Small mammal diversity and abundance in Douglas fir old growth forests
by Patricia Catherine Cramer

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Biological Sciences
Montana State University
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Abstract:
Small mammal diversity and abundance was compared between two Douglas fir (Pseudotsuqa menziesii) old growth stands, which differed in structural complexity. The study was conducted in the Hyalite drainage of the Gallatin National Forest, 35 kilometers south of Bozeman, Montana, in the Lick Creek and History Rock Creek drainages. The forest stands were similar in elevation, slope, precipitation, tree species composition and ages of trees, but differed in soil types and aspects. They differed significantly in the amount of downed woody debris, and downed logs 7.6 cm and greater in diameter. The two stands were not significantly different in the number of canopy layers, mean ground vegetation heights, and duff depths. Small mammals were live-trapped and after 7,200 trap-nights, 508 animals were captured a total of 1,105 times. Significantly more total animals were trapped in the more complex forest, History Rock. There were significantly more red-backed voles (Clethrionomys gapperi) in the History Rock stand, and significantly more deer mice (Peromvscus maniculatus) in the simpler stand, Lick Creek. The Shannon Diversity Index was applied to these trapping results, and the Lick Creek stand ranked significantly greater in species diversity than did the History Rock site, in spite of the greater number of individuals and species in History Rock. Significantly greater numbers of snowshoe hare (Lepus americanus) pellets were found in the History Rock stand, but no significant differences were found in numbers of red squirrels (Tamiasciurus hudsonicus) or northern pocket gophers (Thomomvs talppides) between the two stands.

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date April 23, 1992

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ABSTRACT

Small mammal diversity and abundance was compared between two Douglas fir (Pseudotsuga menziesii) old growth stands, which differed in structural complexity. The study was conducted in the Hyalite drainage of the Gallatin National Forest, 35 kilometers south of Bozeman, Montana, in the Lick Creek and History Rock Creek drainages. The forest stands were similar in elevation, slope, precipitation, tree species composition and ages of trees, but differed in soil types and aspects. They differed significantly in the amount of downed woody debris, and downed logs 7.6 cm and greater in diameter. The two stands were not significantly different in the number of canopy layers, mean ground vegetation heights, and duff depths. Small mammals were live-trapped and after 7,200 trap-nights, 508 animals were captured a total of 1,105 times. Significantly more total animals were trapped in the more complex forest, History Rock. There were significantly more red-backed voles (Clethrionomys gapperi) in the History Rock stand, and significantly more deer mice (Peromyscus maniculatus) in the simpler stand, Lick Creek. The Shannon Diversity Index was applied to these trapping results, and the Lick Creek stand ranked significantly greater in species diversity than did the History Rock site, in spite of the greater number of individuals and species in History Rock. Significantly greater numbers of snowshoe hare (Lepus americanus) pellets were found in the History Rock stand, but no significant differences were found in numbers of red squirrels (Tamiasciurus hudsonicus) or northern pocket gophers (Thomomys talpoides) between the two stands.

INTRODUCTION

Although there is a wealth of scientific information regarding old growth forests of the Pacific Northwest in the United States, (Bull and Meslow 1977, Cline et al. 1980, Forsman 1980, Franklin et al. 1981, Greene 1988, Gunther et al. 1983, Harris 1984, Mannan et al. 1980, Maser et al. 1978, Maser et al. 1979, Meslow and Wight 1975, Reynolds et al. 1982), there is a limited amount of research that has been conducted in Montana's old growth forests and, in particular, in these forests east of the continental divide. As a result, Montanan U.S. Forest Service biologists and managers find themselves applying scientific data gathered in other areas of the country to this area. An additional problem in these old growth forests is the requirement to manage for management indicator species (MIS). The National Forest Management Act (NFMA) of 1976 mandates that each National Forest select management indicator species to assist in estimating the effects of their Forest Plan, as well as to maintain and improve the habitats of these species (36 CFR 219.19). There are four categories of these management indicator species: 1) endangered species, 2) special needs species, 3) hunted species, and 4) ecological indicators. The fourth category is chosen because their population changes are "believed to indicate the effect of management activities on other species

of selected major biological communities" (36 CFR 219.19 [a][1], Warren 1990). These ecological indicator species have large home ranges and are closely associated with a particular habitat, such as old growth, where they may be used by managers to monitor the particular habitat. Most of the national forests in the U.S. Forest Service Northern Region, including the Gallatin, have chosen the pine marten (Martes americana) as a ecological management indicator species for old growth forests. A key reason for selecting the marten is that the minimum habitat area per pair is thought to range from 2.6 km^2 (Allen 1984) to about 7.7 km^2 in the northern Rocky Mountains (Warren 1990). Thus, preserving an area capable of supporting pine martens, should preserve the habitat of many other species dependent on old growth conditions.

Research has shown strong correlations between the presence of pine marten and three prey species: red-backed voles (Clethrionomys gapperi), meadow voles (Microtus pennsylvanicus), and red squirrels (Tamiasciurus hudsonicus) (Allen 1984, Buskirk 1984, Clark et al. 1987, Cowan and Mackay 1950, Douglass et al. 1983, Koehler and Hornocker 1977, Koehler et al. 1990, Lensink et al. 1955, Soutiere 1979, Weckwerth and Hawley 1962). The red-backed vole is a known preferred prey species of the marten, and red squirrel middens are known to provide winter resting sites for the marten (Buskirk 1984, 1989). Red squirrels, along with snowshoe

hares (Lepus americanus) and northern flying squirrels (Glaucomys sabrinus) are secondary prey species of marten (Allen 1984, Buskirk 1984, Clark et al. 1987, Marshall 1946, Raine 1986).

Understanding the relationships of these small mammal prey species to the structure of the old growth forests in Montana can assist biologists in making educated decisions regarding preservation of habitat for the pine marten and, at the same time, perhaps better manage old growth forest communities. The purpose of this study was to compare small mammal diversity and abundance with the vegetative and structural characteristics of two old growth Douglas fir (Pseudotsuga menziesii) stands. My objective was to determine the influence of these structural characteristics of the forest on the abundance and diversity of small mammals. Through live-trapping and survey techniques, this research was conducted during the summers of 1990 and 1991.

STUDY AREA

This study was conducted in the Hyalite drainage of the Gallatin National Forest within the Gallatin Mountain Range, approximately 35 km south of Bozeman, Montana, (Fig. 1). The Hyalite drainage was selected because numerous previous analyses of the area conducted by the U.S. Forest Service created a large data base which facilitated the selection of study stands. The Lick Creek and History Rock areas were selected because of their consistent slopes, elevations, tree compositions, sizes of continuous forest, ages of trees and accessibility. Two specific old growth Douglas fir stands were studied. One stand is on a dry, southwest-facing slope in the Lick Creek drainage and is the lesser complex of the two old growth forests. This stand is on a northwest- to southeast-trending ridge of about 80 hectares of continuous old growth forest. The second stand is across the Hyalite reservoir road, in the History Rock Creek drainage. This stand is on a south- to southeast- facing slope and is slightly more moist than the Lick Creek site. The stand in the History Rock drainage is along an east-to-west trending ridge of more than 120 continuous hectares of old growth Douglas fir. The study sites in both areas lie between 2072 and 2195 meters in elevation. The slopes of both areas were predominantly 40 to 60%.

Three study plots were placed within each stand for a total of six. The study plots were designated History A, History B, History C, Lick A, Lick B, and Lick C.

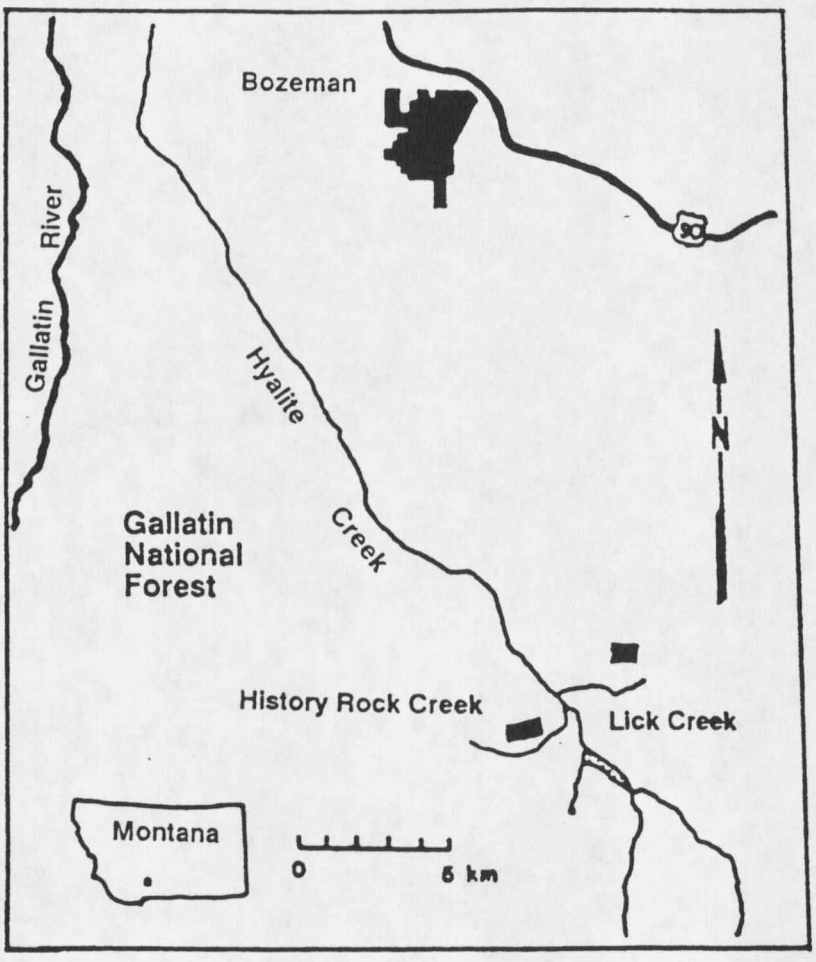


Figure 1. The study areas stands, near Lick Creek and History Rock Creek, located in the Hyalite Creek drainage, Gallatin Mountains, 35 km south of Bozeman, Montana (Map adapted from Hardy and Hansen-Bristow 1990).

U.S. Forest Service stand exams revealed that there was an average of 188 trees per hectare in the History Rock stand with a mean diameter at breast height (dbh) of 48 centimeters. The average number of trees per hectare in the Lick Creek stand was 203, with a mean dbh of 46 centimeters. All Lick Creek plots have two canopy layers. History Rock C has three canopy layers, while History Rock A and B have three or more canopy layers.

Following the habitat type (h.t.) classification of Pfister et al. (1977), the U.S. Forest Service (U.S.F.S.) has classified the Lick Creek site as PSME/SYAL h.t. CARU phase, Psuedotsuga menziesii/Symphoricarpos albus-Calamagrostis rubescens, which is a Douglas fir/Snowberry-Pinegrass site. The U.S.F.S. classification of the History Rock site is ABLA/CAGE h.t. CAGE phase, Abies lasiocarpa/Carex geyeri-Carex geyeri, which is a Subalpine fir/Elk sedge-Elk sedge type.

The Forest Service Soil Survey of the Gallatin National Forest (Davis and Shovic 1984 and Shovic, personal communication 1991) indicates that all three Lick Creek study plots are on a Cryochrept soil type of sandstone origin with greater than 35% coarse fragments in the subsoil. This soil is characterized by a low water holding capacity and low fertility. The History Rock plots A and B are on a soil type similar to the Lick Creek area but are on a southeast facing slope, which is cooler and moister. The soil is characterized as a Cyroboralf with greater than 35% coarse fragments, a low

clay content, and parent materials of sandstone and limestone. This soil is both more fertile and deeper than that at the Lick Creek site and has fewer rock outcrops. The History C plot is characterized as a Cryoboralf with less than 35% coarse fragments, but with a high clay content since it is derived from sandstone and shale. The shale parent material is a major factor in this area for inducing past landslide activity. The high clay content of History C soil greatly enhances its water holding capacity, which is much better than in the Lick Creek plots.

Annual precipitation at the Lick Creek SNOWTEL Station (within 3 km of the study plots), was 79.0 cm in 1989 and averaged 89.9 cm per year between 1961 to 1985 (Farnes 1989). Mean seasonal precipitations are presented below.

Table 1. Lick Creek SNOWTEL Station, mean seasonal precipitation for 1961 to 1985*.

Season	Mean precipitation in cm.
Spring (April-June)	33.2
Summer (July-September)	15.9
Fall October-December)	19.2
Winter (January-March)	21.6

* Taken from Farnes (1989)

METHODS

Selection of Plots

Each study plot was 100 m by 100 m and had 100 trap-sites spaced in a 10 m grid. Each plot was a minimum of 300 m from other plots to minimize capturing individuals of small mammals on more than one study plot (Buckener 1957, Merritt and Merritt 1978, Merritt 1981). Study sites were located 150 m or more from a forest edge and at least 200 meters from riparian areas to minimize trapping animals characteristic of those specific areas, that were not necessarily residents of forest interiors. All study plots were placed in Douglas fir old growth forests and contained no more than .2 ha of natural meadows. Therefore, there were limited choices on how study plots could fit within the stands. As a result, plots were not chosen randomly, but were located on aerial photos and topographic maps before entering the area, to eliminate any field-based bias in site selection.

Vegetation Measurements

The U.S. Forest Service analyses of the stands had determined elevation, slope, number of acres, trees per acre, average diameter of trees at breast height (dbh), the soil type and habitat type. I gathered additional data on canopy cover, fuel loading (downed debris), tree ages, ground vegetation and old growth scorecard rating in each study plot.

Canopy Cover

Canopy cover was estimated with a densitometer. To insure randomness, canopy cover measurements were taken at alternate trap sites on alternate rows. On rows 1, 5, and 9, readings were taken at all even-numbered trap sites; on rows 3 and 7 readings were taken at all odd-numbered trap sites. At each of these trap sites the densitometer was read in the four cardinal directions of the compass, creating a total of 100 readings per study plot. These readings were then averaged to calculate a mean percentage of canopy cover.

Downed Debris

The amount of downed woody material was estimated by the U.S.F.S. method (Brown 1974). Each study plot was divided into four quadrants, and a point within the center of each quadrant was selected. From that point the direction of a transect was chosen randomly from the second hand on a watch

(with the "12" oriented upslope). A 15.24 meter string was run in the chosen direction, and the numbers of woody stems in each of four diameter size classes (0-.6 cm, .6-2.5 cm, 2.5-7.6 cm, >7.6 cm), intersecting the plane of the transect, were recorded. Total downed woody material and downed woody material larger than 7.6 cm were analyzed separately. Duff depths were also measured to the nearest .25 cm at two points along each transect. In addition, two transect readings were taken outside of each plot. These transects traversed areas that appeared to have different amounts of downed woody material than the interior. One transect went through an area of higher downed woody material, and one went through an area of less downed woody material. These transects were selected to evaluate if the interior of the plot was significantly different from the outlying areas. Results of these estimates of both in-site and out-of-site downed woody material were averaged for each plot and recorded as tons/acre, then converted to tonnes/hectare.

Ground Vegetation

Ground vegetation was analyzed August 21 through August 30, 1991 for species frequency and mean heights by combining the line-transect and point methods of vegetative analysis (Greig-Smith 1983). I established a 100 m line-transect along each of two randomly selected trapping rows oriented 90 degrees to the slope of each study site. Horizontal transects

worked best because most of the fallen trees were orientated approximately parallel to the slope, and a randomly selected transect along the slope may run along fallen trees instead of along ground vegetation. A point was dropped every meter, and species of plants in contact with the point at ground level were recorded. The greatest height of the contact plants was recorded, if no plants were in contact with the point at the ground, then the greatest height of the nearest ground vegetation within 15 cm was recorded. Bare ground, log, woody stems and rock contacts were also recorded.

Tree Ages

A tree corer was used to core trees at breast height to estimate ages. An effort was made to select the largest trees of all species, as well as representative trees of average diameter. Five to thirteen cores were taken in each study plot and included core samples from most tree species.

Old Growth Condition

The old growth condition of each study plot was rated with the old growth scorecard developed specifically by biologists on the Gallatin National Forest using Warren (1990) as a guide (Appendix 1). It is an evaluation method that accounts for the number of trees per acre greater than 25.4 cm dbh, greater than 38.1 cm dbh and greater than 50.8 cm dbh. The number of snags per acre are counted and their heights and diameters are evaluated. The number of canopy layers, percentage of decadence and percentage of canopy cover are recorded. The amount of downed logs in tons per acre, in diameter classes of 25.4 cm and larger and 50.8 cm and larger are also given a value in the analysis. I sampled each plot by walking through all portions of the plot and making the observations and measurements described in the scorecard. The scorecard incorporates sub-scores for each of these structural characteristics, which are summed to achieve an overall old growth rating from 0 to 40.5. This scorecard method was used to rate the study plots in an effort to see if this method may be able to predict an area's ability to support the studied small mammals (Nordyke and Buskirk 1988).

Live Trapping

Animals were live trapped from July 12 to September 24, 1990, with Sherman live traps, 8 x 9 x 23 cm in size. Small mammals were trapped in each study plot during four trapping periods. The dates of the trapping periods were July 12-31, August 1-14, August 21-September 6 and September 11-24. There was a three-week period between each trap period. Each study plot in the History Rock stand was paired with one in the Lick Creek stand and both were trapped simultaneously for three consecutive nights. Traps were set in the evening and checked the next morning. An effort was made to keep the number of hours traps were open equal in both forests, by varying the pattern of visits to each plot.

Traps were baited with a smear of peanut butter on the back door, along with a small handful of oats to provide energy throughout the capture period. A small wad of cotton was placed in the trap for warmth and to absorb urine (Buckener 1957, Krebs 1966). Trap doors were set very lightly to capture shrews readily.

Each individual animal trapped was tagged in its right ear with a numbered fish fingerling tag. In addition to the tag number, the following data were recorded for each animal: location on the study plot grid, weight, sex, age class and breeding status. If the animal was a recapture, tag number, weight, location and breeding status were recorded. Weights

were recorded using an Ohaus spring scale to the nearest gram.

Estimates of Population Parameters

Within each study plot, Clethrionomys gapperi and Peromyscus maniculatus population parameters were estimated for each trap period using the minimum number alive (MNA) technique (Chitty and Phipps 1966, Krebs 1966) for each of the two species' total populations. MNA was employed because it does not require randomness, which is usually unattainable in field studies (Krebs and Meyers 1974). Survivors and recruits were also estimated for each period. Survivors were the animals that were recaptured. Recruits were new animals that were trapped and could have been the results of reproduction, immigration and animals becoming less trap shy. Survival rates (survivors/MNA) (Douglass 1989) and recruitment rates (recruits/MNA) (Fairbairn 1978) were calculated. These values were then averaged within each plot to produce a mean which was used for comparisons between forest stands.

Dominance by age and sex class was inferred by reference to Bondrup-Nielsen (1986a) Bujalska (1985) Fairbairn (1978) Mihok (1979, 1981) Van Horne (1982) and Vitala and Hoffmeyer (1985), who found that adult female red-backed voles and adult deer mice of both sexes were dominant in their study populations. In this study all red-backed voles weighing 17 or more grams and deer mice weighing 16 or more grams were classified as adults.

Estimates of Small Mammal Species Diversity

Species diversity of the trapped animals was estimated using the Shannon Diversity Index (H') (Magurran 1988). The numbers of individuals trapped of each species were used to calculate the diversity index of each study plot.

Red Squirrel Surveys

Time-area counts were used, in which permanent stations were set in the study area and the observer listened and looked for squirrels within a prescribed distance, for a set amount of time (Flyger 1959, Bouffard 1978, 1982). This method was selected because of its usefulness in situations where variations in forest canopy layers, density of downed logs and other stand characteristics do not allow for equal survey effort (other than live trapping) between the two forests. Auditory signals are the least influenced sign of squirrels that can be used between the two different areas with a minimal amount of time spent surveying.

Time-area counts were conducted in two phases in 1991, from July 9 to July 19, and August 30 to September 6. The four corners of each study plot were used as observation-listening points for squirrel activity within a 110 meter radius. Each

observation point was visited for 15 minutes and any squirrel sighted or heard vocalizing was recorded. The types of vocalization, such as territory and alarm calls and chattering, were also recorded. There were three observation periods, at 7:00 am, 9:00 am and 11:00 am. Observation periods were rotated throughout the study plots, so each study plot was surveyed twice within each observation time period. Each study plot was surveyed three times within each phase. Each squirrel vocalization and sighting was recorded on a detailed map of the study area and an attempt was made to distinguish between individual squirrels and their territories. An index of numbers of squirrel territories sighted or heard within 110 meters of the study plot was calculated and compared between plots.

Snowshoe Hare Surveys

Fecal pellet count plots were installed in each study plot, and the data from these were used as indices of habitat utilization by snowshoe hares (Wolff 1980, 1982). Within each study plot, 30 1 m^2 plots were established by randomly placing three pellet plots at trap-sites along each of the ten rows of trap-sites. Pellets were counted and removed June 17 to 23, 1991, and new pellets collected and counted October 14 to 19,

1991. Estimates of the number of pellets per study plot were calculated from the data, and an index of the number of pellets / study plot/ day was derived (Adams 1959).

Pocket Gopher Survey

Within each of the six study plots, indices of pocket gopher activity were estimated during September, 1991, through the use of active mound counts (Reid et al. 1966, Turner et al. 1973, Youmans 1979). Pocket gopher activity is at its peak in September (Reid et al. 1966, Youmans 1979). Each study plot was surveyed for activity by walking each of the 10 rows across the plot and looking five meters to both sides of the row. Mounds, mound clusters and earth plugs were flattened and then visited 24 and 48 hours later. Holes and burrows repaired by mounding or earth plugs indicated an active burrow system, and these areas were noted on maps of the study plots to give an index of relative abundance of pocket gophers by active burrow systems (Turner et al. 1973).

Statistical Methods and Analyses

Statistical analyses were conducted partially by using MSUSTAT, (Stat package by R.E. Lund, Montana State University, copyright 1983). A significance level of $P \leq .05$ was used for

all tests. Differences in numbers of animals trapped, squirrel territories, and percentages of dominant animals of deer mice and red-backed voles between the two forest stands were tested with an analysis of variance. A linear regression was used to test for correlations between forest characteristics and numbers of animals trapped, minimum number alive (MNA) and Shannon Diversity Indices. Population parameters such as MNA, recruitment, survival rates; and the number of hare pellets in each study plot and the old growth scorecard ratings were compared between forest stands by the Mann-Whitney U test (Tate and Clelland 1957). A t-test was performed to compare the small mammal diversity indices between forest stands.

RESULTS

Vegetation Measurements

Douglas fir dominates the Lick Creek stand, (over 95%), with only two-to-five lodgepole pine (Pinus contorta) trees on each plot and no Engelmann spruce (Picea engelmannii) or subalpine fir (Abies lasiocarpa) present. Lick B has the most variety of trees of all the Lick Creek plots, with a few limber pines (Pinus flexilis) and Rocky mountain junipers (Juniperus scopularum) along a rocky edge of the plot. The History Rock area has a more diverse tree community. History A has approximately 70% Douglas fir, 20% subalpine fir, 6% Engelmann spruce and 4% lodgepole pine. History B is 50-to-60% Douglas fir, 30% subalpine fir, 10% Engelmann spruce and 5% lodgepole pine. History C has the fewest number of trees of all study plots and is composed of approximately 85% Douglas fir and 5% each of Engelmann spruce, subalpine fir and lodgepole pine.

The canopy cover of the two forest stands did not differ significantly (ANOVA, $P \leq 0.286$), (Table 2). Estimates of mean canopy coverage range from 71.2% in History Rock C to 88.0% coverage in Lick Creek A, indicating fairly similar environments.

Table 2. Estimates of mean percentage of canopy cover, downed debris, duff depth, mean heights of ground vegetation and old growth scorecard ratings for each study plot in History Rock and Lick Creek stands.

	History Rock Plots			Lick Creek Plots		
	A	B	C	A	B	C
Mean % canopy cover	81.5	81.9	71.2	88.0	82.5	79.8
Downed debris mean tonnes/ha	162.3	152.1	93.3	27.5	12.1	7.1
Range tonnes/ha	31-312	73-313	9-212	8-75	4-27	4-15
Logs >7.6 cm mean tonnes/ha	37.8	45.5	38.7	0.0	1.6	1.5
Mean duff depth (cm)	5.3	4.0	2.0	5.6	3.3	5.6
Ground Vegetation mean height (cm)	22.8	21.0	31.9	15.4	13.2	26.0
Old growth Scorecard Rating	29.5	26.5	25.5	16.0	15.0	16.0

The amount of downed woody debris was significantly greater in the History Rock plots than in the Lick Creek plots (ANOVA, $P \leq 0.006$), (Table 2). The variation was large with Lick C averaging only 7.1 tonnes/ha and History A containing 162.3 tonnes/ha.

There were no significant differences between downed

woody material within and outside of any of the study plots (Mann-Whitney values, $P \leq 0.311$ to 1.00)

The amount of downed logs 7.6 cm and greater (Table 2) were also analyzed because of their importance to small mammal species as a source of shelter and food (Doyle 1990, Maser et al. 1979, Ramirez 1981, Tevis 1956). The differences between the mean amounts of these larger logs in the two forest stands was significant (ANOVA, $P \leq 0.000$).

The mean duff depth of each plot was calculated (Table 2). The difference between duff depths of the two different stands was not significant (ANOVA, $P \leq 0.434$).

The variation of mean ground vegetation heights between stands was not significant (ANOVA $P \leq 0.220$). Plot Lick C appeared to be different within the Lick Creek stand. This may have been due to a small meadow (less than .3 ha) within the plot, where there was more ground vegetation than within the forested areas.

Old Growth Condition

Old growth scorecard ratings show the History Rock study plots scored significantly higher than Lick Creek plots (Mann-Whitney, $P \leq 0.030$), (Table 2).

Ground Cover

In ground vegetation analysis, of all the plant species, bare ground, logs, woody stems, and rocks; bare ground was consistently the most common feature encountered (Table 3), with significantly higher amounts recorded in the Lick Creek plots (ANOVA, $P \leq 0.050$). The most common plant species in the Lick Creek plots were elk sedge (Carex geyeri) and spirea (Spiraea betulifolia). In the History Rock stand, there was no one most commonly encountered species of ground vegetation among the plots; however, grasses and sedges were uniformly the most encountered.

The largest and oldest trees in all study plots were Douglas firs (Table 4). History Rock plots are a little older, although I was unable to date some of the large trees in Lick Creek stands because of heart rot and therefore rotting tree cores (especially in Lick C). The oldest measured tree was a 252 year old Douglas fir in History B. The largest tree was a Douglas fir in Lick B with a core diameter (with no bark) of 74 cm.

Table 3. Frequencies of occurrence of ground cover in History Rock and Lick Creek plots, August 21-30, 1991.

CATEGORY	History Rock Plots A	B	C	Lick Creek Plots A	B	C
BARE GROUND	49.5	58.5	58.5	62.0	72.5	67.5
LOG (>5 CM DIAMETER)	5.0	15.0	7.0	0.5	0.5	2.5
WOODY STEMS (<5 CM DIAMETER)	1.5	10.0	5.5	2.5	1.5	1.0
ROCK	1.0	0	0	0.5	8.0	1.0
SEDGES						
Cyperaceae						
-*Carex geyeri*	3.0	2.0	7.0	6.0	6.0	5.5
-*Carex* spp.	0.5	1.5	4.0	1.0	1.0	0
GRASSES						
Poaceae						
-*Calamagrostis rubescens*	9.5	0	1.0	2.0	1.5	1.5
-*Melica spectabilis*	0	0	0.5	0	0	0
-*Bromus* spp.	3.5	3.0	2.0	1.0	1.0	1.0
FORBS						
Berberidaceae						
-*Berberis repens*	0.5	0.5	0.5	2.0	0.5	2.5
Ranunculaceae						
-*Thalictrum occidentale*	2.5	0.5	1.0	1.0	0	0.5
-*Clematis columbiana*	0.5	0	0	0.5	0	0
Rosaceae						
-*Spiraea betulifolia*	3.0	0.5	0.5	3.0	3.0	5.0
-*Fragaria virginiana*	2.5	0	1.5	1.5	0	1.5
-*Potentilla gracilis*	0	0	0	0	0.5	0
-*Rosa woodsii*	0	0	0.5	0	0	0
Fabaceae (Leguminosae)						
-*Astragalus miser*	0.5	0	0	2.5	0	1.5
Geraniaceae						
-*Geranium viscosissimum*	0	0	0.5	0	0	0
Apiaceae (Umbelliferae)						
-*Osmorhiza chilensis*	1.5	0.5	1.0	0	0	0.5

Table 3. Continued.

CATEGORY	History Rock Plots A	B	C	Lick Creek Plots A	B	C
Ericaceae						
-*Chimaphila umbellata*	0	0	1.0	0	0	0
Rubiaceae						
-*Galium boreale*	2.0	1.0	1.5	1.0	0.5	2.0
Saxifragaceae						
-*Mitella pentandra*	0	0.5	0.5	0	0	0
Caprifoliaceae						
-*Symphoricarpos albus*	1.5	1.5	0	1.0	0	1.0
Asteraceae						
-*Hieracium* spp.	0.5	0.5	0	0.5	0	0.5
-*Antennaria racemosa*	0	0	0.5	1.0	0	0
-*Arnica cordifolia*	0.5	0	0	0	0	0
-*Achillea millefolium*	0	0	0.5	0	0	0.5
-Unknown *compositae*	2.0	1.0	0	1.5	0.5	2.0
Orchidaceae						
-*Goodyera oblongifolia*	0	1.5	0	1.0	0	0
Liliaceae						
-*Disporum trachycarpum*	1.0	0	0	0	0	0
-*Allium* spp.	0	0	0	0	1.0	0.5
TREES						
Cupressaceae						
-*Juniperus communis*	0	0	0.5	1.5	0.5	0
-*Abies lasiocarpa* seedlings	0	0.5	0	0.5	0	0
MOSSES						
Mniaceae						
-*Mnium* spp.	3.0	1.0	2.5	3.0	0	0.5
Brachytheciaceae						
-*Brachythecium* spp.	5.0	0.5	1.0	1.5	1.5	0
LICHENS						
Peltigeraceae						
-*Peltigera* spp.	0	0	1.0	0.5	0	0

Table 4. Ages of selected trees in History Rock and Lick Creek plots. Core diameter is diameter of tree excluding bark. With trees where core sample did not sample all the way to the middle of the tree, or part of the core was lost, a + sign indicates the tree is older and larger than recorded, by only by 10 years of less, and five centimeters or less.

Study Plot	Age	Core Diameter in centimeters
History A		
Douglas firs		
	249+	59.0+
	245	66.0
	230+	65.5+
	227	63.0
	217	63.0
	198	54.0
	195	62.0
	189	60.0
Lodgepole pines		
	203+	36.0+
	175	30.0
Engelmann spruce		
	190	35.0
	131	26.0
History B		
Douglas firs		
	252+*	55.0+*
	246+	65.0+
	224	57.5
	211	61.0
Lodgepole pines		
	240+	57.5
History C		
Douglas firs		
	215	45.0
	199	56.0
	191	57.0
	189+	60.0+
	168	46.0
	162	62.0
	155	36.0
	143+	46.0+
	75	20.0

Table 4. Continued.

Study Plot	Age	Diameter of core in centimeters
History C		
Lodgepole pines		
	221	42.0
	161	42.0
	115	28.0
Junipers		
	140+	17.5+
Lick A		
Douglas firs		
	229+	60.0+
	203	53.0
	194	60.0
	185	47.0
	174	47.0
	175+	47.0+
	162	50.0
	149	47.0
Lick B		
Douglas firs		
	176	53.0
	145	51.0
	139	60.0
	136	52.0
	129!	74.0!
	129+	41.0+
	107	36.0
	105	29.0
Junipers		
	155	20.0
Lick C		
Douglas firs		
	159	42.0
	152	51.0
	142	36.0
Lodgepole pines		
	135+	26.0

* Oldest tree recorded
! Largest tree recorded
~ Approximate age

Live Trapping

During the course of this study, there was a total of 7,200 potential trap-nights with a final adjustment of 6,854 actual trap-nights due to accidental closure of traps . There were 3,433 actual trap-nights in the History Rock stand and 3,421 trap-nights in the Lick Creek stand. A total of 508 animals were caught 1,105 times, for an overall trapping success of 16%. There were significantly more animals caught in the History Rock stand (317) than in the Lick Creek stand (191), (ANOVA, $P \leq .003$).

Distribution of Species

Nine species of mammals were captured (Table 5). The species most frequently trapped was Clethrionomys gapperi. A significantly greater number of these individuals was caught in the History Rock stand (231) than in the Lick Creek stand (50) (ANOVA, $P \leq .004$).

The next most frequently trapped species was Peromyscus maniculatus, with a total of 121 captured. There were significantly more trapped in the Lick Creek stand (92) than the History Rock stand (29) (ANOVA, $P \leq .019$). Sixty two yellow-pine chipmunks (Tamias amoenus) were captured, 24 in the History Rock stand and 38 in the Lick Creek stand. These results were not significantly different (ANOVA, $P \leq .521$). A total of 31 montane shrews (Sorex monticolus) were captured

with 22 in the History Rock plots and 9 in the Lick Creek plots. This sample size was inadequate to test statistically. Five other species of small mammals were trapped (Table 5).

Table 5. Total numbers of individual animals live-trapped during four trapping periods (July 12 - September 24, 1990) in the History Rock and Lick Creek plots. Numbers of animals captured/100 trap-nights (no/100 t-n) are presented below the number of animals trapped for the four most common species.

	History Rock Plots				Lick Creek Plots			
Species	A	B	C	Total	A	B	C	Total
Clethrionomys gapperi	66	75	90	231	13	7	30	50
no/100 t-n	5.8	6.6	7.7	-	1.1	.6	2.7	-
Peromyscus maniculatus	8	5	16	29	35	35	22	92
no/100 t-n	.70	.44	1.4	-	3.0	3.1	1.9	-
Tamias amoenus	8	4	12	24	5	25	8	38
no/100 t-n	.71	.35	1.0	-	.43	2.2	.71	-
Sorex monticolus	7	7	8	22	3	0	6	9
no/100 t-n	.62	.61	.69	-	.25	0	.53	-
Glaucomys sabrinus	0	1	0	1	1	0	1	2
Neotoma cinerea	1	0	0	1	0	0	0	0
Zapus princeps	1	0	0	1	0	0	0	0
Lepus americanus	0	0	0	0	0	1	0	1
Mustela erminea	0	0	1	1	0	0	0	0
Total number of Individuals	91	96	130	317	57	68	67	192

Population Parameter Estimates

Significant differences between the two forest stands were found in most population parameters of both Clethrionomys gapperi and Peromyscus maniculatus,(Tables 6 and 7). Because there were more P. maniculatus in the Lick Creek stand and more C. gapperi in the History Rock stand, the mean MNA (minimum number alive) of each species was significantly different between the two forest stands. There were significant differences between forest stands in C. gapperi mean survivors (M-W,P≤ 0.001) as well as mean recruits (M-W,P≤ .001). There were also differences between mean survivors (M-W,P≤ 0.007) and mean recruits (M-W,P≤ 0.010) of Peromyscus maniculatus. Differences were not significant between forests in the mean survival rates or recruitment rates in either species (C. gapperi survival rate, P≤ 0.093, recruitment rate, P≤ 0.200, P. maniculatus survival rate P≤ 0.077, recruitment rate P≤ 0.158, M-W.).

Table 6. Population parameters of Clethrionomys gapperi within each study plot.

Study plot	Mean MNA	Mean survivors	Mean recruits	Mean survival rate	Mean recruitment rate
History A	28.0	15.3	18.0	0.7	0.6
History B	31.5	17.3	19.3	0.7	0.5
History C	40.0	22.3	26.0	0.7	0.6
History mean	33.2	18.3	21.1	0.7	0.6
Lick A	4.3	1.3	4.0	0.3	0.8
Lick B	2.5	1.0	2.0	0.6	0.5
Lick C	13.3	6.3	10.0	0.6	0.6
Lick mean	6.7	2.9	5.3	0.5	0.6

Table 7. Population parameters of Peromyscus maniculatus within each study plot.

Study plot	Mean MNA	Mean Survivors	Mean recruits	Mean survival rate	Mean recruitment rate
Hist A	3.0	0.7	3.3	0.2	0.2
Hist B	2.0	1.0	1.3	0.7	0.4
Hist C	5.5	2.0	4.7	0.5	0.4
History mean	3.5	1.2	3.1	0.5	0.3
Lick A	12.8	5.3	10.7	0.6	0.7
Lick B	20.5	14.7	8.3	0.8	0.4
Lick C	9.3	5.7	3.7	0.6	0.4
Lick mean	14.2	8.6	7.6	0.7	0.5

Dominant Animals

There were many more adult female red-backed voles in the History Rock plots (52) than in the Lick Creek plots (8), however, the actual percentages of dominant adult females were comparable (M-W, $P \leq 0.386$) (Table 8 and 9). More adult deer mice were trapped in Lick Creek than in History Rock plots, but the percentages of adults in these trapped populations were not significantly different (M-W, $P \leq 0.194$).

Table 8. Numbers of mature female red-backed voles (Clethrionomys gapperi) trapped per study plot.

Study plot	Number of females	Total number voles	Percentage of females
History A	19	66	29
History B	12	75	16
History C	21	90	23
Lick A	2	13	15
Lick B	2	7	29
Lick C	4	30	13

Table 9. Numbers of adult deer mice (Peromyscus maniculatus) trapped per study plot.

Study plot	Number of adults	Number of immature	Total number	Percent adults
History A	4	4	8	50
History B	1	4	5	20
History C	7	9	16	44
Lick A	21	14	35	60
Lick B	17	18	35	49
Lick C	10	12	22	45

Small Mammal
Diversity Indices

Lick Creek study plots scored consistently higher in Shannon Diversity Indices than did the History Rock study plots (Table 10). There were no significant differences in diversity indices among the three History Rock plots (Table 11). Lick B and Lick C differed significantly from one another. Lick C differed from all History plots, and History B differed from all Lick plots. Overall mean diversity indices of the two forest stands were found to show a significant difference, with the Lick Creek forest producing a higher diversity index of trapped animals (t-test, t=2.01). Although an analysis of simple linear regression produced no strong correlation coefficients between diversity indices and six measured forest characteristics (Table 12), the lack of downed debris and downed logs greater than 7.6 cm explained 52% and 60% respectively, of the variation in diversity indices.

Table 10. Shannon Diversity Indices (H') for trapped animals in the History Rock and Lick Creek stands.

Study Plot	H'
History A	.97
History B	.71
History C	.94
History Rock Forest Mean	.87
Lick A	1.09
Lick B	.99
Lick C	1.28
Lick Creek Forest Mean	1.12

Table 11. Results of t-tests of Shannon Diversity Indices for the Lick Creek and History Rock plots. Level of significance is $P \leq 0.05$.

	Hist A	Hist B	Hist C	Lick A	Lick B	Lick C
History A	-	0	0	0	0	*
History B	0	-	0	*	*	*
History C	0	0	-	0	0	*
Lick A	0	*	0	-	0	0
Lick B	0	*	0	0	-	*
Lick C	*	*	*	0	*	-

Table 12. Correlation coefficients (r) of vegetative characteristics with Shannon Diversity Indices (H') measured for each plot.

Vegetative Characteristic	r
Total downed debris	-0.718
Downed logs ≥ 7.6 cm diam	-0.773
Mean duff depth	0.507
Mean % canopy cover	0.113
Ground vegetation mean height	0.044
Old growth score-card rating	-0.647

Small Mammal and Forest Characteristics Relations

Individual animals trapped were tested for correlations with certain forest vegetative characteristics (Table 13). Similar correlation coefficient values of numbers were found between individual animals trapped and their MNA, for red-backed voles and deermice. The numbers of Clethrionomys gapperi captured were positively correlated with total downed logs (r= 0.809), downed logs 7.6 cm and over (r= 0.945), mean ground vegetation height (r= 0.771), and old growth scorecard rating (r= 0.901). The numbers caught were negatively correlated with mean canopy cover (r= -0.699). Numbers trapped were little affected by duff depth (r= -0.465).

Peromyscus maniculatus population characteristics did not positively correlate with the majority of forest characteristics measured. Numbers of Peromyscus trapped negatively correlated with the total downed logs (r= -0.893), downed logs greater than 7.6 cm (r= -0.906), mean ground vegetation height (r= -0.580), and old growth scorecard rating (r= -0.905). Peromyscus were apparently little affected by canopy cover (r= 0.409) and duff depth (r= 0.106).

Tamias amoenus did not correlate with any forest characteristic. This may be due, in part, to low numbers captured (62). Sorex monticolus trapped did correlate with certain forest characteristics, but these results are inconclusive because of low numbers captured (a total of 31).

Table 13. Correlation coefficients (r) of species trapped with forest characteristics.

Characteristics Correlated	r
Mean percentage of canopy cover	
Red-backed voles	-0.699
Deer mice	0.409
Chipmunks	-0.169
Shrews	-0.587
Total downed debris	
Red-backed voles	0.809
Deer mice	-0.893
Chipmunks	-0.431
Shrews	0.673
Logs >7.6 cm in diameter	
Red-backed voles	0.945
Deer mice	-0.906
Chipmunks	-0.345
Shrews	0.764
Mean duff depth	
Red-backed voles	-0.465
Deer mice	0.106
Chipmunks	-0.497
Shrews	-0.098
Mean ground vegetation height	
Red-backed voles	0.771
Deer mice	-0.580
Chipmunks	-0.310
Shrews	0.863
Old growth scorecard rating	
Red-backed voles	0.901
Deer mice	-0.905
Chipmunks	-0.383
Shrews	0.771

Red Squirrel Surveys

Although I noted more squirrel activity (actual sightings, calls), in the History Rock stand as a whole, (Table 14), the number of territories detected per study plot was not significantly different between the two forest stands (ANOVA, $P \leq .176$).

Table 14. Red squirrel (*Tamiasciurus hudsonicus*) territory survey results in the History Rock and Lick Creek plots (surveys conducted July 1991, September 1991).

Study Plot	Number of squirrel territories
History A	17
History B	15
History C	9
History total	**41**
Lick A	11
Lick B	10
Lick C	4
Lick total	**25**

Snowshoe Hare Surveys

Fall pellet counts were conducted for only four of the six study plots, due to snowfall preventing additional counting periods (Table 15). Because of the absence of a complete data set on fall counts, spring pellet counts were analyzed. It was assumed that loss and decomposition of pellets were similar between the two stands. The difference in total number of pellets counted in each study plot was significantly different between sites (M-W, $P \leq .000$). Ratios of plots were calculated by taking the study plot with the lowest value of mean number of pellets per 1 m^2, and dividing that value into the same mean value of all study plots. This ratio is an indicator of the magnitude of differences between the plots (Table 15).

Table 15. Snowshoe hare (Lepus americanus) pellet counts in History Rock and Lick Creek plots. Pellets were removed June 1991 and October 1991.

Spring Counts
(June 17 - June 23, 1991)

Study Plot	Total no. pellets collected	Mean no. pellets/ 1 m^2	Mean no. per whole study plot	Ratio of Plot: Lick A
History A	384	12.80	384,000	9:1
History B	329	10.96	328,000	7:1
History C	88	2.93	87,900	2:1
Lick A	45	1.50	45,000	1:1
Lick B	58	1.93	57,900	1:1
Lick C	108	3.60	108,000	2:1

Fall Counts
(October 14 to October 19, 1991)

Study Plots	Total no. pellets collected	Mean no. pellets/ 1 m^2	Mean no. /whole study plot	Number pellets/ plot/day	Ratio of Plot: Lick B
History A	165	5.50	165,000	1,375	25:1
History B	160	5.30	159,000	1,336	24:1
History C	32	1.07	32,000	276	5:1
Lick A	-	-	-	-	-
Lick B	7	.23	6,900	56	1:1
Lick C	-	-	-	-	-

Mean/1 m^2 = Total pellets counted divided by 30 1 m^2 plots

Mean no./whole study plot = mean x 30,000 1 m^2 plots

Number pellets/plot/day = mean number per study plot divided by number of days between counts

Pocket Gopher Survey

Evidence of pocket gopher activity (burrows, mounds, loose earth), were rare in the History Rock stand, and none of the three study plots had any signs of recent pocket gopher activity. All three Lick Creek plots had occasional signs of past gopher activity on the edges of the plots (no more than 10 meters within), but only Lick B had an active burrow system of one gopher when activity was monitored in September 1991.

DISCUSSION

Forest Comparisons

The two forest stands differ from one another in that they are on slightly different soil types and have different aspects. The Lick Creek stand occupies a Cryochrept soil of sandstone origin, and the History Rock stand is on a Cryoboralf soil of sandstone and limestone origin (Davis and Shovic 1984). The Lick Creek soil is a drier and less fertile soil than the History Rock soil. History Rock is on a southeast-facing slope, and is a moister site than Lick Creek. History Rock is classified as a subalpine fir climax habitat type, whereas Lick Creek is a Douglas fir climax habitat type.

The forest characteristics sampled in this study that are significantly different between the two forest stands are the total amount of downed debris and downed logs 7.6 cm in diameter and greater. The overall old growth scorecard ratings of these stands also proved to be significantly different.

The two forest stands were similar in canopy cover, number of canopy layers, mean ground vegetation heights and duff depths, showing no significant differences when tested statistically. Douglas fir dominates all study sites, it is

also the largest and oldest tree species in both forest stands, with trees ranging up to approximately 252 years old.

Small Mammal Correlations

The red-backed vole prefers old growth habitat with a high density of rotting logs and roots that can be used for cover from predators, as runways, nesting sites and a source of food, especially fungi, which is an important component in its diet (Franklin et al. 1981, Gunderson 1959, Maser et al. 1979, Maser and Trappe 1984, Ramirez 1981, Walter 1991). Tevis (1956) even considered log cover to be the limiting factor for these voles. This species was also found to be positively correlated with abundant ground vegetation (Healy and Brooks 1988, Miller and Getz 1977, Rickland 1960, Wywialowski and Smith 1988, Wywialowski 1987). Getz (1968) related red-backed vole distribution to moisture and their water balance. These voles have low kidney efficiency (Getz 1968, Miller and Getz 1972, 1973) and are restricted, therefore, to moist sites (Butsch 1954, Rickard 1960). These habitat characteristics which are important to red-backed vole distribution are found in the History Rock stand to some degree. This stand is on a moister site than Lick Creek, has higher amounts of fallen logs (greater than 80 tonnes/hectare), and higher mean vegetation heights, although the latter is not statically significant. Numbers of red-

backed voles in this study were positively correlated with downed woody material and mean ground vegetation heights. Downed logs greater than 7.6 cm showed the strongest correlation with 89% ($r= 0.945$, $r^2= 0.893$) of the variation in vole numbers explained by this forest characteristic. Overall downed woody material explained 65%, and ground vegetation height explained 59% of the variation.

Deer mice are not closely restricted to downfall and ground vegetation cover (Kirkland 1977, Miller and Getz 1977, Rickard 1960, Schloyer 1976, Walter 1991, Wywialowski 1987, Wywialowski and Smith 1988), but rather have been found in a wide variety of habitats (Brown 1967, Hoffman 1960, Manville 1949, Rickard 1960). Some authors, however, have found the deer mouse associated with habitats containing high densities of fallen logs and or brush cover (Belk et al. 1988, Doyle 1990, Goodwin and Hungerford 1979). Wywialowski (1987) found deer mice were less vulnerable to predators than red-backed voles in lesser densities of cover. Rickard (1960) characterized the deer mouse as apparently relying less on vegetation as protection from predators than do most microtines. In this study, deer mice were negatively correlated with the same characteristics with which red-backed voles were most strongly positively correlated. A low percentage of downed logs greater than 7.6 cm explained 82% of the variation in deer mice numbers trapped, while the low amount of overall downed debris explained 80% of the variation

in deer mice. Deer mice weakly and negatively correlated with mean height of ground vegetation (r^2= 0.34). Peromyscus have a greater dietary variation than Clethrionomys (Schloyer 1976, Ramirez 1981, Gunther et al, 1983) and are able to exploit a broader spectrum of food resources (Kirkland 1977). Perhaps because of their different food strategies and habitat requirements, the deer mice in this study predominated on the less vegetated sites of the Lick Creek stand.

In Raphael's study (1988), Sorex monticolus was strongly associated with dense herbaceous cover and with old growth forest attributes. He suggested that this shrew is also a good candidate as an ecological indicator of mature spruce/fir stands. This study suggests a similar correlation although only 31 of these particular shrews were captured. Further investigations of this species in southwest Montana Douglas fir stands may reveal similar findings to those of Raphael (1988).

Population Parameters

In analyzing population parameter estimates of deer mice and red-backed voles, there were significant differences between forests when comparing the mean MNA, survivors and recruits of both these species. There were no significant differences detected however, between the two stands when

comparing the mean survival and recruitment rates for each of the two species. Because of the low number of captures of deer mice in the History Rock stand and red-backed voles in the Lick Creek stand, the data may be insufficient to detecting differences in survival and recruitment rates between the two stands.

The period when trapping was conducted, (July through September) is a time of increasing recruitment of both species of mice (Fairbairn 1978, Merritt 1981, Merritt and Merritt 1978, Mihok 1979, Miller and Getz 1977). Populations of both species, in both forest stands, on the whole, steadily increased during the trapping periods. Throughout much of the study period, recruits outnumbered survivors in both species. In looking at survival rates, Chitty and Phipps (1966) suggested low rates are below 50%. Others, (Chitty and Phipps 1966, Fairbairn 1978, Krebs 1966, Krebs and Myers 1974) have suggested high survival rates are above 80%. Survival rates for Clethrionomys gapperi in History Rock plots and Peromyscus maniculatus in Lick Creek plots were normal for stable populations (averaging 60% to 80%) and some may even be considered high, according to Krebs et al. (1969), who stated anything above 70% was high.

In analyzing a habitat to determine the stability of the local populations, and in turn the quality of that habitat in relation to a particular species, it is of assistance to examine the proportion of dominant animals within the

population. Dominant animals of a species occupy optimal habitat (Mihok 1981), have greater home range stability and have higher survival probabilities (Van Horne 1981). These optimal, stable areas of dominant animals tend to be species sources, where reproduction occurs and immature, subordinate animals disperse from in response to social pressure (Fairbairn 1978). These surplus subordinates retreat to outlying areas of less than optimal habitat known as sinks. These sink areas tend to have high amounts of immature animals, high turnover rates, and widely fluctuating densities (Lidicker 1975).

Previous studies have indicated that mature female red-backed voles are dominant over all other age and sex classes of the species, are territorial and occupy optimal habitats (Bondrup-Nielsen 1986a, 1986b, Bujalska 1985, Mihok 1979, 1981, Vitala and Hoffmeyer 1985). The social system of deer mice dictates that adults are dominant over juveniles and occupy the preferred habitats (Fairbairn 1978, Mihok 1979, Van Horne 1982).

Although there were more female red-backed voles in the History Rock stand, there were similar percentages of females between the two stands. This suggests that both stands may be a species source.

Adult deer mice comprised 41 to 60% of trapped deer mice excluding History plots A and B. In each of these plots sample size was small, less than ten mice were caught in each.

Again, as with the red-backed voles, there was not a significant difference between the proportions of adults in the two stands, suggesting that they are both species sources and are not population sinks.

Old Growth Scorecard Implications

The overall old growth scorecard ratings of the study plots were positively correlated with red-backed vole abundance, with 81% of the variation in red-backed vole numbers explained by old growth scorecard ratings. Previous studies (Nordyke and Buskirk 1988, Raphael 1988) have evaluated the use of small mammals as ecological indicators of old growth conditions. Their findings have confirmed the use Clethrionomys gapperi as a useful ecological indicator of old growth conditions in spruce/fir stands. In this present study, red-backed voles showed a strong positive correlation with the dead, downed, woody component of the forest floor. My study suggests that the red-backed vole may be an appropriate ecological indicator of complex old growth Douglas fir with a high amount of dead downfall on the forest floor in southwestern Montana, east of the Continental Divide. A high old growth scorecard rating, as used by the Gallatin National Forest, is suggestive of red-backed vole abundance in Douglas fir stands. Red-backed vole abundance may also be a good

indicator of pine marten use of the area. Red-backed voles are an important prey item of marten, and marten populations are largely regulated by food throughout the year (Clark 1984, Simon 1980, Weckwerth and Hawley 1962). Soutiere (1979) found winter distribution of marten to be governed more by prey availability than by other habitat factors. Marten, like the red-backed vole, also prefer habitats with a well established understory of fallen logs and stumps (Burnett 1981, Clark et al. 1987, Fager 1991). With these relations in mind, biologists may be able to make a preliminary selection of potential prime old growth Douglas fir for marten based on the site's old growth scorecard rating.

Small Mammal Diversity

Overall, the Lick Creek stand produced a significantly higher diversity of small mammals which were live-trapped (as measured by the Shannon Diversity Index), even though significantly fewer animals and fewer species were trapped in Lick Creek than in the History Rock stand. High calculated diversity indices result from a large number of species and a proportionally even distribution of numbers in each species (Poole 1974). The dominance in numbers by red-backed voles (73% of the total captures) in the History Rock stand contributed to its low diversity index, in spite of the

greater number of individuals and species in History Rock.

While the two stands were different in diversity indices, History Rock A and C diversity indices were similar to Lick Creek A and B. This may not have been a true measure of the small mammal diversity in these plots. If the trapping technique had provided effective sampling of a greater number of small and medium-sized mammal species, the diversity indices may have been more accurate.

Red squirrel, snowshoe hare and pocket gopher numbers were estimated by survey techniques. Red squirrel territory detections (as reported by visual and auditory perceptions of squirrel activity) were comparable between the two stands, even though I noted virtually no squirrel activity within the Lick Creek study plots. This discrepancy may be explained by the variability of the forests outside the plots. Even though the Lick Creek study plots were almost pure Douglas fir, a majority of the squirrel activity noted was in the areas adjacent to the plots where lodgepole pine was present. Smith (1968) found that lodgepole trees provide more consistent serotinous cones and seeds, thus being more storable. The squirrels in this study may have been selecting for lodgepole cones at the time of surveys, even though Douglas fir seeds are preferred by this squirrel over lodgepole (Smith 1968). Douglas firs have very large cone crops (mast years), interspersed with almost complete cone crop failures. Squirrels will switch from their diets of Douglas fir to

lodgepole and other species in crop failure years (Smith 1968). In the History Rock stand Douglas fir is not as dominant as it is in the Lick Creek stand, rather there is a mosaic of tree species. Reinhart and Mattson (1989) found red squirrel abundance and activity were highest in mesic and wet habitat types, which had more overstory diversity, which in turn offered red squirrels other species of cone crops when one species had a crop failure.

The data on snowshoe hare pellet counts, suggests that the History Rock area also had a higher usage by snowshoe hares. Pocket gopher activity was so minimal that no comparisons could be made.

Implications

Within the Gallatin National Forest there are a minimum of 17 old growth forest types (East Side Old Growth Task Force 1991). I evaluated two types on the basis of stand complexity and the relation to small mammal diversity and abundance. Even though the more complex stand had a greater abundance of animals, not all species were trapped there in greater numbers. We, as scientists and resource managers, must be careful in evaluating and rating old growth forests. Even though a stand may rate a high score in terms of an old growth scorecard, and therefore be considered prime habitat for red-backed voles or marten, it doesn't necessarily mean that the

area is better qualified as wildlife habitat for all species. We must be aware that there is a spectrum of habitats that fulfill different needs for different animals (and plants). Although I would recommend the History Rock stand as a "better" old growth habitat for red-backed voles and marten, I must also include the fact that the Lick Creek stand may very well be "better" for deer mice and yellow pine chipmunks, although these two species are not known as dependents on old growth forests. In managing public lands for maintenance of old growth communities, it is important to preserve stands that are quite different from one another, regardless of scorecard ratings. That way we provide more diverse ecosystems, on which the diversity of animal species depends.

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APPENDIX

OLD GROWTH/WILDLIFE CHECKLIST
GALLATIN NATIONAL FOREST

5/14/91

Std Number_____ Hab Type_____ Elev_____ Aspect/Slope_____

Major Overstory Species_____ Examiner_____ Date___

Stand Acres_____ Aerial Photo No._____

1. Rate individual stand:

----------FIELD DATA----------

	Points 0	1	2	3	Weight	Sum
(next 3 only for stands without stand exams)						
Trees/ac > 10" dbh	0-5	6-10	11-20	20+	.5	_____
Trees/ac > 15" dbh	0-5	6-10	11-20	20+	.5	_____
Trees/ac > 20" dbh	0	1-2	3-4	5+	.5	_____
Are there >2 snags/ac > 10" and > 40' tall? (no=0, yes=3)					1	_____
Are there > 2 snags/ac >15" and > 40' tall? (no=0, yes=3)					2	_____
(If there are no snags of these heights, are there some >15' and < 40' tall? (no=0, yes=1)					.5	_____

Describe snag density, rot, species, etc. _____

_____

Down logs tons/ac						
>10" diameter	<10	10-20	21-30	>30	1	_____
>20" diameter	<10	10-20	21-30	>30	2	_____
Canopy layering (# of layers)	0	1	2	3	1	_____
Decadence (% of overstory w/ conks or broken tops)	0	1-10	10-20	>25	2	_____

- - - - - - - - - -IN OFFICE FROM PHOTOS- - - - - - - - - -

Canopy cover, Polesize and larger trees (%)	<10	>70	10-39	40-69	1	_____

STAND SCORE _____

	0	1	2	3	Weight	Sum

2. Rate old growth patch (may include several adjacent stands):

Insularity 76-100 51-75 26-50 <25 1 _____
(% of boundary against seedling or sapling stands)

Contiguous acres <50 50-150 150-250 250+ 2 _____
If > 250 contiguous acres, estimate acres here _____.

Patch shape* A B C D 1 _____

*A=linear, narrow; B=linear, wider than 200'; C=irregular; D=circular

PATCH SCORE _____

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