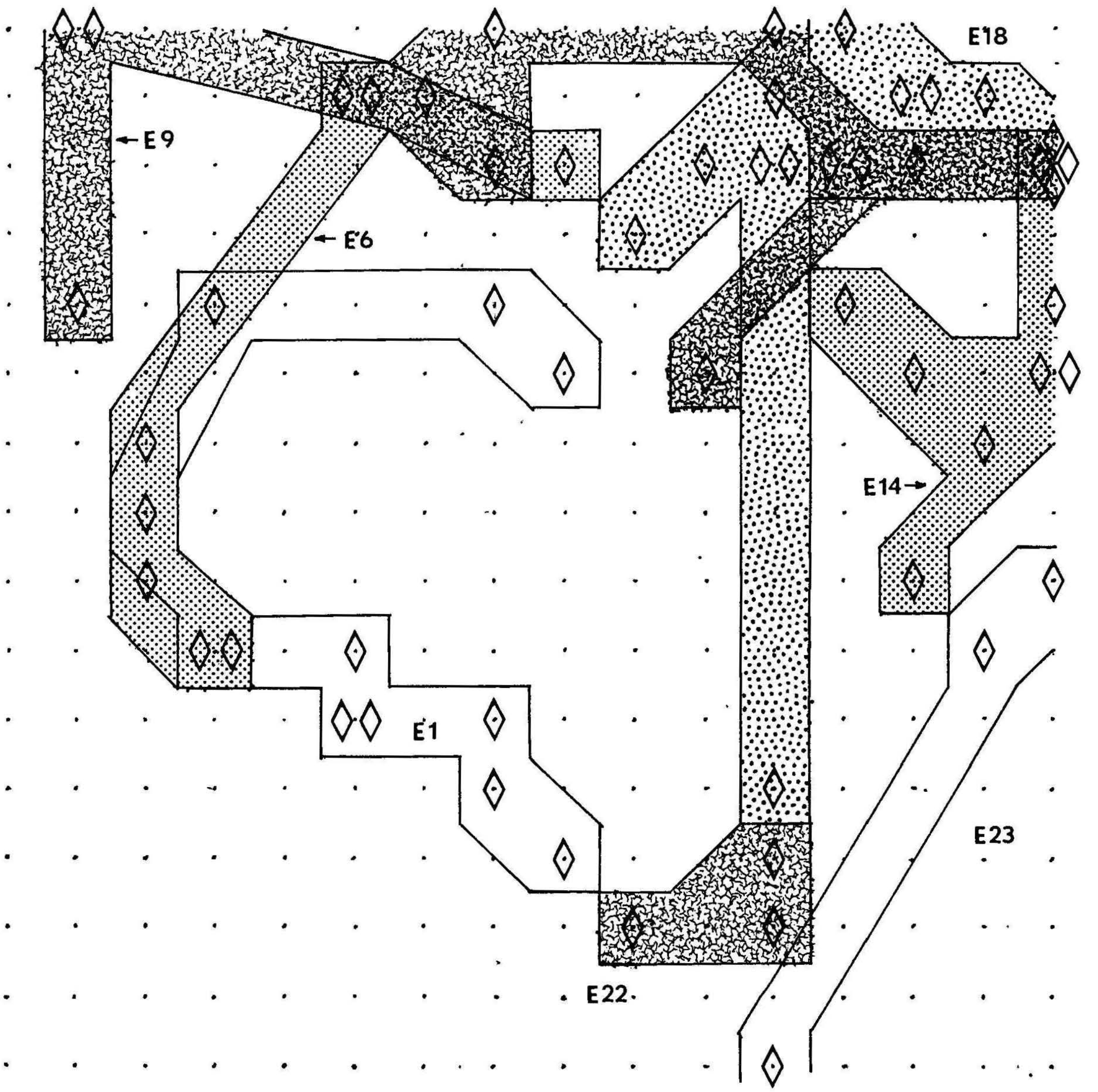


Figure 7. Female Eutamias townsendii home ranges. Diamonds indicate capture locations.

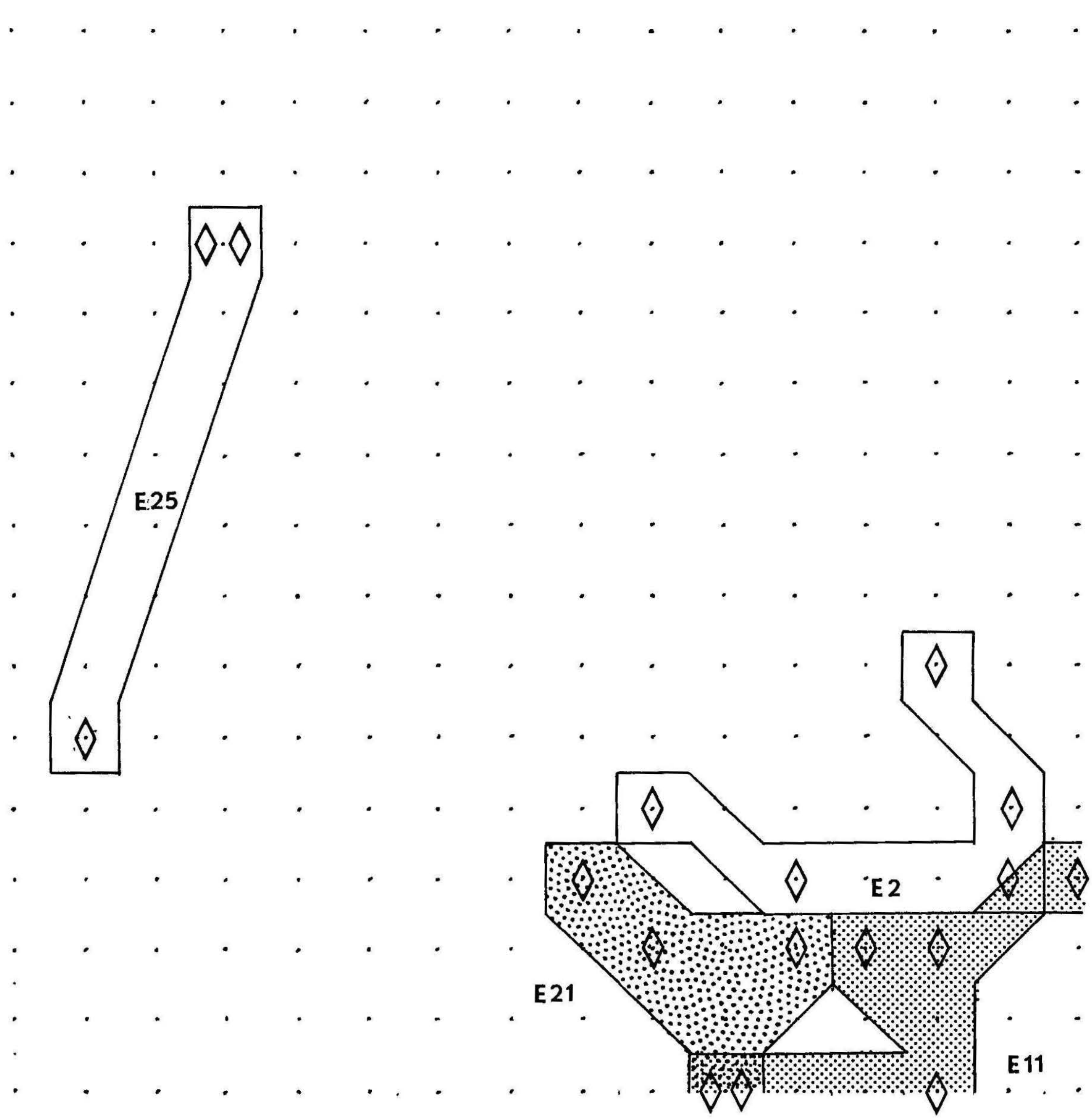
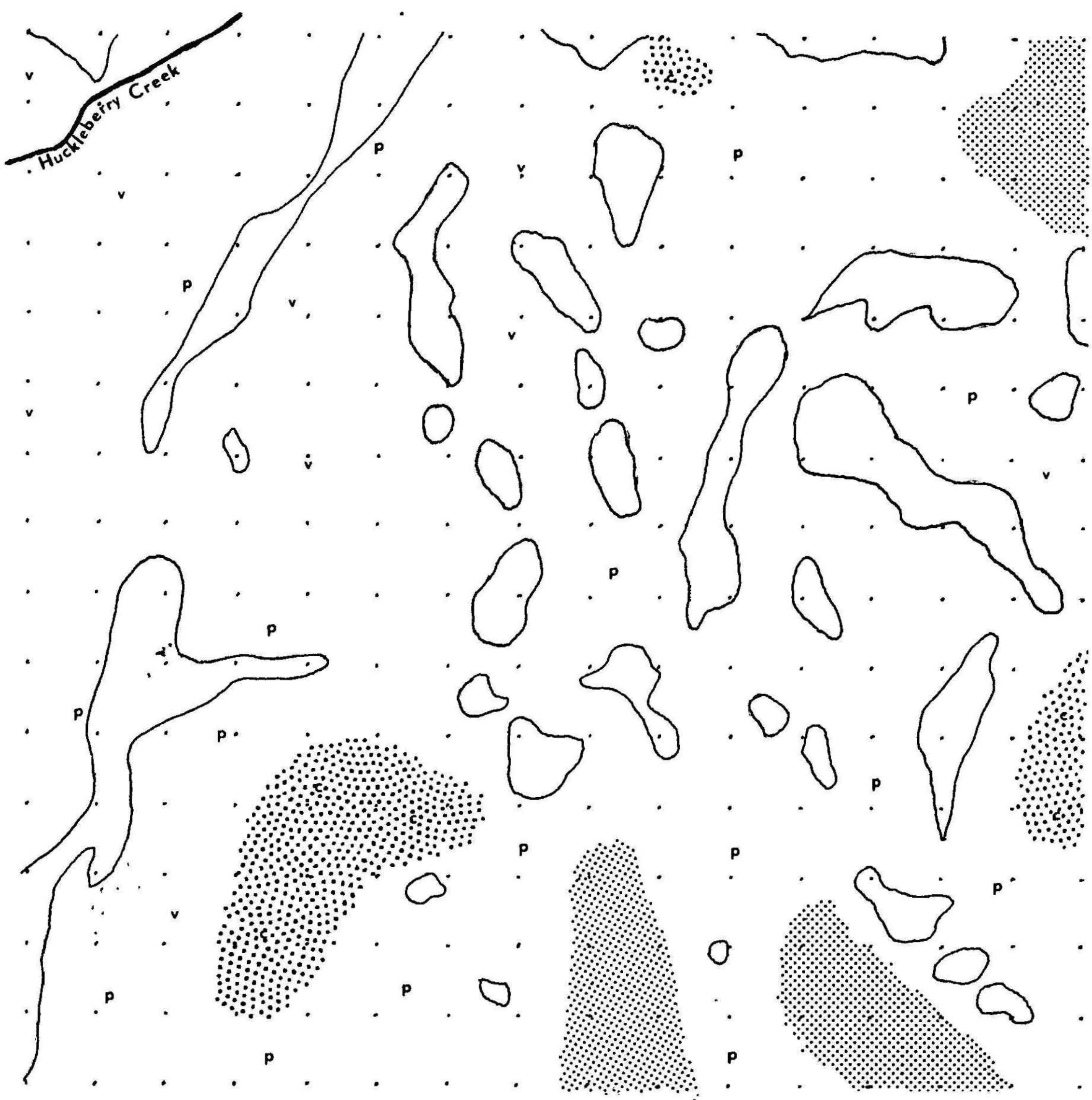


Table III. Individual Home Range Areas of Eutamias

Individual	Captures	Area (m^2)
Eutamias amoenus ♂		
E15	5	3150.0*
E19	7	3937.5
E 7	8	3150.0*
E10	9	4050.0*
Eutamias amoenus ♀		
E 4	6	4500.0*
E 8	14	5962.5*
E 5	16	5737.5*
E 3	17	6525.0
Eutamias townsendii ♂		
E22	3	1012.5
E23	3	2250.0*
E 6	6	2925.0
E14	9	2700.0*
E 9	10	5737.5*
E 1	12	4500.0
E18	13	5175.0*
Eutamias townsendii ♀		
E25	3	1800.0
E21	4	1575.0*
E 2	5	2250.0
E11	5	2137.5*

*captured at stations on grid boundary

Figure 8. Plant Community Map



tree island

pumice rubble basin

talus

p *Phyllodoce*-*Cassiope* meadow

v *Valeriana sitchensis* meadow

c *Carex nigricans* meadow

by the investigator as being representative of the meadow communities, and should not be construed as being the actual composition of all communities in the grid.

The heath, Phyllodoce-Cassiope, community was found on the dry slopes and dry ridges (Plate II). It was most abundant in the southern end of the grid. Western cassiope, Cassiope mertensiana (Bong.) G. Don, dominated the community. Red mountain heath, Phyllodoce empetriformis (S.W.) D. Don, was low in density, except in the heath-tree island ecotones where it was abundant. Blueleaf huckleberry, Vaccinium deliciosum Piper, was in high density in the heath.

The mountain heliotrope, Valeriana sitchensis Bong., community was found in low, moist, and well drained areas (Plate III, Figure 1). This lush community was dominated by broadleaf lupine, Lupinus latifolius Agardh, with V. sitchensis at low densities. This community formed ecotones with the heath communities on the slopes rising to the tree islands.

The black alpine sedge, Carex nigricans C. A. Mey., community was found exclusively in pumice rubble basins (Plate III, Figure 2). Large snowbanks persisted in these basins until early August. During the melt, standing water was not noticed in the basins, indicating sub-surface drainage. The community grew in large patches sparsely scattered across the pumice.

Tree saplings were found in some meadow communities. Most of these were subalpine fir, Abies lasiocarpa (Hook.) Nutt., with a few whitebark pine, Pinus albicaulus Engelmann (Plate V, Figure 1). No mountain hemlock, Tsuga mertensiana (Bong.) Carr., individuals were found outside of the tree islands.

Tree Island

Appendix II illustrates the tree island species composition of sector P. There were two types of tree islands in the grid: those composed almost totally of subalpine fir, Abies lasiocarpa and those dominated by mountain hemlock, Tsuga mertensiana, with A. lasiocarpa as a subordinate (Plate IV). The undergrowth in the islands was generally sparse, but consisted of grouse huckleberry, Vaccinium scoparium Leiberg, and Valeriana sitchensis.

Appendix II expresses the data after Curtis and McIntosh (1950). The Importance Value (IV) of each species was calculated by adding the density (number of trees/total trees) and the dominance (basal area/ total basal area) of each species. The basal area (BA) is the area of a cross section of the trunk of a tree at breast height (four feet) and was calculated from the circumference of each tree.

Two Engelmann spruces, Picea engelmannii Parry, were within the study area. One individual, in the tree island near station Hd2, was about 20 meters tall and 200 centimeters in circumference, or a BA of 3,215 centimeters. The other was less than breast height, located in the tree island near station Ic1.

Temperature and Weather

Figure 9 illustrates the temperatures taken in the heath meadow and tree island communities. The moderating effect of the tree canopies is clearly shown. Although the temperature in the meadow dropped below freezing several times, the temperature in the island remained above $0^{\circ}C$. On clear days the temperatures in the meadow rose above $30^{\circ}C$ several times, while the island temperatures were considerably lower.

The maximum temperature for each day came at about 3 p.m. (Pacific Daylight Time) in the meadow and anywhere from Noon to 6 p.m. in the island.

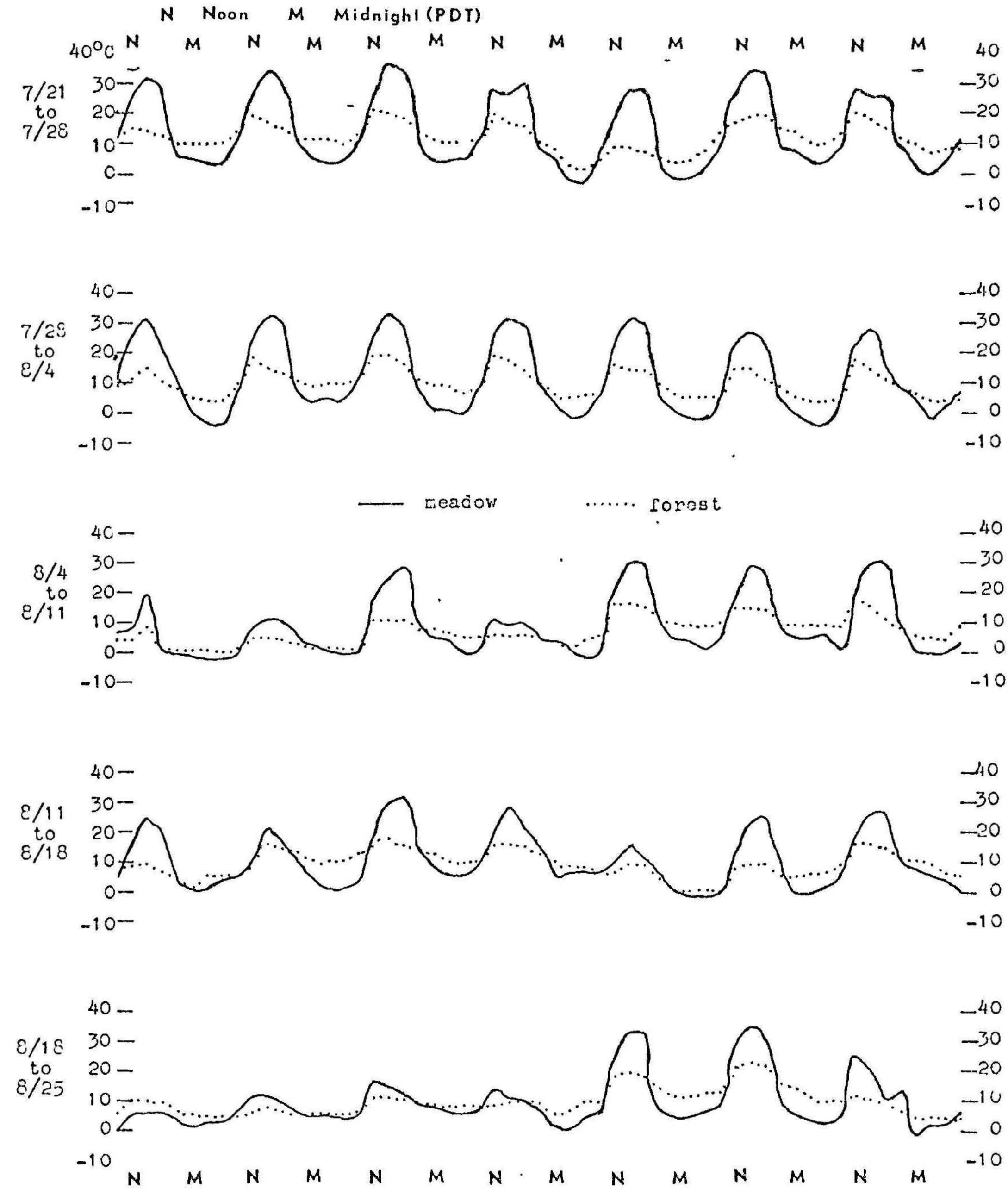
The effects of weather are also shown. On August fourth and fifth about an inch of snow fell, remaining on the ground until the sixth. On August 18th through the 21st there was considerable cloudiness with some rain and snow, followed by a clear and warm August 22nd. These were the only records of precipitation during the study period. The other days were clear and warm with a few scattered clouds.

Cover

Six types of cover were determined in the study area. Table IV lists the cover types and the respective number of trap stations associated with each type.

In Table V the light penetration data for each community is shown. The mean percentage of direct sunlight that penetrated the floor of each community is given along with the standard deviation from that mean.

Figure 9. Meadow and Tree Island Temperatures, July 21 through August 25



Data for the *Carex* community was not presented because of the little cover available. The plants in the *Carex* community were sparsely spaced. Light penetration data for the ecotones, talus slides (Plate VI), and streamside (Plate V, Figure 2) were not gathered due to the variable composition of these cover types.

In comparing the means, using the t-Test, a significant difference was found between the *Valeriana* and the Tree Island communities ($t = 5.0$, 8 d.f.). No significant differences were found when the *Valeriana* and Tree Island communities were compared to the *Phyllodoce-Cassiope* community ($t = 0.1$, $t = 0.1$, respectively, 8 d.f. each).

Significant differences were found when the variances of the *Valeriana* and Tree Island communities were compared to the variance of the *Phyllodoce-Cassiope* community, using the F-Test ($F = 119.3$, $F = 477.0$, respectively, 8 d.f. each). The variances of the *Valeriana* and the Tree Island communities were not significantly different ($F = 4.0$, 8 d.f.).

Cover Associations

The trapping records of each species were analyzed to determine if there were significant preferences or avoidances of particular cover types. Table VI places the capture records of *Eutamias* in a Chi-square Contingency Table.

The total captures of each sex of *E. amoenus* and *E. townsendii* were multiplied by the percentage of the trap stations located in each cover type. The product is the expected number of captures, if the animals were associating randomly with respect to cover types and each

Table IV. Cover Types and the Number of Trap Stations in Each Type

Cover Type	Number of Trap Stations	Percent of Total Stations
Phyllodoce-Cassiope community	90	35.2
Valeriana community	16	6.3
Carex community	14	5.5
Tree Island community	46	18.0
Ecotones	66	25.8
Talus	22	8.6
Streamside	2	0.8
Totals:	256	100.2

Table V. Cover-Community Light Penetration in Percent of Direct Sunlight

Direct sunlight reading (9/1/69): 7,200 foot candles

Communities	N	Mean	Standard Deviation
I *Phyllodoce-Cassiope*	5	9.7	6.9
II *Valeriana*	5	2.5	0.6
III *Carex*	-	no significant cover present	
IV Tree Islands	5	0.9	0.3

other. These are expressed in the parentheses of Table VI. The numbers to the left of these are the actual captures made in each cover type.

To determine if the actual captures were significantly different from the expected captures, the difference of each of these two values was computed through the Chi-square (X^2) formula and added to obtain a value for the entire table. This value was compared to a value obtained from a table of critical values of X^2 (Mendenhall, 1967) at 15 degrees of freedom. The contingency table's value was found to be higher than the critical value. Therefore, there were significant differences from the expected number of captures. The sexes of the chipmunks were not associating randomly with the cover types and/or each other.

The X^2 of each row and column of the contingency table was analyzed to gain information on where the specific differences were occurring. In the case of *Eutamias*, significant differences were found in the tree island and talus cover types, and in the movements of male *E. townsendii*. Therefore, male *E. townsendii* was significantly more abundant in the tree islands and talus slides.

Although significance cannot be established with the other associations, it is realized that a lack of significance may be due to insufficient data. If trapping had continued, perhaps more significant data would have been found. Therefore, it is important to look at trends.

Both species appeared to be abundant in the tree islands. The only exceptions were possibly *E. townsendii* females.

E. townsendii females appeared to be abundant in the talus slides, as were the males. Few E. amoenus males and females were found in the slides.

Both species tended to be not abundant in the Carex communities.

Table VII shows the capture records of the other species of small mammals. The X^2 value for each species is shown.

P. maniculatus and the Gapper red-backed mouse, Clethrionomys gapperi (Vigors), were significantly not associating randomly with the cover types. P. maniculatus was abundant in the talus slides while apparently not associating with the tree islands. C. gapperi was abundant in the tree islands.

Zapus trinotatus and the water rat, Microtus richardsoni (DeKay), were the only animals found at the two streamside stations.

Observations

Chipmunks are active diurnal mammals. During the course of the study their movements were noticed throughout the study area.

The least secretive of the two species of chipmunks was E. amoenus. These alert and curious animals were seen on the ground usually scampering among the tree islands. They were the most vocal of the animals.

E. townsendii was most often noticed in the tree branches where they could be approached within a few feet before being frightened away. Although not as vocal as E. amoenus they would become quite boisterous when confronted as above.

Table VI. Cover Association--*Eutamias*

Chi-square Contingency Table

Null hypothesis (H_o): The sexes of each species associate independently of the cover types and each other.

To reject H_o, the sum of X^2 must be greater than 25.00 at 15 degrees of freedom (d.f.), 11.07 at 5 d.f., and 7.81 at 3 d.f.

Cover Types: I *Phyllodoce*-*Cassiope*, II *Valeriana*, III *Carex*, IV Tree Island, V Ecotones, VI Talus.

Numbers in parentheses are the expected captures, if the animals associated randomly (H_o).

Numbers not in parentheses are the actual captures.

	Cover Types						
Species	I	II	III	IV	V	VI	X^2 (5 d.f.)
Eutamias amoenus							
male	12(11)	3(2)	0(2)	10(6)	6(8)	1(3)	6.43
female	19(18)	1(3)	1(3)	12(9)	16(13)	3(5)	5.21
Eutamias townsendii							
male	18(22)	0(4)	0(3)	18(11)	16(16)	11(6)	16.35
female	7(6)	1(1)	1(1)	3(3)	1(5)	5(2)	9.37
X^2 (3 d.f.)	2.54	5.83	6.33	8.12	4.39	10.80	37.36 (15 d.f.)

When approached in the open, both species were quick to run to a tree island or other suitable cover. When in flight, E. amoenus was quite loud in vocalizations, usually stopping inside the island to continue the protest. E. townsendii, in flight, was silent and once under cover, never seen or heard.

Citellus saturatus was seen on occasion in the heath meadow. These animals were as large or larger than the capacity of the Sherman trap; therefore, it is believed that many of these animals that lived in the study area were not captured. It is possible that Citellus was responsible for the dismantling of several Sherman traps found in the heath meadow and talus slides.

The pika, Ochotona princeps (Richardson), was observed or heard many times in the talus slides. It has been the experience of the investigator that these animals will not go to Sherman traps, baited with grain.

The hoary marmot, Marmota caligata Howell, is a large resident of this life-zone. The dens of these animals were found in the heath and talus slopes just above the study area to the south. They foraged diurnally, associating with all meadow communities. None were seen in the tree islands. Although seemingly unafraid of man, they were quick to whistle a warning and take cover when hawks were in the air.

Predators

From the observation post on Sourdough ridge many sightings of predators were noted in or about the study area. Most of those observed were hawks.

Table VII. Cover Association--Other Than *Eutamias*

Cover Types: I *Phyllodoce-Cassiope*, II *Valeriana*, III *Carex*, IV Tree Island, V Ecotones, VI Talus.
Numbers in parentheses are the expected captures, if the animals associated randomly (H_o).
Numbers not in parentheses are the actual captures.
X^2 = Chi-square values at 5 degrees of freedom. At 95 percent confidence X^2 must be greater than 11.07 to reject H_o.

	Cover Types						
Species	I	II	III	IV	V	VI	X^2
Peromyscus maniculatus	4(4)	0(1)	0(1)	0(2)	2(3)	4(1)	<u>13.33</u>
Citellus saturatus	2(3)	0(1)	0(0)	1(1)	3(2)	2(1)	2.83
Clethrionomys gapperi	2(3)	0(1)	0(0)	7(2)	0(2)	0(1)	<u>16.83</u>
Microtus oregoni and/or *Phenacomys intermedius*	2(2)	0(0)	0(0)	2(1)	2(2)	0(1)	2.00
Sorex cinereus	1(2)	0(0)	0(0)	2(1)	2(1)	0(0)	2.50
Zapus trinotatus	0(1)	0(0)	0(0)	3(1)	0(1)	1(0) stream	6.00
Microtus richardsoni	0(1)	2(0)	0(0)	0(1)	0(1)	1(0) stream	8.00

The red-tailed hawk, Buteo borealis Cassin, was observed several times. There appeared to be one pair foraging in the area. They soared high above the open slopes and meadows, occasionally dropping into the forest zone of the creek drainage. Their distinctive calls were heard moving in the forest, while the hawks at times remained unseen.

Two pairs of rough-legged hawks, Buteo lagopus (Gmelin), were observed on July 22, soaring high above the ridges. Each pair foraged as a team. Occasionally one individual would remain high in the air, soaring on the updrafts, while the other would swoop down at a high speed stopping inches from the ground, then skimming down the slope. The bird would then return to its partner in the air. Several times an individual was seen hovering, with beating wings, over a fixed spot on the ground. Sometimes a swoop would follow this behavior.

On the morning of July 29, a coyote, Canis latrans Say, was observed moving through the study area. It crossed Huckleberry Creek heading north out of the grid and was last seen on the southeast slope of McNeely Peak.

Many predators were probably not observed because of their secretive habits. On returning to the study area in October, tracks of marten, Martes americana (Merriam); ermine, Mustela erminea Linnaeus; and red fox, Vulpes fulva Merriam, were seen in the six inches of snow. At that time the chipmunks were still quite active among the tree islands.

DISCUSSION

To understand the animal ecology of an area it is necessary to know something about that area's environment and resultant plant synecology. Plant communities not only provide food and cover for animals, they also reflect the long-term environmental factors affecting both plant and animal.

The Subalpine Environment

The Hudsonian life-zone of Mount Rainier ranges from about 4,500 feet to nearly 7,000 feet in elevation. The lower limit of the zone is generally defined as where mountain hemlock, *Tsuga mertensiana*, replaces silver fir, *Abies amabilis* (Dougl.) Forbes, as the dominant species of the climax forest. The upper limit is determined as timberline.

Timberline on Mount Rainier was set at 6,500 feet by Taylor (1922). Franklin and Dyrness (1969), however, distinguished three types of timberline: "forest line," the upper limit of the contiguous closed forest; "tree line," the upper limit of erect tree growth; and "scrub line," the upper limit of krummholz trees. He considered timberline to be the broad region between forest line and scrub line. On Mount Rainier he found forest line at about 5,200 feet (1,580 meters) and scrub line at about 6,900 feet (2,100 meters) in elevation.

This ecotone between the closed forest of the lower Hudsonian and the treeless alpine tundra is defined here as the "subalpine zone." The author has observed that the mammalian fauna described by Taylor and Shaw (1927) as endemic to the Hudsonian zone is in fact endemic to that zone's timberline region and not to the closed forest of the lower Hudsonian. The fauna of the lower Hudsonian is believed to be continuous with the fauna of the Canadian and Transition zones. Therefore, from an animal ecologist's viewpoint, the timberline region is separated from the lower Hudsonian.

The subalpine is an environmental tension zone (Franklin and Dyrness, 1969). Temperature and moisture are the chief limiting factors which act through the combination of heavy snows, long winters, and short growing seasons to limit the advancement of stabilized tree communities (Griggs, 1946).

Formozov (1946) observed that snow cover has an unequal distribution in mountainous regions. Air masses rising along mountain slopes expand and cool, precipitating moisture that can no longer be carried. This causes snowfall to increase directly with increasing altitude, up to a point (Formozov, 1946).

The effects of slope, exposure, and wind maintain large quantities of snow in some areas and none in others. In general, slopes of northern exposure support larger snow masses than slopes of southern exposure. Formozov (1946) found that snow depth on southern slopes is, to a certain extent, inversely proportional to the steepness of slope. On northern slopes he observed that snow depth is, within limits, directly proportional to the steepness of the slope. Wind transports snow from ridges into valleys and from windward to leeward slopes.

These differences in snow depth change the length of the growing season from one area to another. In the Cascades, the author has observed that northern slopes may be as much as two to three weeks later than southern slopes in snow melt. With the large snowfall common to the Cascades, this delay can be critical. Huckleberry Park is a subalpine parkland on a northern slope. High peaks dominate the landscape, preventing direct sunlight from reaching the area until mid-morning in the summer and not at all in winter, due to the low angle of the sun in the south. The growing season in 1969 was at most 10 weeks long.

The steep (about 40 degree) northern slope, coming down from Sourdough Ridge, maintains a large snowbank during the winter. On occasion this bank releases large and small avalanches. The investigator, on snowshoeing to the crest of the ridge in December of 1968 and 1969, noticed several large avalanche tracks. These tracks originated near the summit of the ridge and ended in the open areas of the parkland. Avalanches are strong factors limiting tree growth in high mountains (Formozov, 1946). Those areas supporting tree islands are relatively snow free and not under constant avalanche threat, as are many of the meadow areas near the steep and unobstructed slopes.

The subalpine environment is not static. As climatic conditions change, there is a continual alternation between meadow invasion by the forest and reclamation by the meadows. Franklin and Mitchell (1967) described meadow invasions in the timberline region of the Cascade Range. He attributed the initiation of new tree islands to *Abies lasiocarpa* and *Pinus albicaulus*. The results from Huckleberry Park agree with Franklin's findings; i.e., *A. lasiocarpa* and *P. albicaulus* were the only trees found in meadow communities.

Once established in the meadow, young pioneering trees exert an increasing influence on the microclimate. Through the blackbody effect--described by Swedberg (Franklin and Mitchell, 1967)--these trees cause an early snowmelt and thus lengthen the growing season. Less pioneering species are then able to establish themselves in the island, e.g., *Tsuga mertensiana*.

If it were not for the changing environmental factors, meadow invasion would be complete, with the timberline ecotone becoming narrow (Daubenmire, 1968). Franklin (1966b) found evidence of meadow invasions in the Sunrise and Paradise parklands of Mount Rainier and attributed them to a past climatic shift. He did not find evidence of recent invasions, however, suggesting a reversal of that shift. Without continuing invasions, the disruptive factors of avalanche, rockfall, and fire will return some of the forest to meadow.

These forest invasions and retreats on the alpine meadow have produced a mosaic of plant communities. Interspersed meadow and tree island communities offer the mobile inhabitants of the subalpine a variety of food and cover.

The food variety in the meadow communities is great. In June plants follow the retreating snowbanks, fostering a myriad of spring flowers. These flowers are probably an early food source for the small mammals.

The retreating snow also reveals the subnivean tunneling activities of the microtines (Plate I, Figure 2) and pocket gophers, Thomomys talpoides (Richardson). These animals forage during the winter on roots and seeds left from the previous summer (Ingles, 1965).

Through July and August, the ever-changing series of flowers paint the meadows in many beautiful colors. Eutamias, Citellus, and Marmota can be observed foraging on these flowers during the day.

By September, most of the plants have gone to seed. Eutamias has been observed gathering these seeds presumably for its winter stores. Vaccinium deliciosum and V. scoparium produce berries in quantity. It is not uncommon at this time of the year to find a black bear, Ursus americanus Pallas, feeding in the subalpine zone of the huckleberries.

In the tree islands, fir and pine nuts are probably the main source of food. Cones stripped of their seed by either Eutamias or Citellus were found scattered in and about the tree islands.

Cover

The cover and food of a habitat cannot be separated; one is a part of the other. The vegetation that provides cover also provides the primary food source in the food chain. Herbivores use cover for concealment and forage. Elton (1939) observed that herbivores on occasion eat too much of their cover, exposing themselves to increased predation.

Predators also use cover to provide themselves with food. Cover conceals the predator's presence and/or behavior while it stalks its prey.

This combination of predator-prey use of cover involves complex behavioral adaptations on the part of both predator and prey. Wecker

(1964) found that habitat selection by Peromyscus maniculatus is dependent on both inherited and learned factors concerning the nature of the habitat's cover. Inherited behavioral patterns, allowing a young individual to adjust to the population's habitat, are selected over behavioral patterns in which the individual must totally acquire the proper habitat behavior. On the basis of this general inherited behavior, the individual learns and builds further behavioral patterns that reinforce its selection of habitat.

"Cover" is a term that describes the habitat characteristics used by the inhabitants to minimize their detection by other animals. Some of these characteristics are: topography, vegetational density and pattern, and light penetration. In this study, light penetration was used as an index of cover. This is an important factor because visual perception of the animal and its habitat is dependent on it.

From the light penetration and temperature data (Table V and Figure 9) it is shown that the tree islands offered the most dense and least variable cover. The tree canopies all but eliminated direct sunlight. Most of the light that did penetrate was considered to be reflected light from the surrounding areas. This low light intensity, coupled with the insulative effect of the tree canopies, moderated the temperature.

The least cover was offered by the Carex community. This corresponded to the low number of small mammal captures associated with the community.

The heath community offered a low and highly variable amount of cover. *Vaccinium* grows in high densities, however, providing an abundant food source of flowers and huckleberries.

The *Valeriana* community offered a constant cover. The plant species variety in this community was second only to that of the heath suggesting a high food variety.

The talus slides have a different type of cover that is difficult to assess. In this jumble of boulders, animals use the labyrinth of connected spaces between the rocks as cover, However, these animals must come out of the safety of the talus to forage. Therefore, those small mammals associated with the talus slides are dependent upon other cover types for safety while foraging.

The cover available to the fauna of the subalpine is diverse. It is believed that this diversity, coupled with the food variety suggested by the numerous plant species, maintains the large number of small mammal species.

The Small Mammal Community

Because of their secretive habits, it is difficult to work with small mammals. A method developed to study the ecology of small mammals is the analysis of home range. Burt (1943) defined "home range" as the area traveled by an individual in its normal activities of food gathering, mating, and caring of young. It is not a definite area. It changes with the availability of food, population density, cover, and territoriality of the species. Therefore, the measurement of home range should not be used so much as a defining characteristic of the species as it should an index to the many factors influencing the individual animal.

Several methods have been developed to analyze home range (Hayne, 1949; Stickel, 1954). The most popular method is the live-trap, mark, release, and recapture of individuals. This is done using a trap grid, with a known distance between each trap station. After successive recaptures of an individual, it is possible to gain some knowledge of the animal's home range.

One problem inherent in grid trapping is that traps near an individual's nest interfere with the longer movements of the animal. Brant (1962) alleviated this problem by rotating the traps about the grid in such a way that long and short distant movements by the animal could be recorded without disturbing the uniformity of the trapping effort. A modification of Brant's method was used in this study.

Eutamias

The two species of chipmunks found in the subalpine of the Washington Cascades, *E. amoenus* and *E. townsendii*, apparently live sympatrically. Dalquest (1948) explained the appearance of these two species in the same habitat on the basis of *E. townsendii* being attracted out of the forest into the habitat of *E. amoenus* to forage on huckleberries. The data from this study suggest that huckleberries are not all that is involved.

From their ranges (Hall and Kelson, 1959) it can be interpreted that *E. amoenus* and *E. townsendii* developed from two different faunas. According to Dalquest (1948), *E. townsendii* developed from a Pacific coast stock that was prevented from emigrating to the north and east during the Pleistocene by ice sheets coming down from the north. At this time, E. amoenus moved southward from Canada ahead of the advancing ice. This species, among other taigan forms, found refuge from the deserts and plains of the Columbian Plateau in the southern Cascade Mountains. As the ice retreated, E. amoenus followed the Cascades into the north and met E. townsendii immigrating from the coast.

Gause state in 1934 (Odum, 1959) that two species could not occupy the same niche. If two similar species occupy the same habitat, they either use different food, are active at different times, or in some other way occupy different niches. The two subspecies, E. amoenus ludibundus and E. townsendii cooperi, that associated with the subalpine habitat, apparently occupied niches that minimized the competition between them.

The home range maps (Figures 4, 5, 6, and 7) show that there was considerable overlap of activity between the two species. Individuals of both species were observed foraging next to each other. On checking the two traps at a station, it was not uncommon to find one trap containing E. amoenus and the other E. townsendii.

Broadbooks (1949), in his study of E. amoenus on the east slope of the Cascades, found little territorial behavior. Territory is the area actively defended by an individual from intrusions by other members of the same or other species, and thus differs from home range (Burt, 1949). The home ranges determined by Broadbooks overlapped extensively. The only cases of territoriality he observed were lactating females defending the immediate areas around their nests.

This territorial tendency among the females may be evident, to a certain extent, in Figures 5 and 7. _E. townsendii_ females, with the exception of E25, established their home ranges in the southeast corner of the grid, where _E. amoenus_ females did not occur. Overlap of the _E. townsendii_ ranges was minimal. It is curious that the only lactating female found was an _E. townsendii_ (E25) whose home range was far from the ranges of the other _E. townsendii_ females.

Broadbooks (1949) listed the following factors affecting an individual chipmunk's home range: 1) protective cover, 2) location of food plants, and 3) desirable travel routes. The cover association data from Huckleberry Park tend to separate the two species by these factors.

Both species used the tree islands extensively. This was most likely due to the high cover value, which also provided safe avenues of travel to foraging areas.

E. townsendii, being more abundant in the talus slides, and _E. amoenus_, apparently being repelled from these slides, offers a factor to explain how the niches of these species are separated. _E. townsendii_ used the talus slides for cover and perhaps nest sites. From these slides it traveled into the tree islands and meadows to forage alongside _E. amoenus_. If _E. townsendii_ does nest in these slides, _E. amoenus_ may have been excluded from this limited, but secure, cover type through competition for nesting space.

Food does not appear to be a limiting factor in this interspecific competition. More work, however, needs to be done on the feeding habits of these two species.

It is interesting to note that no immature chipmunks were captured during the study. Broadbooks (1949) found E. amoenus populations rising sharply in June and July when the young began to appear from the nests. This rise peaked in July and August, dropping to zero in the fall when the chipmunks went into their burrows for the winter.

Only one lactating female (E. townsendii, E25) was found in Huckleberry Park, on August 11. All of the males captured of both species had large scrotal testes in July and August. This, combined with the total lack of immatures, suggests that the majority of females were not breeding.

The phenomenon was not restricted to Eutamias. Only two immatures (Microtus richardsoni and M. oregoni or Phenacomys intermedius) were captured during the entire study.

The winter of 1968-69 was one of unusually heavy snowfall. Perhaps, due to factors related to the snow depth, breeding was in some way inhibited. It is obvious that more information about the winter and breeding biology of these forms is needed.

Peromyscus maniculatus

The deer mouse population was low compared to populations the investigator has examined in lower elevations. Brown (1967) found, in the Medicine Bow mountains of Wyoming, that the P. maniculatus populations decreased with increased altitude.

The cover association data from Huckleberry Park show that Peromyscus was more abundant in the talus slides, while apparently not associating with the tree islands. Dalquest (1948) described the subspecies *P. m. oreas* Bangs, that inhabits the Cascades, as being partially arboreal. If this is the case, then in the subalpine, these mice have apparently adapted to a different niche. Perhaps they cannot compete with other forms in this zone. Further information is needed on the ecology of these mice in this environment.

Clethrionomys gapperi

The red-backed mouse in Huckleberry Park demonstrated a strong association to tree islands. This mouse was captured at stations near downed logs that were probably used as cover for runways. Since these mice do not make their own runways (Dalquest, 1948), they probably follow the runways of *Microtus oregoni* and *Phenacomys intermedius*. Dalquest (1948) found this mouse in several habitats. Perhaps it is limited to the tree islands in the subalpine through competition for cover with *Peromyscus*. Again, further information is needed.

Microtus oregoni

Since this species is difficult to distinguish from *Phenacomys intermedius* in the field, nothing significant can be stated. However, after handling these mice, the investigator believes that the captures in the tree islands and tree ecotones were *M. oregoni*. This mouse was very timid and as soon as released was quick to find refuge in the undergrowth of the trees.

Phenacomys intermedius

The author believes that two captures of this vole were made in the heath. These two animals were less timid and did not appear to be concerned with escape behavior when released. One individual remained at the spot where it had been released and proceeded to feed on *Cassiope* flowers.

This vole is endemic to the alpine and subalpine zones (Dalquest, 1948). Its fecal deposits, winter subnivean surface nests, and runways were quite evident in the heather of Huckleberry Park, suggesting that they were more abundant than the trapping record revealed. Brown (1967) found them in low numbers in the Medicine Bow mountains and found no preference for proximity to water or ground cover density. This is a very interesting animal, whose ecology is not well known.

Microtus richardsoni

The water rat is the largest microtine in Washington (Dalquest, 1948). Like *Phenacomys* it is endemic to the alpine and subalpine zones. It is closely associated with streams and therefore was only captured near Huckleberry Creek. It constructs numerous runways in and about the stream channel. Racey (1960) observed that it constructed runways into nearby meadow areas from streams in British Columbia. Although no runways were observed leaving the stream channel of Huckleberry Creek, an immature was caught 25 meters from the creek in a *Valeriana* community.

Zapus trinotatus

The jumping mouse was caught only in the northwest section of the grid, apparently associated with the creek. Svihla and Svihla (1933) and Brown (1967) found the mouse preferred sites adjacent to water and having dense ground cover. This would explain the apparent association, although not significant, with the tree islands near Huckleberry Creek.

Citellus saturatus

Citellus was observed more than captured. This diurnal squirrel apparently associates with the meadow communities. Gordon (1943), Broadbooks (1949), Tevis (1952, 1953), Clark (1965), and Cameron (1967) described the competition, both indirect and direct, between _Citellus_ and _Eutamias_. _Citellus_ carnivorous behavior was not observed in Huckleberry Park. Competition for plant food probably does occur, although it is felt that the niches are sufficiently separated, at least cover-wise, to provide sufficient space in the habitat for both of them.

Sorex cinereus

The cinereous shrew, _Sorex cinereus_ Kerr, was the only shrew found in Huckleberry Park. Four of the five captured were dead in the trap, so that positive identification, via skull analysis, was made. Little is known about this shrew's biology.

Predation

Hawks are probably the most efficient predators in the subalpine. Craighead and Craighead (1950) observed the efficiency of these predators on small mammal populations in Michigan and Wyoming. Using height as cover, they are capable of surprising many an unwary prey, which has left the protective cover of a tree island, talus slope, or burrow.

The mammalian predators, using vegetative and topographic cover to forage, are difficult to study. Like the hawks, they are at the top of the food chain and must forage over a large area to obtain enough food. Most of them are not confined to the subalpine, ranging into the lower zones in the winter to follow the non-hibernating herbivores and escape the winter snows (Formozov, 1946).

A few *Martes americana* and *Vulpes fulva* spend the winters in the subalpine. In December of 1968 and 1969, the author observed the tracks of these two carnivores in the seven feet of snow at Yakima Park, Mount Rainier National Park. *Martes* tracks were observed going from tree island to tree island. It is believed that they were seeking entrances into the subnivean tunnels of the non-hibernating cricetids.

SUMMARY

During the summer of 1969 a small mammal ecology study was conducted in Huckleberry Park, in the subalpine life-zone of Mount Rainier National Park, Washington. The study emphasized the relationship of each species to the cover available in each habitat type. A grid live-trap system was used to determine the home range and cover association of each species.

The home ranges of *Eutamias amoenus* and *Eutamias townsendii* overlapped extensively. *E. townsendii* males, however, were abundant in the talus slides, while *E. amoenus* apparently avoided the slides, suggesting competition over cover. Both species were abundant in the tree islands which were probably used as avenues of travel to foraging areas.

There was an unusual lack of immature small mammals. This may have been related to the unusually heavy snowfall of the previous winter.

Peromyscus maniculatus was abundant in the talus slides and apparently avoided the tree islands. *Clethrionomys gapperi* was found associated with the tree islands. *Microtus richardsoni* and *Zapus trinotatus* appeared to be associated with Huckleberry Creek. *Citellus saturatus* was apparently associated with the meadow communities. *Sorex cinereus* was the only shrew found in the area.

Several predator species were noticed in the area during the summer. Evidence for the presence of *Martes americana* and *Vulpes fulva* was found during the winter.

CONCLUSION

The subalpine life-zone is a dynamic environmental tension zone. In this isolated region the most extreme limiting factors exist that still allow life to survive. Here, the growing season is compressed into three months. In that time each species of plant and animal must compete for food and leave offspring so that its population will survive the long winter. This study has attempted to show how some of the inhabitants relate their movements to the cover available in the tree island-meadow mosaic of this zone. By relating to different types of cover several species are able to live sympatrically, utilizing similar food sources. Further study is needed in this interesting life-zone to gain insight into the biology of forms living near the limits of a life-sustaining environment.

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APPENDIX

APPENDIX I

Meadow Plant List

A: Species composition of a *Phyllodoce empetriformis*-*Cassiope mertensiana* community at plot location Nb1 to Nb2 + 10 meters.

Species	Percent Coverage	Percent Frequency
Cassiope mertensiana (Bong.) G. Don	36.7	88
Vaccinium deliciosum Piper	16.3	88
Antennaria alpina (L.) Gaertn.	3.6	64
Pedicularis bracteosa Benth.	3.5	40
Luzula glabrata (Hoppe) Desv.	2.7	48
Moss sp.	2.6	8
Veronica cusickii Gray	2.5	60
Aster alpigenus (T.&G.) Gray	2.3	32
Castilleja oreopola Greenm.	1.9	36
Carex nigricans C.A. Mey.	0.8	12
Lupinus latifolius Agardh	0.8	12
Polygonum bistortoides Pursh	0.8	12
Ligusticum grayi Coult. & Rose	0.5	20
Potentilla flabellifolia Hook. ex T.&G.	0.4	16

Abies lasiocarpa (Hook.) Nutt.	0.4	16
Pedicularis groenlandica Retz	0.2	8
Phyllodoce empetriformis (S.W.) D. Don	0.1	4
Arnica latifolia	0.1	4

B: Species composition of a *Valeriana sitchensis* community at plot location Aa3 to Ed2 + 10 meters.

Species	Percent Coverage	Percent Frequency
Lupinus latifolius Agardh	21.2	100
Veronica cusickii Gray	14.5	92
Polygonum bistortoides Pursh	9.1	76
Luzula glabrata (Hoppe) Desv.	8.2	64
Potentilla flabellifolia Hook. ex T.&G.	6.4	60
Anemone occidentalis Wats.	5.3	36
Grass sp.	4.3	20
Vaccinium deliciosum Piper	3.9	20
Valeriana sitchensis Bong.	2.9	20
Carex nigricans C.A. Mey.	2.7	28
Castilleja oreopola Greenm.	2.3	32
Microseris alpestris (Gray) Q. Jones	1.4	12
Antennaria alpina (L.) Gaertn.	0.5	20

Ligusticum grayi Coult. & Rose	0.1	4

C: Species composition of a *Carex nigricans* community at plot location Nd1 to Nd3 + 10 meters.

Species	Percent Coverage	Percent Frequency
Moss sp.	21.2	76
Carex nigricans C.A. Mey.	20.2	80
Aster alpigenus (T.&G.) Gray	2.6	48
Luetkea pectinata (Pursh) Kuntze	2.2	12
Veronica cusickii Gray	2.0	40
Grass sp.	1.6	24
Cassiope mertensiana (Bong.) G. Don	1.4	16
Potentilla flabellifolia Hook. ex T.&G.	0.8	12
Vaccinium deliciosum Piper	0.7	28
Antennaria alpina (L.) Gaertn.	0.7	28
Microseris alpestrus (Gray) Q. Jones	0.5	20
Castilleja oreopola Greenm.	0.1	4

APPENDIX II

Tree Island Species Composition of Sector P

( ) - Number of trees less than 4 feet high
Den. - Density = number of species trees/total trees
BA - Basal Area
Dom. - Dominance = BA of species/total BA
I.V. - Importance Value = Density + Dominance

A: Island Pdl. Area = 167 m^2.

Species	No.	Den.	Total BA	Dom.	I.V.
Tsuga mertensiana	28(9)	.37	15,982 cm^2	.62	.99
Abies lasiocarpa	44(33)	.59	6,100	.24	.83
Pinus albicaulus	3	.04	3,657	.14	.18
Totals:	75	1.00	25,739 cm^2	1.00	2.00

B: Island Pbl. Area = 65 m^2.

Species	No.	Den.	Total BA	Dom.	I.V.
Abies lasiocarpa	23(14)	1.00	10,465 cm^2	1.00	2.00

PLATES

Plate I

Figure 1: Study site, Huckleberry Park, MRNP, in late June; looking northeast from Sourdough Ridge; base of Antlers Peak in background.

Figure 2: Microtine subnivean runway, exposed by snowmelt in June, Huckleberry Park.

Plate I

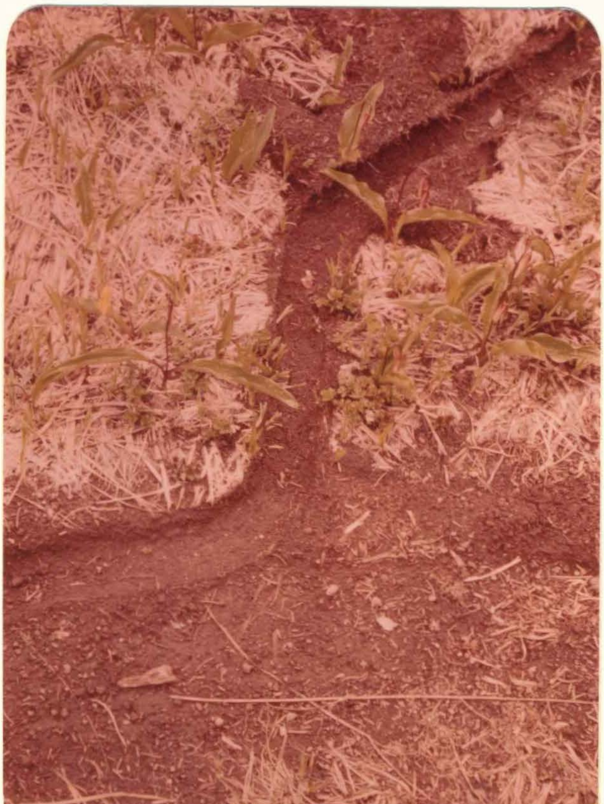

Plate II

Figure 1: Heather, Phyllodoce-Cassiope, community at station Nb4. (Ice axe 3 feet in height).

Figure 2: Heather community and talus at station Oa4.

Plate II

Plate III

Figure 1: *Valeriana* community at station Aa3.

Figure 2: *Carex* community in pumice rubble basin, about sectors J and N.

Plate III

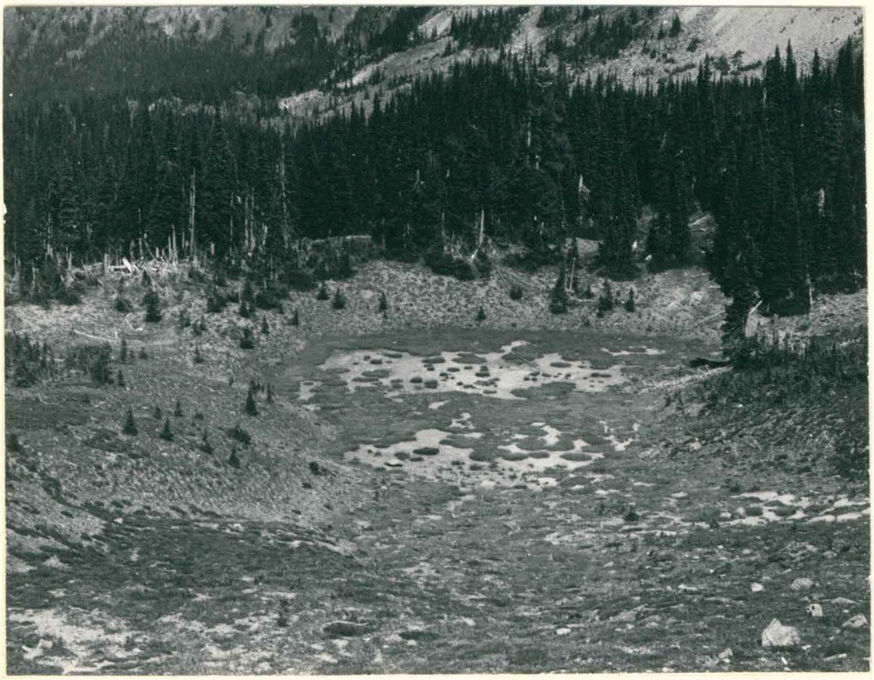

Plate IV

Figure 1: *Abies lasiocarpa* tree island near station Pb1.

Figure 2: Mixed tree island near station Pd1.

Plate IV

Plate V

Figure 1: Lone Pinus albicaulus in heath community near station Ob1.

Figure 2: Huckleberry Creek near streamside station Ad4.

Plate V

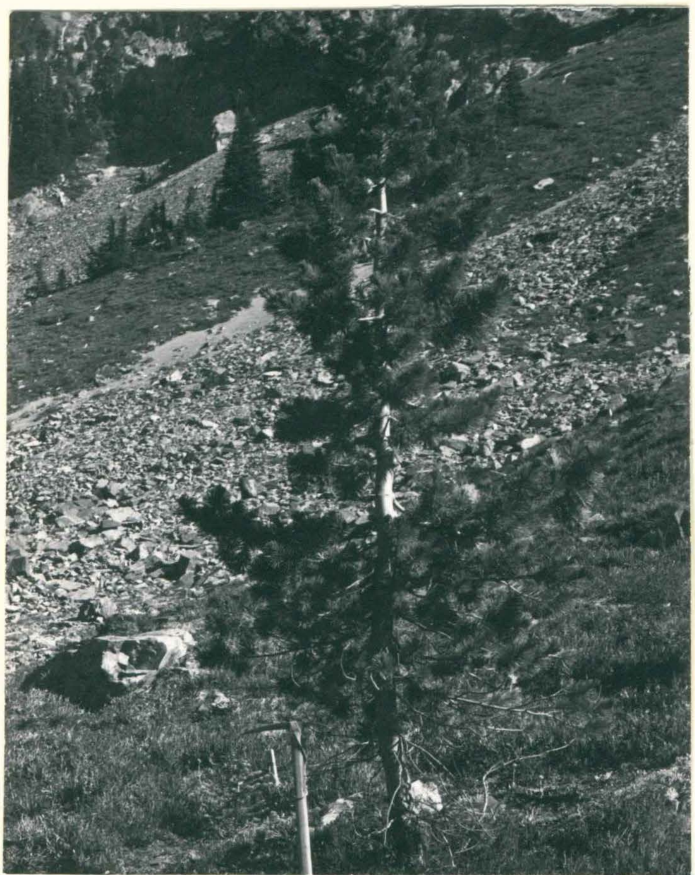

Plate VI

Talus slide, station Pa3.

Plate VI