This is to certify that the

thesis entitled

Small Mammal, Reptile, Amphibian, and Bat Species
Associations With Habitat Type Classes and
Successional Stages in West Central Idaho

presented by

Brian E. Knapp

has been accepted towards fulfillment
of the requirements for

Master of Science degree in Fish. & Wildl.

Jonathan B. Haufler
Major professor

Date 10/20/97

SMALL MAMMAL, REPTILE, AMPHIBIAN, AND BAT SPECIES ASSOCIATIONS WITH HABITAT TYPE CLASSES AND SUCCESSIONAL STAGES IN WEST CENTRAL IDAHO

By

Brian E. Knapp

A Thesis

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Fisheries and Wildlife

1997

ABSTRACT

SMALL MAMMAL, REPTILE, AMPHIBIAN, AND BAT SPECIES ASSOCIATIONS WITH HABITAT TYPE CLASSES AND SUCCESSIONAL STAGES IN WEST CENTRAL IDAHO

By

Brian E. Knapp

This study was directed at identifying species associations of small mammal, herptile, and bat species with 3 habitat type classes (cool-moist grand fir, dry grand fir, and dry Douglas-fir), and 2 successional stages (medium and small tree of the dry Douglas-fir habitat type class) that were part of an ecosystem diversity matrix (EDM). This was done in support of an ecosystem management project, conducted in west central Idaho.

The red-backed vole (*Clethrionomys gapperi*), masked shrew (*Sorex cinereus*), dwarf shrew (*Sorex nanus*), northern pocket gopher (*Thomomys talpoides*), and deer mouse (*Peromyscus maniculatus*) were associated with the cool-moist grand fir habitat type class. The deer mouse and red-backed vole were associated with the medium tree, and the long-toed salamander (*Ambystoma macrodactylum*) with the small tree successional stage of the dry Douglas-fir habitat type class. The relationship of site and vegetation characteristics with individual species were also identified. It was concluded that there is support for the EDM's capability to represent the diversity of species and their needs on the planning landscape.

ACKNOWLEDGMENTS

This thesis was not only the product of my own efforts. I would like to acknowledge and express my appreciation to those organizations and people without whom this thesis would never have been possible. I would especially like to thank my major professor, Dr. Jonathan Haufler, for the opportunity to do this project, and for all his time, guidance, and support. I would also like to thank the members of my committee, Dr. Rique Campa, Dr. Carl Ramm, and Dr. Donald Straney, for their time, insights, and assistance in producing this thesis.

Boise Cascade Corporation provided the means which made this project possible. I would like to thank several employees of BC who provided invaluable assistance in the completion of the project. I would especially like to thank Brad Holt, Carolyn Mehl, and Steve Warren for all their time and help. I would also like to thank the foresters and secretaries at the Cascade office for providing much assistance, and for making Cascade a great place to work. I would also like to thank Michigan State University for providing me with a place to work and the opportunity for an education.

The interns that worked for me, Chris Hoving and Grant Goltz worked long hard days for extended periods without days off, and without complaint. Their effort was instrumental in obtaining the data for this study, and their company was greatly appreciated. I would also like to thank my fellow graduate students for thought provoking

discussions, their support, and for making MSU a nice place to have spent several years. I would especially like to thank my office mates, Christine Hanaburgh and Delia Raymer for their friendship, support, and insights. I would also especially like to thank my hunting partners, Peter Fritzell and Bob Holsman. Life in graduate school would have been hell without the opportunity to occasionally spend some time afield in the company of great friends. Finally, and above all other people, I would like to thank my parents, without whose support, guidance, and teaching, none of my accomplishments in life would be possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The concept of ecosystem-based management 1st appeared in the literature in the early 1930's and 40's, in reports produced by committees of the Ecological Society of America (Shelford 1933), reports on fauna of the national parks (Wright and Thompson 1935), and in the writings of other early ecologists (Grumbine 1994). Leopold (1949) also presented ecosystem-based ideas in "Sand County Almanac". However, Grumbine (1994) stated that the focus of our current attention on ecosystem management is generally credited to Frank and John Craighead, who wrote (Craighead 1979) of Yellowstone National Park being inadequate in size because the park did not contain the complete ecosystem necessary to support the system's top predator, the grizzly bear (*Ursus arctos*) (Grumbine 1994).

The ever increasing human population has created demands for natural resources and space, and has reduced available habitat for many species. The limitations of these resources, the state of flux in the human perception of our relationship with the environment, and the intensification of both endangered species and biodiversity issues have created a environmental situation, and socio-political climate, that advocates the application of ecosystem management concepts (Roloff and Haufler 1993, Grumbine 1994). Some authors (Franklin 1993, Rohlf 1991) have argued that the current single species management approach, and the Endangered Species Act (ESA), especially for smaller little known or unknown species, are incapable of protecting the biodiversity of ecosystems. This is not intended to mean that the ESA or single species management should be eliminated, but rather that ecosystem management should be used to improve on the protection of biodiversity (Franklin 1993). The increasing intensity of the endangered species and biodiversity issues led President Clinton, in 1993, to order the USFS and BLM to adopt an ecosystem-based management approach (Grumbine 1994, Thomas and Dombeck 1996). Many agencies and private organizations are now trying to use ecosystem management approaches (Haufler et al. 1996).

Ecosystem management is characterized by several components. It is an ecologically-based land management approach. Ecosystem management attempts to maintain the diversity, structure, and functions of ecosystems across a given area over time. At the same time, ecosystem management attempts to provide for the achievement of multiple use objectives, including ecological, economic, and social (Grumbine 1994, Haufler et al. 1996). The maintenance of proper ecosystem structure and functions is dependent upon maintaining diversity at the ecosystem, community, species, and genetic levels (Meffe and Carroll 1994). Landscapes are comprised of hierarchies of successively smaller ecosystems, groups of smaller ecosystems composing larger ecosystems, which are distributed as a dynamically shifting mosaic across that landscape. The dynamic nature of these ecosystems is due to the progress of succession, and setbacks in succession, caused by both human and naturally induced disturbances (Haufler 1990). One of the goals of ecosystem management is to understand the distribution of ecosystems across a landscape, and their role in maintaining the biodiversity (Haufler pers. comm.). Given this understanding, it is believed that by producing the ecosystem conditions of natural disturbances, ecosystem managers can provide “adequate” quantities and appropriate patch sizes and distributions of ecosystems across the landscape, thus maintaining the diversity, structure, and functions of the planning landscape (Haufler 1994).

A tool which can be used to gain an understanding of the distribution of ecosystems across a landscape, and their role in contributing to the larger landscape, is the ecosystem diversity matrix (EDM). The EDM is comprised of ecological land units (ELU’s), which are defined by a combination of their habitat type and successional stage (Haufler 1994). Daubenmire (1968) defined a habitat type as the land capable of producing an ecologically equivalent plant community at climax (Steele et al. 1981). The potential community at climax gives an indication of a site’s potential productivity, and its ecological functions at climax. Different habitat types have their own successional pathways (Anderson 1985). Each stage of succession along a given pathway has different plant and animal community compositions, and distinct ecological functions. By combining habitat types and successional stages, ELU’s can be used to represent ecologically distinct components of a landscape ecosystem. Using ELU’s as a basis for analysis, the ecosystem diversity matrix provides a tool to track quantities and distributions of ecosystems, and their components on the landscape. The EDM is basically a matrix with habitat type classes represented in columns and successional stages in rows. Each cell in the matrix contains the acreage of the planning landscape that is in each habitat type and successional stage combination (ELU) (Haufler 1994).

Wildlife species have been shown to respond to changes in succession (Anderson 1985, Hunter 1990, Yahner 1995). Huff et al. (1993) found stand age to be the best indicator of bat activity. In addition, Krusic et al. (1996) found within stand bat activity to be greatest in overmature hardwood stands (>119 yrs.) and within regenerating stands (0-9 yrs) of both hardwoods and conifers of the White Mountain National Forest, New Hampshire and Maine. Krusic et al. (1996) also found stand age to be the best determinant of bat activity within stands. Succession influences the activity of highly mobile species within stands, and the composition of less mobile species inhabiting stands. A greater diversity of invertebrates, with very different life histories, have been found in old growth Douglas-fir (*Pseudotsuga menziesii*) forest canopies than in the canopies of nearby 2nd-growth stands (Franklin 1993, Schowalter 1989). Thomas and Verner (1986) identified successional stage as important in determining the availability of conditions and resources required by many species. For example, tree diameter, snag diameter, and the size of downed woody materials is dependent upon the size of the trees in the initial stand, which is often dependent upon successional stage.

Various species of wildlife have shown different responses to general habitat characteristics, which may be important in determining their presence or abundance (Brown 1967, DeGraaf et al. 1991, Perkins 1976, Williams and Braun 1983). Patterson et al. (1990) found that small mammal species differed significantly in the use of 12 of their 24 habitat variables, in ways that were generally consistent with the species morphology, diet, and behavior. DeGraaf et al. (1991) concluded that small mammals are tied into the moisture levels of a given site. Higher degrees of patchiness and vegetation density at the ground herb and shrub layers were also shown to be related to the richness of the rodent fauna in forest ecosystems (DeGraaf et al. 1991). In addition, Tummlison et al. (1990) found that at a coarse scale, substrate size was an important indicator of salamander presence. Krusic et al. (1996) found differences in bat activity between forest types in White Mountain National Forest, New Hampshire and Maine. However, wildlife responses to habitat types, as defined by Daubenmire (1968), and ELU's have not been investigated.

Since the EDM is a matrix of habitat type class and successional stage combinations, it provides an excellent tool to investigate the factors influencing wildlife species distributions across the landscape. By identifying species associations with different ELU's, the EDM can be used to gain further understanding of the distribution of wildlife species across the landscape (Haufler pers. comm.). A species is considered to be associated with an ELU if it is relatively more abundant on that ELU than on other ELU's, as compared to a population that is distributed randomly among ELU's. In addition, the identification of species associations with ELU's will aid in the determination of what is adequate representation of ELU's across the planning landscape. The use of the EDM and knowledge of species associations with ELU's, in a geographic information system (GIS) will further allow resource managers to predict the results of both natural and human induced disturbances across and within the landscape on faunal communities. Knowledge of habitat associations can also provide managers with information about how best to manage ecological land units to enhance the habitat for species of interest. According to Roloff and Haufler (1993), these capabilities become increasingly important to resource managers as habitat fragmentation, endangered species, and biodiversity issues become more prominent.

Small mammals, reptiles, and amphibians are important members of ecosystems. Through their behaviors and dietary habits, they have a large impact on the plant, animal, and insect communities of ecosystems. They provide a food source for many of the predator species within ecosystems. Through their dietary habits they influence insect populations and impact the regeneration and density of plant species. Small mammals and herptiles create macropores in the soil, and aid in keeping soil aerated. Due to their relative immobility, and inability to acquire their life requisites from outside a given area, small mammals and herptiles make excellent indicators of habitat quality and ecosystem health (Szaro 1988). Bats, though more mobile, also have major impacts on insect, and therefore plant and animal communities (Wackenhut and McGraw 1996). As important members of ecosystems, it is necessary to consider small mammals, reptiles, amphibians, and bats in management decisions. The ecosystem management approach, by considering species associations with ELU's, and providing for the full range of habitat requirements of all species, could prove useful in accounting for small mammals, reptiles, amphibians, and bats when managing landscapes.

OBJECTIVES

This investigation was initiated in June of 1994. The study has several objectives relevant to ecosystem management. The primary objective of the study was to identify species associations with selected habitat type classes, and secondarily with selected successional stages within one habitat type class. The 2nd objective of the study was to document the relative abundance of individual species in the Idaho planning landscape. The 3rd objective was to identify site and stand characteristics, such as vegetation variables, that may influence individual species' relative abundances, and that may aid in predicting the animal species composition at different sites.

STUDY AREA

The study area was situated in the Donnelly and Cascade area of Valley County, Idaho, (T15-17N; R2E), on the southern lobe of the Idaho Batholith. The area is primarily drained, to the west and then south, by the North fork of the Payette River, and by the Gold Fork River. Most of the area is underlain by granitic rock of the Idaho Batholith. Soils from the granitic parent material are usually moderately coarse to coarser in texture throughout their profiles. Most soils are deep except on extremely steep slopes, ridges, and headlands. The area has a primarily mountainous relief ranging from 1,520m-2,740m (5,000-9,000ft) (Steele et al. 1981).

Average annual precipitation is 81.5cm (31.2in), varying widely with the season. July and August precipitation averages about 1.3cm (0.5in), with a wet season occurring between November and March. Winter snows comprise 55-60% of the annual precipitation. Slopes below 1370m (4500ft) are usually bare in winter. Average annual air temperatures vary between 8°C and -6°C (46°F and -22°F), with a mean around 2°C (36°F) (Steele et al. 1981).

Boise Cascade lands in the Donnelly and Cascade area contain 3 primary habitat type classes, the cool-moist grand fir, dry grand fir, and dry Douglas-fir habitat type classes. Each of the 3 predominant habitat type classes includes several habitat types that are very similar in structure and ecological functions. The similar habitat types, which comprise the habitat type classes, are listed in the descriptions of the habitat type classes that follow in this paper. The 3 habitat type classes listed above are arranged in order from most to least productive (Steele et al. 1981). Within each habitat type class, there are two predominant age-based successional stages on Boise Cascade lands. These are being defined as small tree (preponderance of trees 12.7-30.5cm, 5.0-12.0in dbh), and medium tree (preponderance of trees 30.5-50.8cm, 12.0-20.0in dbh) successional stages.

The cool moist grand fir habitat type class usually occurs at elevations between 1,160 and 1,950m (3,800-6,400ft). It is usually on the mid to lower slopes, with a northerly aspect. It tends to occur on clay loam to sandy loam soils, from granitic or occasionally basalt or andesite parent materials, with an average pH of around 6.1. The early seral dominants are ponderosa pine (*Pinus ponderosa)* on warmer sites, and western larch (*Larix occidentalis*) and lodgepole pine (*Pinus contorta*) on cooler sites. Douglas-fir (*Pseudotsuga menziesii*) dominates later seral stages, and grand fir (*Abies grandis*) dominates sites of this group at climax. The shrub layers on cool moist grand fir sites are usually composed of huckleberry (*Vaccinium* sp.) with ninebark (*Physocarpus malvaceus*) well represented on warmer dryer sites, and rocky mountain maple (*Acer glabrum*) well represented on cooler moist sites. On sites where ninebark is present, snowberry (*Symphoricarpos albus*) and white spirea (*Spirea betulifolia*) may be present, with a layer of pine grass (*Calamagrostis rubescens*). Pine grass rarely forms a dense covering on sites where rocky mountain maple is common, but some of the shrubs commonly found with ninebark may be present. Cool moist grand fir sites tend to be highly productive (Steele et al. 1981). Included in the cool-moist grand fir habitat type class, and very similar in structure and ecological functions, are the *Abies grandis / Acer glabrum, Abies grandis / Xerophyllum tenax, Abies grandis / Coptis occidentalis, Abies grandis / vaccinium globulare, Abies grandis / Clintonia uniflora, Abies grandis / vaccinium caespitosum,* and *Abies grandis / Linnaea borealis* habitat types.

The dry grand fir habitat type class usually occurs at elevations between 1,310 and 1950m (4,300-6,400ft). These sites are usually found on dryer gentle benches, upper slopes, and ridges. They tend to occur on clay loam to sandy loam soils, from primarily granitic parent material, with an average pH of 6.0. However, they may also be found on soils formed from rholite, andesite, and quartz diorite parent rock. The species that dominate seral stages are ponderosa pine and Douglas-fir, with grand fir dominating at climax. The undergrowth usually contains a thin cover of *Spirea*, with *Thalictrum occidentale* (western meadowrue) as the dominant forb. Also common on undisturbed sites are pine grass and elk sedge (*Carex geyeri*). Disturbed sites often have shiny leaf ceanothus (*Ceanothus velutinus*), bitter cherry (*Prunus emarginata*), schoulers willow (*Salix scouleriana*), and service berry (*Amelanchier alnifolia*) as common components. Snowberry may also dominate the understory on some sites. Heartleaf arnica (*Arnica cordifolia*) and prince's pine (*Chimaphila umbellata*) can dominate the understory layer in the lower light conditions of a dense overstory. In more open canopy conditions of the seral stages, pine grass can form a thick sod. Dry grand fir sites tend to be very productive (Steele et al. 1981). Included in the dry grand fir habitat type class, and very similar in structure and ecological functions are the *Abies grandis / Spirea betulifolis,* and *Abies grandis / Calamagrostis rubescens* habitat types.

The dry Douglas-fir habitat type class ranges in elevation from 980 to 2,160m (3,200-7,100ft). It is mostly found on soils with granitic and basalt parent materials, with an average pH of 6.4, but may also come from andesite or Precambrian metasediments. Dry Douglas-fir sites usually occupy warm dry southerly aspects, on the lower to mid slopes. Overstory species vary between ponderosa pine at lower warmer elevations, and mixed Douglas-fir and ponderosa pine on higher moister sites. The understory is usually dominated by common snowberry, but is often mixed with spirea, *Rosa* species, and ninebark. Pine grass and elk sedge often form a layer below the shrubs. Quaking aspen (*Populus tremuloides*) may be present in the seral stages of this habitat type class. Sites of the dry Douglas-fir habitat type class tend to be moderately to highly productive (Steele et al. 1981). Included in the dry Douglas-fir habitat type class, and very similar in structure and ecological functions, are the *Pseudotsuga menziesii / Symphoricarpos albus, Pinus ponderosa / Symphoricarpus albus, Pinus ponderosa / Physocarpus malvaceus, Pseudotsuga menziesii / Physocarpus malvaceus, Pseudotsuga menziesii / Calamagrostis rubescens, Pseudotsuga menziesii / Carex geyeri,* and *Pseudotsuga menziesii / Spiraea betulifolia* habitat types.

Fire has been shown to be a common part of the ecosystems of this area, and it is important to recognize its influence on stand structure and species composition. Fire scars are common on many samples of trees taken in central Idaho, indicating that 1 or more ground fires would be expected in the life of any stand (Steele et al. 1981). The dry grand fir and dry Douglas-fir habitat type classes are believed to have had frequent light understory burns, with fires occurring every 3-30 years. Frequent understory burns kept stand conditions open and park like with the majority of trees being large and of fire adapted species (ponderosa pine, western larch). Less fire resistant species (grand fir, Douglas-fir) were uncommon in these fire conditions (Arno and Peterson 1983). It is also believed that historically the cool moist grand fir habitat type class was subjected to a range of frequent (3-30 yr.) understory burns on the dryer sites, to infrequent (70-120 yr.) stand destroying fires on wetter sites (Arno 1980). With infrequent stand destroying fires, forests would be comprised of species of both fire adapted and non-adapted trees. These stands would have had dense understory layers forming fire ladders into the upper canopy, very similar to the conditions that fire suppression has created over much of the landscape of today (Arno and Peterson 1983).

Since European settlers arrived in the area, grazing has had a significant impact on the plant communities of central Idaho. Grazing is now managed in this area, and will likely continue to be an influence in the region (Steele et al. 1981). Logging has significantly influenced the area's ecosystems as well, and will continue to be a major influence (Steele et al. 1981). The study area is primarily used for timber production.

Historically, all stands included in the study were managed with selective timber harvesting, with approximately 15 years between re-entry. As a result of the selective harvesting, these stands possessed multiple age-classes of trees, but were assigned to 1 of 2 vegetative growth stages (VGS's) (Table 1). If the preponderance of trees were between 12.7cm and 30.5cm dbh (5.0-12.0in), they were considered small tree stands. If the preponderance of trees were between 30.5cm and 50.8cm dbh (12.0-20.0in), they were assigned to the medium tree group of stands. Mean basal area of large trees (≥ 6in) in individual stands varied between 9.0 and 29.8m^2/ha (40.0-132.9ft^2/acre) (Table 1). Stands were chosen based on habitat type, VGS, and stand size or width. Stands were only used if they were large enough to contain the trapping setup with no trap within 50m of boarder of the stand or road, to avoid the influence of the conditions within adjoining stands and roads. Tree density varied among stands as well (116-435trees/ha, 48-180trees/acre). Percent canopy closure ranged from 20% to 52% among stands. Understory density, height, and composition (shrubs, grass, forbs, etc.) varied among stands as well.

Table 1. Stands used in Valley County Idaho in 1995 and 1996, listed by stand ID, habitat type class, and vegetative growth stage (medium tree, or small tree). Mean basal area (standard error) of large trees ($\geq$6in) (in square meters/ha), large tree density (standard error) (in trees/ha), and percent canopy closure (standard error) are also given for individual stands.

Stand ID	Habitat Type Class	Vegetative Growth Stage	Basal Area	Large Tree Density	% Canopy Closure
9	Cool-Moist Grand Fir	Small Tree	19.10(2.72)	367.56(87.71)	37.50(5.85)
11	Cool-Moist Grand Fir	Small Tree	13.96(1.33)	284.17(52.42)	36.21(6.04)
12	Cool-Moist Grand Fir	Small Tree	9.92(2.10)	148.26(28.98)	41.00(6.23)
41	Cool-Moist Grand Fir	Small Tree	9.45(2.31)	237.83(53.47)	36.79(5.83)
B	Cool-Moist Grand Fir	Small Tree	14.50(2.77)	234.75(42.50)	37.50(5.95)
E	Cool-Moist Grand Fir	Small Tree	9.19(2.01)	154.44(14.71)	30.07(5.45)
13	Cool-Moist Grand Fir	Medium Tree	28.35(2.74)	386.09(29.57)	51.79(5.85)
26	Dry Grand Fir	Small Tree	16.51(2.68)	234.75(24.19)	42.00(5.98)
27	Dry Grand Fir	Small Tree	13.14(2.32)	244.01(53.47)	20.07(4.66)
D	Dry Grand Fir	Small Tree	14.85(1.71)	244.01(64.27)	40.79(5.64)
F	Dry Grand Fir	Small Tree	11.44(2.02)	117.37(10.70)	37.36(5.59)
6	Dry Grand Fir	Medium Tree	17.03(0.69)	154.44(39.88)	38.07(5.42)
G	Dry Grand Fir	Medium Tree	15.18(2.38)	157.53(59.33)	27.07(5.17)
17	Dry Douglas-fir	Small Tree	15.52(2.75)	172.97(33.84)	30.00(5.19)
18	Dry Douglas-fir	Small Tree	12.38(3.58)	194.59(52.27)	33.86(5.59)
A	Dry Douglas-fir	Small Tree	10.46(2.08)	182.24(34.35)	47.14(6.04)
2	Dry Douglas-fir	Medium Tree	12.15(3.31)	157.53(43.21)	48.57(5.99)
19	Dry Douglas-fir	Medium Tree	30.51(2.64)	444.78(73.61)	49.36(5.83)
C	Dry Douglas-fir	Medium Tree	13.92(3.88)	135.91(35.67)	40.79(5.69)

METHODS

Experimental Design

A total of 19 stands were sampled to identify species associations with different habitat type classes and successional stages. Stand 9 (Table 1) had to be replaced when the specific phases included in each habitat type class were changed, shifting stand 9 to a different habitat type class. Six replicates in each habitat type class were selected. After reclassification of successional stages, varying numbers of replicates (1-5) remained in each of 2 successional stages, within habitat type classes (Table 1).

Two 1 month long small mammal and herptile trapping sessions were conducted in each of the 18 stands used each year: from mid-July to mid-August 1995, October 1995, June 1996, and July 1996. Since only 6 stands could be trapped at a time, due to logistical constraints, 3 trapping periods, lasting 1 weak, were conducted during each 1 month trapping session. To avoid temporal effects between ELU's, 1 replicate of each ELU was trapped in during each trapping period. Trapping periods lasted 7 days, including 2 set-up days and 5 trap nights. A trap night was defined as a 24 hour period in which all the traps in a given stand were set. This trapping design gave 5 trap nights in each stand per trapping session, 10 trap nights in each stand per field season, 20 trap nights in each stand total, and a total of 360 trap nights during the study in all stands combined.

During the summer of 1995 Anabat V bat detectors (Titley Electronics, Balina N.S.W., Australia) were left set up in each stand on 2 separate nights between mid July and the end of September. During the 1996 field season, 2 or 3 bat detector nights were obtained in each stand between mid-June and mid-August. Bat detectors were moved between stands daily until all stands had 1 detector night. The cycle was then repeated, to avoid temporal effects. This allowed a total of 4 or 5 bat detector nights in each stand.

Four vegetation sampling plots were located in each of the 19 stands. This gave a total of 24 plots per habitat type class, and 76 plots total. In the dry Douglas-fir habitat type class, three small tree and three medium tree stands were compared, with 12 vegetation sampling plots per ELU. In addition, 36 moosehorn readings (Cook et al. 1995) and 72 sets of profile board horizontal cover estimates (Hays et al. 1981, Higgins et al. 1994) were made in each trapping site.

Trapping

The trapping design was intended to catch as many species of small mammals, reptiles, and amphibians concurrently as possible. Individuals were marked with the toe clip method to identify individuals which had been captured previously. The design consisted of 2 drift fence triads, placed 150m (492ft) apart within the given stand. Triads consisted of 3 drift fences running out from the center at 120° from each other (Fig. 1). Each arm of the triad was made of 7.5m (25ft) of aluminum valley flashing, buried 21cm (8in) deep in the soil, and having 47cm (16in) extending above the surface. A pitfall trap was placed at the end of each triad and at the intersection of the 3 aluminum drift fence arms (Jones 1981). Pitfalls were made of 2 number 10 coffee cans, taped end to end, with the bottom removed from the top can. Holes were punched in the bottom of the lower can to allow for the drainage of rain water. Funnel traps (C. Peterson, Idaho State University, Pers. Comm.) were placed on both sides of the drift fence arms, approximately in the middle. Funnel traps were 21cm (8in) diameter tubes of 3.5mm (1/8in) metal screen, 76cm (30in) long, with a cone of the same material in each end.

The 1st triad was randomly located within the stand using a number grid over a map of the stand, and randomly generating numbers until an intersection within the stand was located. The 2nd triad was located by generating a random bearing from the 1st triad and placing it 150m (492ft) out on that bearing. Three rows of 10 Sherman traps (HB Sherman Co., Tallahassee, Florida) (10cm X 9cm X 30.5cm, 4in X 3.5in X 12in) were placed along the bearing between the 2 triads (Fig. 1). Both traps and rows of traps were spaced 10m (32.7ft) apart, forming a 10 x 3 grid. Pitfall traps were used to catch amphibians and small mammals. Funnel traps were intended to catch snakes, which are not susceptible to pitfall traps (Bury and Corn 1987). Sherman traps were used to catch species of small mammals that are not susceptible to pitfalls, such as chipmunks and deer mice.

Small mammals were identified according to Burt and Grossenheider (1980), and Whitaker et al. (1980). Herpetiles were identified according to Behler (1979). Shrew species overlapped extensively in color, body measurements, and other physically distinguishing characteristics. It was therefore necessary to identify shrews to species using dental characteristics, and skull measurements given in Junge and Hoffmann (1981). Species identifications were verified against museum vouchers at the University of Idaho.

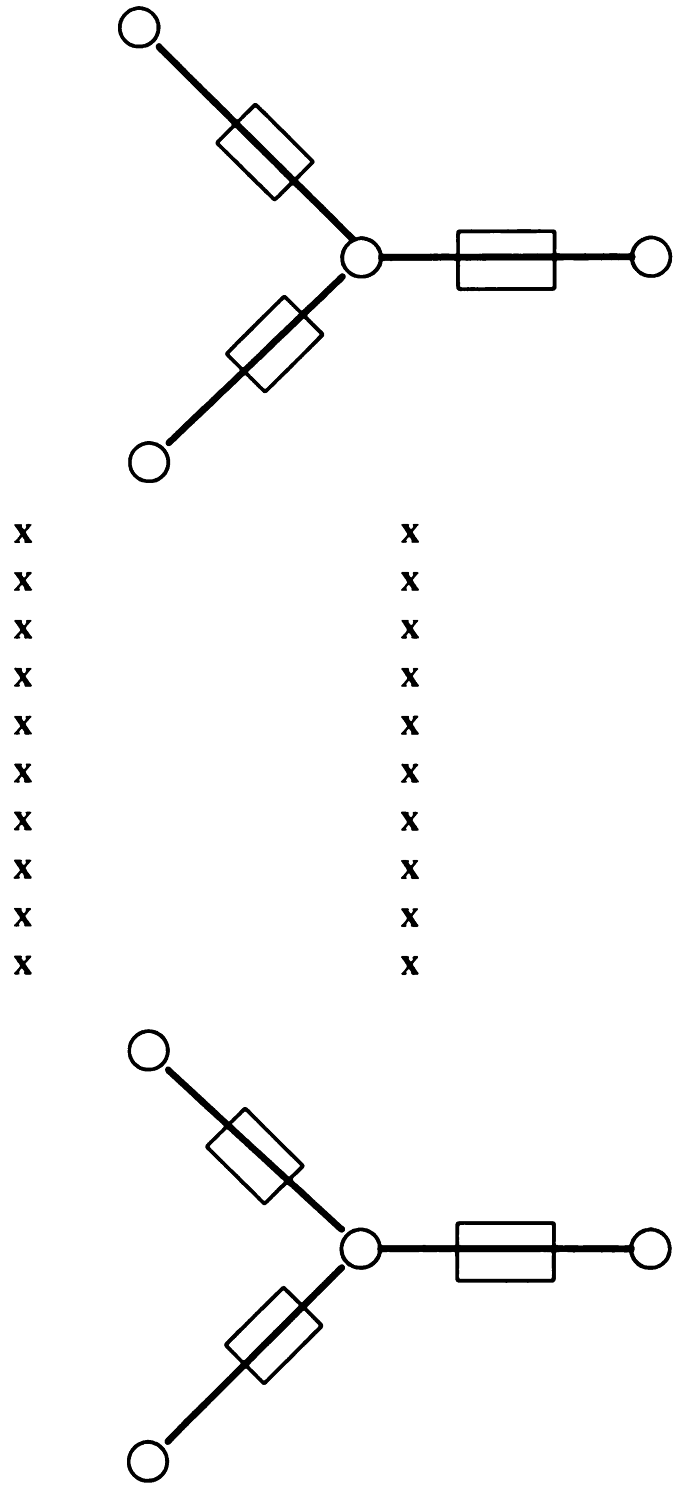


Figure 1. Schematic of trap setup within stands on study area in Valley County, Idaho in 1995 and 1996. In the Figure, circles represent pitfall traps, squares are funnel traps, heavy lines are drift fences, and X's are Sherman traps. Sherman traps are spaced 10m apart, within and between rows. Note that these dimensions are not depicted accurately.

Bat Detection

Anabat 5 bat detectors, with delay switches and tape recorders, were used to detect and record the calls of echolocating bats. The bat detectors, which turn on and off at a set light level, were placed in stands in the evening and retrieved in the morning. Sensitivity levels of the bat detectors were always set to 4.5. Bat calls recorded by bat detectors in the field were played into a computer interface module. The Anabat 5 software allow the computer to function as a spectrum analyzer, which produced a graphic image of the echolocation calls. This graphic image was used to identify the species of bat which had produced the call, by making comparisons with call shapes, frequency ranges, and frequency rates of change given in the literature (Fenton et al. 1983, Thomas and West 1989, Corben 1994). Echolocation call descriptions and measures were taken from Fenton and Bell (1981), Fenton et al. (1983), Thomas et al. (1987), and Thomas and West (1989).

Vegetation Sampling

To allow greater understanding of species distributions across landscape, and to assist managers in enhancing the habitat for species of concern, it is important to understand why each species is associated with a given ELU. In addition, understanding important habitat features for a species can aid in the development of models with greater predictive value of species presence and relative abundance. We therefore needed to identify the specific habitat features that contribute to a species' association with an ELU. Since this project dealt with a wide diversity of species, with diverse life histories, it was important to collect data on a relatively comprehensive assortment of habitat variables in the vegetation sampling design.

The vegetation sampling design (Fig. 2) consisted of a 0.0081ha (1/50th acre) fixed circular plot, nested within a 0.081ha (1/5th acre) fixed circular plot, which in turn had 3 15.24m (50ft) point intercept transects around its exterior. All information from vegetation plots was recorded using CMT data loggers (CMT Corvallis MicroTechnology Inc. 413 S.W. Jefferson Ave. Corvallis Or. 97333).

Within the 0.0081ha (1/50th acre) plot, information about the height and number of all small (<15.28cm) (< 6.0in. dbh) trees was collected. Height of small trees was measured using a logger's measuring tape. Where small trees were too tall for measurement using the loggers tape, heights were measured using a clinometer, and trigonometric hypsometry, from a distance of 18.3m (60ft) parallel with the tree on the slope (Hays et al. 1981). Numbers of small trees by height class were recorded to the nearest 30cm (1ft).

Within the 0.081ha (1/5th acre) fixed circular plot, relevant information about snags, trees, and stumps was collected. Relevant information about snags included dbh, and height. The dbh of snags was measured using a dbh tape, or dbh side of a loggers tape (Hays et al. 1981). Snag heights were measured using a clinometer from 18.3m (60ft) at a point parallel on the slope. Where it was not possible to measure height from a point parallel on the slope, distances were adjusted for slope (Hays et al. 1981).

Large tree information included species, dbh, height, and height to 1st live branch. Large trees were identified to species using vegetative characteristics, such as cones, crown shape, needles, and bark. Diameter at breast height was measured using a dbh tape, or the dbh side of a loggers tape. Height, and height to the 1st live branch of large trees, was measured using a clinometer from 18.3m (60ft) across slope, or from a distance adjusted for

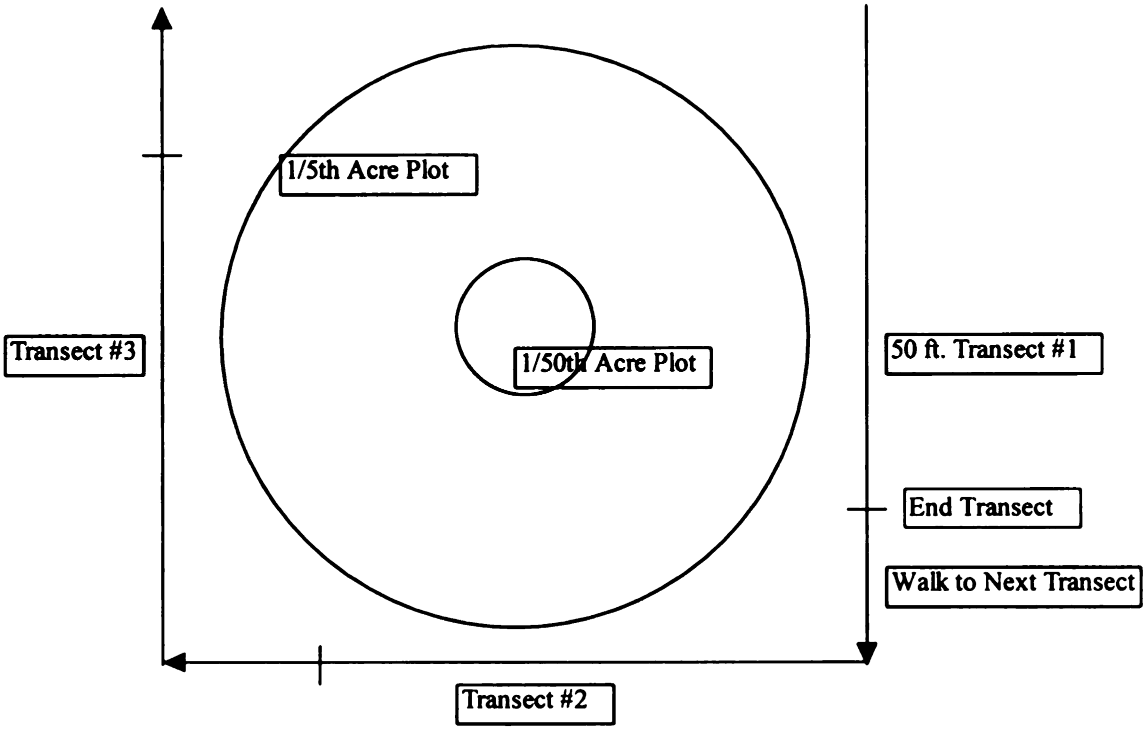


Figure 2. Schematic of vegetation plot structure used to quantify vegetation attributes in Valley County, Idaho during 1995 and 1996. The plot consists of a 1/50th acre (0.0081ha) circular plot nested within a 1/5th acre (0.081ha) circular plot, with three 50ft. (15.24m) transects, at right angles, around the perimeter.

slope (Hays et al. 1981). Information collected about stumps included diameter and density. Stump height was measured using a loggers tape (Hays et al. 1981). Stumps within the 0.081ha (1/5th acre) plot were counted to estimate density.

The 3 15.24m (50ft) line transects around the fixed circular plots were used to collect information with a point intercept method (Higgins et al. 1994). The transect was used to collect information on the presence and cover of forest litter, herbaceous vegetation, living woody vegetation, and number and diameter of coarse woody debris pieces at ground surface, in the 1st meter above the ground, and above 1m from the ground. Transects were run north to south, east to west, and south to north, along 3 sides outside of the large fixed circular plot. Pieces of coarse woody debris > 15.24cm (6in) at their largest end were also counted and measured for length and for diameter at the largest end. Length of coarse woody debris pieces was measured using a logger's tape. Diameter at the largest end of coarse woody debris was measured using a logger's tape or dbh tape (Hays et al. 1981). Coarse woody debris density in logs/ha was estimated using the formula $\hat{X} = 10^5 \bullet \frac{\pi}{2L} \bullet \sum_{n}^{1} \frac{1}{\ell_i}$ where L equals line transect length, and ℓ equals log length (deVries 1986). A pole was placed every 60.96cm (2ft) along the transect, and the identity of materials contacting it in each of the 6 strata was recorded (Higgins et al. 1994). Information on canopy closure was also collected at the start of each transect, and at plot center. Canopy closure measurements were made with a moosehorn circular densiometer (Cook et al. 1995). Using the moosehorn, the number of the 25 line intersections with vegetation over them at all heights, and at heights greater than 4.9m (16ft) were counted.

The bubble level in the moosehorn was used to assure that the instrument was held vertically.

Site information was also recorded at each plot. These data included universal transverse mercator system (UTM) coordinates (Koeln et al. 1994, Samuel and Fuller 1994), slope, aspect, elevation, and plot number. Universal transverse mercator system coordinates were determined using a CMT global positioning system (GPS) based on the North American Datum from 1983 (NAD-83) (Koeln et al. 1994, Samuel and Fuller 1994). Latitude and longitude were projected onto a state plane projection. Slope was measured using a clinometer. Aspect was measured using a compass. Mean aspect was calculated as

$$\tilde{X}_0 = \begin{cases} \tilde{x}_0' & \text{if } \bar{S} > 0,\ \bar{C} > 0, \\ \tilde{x}_0' + \pi & \text{if } \bar{C} < 0, \\ \tilde{x}_0' + 2\pi & \text{if } \bar{S} < 0,\ \bar{C} > 0, \end{cases} \qquad \text{where } \tilde{x}_0' = \arctan(\bar{S} / \bar{C}),$$

$\bar{C} = \frac{1}{n}\sum f_i \cos\phi_i$, $\bar{S} = \frac{1}{n}\sum f_i \sin\phi_i$, f_i is the frequency of the observation, n is the sample size, and ϕ_i is the aspect of individual plots measured in radians (Mardia 1972). Elevations were estimated using a map.

Horizontal and vertical cover measurements were also collected at actual trap locations. At each point a moosehorn reading of vertical cover, and 2 sets of profile board estimates of horizontal cover were taken. Horizontal cover estimates were made using a 1m (3.27ft), 35cm (14.5in) wide profile board, divided vertically into 25cm (9.8in) sections. The profile board was held 1m (3.27ft) (Nudds 1977) from the observer, who estimated the percent of each section of the board that was visually obscured by vegetation. The observer viewed the profile board from approximately the same height as the center of the profile board section for which visual obscurity was being estimated (Higgins et al. 1994, Hays et al. 1981). To avoid directional biases, profile board estimates were made on opposite sides of the point, in a direction perpendicular to the transect line at Sherman trap points. At each of the 3 triad points, estimates were made in opposite directions perpendicular to the line going directly away from center, midway between each set of triad arms. Points on these lines were 2m (6.6ft) from the triad center. Ten transect line points were located 10m (32.7ft) apart on each of the 3 Sherman trap lines.

Data Analysis

Small Mammal, and Herptile

Capture data for each species was tested for differences in means among habitat type classes, and between small tree and medium tree vegetation growth stages (VGS's)within the dry Douglas-fir habitat type class. The capture data were used in the relative abundance format of captures per trapping event, which is in essence animals captured per 5 trap nights. Data were left in this format because all stands had the same number of trap nights, and to avoid problems with defining the efficiency of different trap types, which were used simultaneously in the trapping design. All statistical tests were conducted at the 90% (α=0.10) confidence level. SAS/STAT Program version 6.0 (SAS Institute Inc., Cary, NC) was used to run all statistical tests.

Because of the high temporal variability among trapping sessions due to seasonal differences, comparisons of capture rates among different habitat type classes and VGS's were made within each trapping session individually, and across all trapping sessions. Temporal effects of weather changes, caused by having 3 separate 7-day trapping periods within each trapping session may also have existed in the data. Trapping was therefore done in 2 replicates of each habitat type class, and 1 replicate of each VGS within the dry Douglas-fir habitat type class, in each of the 3 week long trapping periods per 1 month trap session. To minimize the influence of these temporal effects on the analysis, and because the data had missing values, it was necessary to use the general linear model (GLM) to test for differences in capture rates among habitat type classes and between VGS's (Ott 1993). The GLM was used because it provides an equivalent test to ANOVA when data have missing values. The temporal effects were minimized by including them in both the within group variability, and between group variability compared in the GLM. Because of the small sample sizes, and small catches of some species, a non-parametric test was used for comparisons of capture rates among habitat type classes, and between VGS's as well. The non-parametric alternative used was the Kruskal-Wallis non-parametric analysis of variance. This was done by ranking the data, and then using the GLM on the ranks (Ott 1993, SAS Institute Inc. 1989). This test will be referred to as the Kruskal-Wallis test in this paper. The GLM was used by itself on individual trapping sessions as a means to compare with the results of the Kruskal-Wallis test, used in the same way, to identify any major inconsistencies and points of concern to investigate. The joint ranks multiple comparison test (multiple comparison test) was used to identify which habitat type classes were different from others when the Kruskal-Wallis test showed a significant difference (Miller 1985, Siegel and Castellan 1988, Toothaker 1991). The joint ranks multiple comparison test is intended to be used on the ranks of data, unlike Tukey's or Duncan's tests, which are not recommended for use on ranks of data. The GLM for repeated measures was done using the multivariate analysis of variance (MANOVA) option to test for differences in habitat type classes across all 4 trapping sessions. The MANOVA option did not use any replicates (stands) with missing values among the trapping sessions, and ran the GLM for repeated measures on the remaining replicates (stands) (SAS Institute Inc. 1989). For this reason, only 17 stands were used with the GLM for repeated measures.

Bat

Bat data could not be used in a relative abundance format for several reasons. 1st, it was not possible to identify individual bats on the tape recordings of echolocation calls. One bat could therefore be counted as several individuals, or only as a single individual. secondly, there were questions as to the ability of the equipment and technique to separate out several species of bats. The similarity of these calls in conjunction with the geographic variability of a species calls, and the inability to calibrate using the calls of known individuals of various species from the study area, created the potential for some individuals to be misidentified (D. Genter, Montana Natural Heratige Program, pers. comm., Thomas et al. 1987, Thomas and West 1989). In addition, some tapes became full before a full bat detector night had been completed. To avoid these problems, the data were represented as the percentage of detector nights an individual species was detected in a given stand. This relative presence format eliminates the problems listed above, by making it inconsequential if an individual is counted more than once, and minimizes the potential for an individual misidentification to influence the outcome of tests. Bat data were tested using GLM, the Kruskal-Wallis test, MANOVA (Ott 1993, SAS Institute Inc. 1989), and the multiple comparison test (Miller 1985, Siegel and Castellan 1988, Toothaker 1991) in the same way as previously described.

Vegetation

To identify habitat variables that were important to individual animal species, and characterized habitat type classes and VGS's, tests were run to identify differences in habitat variables among habitat type classes, and between VGS's within the dry Douglas-fir habitat type class. The primary test used was the Kruskal-Wallis test (Ott 1993, SAS Institute Inc. 1989). If the Kruskal-Wallis test showed a significant difference among habitat type classes (Ott 1993, SAS Institute Inc. 1989), the joint ranks multiple comparison test was used to identify which of them had significantly different values (Miller 1985, Siegel and Castellan 1988, Toothaker 1991). If a species was relatively more abundant in a habitat type class or VGS, and a habitat variable was also relatively more or less abundant in the same habitat type class or VGS, the variable was presumed to potentially be influencing the relative abundance of that species. To lend support to this presumption, differences between relative abundance groups of individual species for habitat variables were also investigated. It should be noted however, that the failure of the relative abundance group tests to corroborate a relationship does not necessarily refute a relationship identified by habitat type class and VGS tests. The data proved inappropriate for the use of multivariate techniques because of a lack of multivariate normality, the small sample size, non-linear relationships, and an inability to linearize those relationships. Since the data proved inappropriate for use with multivariate techniques, no attempt was made to identify interacting variables. Interaction between variables could mask relationships that are apparent at the habitat type class or ELU level, and yet not apparent at the individual species by variable level.

Stands were grouped based on the mean relative abundance of individual species across the 4 trapping sessions. This was done for each of 10 small mammal species, and 2 amphibian species. Habitat variables were then tested for differences between the groups (C.W. Ramm, Michigan State University, pers. comm.). To identify natural groups, stands were sorted by relative abundance of an individual animal species, and then numbered in that order from 1 to 19. The data were then plotted with the assigned number on the X axis, and relative abundance on the Y axis. Large breaks or jumps in relative abundance were then identified occularly as natural cut off points. Stands were allowed be broken into a maximum of 4 relative abundance groups, with no less than 3 stands in a group. Stands located together between natural breaks in the data were then assigned to the same group. For a complete description of the methods used for grouping stands, with examples, see Appendix B.

Differences in habitat variables between relative abundance groups for individual species were tested for in several ways. The primary test used was the Kruskal-Wallis test, which was done by using GLM on the ranks of the data (Ott 1993, SAS Institute Inc. 1989). The general linear model (GLM) was used by itself as a parametric alternative for comparison, to identify any major inconsistencies which required investigation. The multiple comparison test was used to separate groups which showed significantly different values for a given variable in the Kruskal-Wallis and/or GLM tests (Miller 1985, Siegel and Castellan 1988, Toothaker 1991).

The combining of stands into relative abundance groups, and testing for differences in vegetation and site characteristics among the relative abundance groups, was limited in effectiveness. Small sample sizes, large numbers of variables, and high variability of conditions, both within and between stands of the same habitat type class or VGS, made the identification of important variables for individual species difficult, and made interpretation of results questionable. For this reason only habitat variables that can be supported biologically, and through literature will be discussed in the main body of this thesis. A complete discussion of grouping techniques, and the less supportable results and discussion of the vegetation analysis, are provided in Appendix B.

RESULTS

Small Mammals

A total of 17 small mammal species were captured during the 2 years of trapping. Of these, the yellow-pine chipmunk (*Eutamias amoenus*), deer mouse (*Peromyscus maniculatus*), northern red-backed vole (*Clethrionomys gapperi*), dusky shrew (*Sorex monticolus*), masked shrew (*Sorex cinereus*), meadow vole (*Microtus pennsylvanicus*), vagrant shrew (*Sorex vagrans*), dwarf shrew (*Sorex nanus*), northern pocket gopher (*Thomomys talpoides*), and golden-mantled ground squirrel (*Spermophilus lateralis*) were captured in sufficient numbers to conduct statistical analysis. A minimum of 5 individuals had to be captured during a trapping session to be considered to have sufficient numbers for analysis, so a significant difference could potentially be detected. In addition, 4 western jumping mice (*Zapus princeps*) were captured during the 1995 field season, and 2 were captured in 1996 (Appendix A Table 1). Four long-tailed weasels (*Mustela frenata*) were caught in 1995. Three Colombian ground squirrels (*Spermophilus columbianus*) were caught in 1995, and 4 were captured during the 1996 trapping sessions. One red squirrel (*Tamiasciurus hudsonicus*) was caught during the 1995 field season, and 2 were captured in 1996. One bushy-tailed wood rat (*Neotoma cinerea*) was caught in 1996, as was 1 northern flying squirrel (*Glaucomys sabrinus*), and 2 water shrews (*Sorex palustris*) (Appendix A Table 1).

By Habitat Type Classes

The most commonly captured species of small mammal was the yellow-pine chipmunk, with 562 total individuals captured during all 4 trapping sessions (Appendix A Table 2). During trap session 1 (mid July to mid Aug. 1995), a total of 178 individuals were captured, 88 individuals during trap session 2 (October 1995), 134 individuals during trap session 3 (June 1996), and 162 individuals during trap session 4 (July 1996). Specific capture data for the yellow-pine chipmunk can be found in Appendix A Table 2. The Kruskal-Wallis test showed no significant differences in relative abundance among habitat type classes during any of the 4 trapping sessions (Fig. 3) ($P = 0.83$, 0.62, 0.28, and 0.55 for trapping sessions 1 through 4 respectively). The GLM, used for individual trap sessions, showed general agreement with the results of the Kruskal-Wallis test. The GLM for repeated measures showed no significant difference in capture rates between habitat type classes across all trapping sessions ($P = 0.35$). These results indicate that yellow-pine chipmunk abundance did not differ significantly among the 3 habitat type classes investigated.

The deer mouse was the 2nd most commonly captured species, with 436 individuals captured during all 4 trapping sessions combined (Appendix A Table 3). Seventy-one individual deer mice were captured during the 1st trapping session, 88 individuals captured during the 2nd trapping session, 92 during the 3rd, and 185 during the 4th (Appendix A Table 3). No significant difference in capture rates was detected with the Kruskal-Wallis

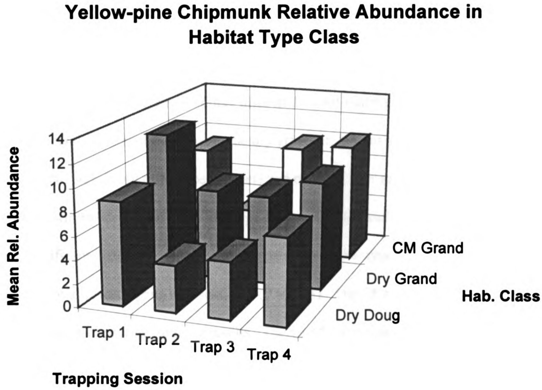


Figure 3. Yellow-pine chipmunk mean relative abundance in habitat type classes, expressed as mean total capture of individuals by trap session, in Valley County Idaho in 1995 and 1996. No significant differences ($P < 0.10$) were found by the Kruskal-Wallis test (Ott 1993). Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class.

test among habitat type classes during trapping sessions 1 and 2 (Fig. 4) (P = 0.66, and 0.62 respectively). A significant difference in capture rates among habitat type classes was detected during the 3rd trapping session (P = 0.03). The Joint ranks multiple comparison test showed the mean capture rate of deer mice in the cool-moist grand fir habitat type class to be significantly different from that in the dry grand fir, but not the dry Douglas-fir habitat type class. No significant difference was detected between deer mouse capture rates in the dry Douglas-fir and dry grand fir habitat type classes with the multiple comparison test (Fig. 4). No significant difference in capture rates between habitat type classes was detected by the Kruskal-Wallis test during trap session 4 (P = 0.18). The GLM applied to individual trapping sessions produced the same results. The GLM for repeated measures showed no significant difference among capture rates in different habitat type classes during all trapping sessions combined (P = 0.40). These results indicate that deer mouse relative abundance showed no consistent significant differences among the 3 habitat type classes.

The 3rd most commonly captured mammal was the northern red-backed vole, with a total of 157 individuals captured during all 4 trapping sessions combined (Appendix A Table 4). Forty-three red-backed voles were captured during the 1st trapping session, 55 during the 2nd trapping session, 27 during the 3rd trapping session, and 32 during the 4th trapping session (Appendix A Table 4). The Kruskal-Wallis test showed significant differences in capture rates between habitat type classes during the 2nd and 3rd trapping sessions (Fig. 5) (P = 0.001, and 0.03 respectively). The multiple comparison test showed a significant difference in

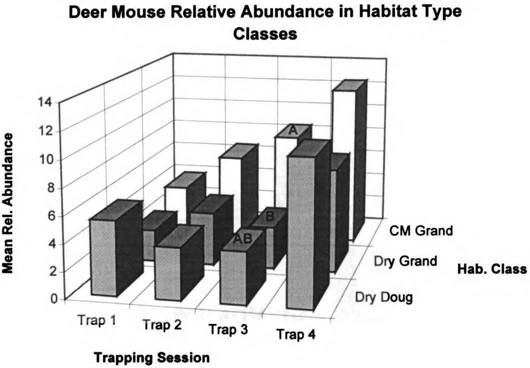


Figure 4. Deer mouse mean relative abundance, expressed as mean total capture of individuals in habitat type classes, by trap session, in Valley County Idaho in 1995 and 1996. Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class. Trap sessions with letters above the columns differed significantly ($P < 0.10$) by the Kruskal-Wallis test (Miller 1985, Ott 1993, Toothaker 1991). Dissimilar letters on columns within trapping sessions indicate significant differences ($P < 0.10$) (joint ranks multiple comparison test) (Miller 1985, Toothaker 1991).

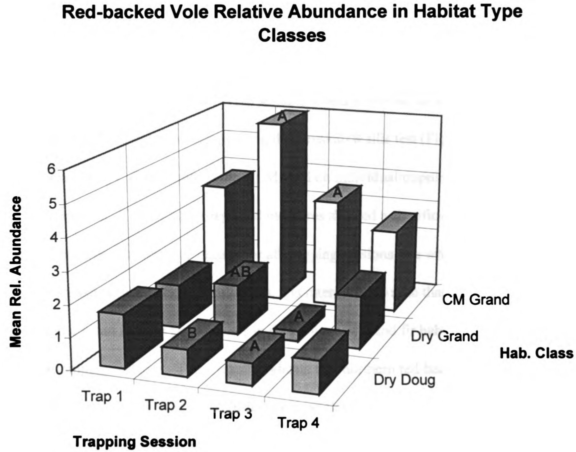


Figure 5. Red-backed vole mean relative abundance, expressed as mean total capture of individuals in habitat type classes, by trap session, in Valley County Idaho in 1995 and 1996. Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class. Trap sessions with letters above the columns differed significantly ($P < 0.10$) by the Kruskal-Wallis test (Miller 1985, Ott 1993, Toothaker 1991). Dissimilar letters on columns within trapping sessions indicate significant differences ($P < 0.10$) (joint ranks multiple comparison test) (Miller 1985, Toothaker 1991).

capture rates between the cool-moist grand fir habitat type class and the dry Douglas-fir habitat type class, but not for the dry grand fir habitat type class during trap session 2. No difference in capture rates was detected among the 3 habitat type classes by the multiple comparison test during trap session 3. Trap sessions 1 and 4 showed no significant differences between habitat type classes using the Kruskal-Wallis test (Fig. 5) ($P = 0.17$, and 0.22 respectively). The results of the GLM used on individual trapping sessions agree with this assessment. The GLM for repeated measures showed a significant difference in capture rates between habitat type classes for all trapping sessions as a whole ($P = 0.01$). Though not statistically significant in all cases, it is interesting to note that the red-backed vole had higher mean relative abundance's in the cool moist grand fir habitat type class during all 4 trapping sessions. These results indicate that northern red-backed voles were more abundant in the cool-moist grand fir habitat type class.

The dusky shrew was the 4th most commonly captured mammal, with 133 total individuals captured during all 4 trapping sessions (Appendix A Table 5). Twenty- seven individual dusky shrews were captured during the 1st trapping session, 22 in the 2nd, 32 in the 3rd, and 52 in the 4th trapping session (Appendix A Table 5). The Kruskal-Wallis test showed no significant differences in capture rates between habitat type classes during any of the 4 trapping sessions (Fig. 6) ($P = 0.21$, 0.21, 0.16, and 0.56 for trap sessions 1 through 4 respectively). The results of the GLM for individual trap sessions were in general agreement with these results. It should be noted, however, that mean dusky shrew capture rates, while not significant, were highest in the cool-moist grand fir habitat type class during

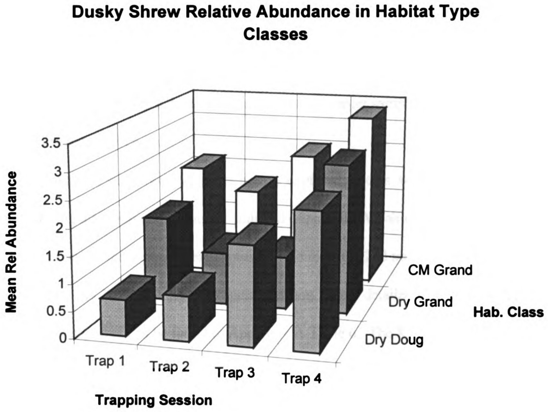


Figure 6. Dusky shrew mean relative abundance in habitat type classes, expressed as mean total capture of individuals by trap session, in Valley County Idaho in 1995 and 1996. No significant differences ($P < 0.10$) were found by the Kruskal-Wallis test (Ott 1993). Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class.

all 4 trapping sessions. The GLM for repeated measures detected no significant differences in mean capture rates between habitat type classes across all trapping sessions (P = 0.11). These results indicate that the dusky shrew showed no significant difference in relative abundance between habitat type classes, though larger sample sizes would likely reveal significant differences.

The masked shrew was also a commonly captured species, with 87 total individuals captured during all 4 trapping sessions combined (Appendix A Table 6). During the 1st trapping session, 26 individuals were captured, 12 during the 2nd trapping session, 29 during the 3rd, and 20 during the 4th trapping session. More detailed information about masked shrew captures can be found in Appendix A Table 6. The Kruskal-Wallis test detected a significant difference in relative abundance among habitat type classes in both trap sessions 1 and 2 (Fig. 7) (P = 0.02, and 0.04 respectively). No difference in capture rates was detected between habitat type classes during either the 3rd or 4th trapping sessions (Fig. 7) (P = 0.16, and 0.12 respectively). The GLM for individual trap sessions showed the same number of trap sessions with significant differences, but switched the significance to the 1st and 4th trap sessions. However, as a whole, the two tests still seem in general agreement.

The multiple comparison test showed no significant difference in the capture rates between the cool-moist grand fir and dry grand fir habitat type classes, or between the dry grand fir and dry Douglas-fir habitat type classes during the 1st trapping session. The multiple comparison test did, however, show a significant difference between the capture rates in cool-moist grand fir habitat type class, and dry Douglas-fir habitat type class during the 1st

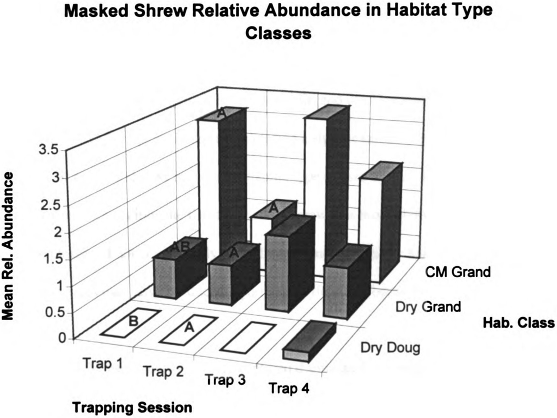


Figure 7. Masked shrew mean relative abundance, expressed as mean total capture of individuals in habitat type classes, by trap session, in Valley County Idaho in 1995 and 1996. Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class. Trap sessions with letters above the columns differed significantly ($P < 0.10$) by the Kruskal-Wallis test (Miller 1985, Ott 1993, Toothaker 1991). Dissimilar letters on columns within trapping sessions indicate significant differences ($P < 0.10$) (joint ranks multiple comparison test) (Miller 1985, Toothaker 1991).

trapping session. The multiple comparison test did not detect a significant difference among habitat type classes during the 2nd trapping session (Fig. 7). It should also be noted that, while not statistically significant, the means of capture rate ranks were ordered from highest to lowest as cool-moist grand fir, dry grand fir, and dry Douglas-fir in all trap sessions. The GLM for repeated measures detected a significant difference between the capture rates of masked shrews in different habitat type classes across all trapping sessions (P = 0.02). These results indicate that the masked shrew was more abundant in the grand fir habitat type classes, if not significantly so in the cool-moist grand fir habitat type class. Larger sample sizes may have produced significant differences between the grand fir habitat type classes.

A total of 30 vagrant shrews were captured during all 4 trapping sessions combined (Appendix A Table 7). Five vagrant shrews were captured during the 1st trapping session, 4 during the 2nd trapping session, 12 during the 3rd, and 9 during the 4th trapping session. Specific capture data are presented in Appendix A Table 7. No significant differences in capture rates were detected by the Kruskal-Wallis test during any of the 4 trapping sessions (Fig. 8) (P = 0.40, 0.19, 0.44, and 0.18 respectively). The results of the GLM for individual trapping sessions were in general agreement with the Kruskal-Wallis test. No significant difference in capture rates was shown by the GLM for repeated measures across all trapping sessions (P = 0.48). These results indicate that vagrant shrew relative abundance was not significantly different among these habitat type classes.

A total of 14 dwarf shrews were captured during all trapping sessions combined (Appendix A Table 8). Six dwarf shrews were captured during the 1st trapping session, 1 during the 2nd trapping session, 2 during the 3rd, and 5 during the 4th trapping session. See

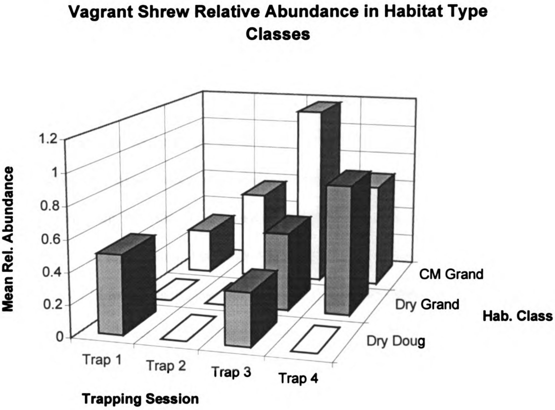


Figure 8. Vagrant shrew mean relative abundance in habitat type classes, expressed as mean total capture of individuals by trap session, in Valley County Idaho in 1995 and 1996. No significant differences (P < 0.10) were found by the Kruskal-Wallis test (Ott 1993). Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class.

Appendix A Table 8 for specific capture information on the dwarf shrew. The Kruskal-Wallis test showed a significant difference in the capture rates between habitat type classes for the 1st trapping session (P = 0.07) (Fig. 9). However, the multiple comparison test detected no significant differences between habitat type classes for trapping session 1. The Kruskal-Wallis test showed no significant difference in capture rates between habitat type classes during trap sessions 2 through 4 (Fig. 9) (P = 0.39, 0.12, and 0.11 respectively). The GLM for individual trap sessions is in general agreement with these results. Though not statistically significant, the order of rank means, from highest to lowest, shows the cool-moist grand fir to be highest in all but the 2nd trapping session, which only had 1 animal captured. The GLM for repeated measures showed a significant difference in capture rates between habitat type classes across all trapping sessions (P = 0.05). Since a significant difference was detected in the individual trap session with the largest number of captures, and was very nearly significant in the two trap sessions with the 2nd and 3rd largest number of captures, and a significant difference was detected across all trapping sessions combined, these results give some support for the dwarf shrew being more abundant in the cool-moist grand fir habitat type class.

A total of 33 individual golden-mantled ground squirrels were caught during all 4 trap sessions combined (Appendix A Table 9). Six golden-mantled ground squirrels were captured during the 1st trapping session, 0 during the 2nd, 10 during the 3rd, and 17 individuals during the 4th trapping session. See Appendix A Table 9 for specific capture information on the golden-mantled ground squirrel. No significant differences were

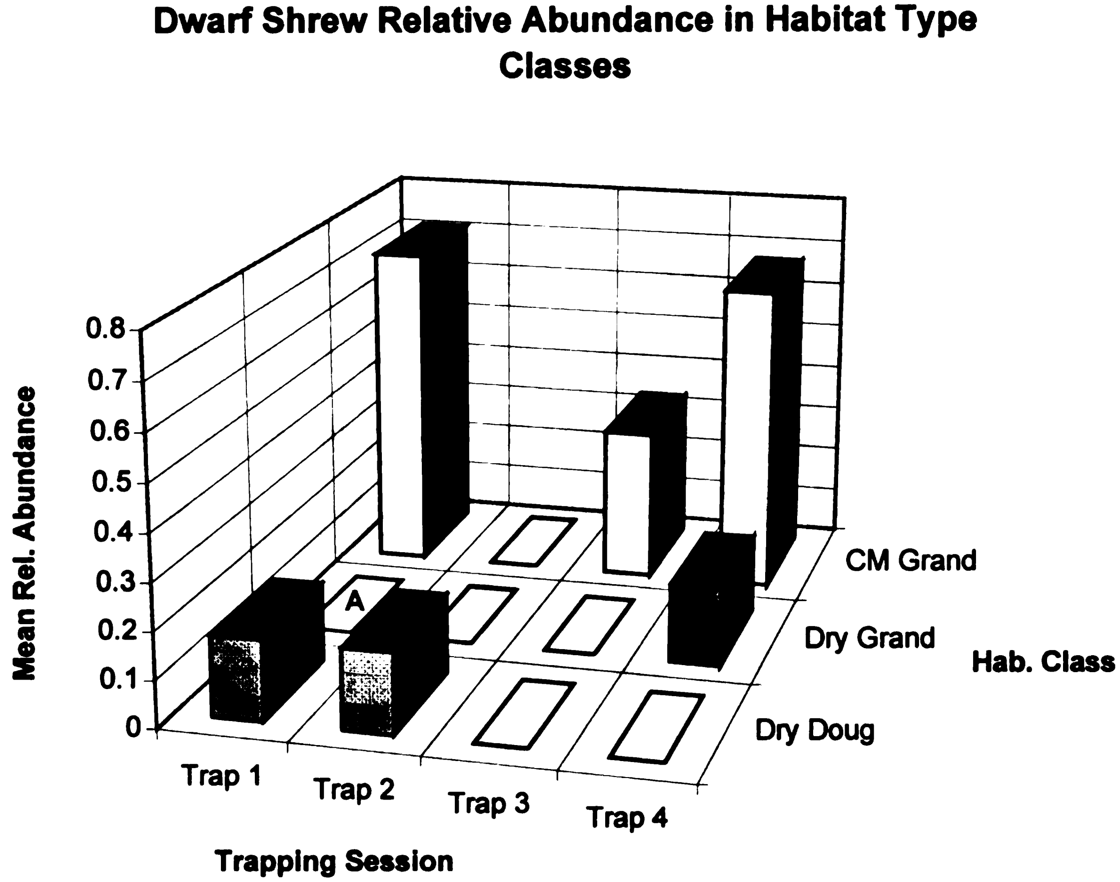


Figure 9. Dwarf shrew mean relative abundance, expressed as mean total capture of individuals in habitat type classes, by trap session, in Valley County Idaho in 1995 and 1996. Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class. Trap sessions with letters above the columns differed significantly ($P < 0.10$) by the Kruskal-Wallis test (Miller 1985, Ott 1993, Toothaker 1991). Dissimilar letters on columns within trapping sessions indicate significant differences ($P < 0.10$) (joint ranks multiple comparison test) (Miller 1985, Toothaker 1991).

detected in capture rates among habitat type classes during the 1st trapping session (P = 0.31) (Fig. 10). Due to the lack of captures during the 2nd trapping session, no calculations were possible. No significant difference in capture rates between habitat type classes was detected during trap sessions 3 and 4 (Fig. 10) (P = 0.32, and 0.17 respectively). The results from the GLM for the individual trapping sessions are in general agreement with the results of the Kruskal-Wallis test. The GLM for repeated measures showed no significant difference in capture rates among habitat type classes across all trapping sessions (P = 0.29). These results show that the golden-mantled ground squirrel did not differ in relative abundance among the 3 habitat type classes.

A total of 25 northern pocket gophers were captured during all 4 trapping sessions combined (Appendix A Table 10). Seven northern pocket gophers were captured during the 1st trapping session, 0 during the 2nd, 8 during the 3rd, and 10 during the 4th trapping session. For more detailed information about northern pocket gopher captures, see Appendix A Table 10. No differences in capture rates among habitat type classes during the 1st trapping session were found to be significant using the Kruskal-Wallis test (P = 0.44) (Fig. 11). No calculations could be made for the 2nd trapping session, due to a lack of captures. A significant difference in the capture rates among habitat type classes was detected for both trapping sessions 3 and 4 (Fig. 11) (P = 0.02, and 0.05 respectively). The multiple comparison test was unable to identify significant differences among the habitat type classes during either the 2nd or 3rd trapping session. The GLM for individual trap sessions gave similar results. The GLM for repeated measures showed a significant difference in the capture rates among habitat type classes across all trapping sessions (P = 0.01). These results indicate that northern pocket gopher relative abundance was

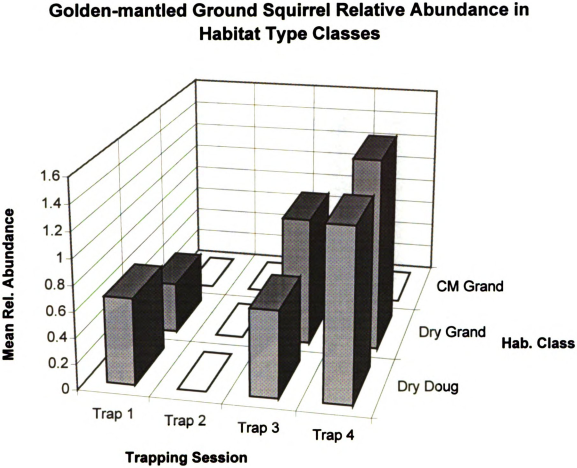


Figure 10. Golden-mantled ground squirrel mean relative abundance in habitat type classes, expressed as mean total capture of individuals by trap session, in Valley County Idaho in 1995 and 1996. No significant differences ($P < 0.10$) were found by the Kruskal-Wallis test (Ott 1993). Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class.

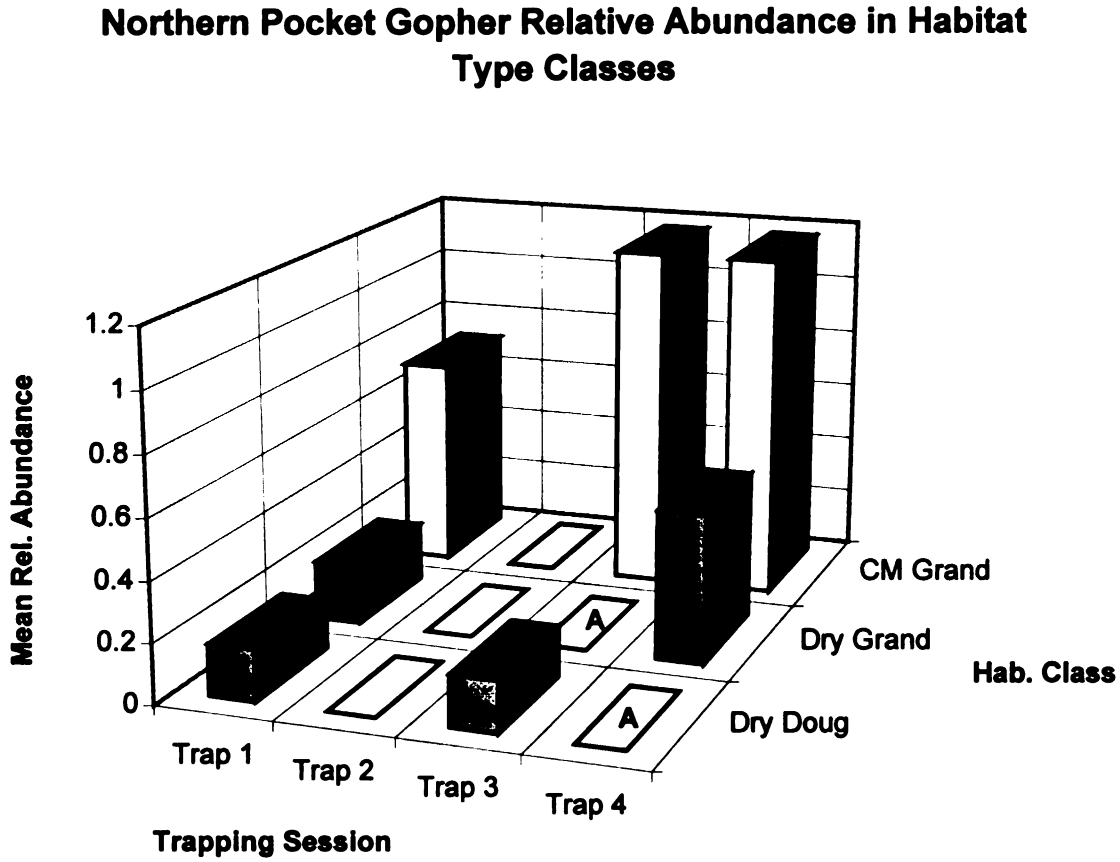


Figure 11. Pocket gopher mean relative abundance, expressed as mean total capture of individuals in habitat type classes, by trap session, in Valley County Idaho in 1995 and 1996. Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class. Trap sessions with letters above the columns differed significantly ($P < 0.10$) by the Kruskal-Wallis test (Miller 1985, Ott 1993, Toothaker 1991). Dissimilar letters on columns within trapping sessions indicate significant differences ($P < 0.10$) (joint ranks multiple comparison test) (Miller 1985, Toothaker 1991).

significantly different between at least some of the habitat type classes, with the cool moist grand fir habitat type class exhibiting the highest relative capture rates.

A total of 20 meadow voles were caught during all trapping sessions combined (Appendix A Table 11). Nine meadow voles were captured during the 1st trapping session, 6 during the 2nd, 0 during the 3rd, and 5 during the 4th trapping session. For more detailed information on meadow vole captures see Appendix A Table 11. The Kruskal-Wallis test detected no significant differences in meadow vole capture rates among habitat type classes during trapping sessions 1, 2, and 4 (Fig. 12) ($P = 0.89$, 0.57, and 0.32 respectively). A lack of captures made it impossible to run the Kruskal-Wallis test on the data from trap session 3. The results from the GLM used for individual trap sessions were in general agreement with the results from the Kruskal-Wallis test. The GLM for repeated measures found no significant difference in capture rates among habitat type classes across all trapping sessions combined ($P = 0.59$). These results indicate that meadow vole relative abundance was not different among these 3 habitat type classes.

Vegetative Growth Stages

Only 2 small mammal species showed significant differences between the dry Douglas-fir medium and small tree ELU's (Vegetative Growth Stages, here after referred to as VGS's), only 1 of which was consistently different. Many small mammal species showed no significant differences between VGS's, or were not caught in numbers sufficient to make analysis meaningful. The probabilities of a greater F (P values) for these species can be found in Appendix A Table 14. The Kruskal-Wallis test detected significant differences in deer mouse relative abundances between the 2 dry Douglas-fir VGS's during all 4 trapping sessions (Fig. 13) ($P = 0.02$, 0.01, 0.02, and 0.02 respectively).

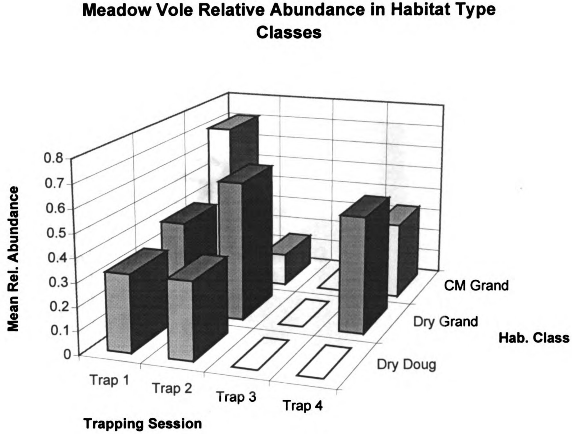


Figure 12. Meadow vole mean relative abundance in habitat type classes, expressed as mean total capture of individuals by trap session, in Valley County Idaho in 1995 and 1996. No significant differences ($P < 0.10$) were found by the Kruskal-Wallis test (Ott 1993). Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class.

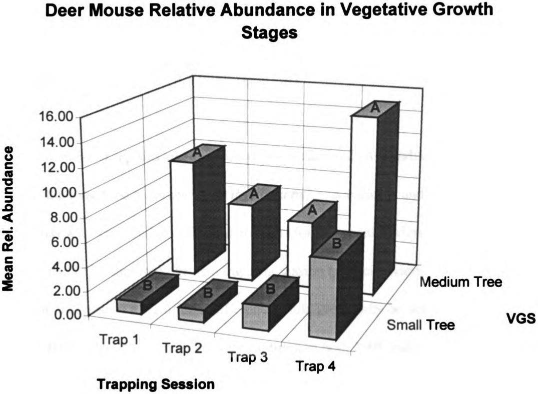


Figure 13. Deer mouse mean relative abundance, expressed as mean total capture of individuals in dry Douglas-fir vegetative growth stages (VGS), by trap session, in Valley County Idaho in 1995 and 1996. Trapping sessions (Trap 1-4) were each 5 days in length. Trap sessions with letters above the columns differed significantly ($P < 0.10$) by the Kruskal-Wallis test (Miller 1985, Ott 1993, Toothaker 1991). Dissimilar letters on columns within trapping sessions indicate significant differences ($P < 0.10$) (joint ranks multiple comparison test) (Miller 1985, Toothaker 1991).

Deer mouse relative abundance was higher in the medium tree VGS during all 4 trapping sessions. The only other small mammal to show a significant difference in relative abundance between VGS's was the red-backed vole, which showed a significant difference only during trapping session 2 (P = 0.001) (Fig. 14).

Herptiles

Six species of reptiles and amphibians were captured (Appendix A Table 1). Of these, only the long-toed salamander (*Ambystoma macrodactylum*), and the western toad (*Bufo boreas*) were captured in sufficient numbers for statistical analysis. A minimum of 5 individuals had to be captured during a trapping session to be considered to have sufficient numbers for analysis, so a significant difference could potentially be detected. In addition 5 pacific tree frogs (*Pseudacris regilla*) were captured in both 1995 and 1996. Two striped chorus frogs (*Pseudacris triseriata*) were captured in 1995. One common garter snake (*Thamnophis sirtalis*) was caught in 1995, and 2 were captured in 1996. One rubber boa (*Charina bottae*) was captured in 1996. These capture results do not necessarily indicate the abundance of individual species, or the richness of herptile species on the landscape as a whole. Trapping was conducted only in the interior of forested stands and not in riparian areas, which is where herptile species are more abundant and diverse in the dry intermountain northwest. Had trapping been conducted in riparian areas, more individuals and species may have been encountered.

Habitat Type Classes

A total of 33 individual long-toed salamanders were captured during all 4 trapping sessions combined (Appendix A Table 12). One long-toed salamander was captured during

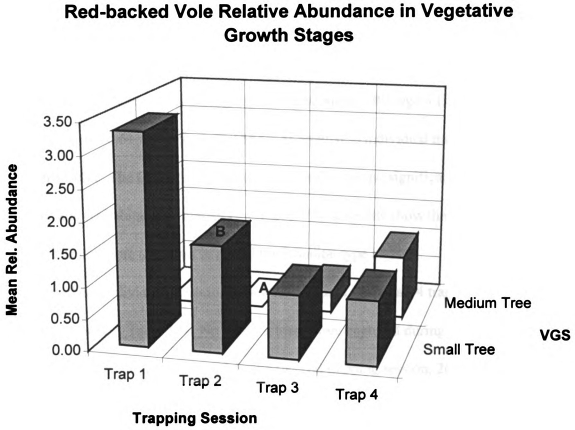


Figure 14. Red-backed vole mean relative abundance, expressed as mean total capture of individuals in dry Douglas-fir vegetative growth stages (VGS), by trap session, in Valley County Idaho in 1995 and 1996. Trapping sessions (Trap 1-4) were each 5 days in length. Trap sessions with letters above the columns differed significantly ($P < 0.10$) by the Kruskal-Wallis test (Miller 1985, Ott 1993, Toothaker 1991). Dissimilar letters on columns within trapping sessions indicate significant differences ($P < 0.10$) (joint ranks multiple comparison test) (Miller 1985, Toothaker 1991).

the 1st trapping session, 18 during the 2nd trapping session, 9 during the 3rd, and 5 during the 4th trapping session. For specific capture data for the long-toed salamander see Appendix A Table 12. The Kruskal-Wallis test showed no significant differences in capture rates between habitat type classes during any of trap sessions 1 through 4 (Fig. 15) (P = 0.29, 0.11, 0.29, and 0.61 respectively). The GLM applied to individual trapping sessions gave similar results. The GLM for repeated measures showed no significant difference in capture rates among habitat type classes ($P = 0.20$). These results show that the long-toed salamander was not more abundant in any of the 3 habitat type classes.

Thirty-three individual western toads were captured during all 4 trapping sessions combined (Appendix A Table 13). No western toads were captured during the 1st trapping session. One western toad was captured during the 2nd trapping session, 26 during the 3rd, and 6 during the 4th trapping session. For more detailed capture information on the western toad, see Appendix A Table 13. Since no individuals were captured during the 1st trapping session, no statistical comparisons were possible. No significant difference in capture rates was detected between habitat type classes for trap sessions 2 through 4 (Fig. 16) (P = 0.39, 0.12, and 0.76 respectively). The GLM applied to individual trap sessions was in general agreement with these results. The GLM for repeated measures showed no significant differences in capture rates among habitat type classes ($P = 0.21$). These results indicate that the western toad was not significantly more abundant in any of the 3 habitat type classes.

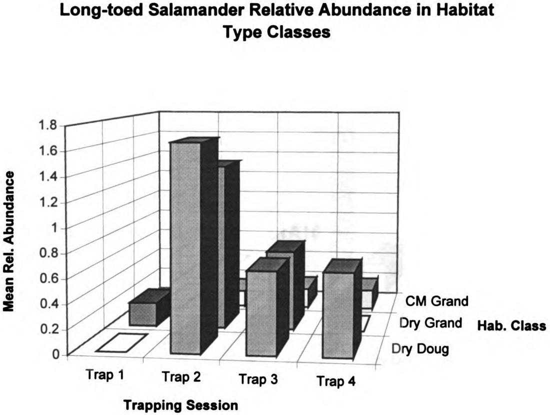


Figure 15. Long-toed salamander mean relative abundance in habitat type classes, expressed as mean total capture of individuals by trap session, in Valley County Idaho in 1995 and 1996. No significant differences (P < 0.10) were found by the Kruskal-Wallis test (Ott 1993). Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class.

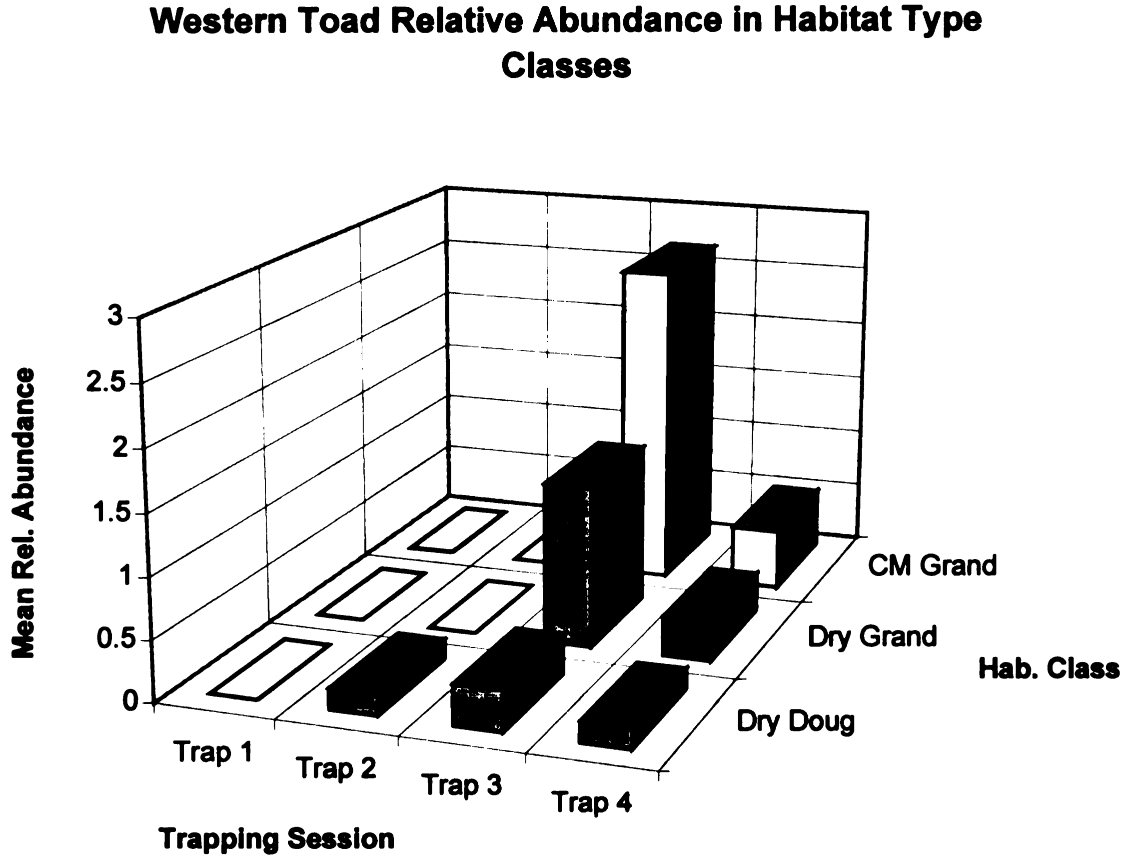


Figure 16. Western toad mean relative abundance in habitat type classes, expressed as mean total capture of individuals by trap session, in Valley County Idaho in 1995 and 1996. No significant differences ($P < 0.10$) were found by the Kruskal-Wallis test (Ott 1993). Trapping sessions (Trap 1-4) were each 5 days in length. CM grand refers to the cool moist grand fir habitat type class, dry grand to the dry grand fir habitat type class, and dry Doug to the dry Douglas-fir habitat type class.

Vegetative Growth Stages

The long-toed salamander was the only herptile to show a significant difference between the 2 dry Douglas-fir VGS's, based on the Kruskal-Wallis test (P = 0.05 for trap session 2) (Fig. 17). Long-toed salamander relative abundance was consistently higher in the small tree VGS through all 3 trap sessions in which captures were made, though not statistically significant in all. Due to the lack of significant results between VGS's in other species, whether due to lack of captures or lack of a relationship, the VGS's will not be expanded on further here. For probabilities of a greater F see Appendix A Table 15.

Bats

Bat detectors were used to detect and identify 6 species, or species groups, of bats (Appendix A Table 1). These species consisted of the big brown bat (*Eptesicus fuscus)*, long-eared myotis (*Myotis evotis*), hoary bat (*Lasiurus cinereus*), silver-haired bat (*Lasionycteris noctivagans*), myotis species group (*Myotis* sp.), and Townsend's big-eared bat (*Plecotus townsendii*). The bat detection equipment can not differentiate among species of the genus *Myotis*, which were therefore grouped. The myotis species group was the most evenly distributed among the VGS's and habitat type classes. It is interesting to note that the Townsend's big-eared bat was detected, as this species was a C2 candidate for the endangered species list in this part of their range prior to this category being dropped by the US Fish and Wildlife Service. Only 1 significant difference was detected by the Kruskal-Wallis test for all tests of bat species relative presence between habitat type classes, and the dry Douglas-fir VGS's. This one significant difference was well within the number of spurious results expected, given

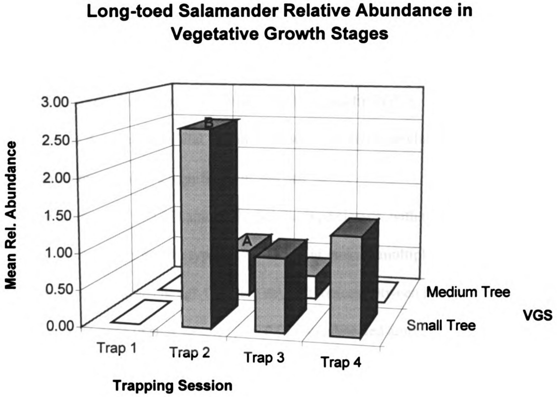


Figure 17. Long-toed salamander mean relative abundance, expressed as mean total capture of individuals in dry Douglas-fir vegetative growth stages (VGS), by trap session, in Valley County Idaho in 1995 and 1996. Trapping sessions (Trap 1-4) were each 5 days in length. Trap sessions with letters above the columns differed significantly ($P < 0.10$) by the Kruskal-Wallis test (Miller 1985, Ott 1993, Toothaker 1991). Dissimilar letters on columns within trapping sessions indicate significant differences ($P < 0.10$) (joint ranks multiple comparison test) (Miller 1985, Toothaker 1991).

α=0.10 and the number of tests run. Therefore no further analysis was conducted on the bat data.

Vegetation

Habitat Type Classes, and Vegetative Growth Stages

Analyses were conducted for differences in vegetative and site characteristics between habitat type classes, as well as the 2 dry Douglas-fir VGS's. Five significant differences were detected in habitat variables between habitat type classes (Table 2). The Kruskal-Wallis test showed a significant difference

in large tree diameter (P = 0.07) among the habitat type classes, with the largest mean being in the dry grand fir habitat type class. The joint ranking multiple comparison test, however, was not sensitive enough to detect any differences between habitat type classes. A significant difference in snag density (P = 0.01) was detected among habitat type classes. The multiple comparison test detected a difference between the cool moist grand fir habitat type class and both the dry grand fir, and dry Douglas-fir habitat type classes. No difference was detected between the dry grand fir and dry Douglas-fir habitat type classes by the multiple comparison test. A significant difference in stump diameter (P = 0.08) was also detected by the Kruskal-Wallis test. The multiple comparison test showed a significant difference between the cool moist grand fir and dry Douglas-fir habitat type classes, but not between either of these and the dry grand fir habitat type class. An elevational difference was also detected between the habitat type classes (P = 0.0003) by the Kruskal-Wallis test. The multiple comparison test detected this elevational difference only between the cool moist grand fir and dry Douglas-fir habitat type classes.

Table 2. Means (standard errors) and test results of vegetation and site variables by habitat type classes.

	Habitat Type Classes			
Variable	CM Grand Fir	Dry Grand Fir	Dry Douglas Fir	Probability of > F
Coarse Woody Debris Length (m)	6.32(0.54)	6.55(0.84)	6.30(0.84)	0.89
Coarse Woody Debris Diameter (cm)	34.46(2.68)	27.32(1.94)	30.75(3.50)	0.19
Coarse Woody Debris Density (#/ha)	472.78(57.71)	817.46(360.57)	516.87(116.94)	0.79
Large Tree dbh (cm)	26.94(1.03)**A**	31.94(1.87)**A**	31.05(1.39)**A**	**0.07**
Large Tree Bole Height (m)	3.66(0.31)	4.69(0.71)	4.53(0.49)	0.38
Large Tree Density (#/ha)	258.91(35.44)	191.94(22.65)	214.58(46.75)	0.57
Small Tree Height (m)	1.96(0.27)	1.44(0.24)	1.54(0.14)	0.31
Small Tree Density (#/ha)	498.41(172.88)	988.0(406.18)	931.4(310.84)	0.47
Snag dbh (cm)	25.84(4.36)	20.79(2.49)	19.91(2.24)	0.62
Snag Density (#/ha)	67.93(11.31)**A**	26.76(7.42)**B**	26.24(6.85)**B**	**0.01**
Stump Diameter (cm)	48.68(3.21)**A**	38.54(4.69)**AB**	33.36(6.06)**B**	**0.08**
Stump Density (#/ha)	174.22(37.51)	272.73(67.47)	282.51(81.36)	0.38
Elevation (m)	1765(36)**A**	1664(25)**AB**	1570(9)**B**	**0.00**
Aspect (Degrees)	203.08(36.60)	205.61(28.49)	221.59(35.43)	0.86
Slope (%)	32.50(4.66)**A**	25.46(4.19)**AB**	18.63(3.09)**B**	**0.09**
Canopy Closure (%)	38.70(2.50)	34.24(3.55)	41.63(3.34)	0.52
Horizontal Cover First 1/4m (%)	46.43(2.25)	36.61(6.84)	35.66(3.35)	0.17
Horizontal Cover Second 1/4m (%)	26.17(3.66)	17.13(5.48)	13.96(2.73)	0.12
Horizontal Cover Third 1/4m (%)	13.75(2.71)	9.82(3.0)	6.31(1.74)	0.11
Horizontal Cover Fourth 1/4m (%)	11.09(2.51)	7.99(2.74)	4.63(1.28)	0.23
Ground Cover Herb. Veg. (%)	32.29(4.54)	37.61(5.10)	33.83(2.97)	0.79
Ground Cover Woody Veg. (%)	3.05(1.1)	3.22(0.83)	2.11(0.58)	0.65
Ground Cover Litter (%)	93.81(1.04)	91.78(5.10)	96.33(2.09)	0.18
Cover < 1m Herb. Veg. (%)	58.71(5.03)	65.0(7.56)	63.61(5.7)	0.56
Cover < 1m Woody Veg. (%)	40.24(6.25)	24.39(5.38)	23.94(5.98)	0.18
Cover < 1m Litter (%)	51.0(5.51)	39.0(4.14)	45.56(4.97)	0.17
Cover > 1m Herb. Veg. (%)	0.24(0.10)	0.06(0.06)	0.06(0.06)	0.18
Cover > 1m Woody Veg. (%)	31.33(5.75)	21.0(4.61)	23.83(2.91)	0.37
Cover >1m Forest Litter (%)	0.86(0.36)	0.39(0.16)	0.44(0.38)	0.47

Values in a row with bold dissimilar letters differed significantly among habitat type classes (joint ranking multiple comparison test) (Miller 1985, Toothaker 1991). Probability of a greater F is from the Kruskal-Wallis test, significant differences (P < 0.10) bolded (Ott 1993).

Differences between the dry grand fir habitat type class, and both the dry Douglas-fir and cool moist grand fir habitat type classes were not detected by the multiple comparison test. A significant difference in the percent slope (P = 0.09) was also detected among habitat type classes by the Kruskal-Wallis test. The multiple comparison test only detected the difference in percent slope between the cool moist grand fir and dry Douglas-fir habitat type classes, but not between the dry grand fir habitat type class and the other 2 habitat type classes.

The Kruskal-Wallis test also found 5 habitat variables that differed significantly between the dry Douglas-fir small and medium tree VGS's (Table 3). Both coarse woody debris length and diameter were significantly different (P = 0.02) between dry Douglas-fir VGS's, with the small tree VGS having the larger mean values in both cases, possibly due to more recent cutting. Aspect was also found to be different between VGS's by the Kruskal-Wallis test (P = 0.02), possibly due to chance. The medium tree VGS showed the more northerly mean aspects. The Kruskal-Wallis test also detected a difference in the percentage of the ground covered by forest litter (P= 0.02) between the dry Douglas-fir VGS's, possibly due to time since harvest. The medium tree VGS had the higher percent litter coverage. The Kruskal-Wallis test detected a difference between the 2 VGS's in the percent vertical coverage of woody vegetation in the 1st meter above the ground (P = 0.06). Again, the higher mean vertical coverage was present in the medium tree VGS.

Table 3. Means (standard errors) and test results of vegetation and site variables by VGS's, in Valley County, Idaho, in 1995 and 1996.

	Dry Douglas Fir ELU's		
Variable	Small Tree	Med. Tree	Prob. > F
Coarse Woody Debris Length (m)	7.48(1.44)	5.12(0.31)	**0.02**
Coarse Woody Debris Diameter (cm)	36.86(4.13)	24.64(2.63)	**0.02**
Coarse Woody Debris Density (#/ha)	398.77(18.68)	634.97(232.55)	0.57
Large Tree dbh (cm)	29.76(2.06)	32.33(1.96)	0.33
Large Tree Bole Height (m)	3.87(0.74)	5.19(0.45)	0.33
Large Tree Density (#/ha)	183.19(6.26)	245.97(99.51)	0.57
Small Tree Height (m)	1.46(0.23)	1.62(0.18)	0.57
Small Tree Density (#/ha)	802.75(324.31)	1060.04(601.16)	0.85
Snag dbh (cm)	22.92(2.85)	16.90(2.8)	0.33
Snag Density (#/ha)	30.88(12.35)	21.61(7.77)	0.85
Stump Diameter (cm)	40.76(6.56)	25.96(9.25)	0.33
Stump Density (#/ha)	227.45(94.48)	337.57(145.39)	0.57
Elevation (m)	1572(13)	1567(16)	0.85
Aspect (Degrees)	150.21(29.42)	292.96(17.76)	**0.02**
Slope (%)	15.75(1.98)	21.50(5.97)	0.57
Canopy Closure (%)	37.01(5.19)	46.24(2.73)	0.14
Horizontal Cover First 1/4m (%)	38.11(3.60)	33.20(6.09)	0.33
Horizontal Cover Second 1/4m (%)	12.38(1.81)	15.54(5.61)	0.85
Horizontal Cover Third 1/4m (%)	5.86(1.75)	6.75(3.45)	0.85
Horizontal Cover Fourth 1/4m (%)	5.52(1.81)	3.73(2.04)	0.57
Ground Cover Herb. Veg. (%)	32.56(5.90)	35.11(2.75)	0.85
Ground Cover Woody Veg. (%)	2.0(0.58)	2.22(1.16)	1.00
Ground Cover Litter (%)	93.0(3.27)	99.67(0.19)	**0.02**
Cover < 1m Herb. Veg. (%)	62.33(8.96)	64.89(8.96)	0.85
Cover < 1m Woody Veg. (%)	14.44(4.64)	33.44(8.20)	**0.06**
Cover < 1m Litter (%)	43.22(9.85)	47.89(4.62)	0.85
Cover > 1m Herb. Veg. (%)	0.11(0.11)	0.0(0.0)	0.37
Cover > 1m Woody Veg. (%)	20.0(4.81)	27.67(2.14)	0.33
Cover >1m Forest Litter (%)	0.89(0.73)	0.0(0.0)	0.13

Probability of a greater F is from the Kruskal-Wallis test, significant differences ($P < 0.10$) bolded (Ott 1993).

Mammal Species, and Habitat Characteristics

Mammal species were compared with habitat variables that differed significantly among the relative abundance groups of each species. As mentioned earlier, only species relationships with habitat variables that are well supported biologically or in the literature will be presented in this section. Variables that do not represent reported relationships are presented in Appendix B.

Having broken stands into groups based on breaks in the relative abundance of each species, the Kruskal-Wallis test was used to identify significant differences ($P < 0.10$) in individual habitat variables among the relative abundance groups. Since the Kruskal-Wallis test works on the ranks of the data, extreme values should not have had a great influence on the results. Significant differences in habitat variables among the relative abundance groups indicated a potential relationship between the variable and the species whose relative abundance was used to form those groups. The number of significant differences, among the 29 variables, ranged from 2 to 7 for different species. For 3 species, the number of groups the data were broken into was changed from 4 to 2, and from 4 to 3, with changes in detected relationships not changing appreciably in 2 of the 3 species. This indicates that group membership should not have had a major influence on the relationships that were detected. Relative abundance groups were numbered from lowest relative abundances (group 1) to highest relative abundances (groups 2, 3, or 4).When the results of the joint ranks multiple comparison test (multiple comparison test) are listed, they will always be given with the group with the highest mean value for that variable 1st, and the next group with a mean value that is significantly different 2nd. Any group listed as not being significantly different from the group with the highest mean will have a mean between the 2 significantly different groups.

For the red-backed vole, the Kruskal-Wallis test detected significant differences ($P < 0.10$) between its 2 relative abundance groups in 7 habitat variables (see Table 4), 4 of which are well supported. With only 2 red-backed vole relative abundance groups, it was not necessary to use the multiple comparison test. A difference was detected in coarse woody debris diameter between relative abundance groups ($P = 0.09$), with higher relative abundance corresponding to greater diameter. A difference between groups was also detected in large tree dbh ($P = 0.05$), with group 1 having the higher mean value. The density of small trees also differed significantly between relative abundance groups ($P = 0.08$), with group 1 having higher densities of small trees. Stump diameters were also significantly different between the 2 relative abundance groups ($P = 0.03$), group 2 having the higher mean values.

The Kruskal-Wallis test detected significant differences ($P < 0.10$) in 4 habitat variables among the 3 relative abundance groups of the dusky shrew (Table 4), all 4 of which are well supported. All 4 significant differences were in the horizontal cover measurements taken at 1/4m increments above the ground. The probabilities of a greater F were 0.00, 0.02, 0.04, and 0.08 for the 1st through 4th 1/4m increments, respectively. The multiple comparison test found a significant difference among relative abundance groups 3 and 1 for all of the 1st 3 1/4m increments, but no groups were found different from group 2. In the 4th 1/4m increment, the multiple comparison test was too

Table 4. Results of tests for significant differences in habitat variables between relative abundance groups of the yellow-pine chipmunk, deer mouse, red-backed vole, dusky shrew, and masked shrew, in Valley County, Idaho, in 1995 and 1996.

	Species				
Variable	ellow-Pine Chipmun	Deer Mouse	Red-backed Vole	Dusky Shrew	Masked Shrew
Coarse Woody Debris Diameter (cm)	Not	Not	Sig.	Not	Not
Coarse Woody Debris Density (#/ha)	Not	Sig.	Not	Not	Not
Large Tree dbh (cm)	Not	Not	Sig.	Not	Sig.
Large Tree Bole Height (m)	Not	Not	Not	Not	Sig.
Small Tree Density (#/ha)	Not	Not	Sig.	Not	Not
Snag dbh (cm)	Not	Not	Not	Not	Sig.
Snag Density (#/ha)	Sig.	Not	Not	Not	Not
Stump Diameter (cm)	Not	Not	Sig.	Not	Not
Slope (%)	Not	Not	Sig.	Not	Not
Canopy Closure (%)	Not	Sig.	Not	Not	Not
Horizontal Cover First 1/4m (%)	Not	Not	Not	Sig.	Not
Horizontal Cover Second 1/4m (%)	Not	Not	Not	Sig.	Not
Horizontal Cover Third 1/4m (%)	Not	Not	Not	Sig.	Not
Horizontal Cover Fourth 1/4m (%)	Not	Not	Not	Sig.	Not
Cover < 1m Herb. Veg. (%)	Not	Not	Sig.	Not	Not
Cover > 1m Herb. Veg. (%)	Not	Sig.	Sig.	Not	Sig.
Cover >1m Forest Litter (%)	Sig.	Not	Not	Not	Not

"Sig." represents a significant difference ($P < 0.10$) in the Kruskal-Wallis test; "Not" indicates no difference detected (Ott 1993).

conservative to detect a significant difference in horizontal cover between any of the 3 dusky shrew relative abundance groups.

Four habitat variables were found to have significantly different mean values among the 3 relative abundance groups of the masked shrew (Table 4), 1 of which is well supported. The Kruskal-Wallis test detected a significant difference in mean large tree diameter ($P = 0.03$) between the masked shrew relative abundance groups. The multiple comparison test detected a significant difference between groups 1 and 3. Neither group differed significantly from group 2.

The vagrant shrew showed significant differences in 7 habitat variables, between its 2 relative abundance groups (Table 5), 2 of which are well supported. Due to the existence of only 2 relative abundance groups for the vagrant shrew, the use of the multiple comparison test was not necessary to separate out significantly different groups. The Kruskal-Wallis test detected a significant difference between the vagrant shrew relative abundance groups in large tree dbh ($P = 0.06$), with group 1 having the higher mean tree diameter. Large tree bole height was also found to differ significantly between the 2 groups ($P = 0.03$), with group 1 having the higher mean bole height.

The Kruskal-Wallis test detected significant differences in 4 habitat variables between the 2 relative abundance groups of the golden-mantled ground squirrel (Table 5). Two of these relationships are well supported. The percent vertical cover of forest litter was significantly greater in the 1st relative abundance group for both the 1st meter above the ground, and above 1m ($P = 0.07$, and 0.04 respectively).

Table 5. Results of tests for significant differences in habitat variables between relative abundance groups of the vagrant shrew, golden-mantled ground squirrel, pocket gopher, meadow vole, and dwarf shrew in Valley County, Idaho, in 1995 and 1996.

	Species				
Variable	Vagrant Shrew	olden-mantled Ground Squirre	Pocket Gopher	Meadow Vole	Dwarf Shrew
Coarse Woody Debris Diameter (cm)	Not	Not	Not	Sig.	Not
Coarse Woody Debris Density (#/ha)	Not	Sig.	Not	Not	Not
Large Tree dbh (cm)	Sig.	Not	Not	Not	Not
Large Tree Bole Height (m)	Sig.	Not	Not	Sig.	Not
Large Tree Density (#/ha)	Not	Not	Not	Not	Sig.
Small Tree Height (m)	Not	Not	Sig.	Sig.	Not
Snag Density (#/ha)	Sig.	Not	Not	Not	Not
Stump Diameter (cm)	Not	Not	Sig.	Not	Not
Aspect (Degrees)	Sig.	Sig.	Not	Not	Not
Canopy Closure (%)	Not	Not	Not	Sig.	Not
Ground Cover Woody Veg. (%)	Not	Not	Not	Not	Sig.
Cover < 1m Woody Veg. (%)	Sig.	Not	Not	Not	Not
Cover < 1m Litter (%)	Not	Sig.	Not	Not	Not
Cover > 1m Herb. Veg. (%)	Sig.	Not	Not	Not	Not
Cover >1m Forest Litter (%)	Sig.	Sig.	Not	Not	Not

"Sig." represents a significant difference ($P < 0.10$) in the Kruskal-Wallis test; "Not" indicates no difference detected (Ott 1993).

Four habitat variables were found to differ significantly between the 2 relative abundance groups of the meadow vole (Table 5), 2 of which are well supported. Large tree bole height was significantly higher in the meadow vole's relative abundance group 1 (P = 0.02). In addition, the Kurskal-Wallis test showed percent canopy closure to be significantly higher (P = 0.01) in the 1st relative abundance group for the meadow vole.

Herptile Species and Habitat Characteristics

Among the 3 relative abundance groups of the western toad, the Kruskal-Wallis test detected 5 habitat variables which differed significantly (Table 6), 1 of which is well supported. Stump density was significantly different among relative abundance groups for the western toad (P = 0.03). The multiple comparison test found relative abundance group 2 to have significantly higher stump densities than group 1, but not than group 3.

Six habitat variables showed significant differences between the 2 relative abundance groups of the long-toed salamander (Table 6), all of which are well supported. Mean large tree density was greater in relative abundance group 1 of the long-toed salamander (P = 0.03), according to the results of the Kruskal-Wallis test. Snag densities were also greater in relative abundance group 1 of the long-toed salamander (P = 0.04). The Kruskal-Wallis test also detected a significant difference in the elevation of stands between the relative abundance groups (P = 0.07), with group 1 having higher mean elevations. The percent vertical cover of woody vegetation in both the 1st meter above the ground, and above 1m, was higher in the 1st relative abundance group of the long-toed salamander (P = 0.06, and 0.0001 respectively). Relative abundance group 1 also had a higher percent vertical cover of forest litter in the 1st meter above the ground (P = 0.02).

Table 6. Results of tests for significant differences in habitat variables between relative abundance groups of the long-toed salamander and western toad, in Valley County, Idaho, in 1995 and 1996.

	Species	
Variable	Long-toed Salamander	Western Toad
Coarse Woody Debris Diameter (cm)	Not	Sig.
Large Tree Bole Height (m)	Not	Sig.
Large Tree Density (#/ha)	Sig.	Not
Small Tree Height (m)	Not	Sig.
Snag Density (#/ha)	Sig.	Not
Stump Density (#/ha)	Not	Sig.
Elevation (m)	Sig.	Not
Cover < 1m Woody Veg. (%)	Sig.	Not
Cover < 1m Litter (%)	Sig.	Not
Cover > 1m Woody Veg. (%)	Sig.	Sig.

"Sig." represents a significant difference ($P < 0.10$) in the Kruskal-Wallis test; "Not" indicates no difference detected (Ott 1993)

DISCUSSION

Analysis

When considering the results of the analysis, there are several important points to keep in mind. First, the sample size for this study was relatively small, with only 19 stands sampled and only 18 used in the analysis of any 1 trapping session. Each habitat type class included just 6 to 7 stands. The 2 dry Douglas-fir vegetative growth stages used in the analysis included only 3 stands. At smaller sample sizes, the probability of a Type 2 error (failing to reject Ho when a true difference existed) is relatively high, and results in a lower power of the test (ability of the test to identify significant differences). Due to the small sample size, and its effect on the probability of a Type 2 error, some true relationships may not have shown up as strong, or at all in the analysis. There may be more relationships between species and ecological units, or habitat variables than the analysis was able to detect. Because the probability of a Type 2 error and the probability of a Type 1 error (rejecting Ho when no true difference existed) share an inverse relationship, a somewhat liberal α was chosen ($\alpha = 0.10$) to partially mitigate the effects of the small sample size and increase the power of the test.

Choosing a somewhat liberal α created the 2nd important consideration when considering the results of the analysis. With the large number of species, habitat type classes, ELU's, and habitat variables, a large number of tests were required to analyze the data. Since there were a large number of tests done at the 90% level of confidence, the number of type 1 errors that may have been committed was somewhat high. For the 12 species tested for differences in relative abundance among habitat type classes, 12 tests were run per trapping session, so 1 Type 1 error could have resulted in each trapping session at $\alpha = 0.10$. One Type 1 error could also have occurred in each trapping session for the tests between the dry Douglas-fir VGS's. Eight significant differences were found in the species by habitat type class tests, and 6 in the species by dry Douglas-fir VGS's, for all 4 trapping sessions. Twenty-nine habitat variables were tested for differences among the relative abundance groups of each species. Of these 29 tests per species, up to 3 Type 1 errors could have occurred. However, just because a certain number of Type 1 errors could occur does not mean that they did occur. Only species relationships with habitat variables that are well supported biologically and in the literature will be discussed in this section (see Appendix B for others). And, there are ways to help identify some of the spurious results. Since the analysis was done to identify habitat associations and the habitat characteristics which could help to explain them, and major management decisions would not be based on the results of this analysis, it was decided that setting α at 0.10 gave the best balance between the problems with the Type 1 and Type 2 errors.

It is important to recognize that where a significant difference was detected by the tests, there is some support for a relationship. Where significant results for a relationship are detected more than 1 time, or in multiple ways, further support is provided for that relationship. For example, if a species shows a significantly different relative abundance between habitat type classes during more than 1 trapping session, and has a mean capture rate that is consistently higher in one habitat type class, there would be more support for a relationship than if a significant difference was only detected once. If another test, such as the GLM for repeated measures, finds a significant difference in relative abundance for a species that also showed significant differences in individual trapping sessions, the relationship receives further support.

When considering a species association with a specific habitat type class, or vegetative growth stage, it could be helpful to keep in mind the specific attributes that characterize that class or stage. If a species shows a relationship with a habitat variable that also characterizes a habitat type class, or VGS that the species is also associated with, it could be considered as added support for the species association with that ecological unit, as well as for the influence the variable has on the species. It could help to explain why the species is associated with the particular habitat type class, or VGS.

Habitat Type Classes, and Vegetative Growth Stages

The study areas in the cool moist grand fir habitat type class were characterized by steeper slopes, and higher elevations than the dry Douglas-fir habitat type class, but not steeper than the dry grand fir stands (Table 2). Moisture and temperature regimes are strongly influenced by elevation in the inland northwest and grand fir is a wetter area tree species than Douglas-fir. At these higher elevations, mountain slopes may be steeper than the lower elevation slopes, where Douglas-fir is more dominant. Snag densities were larger on cool moist grand fir sites than on either dry Douglas-fir, or dry grand fir sites. Stump diameters were also greater on cool moist and dry grand fir sites than on dry Douglas-fir sites. More available moisture may allow grand fir site trees to increase in size faster, and therefore be larger when they are cut. Large tree dbh was greater on dry grand fir, and dry Douglas-fir sites, than on cool moist grand fir sites. This may be due to the fact that only 1 of the 7 cool moist grand fir sites was a medium tree stand, while the 6 stands of the dry grand fir and dry Douglas-fir habitat type classes had 2 and 3 medium tree stands respectively. No difference was found between the mean dbh of dry grand fir and dry Douglas-fir stands, nor between the small and medium tree VGS's within the dry Douglas-fir.

Dry Douglas-fir small tree stands tended to have larger pieces of coarse woody debris of greater length and diameter (Table 3). This could be due to the debris left when the larger trees in these stands were cut or died. Medium tree stands tended to have higher ground cover of forest litter, and higher percent cover of woody vegetation in the 1st meter above the ground. The higher vertical cover of woody vegetation could be due to moister conditions under the canopy of larger trees, or shrubs may take longer to reestablish on sites after disturbance, but I have no data to support this hypothesis. The higher ground cover of litter is probably the result of the larger trees and higher densities of brush. Medium tree dry Douglas-fir stands were found to be on significantly more northerly aspects. No explanation can be offered for this.

Mammal Species

The red-backed vole shows some of the strongest support for an association with a specific habitat type class. Red-backed vole relative abundance was significantly different among habitat type classes in 2 of the 4 trapping sessions (Fig. 5). The multiple comparison test found red-backed vole relative abundance to be highest in the cool moist grand fir habitat type class during 1 of those 2 trapping sessions. The multiple comparison test didn't detect a difference among habitat type classes during the other trapping session, however this test can be too conservative or insensitive to detect differences where true differences are identified by the Kruskal-Wallis test (Miller 1985). The GLM for repeated measures showed a significant difference in red-backed vole abundance across all trapping sessions as a whole as well. Though not statistically significant, mean relative abundance was highest in the cool moist grand fir habitat type during all 4 trapping sessions, while the other 2 habitat type classes switched back and forth in the other 2 positions. Moris (1996) identified the red-backed vole as a mesic specialist. This fits in well with the red-backed vole being associated with the moister grand fir habitat type class. Walters (1991), and Wywialowski and Smith (1988) also identified the red-back vole as preferring moister conditions. Several habitat variables appear to be involved in the association that the red-backed vole shows with the cool moist grand fir habitat type class. The cool moist grand fir habitat types tended to have larger stump diameters, and smaller large tree diameters (Table 2). These same 2 relationships were found to be significant in the same way with red-backed vole relative abundance groups (Table 4). Hays and Cross (1987), and Belk et al. (1988) identified preference of red backed voles for areas with larger pieces of coarse woody debris. Wywialowski and Smith (1988) found a preference for stands with smaller, less dense trees. The red-backed vole also had consistently higher mean relative abundances in the dry Douglas-fir small tree VGS during all 4 trapping sessions, though only significantly different during the 3rd (Fig. 14). Coarse woody debris diameter was significantly higher in the small tree VGS (Table 3), and in the stands of the higher red-backed vole relative abundance group (Table 4). Coarse woody debris length was also significantly higher in the small tree VGS. Perhaps coarse woody debris volume would be a better measure to use in future investigations. Again, Hays and Cross (1987), and Belk et al. (1988) identified preference of red backed voles for areas with larger downed logs. This makes sense, because red-backed voles nest under large pieces of decaying woody debris (Burt and Grossenheider 1980).

Several other factors may be influencing red-backed vole relative abundance. Elevation was greater in the cool moist grand fir habitat type class (Table 2). Elevation has a significant influence on both the temperature and moisture regimes in the intermountian northwest, and red-backed voles have been shown to prefer cool moist forests (Moris 1996, Walters 1991). In the species relative abundance group analysis, small tree density was negatively related to red-backed vole relative abundance (Table 4). This negative relationship may be due to the competition that occurs between small trees and other green vegetation, the red-backed vole's primary food source.

There is also some fairly good support for masked shrew being associated with some habitat type classes. A significant difference in masked shrew relative abundance was detected by the Kruskal-Wallis test among habitat type classes in 2 of the 4 trapping sessions. The multiple comparison test showed the cool moist grand fir habitat type class to have higher relative abundances of masked shrews than the dry Douglas-fir, but not dry grand fir habitat type classes. The multiple comparison test found no differences among habitat type classes during the other trapping session, which showed a significant difference by the Kruskal-Wallis test (Fig. 7). This may be due to the multiple comparison test being too conservative, or too insensitive, to separate out the habitat type classes (Miller 1985). The GLM for repeated measures found masked shrew relative abundance to be significantly different between habitat type classes as well. Though not statistically significant, it is interesting to note that masked shrew mean relative abundance was highest in the cool moist grand fir habitat type class, and 2nd highest in the dry grand fir habitat type class, during all 4 trapping sessions. MacCracken et al. (1985) found the masked shrew to prefer wetter sites, with greater canopy cover for moisture retention. Wrigley et al. (1979) found that the masked shrew preferred wetter conditions as well. The results of both these studies support the association between the masked shrew and the wetter grand fir habitat type classes, if not the cool moist grand fir habitat type class. Only 1 potentially important habitat variable for the masked shrew was detected in both the habitat type class by vegetation, and species relative abundance by vegetation analysis. Mean large tree dbh was significantly different among habitat type classes (Tables 2 and 4). Again, the multiple comparison test was incapable of separating out which habitat type classes were different. The mean large tree dbh was smaller in the cool moist grand fir habitat type class however, and the masked shrew relative abundance group with the largest mean values had the smallest mean large tree dbh's. Large trees with smaller diameters would have smaller canopies which, at lower densities, could allow for more shrub cover, providing good moisture and food availability for the masked shrew (MacCracken et al 1985). Masked shrews only occurred in the dry Douglas-fir habitat type class in one of the 4 trapping sessions. No significant difference in masked shrew relative abundance was detected between the VGS's during that trapping session.

One habitat variable that shows a potential relationship with masked shrew abundance, through the association with the grand fir habitat type classes is stump diameter (Table 2). Masked shrews are known to nest in stumps (Burt and Grosssenheider 1980). Larger stumps could provide more nesting area, with greater protection from predators. This source of decaying woody material may also afford hunting areas with larger densities of bugs, the masked shrews primary food source (Whitaker et al. 1980), with greater protection from other predators.

The northern pocket gopher also showed significant differences in relative abundance among habitat type classes during 2 of 3 trapping sessions where the species was captured (Fig. 11). Pocket gopher relative abundances were higher in cool moist grand fir stands during both trapping sessions where the Kruskal-Wallis test detected a significant difference, though the multiple comparison test was too conservative to separate the habitat type classes in them (Miller 1985). The relative abundance of pocket gophers was higher in the cool moist grand fir habitat type class during the trapping session where no significant difference was detected as well. Also, the GLM for repeated measures detected a significant difference in pocket gopher relative abundance between habitat type classes. Some authors have debated whether or not pocket gophers prefer digging in moister soils (Scrivner and Smith 1981). Soils would tend to be moister in the cool moist grand fir habitat type class. Stump diameter was significantly larger in the cool moist and dry grand fir classes as well as in the higher relative abundance group (Tables 2 and 5). Scrivner and Smith (1981) found pocket gophers to be more abundant in stands with higher densities of smaller shrubs. They hypothesized that the areas with smaller shrubs provided higher densities of palatable roots (Scrivner and Smith 1981). Perhaps the cutting of the large trees released the understory species and smaller trees allowing the increase of palatable roots and tubers, the pocket gophers primary food source.

Dwarf shrew relative abundance was significantly different among habitat type classes during the 1st trapping session, though the multiple comparison test was too conservative or insensitive to distinguish between the habitat type classes (Fig. 9) (Miller 1985). Though not significant, dwarf shrew relative abundance showed its highest mean values in the cool moist grand fir habitat type class during 3 trapping sessions, but was lowest in the cool moist grand fir habitat type class during the other (Fig. 9). The GLM for repeated measures showed a significant difference in dwarf shrew relative abundance among habitat type classes as well. MacCracken et al. (1985) found that dwarf shrews preferred moister conditions. Their finding is in keeping with the potential association of dwarf shrews with the cool moist grand fir habitat class. However, Hoffman and Owen (1980) depict the dwarf shrew as being able to take advantage of a wide variety of conditions, including doing well on drier sites, and found the species to be common in rocky areas. If the requirements of dwarf shrews are similar to those of other long-tailed shrews, as Whitaker et al. (1980) presumed, the dwarf shrew may nest in stumps and logs, and feed primarily on insects. These nesting areas and food sources would be more abundant in the larger stumps of the cool moist grand fir habitat type class. Dwarf shrews, as most shrews, could be a wet area species, which also fits in with conditions of the cool moist grand fir habitat type class. However, support for an association between dwarf shrews and the cool moist grand fir habitat type class is pretty weak, and contradictions are present in the literature (Hoffman and Owen 1980). Larger sample sizes, and higher capture rates would be needed in future investigations to sort this out.

There is some support for an association between the deer mouse and habitat type classes, though this support is weak. Deer mouse density was significantly different between habitat type classes during 1 of the 4 trapping sessions (Fig. 4). The GLM for repeated measures, however, showed no significant difference between habitat type classes. While not significant, it is interesting to note that mean deer mouse relative abundance was highest in the cool moist grand fir habitat type class, and 2nd highest in the dry Douglas-fir habitat type class, during all 4 trapping sessions. Deer mice were caught in large numbers, but apparently larger sample sizes will be needed to clarify this relationship. Much stronger evidence exists for an association between the deer mouse and the dry Douglas-fir medium tree VGS. Deer mouse relative abundance was significantly higher in the dry Douglas-fir medium tree VGS during all 4 trapping sessions (Fig. 13). The GLM for repeated measures also detected a significant difference in deer mouse relative abundance between VGS's. No habitat variables were significantly related to deer mouse relative abundance in more than one way, possibly owing to the deer mouse's "generalist" nature (Walters 1991).

The yellow-pine chipmunk was not associated with any of the habitat types or VGS's investigated (Fig. 3 and Appendix A Table 14). The yellow-pine chipmunk is known to be a generalist species (Moris 1996). Larger sample sizes in future investigations may help to identify any associations which were not detected due to small sample size and high variability.

The dusky shrew was not associated with any of the habitat type classes or VGS's tested (Fig. 6 and Appendix A Table 14). This makes sense, because the dusky shrew uses a relatively broad range of habitats, from marshes to dry hillsides (Burt and Grossenheider 1980). Dusky shrew relative abundance was significantly higher with greater percent horizontal cover in all 4 of the 1/4m increments up to 1m above the ground (Table 4). Belk et al. (1990), Smith and Belk (1996), and Terry (1981) all found the dusky shrew to be most abundant in areas with dense understories and lots of coarse woody debris. These 2 habitat characteristics would both increase the horizontal cover on sites. Being small and susceptible to predation in the open, it makes sense that dusky shrews would prefer areas with greater visual obscurity. The higher densities of vegetation which produces the greater horizontal cover would also provide larger densities of insects, the dusky shrews primary prey. Since the dusky shrew showed this relationship with horizontal cover in all 4 strata, there is fairly strong support for this relationship. However, it may merely mean that the 4 strata should have been combined into 1 measurement. Unfortunately, the 4 strata were not strongly correlated enough to combine.

The vagrant shrew showed no association with any of the habitat type classes, or VGS's tested (Fig. 8, and Appendix A Table 14). Vagrant shrews are known to prefer cool moist conditions (Whitaker et al. 1980), and sample sizes may have been too small to see a difference between habitat type classes. Several habitat variables were found to differ significantly between vagrant shrew relative abundance groups (Table 5). Large tree dbh, and bole height were inversely related to vagrant shrew relative abundance. Terry (1981) found vagrant shrew abundance to be higher in more open patchy stands. Higher densities of herbaceous vegetation would provide hiding cover, and higher insect densities for the vagrant shrew to feed on. Perhaps vagrant shrews prefer the denser understories of smaller tree stands. Vagrant shrews were also more commonly captured in areas with a higher herbaceous cover over 1m from the ground.

The golden-mantled ground squirrel showed no association with any of the habitat type classes, or VGS's tested (Fig. 10, and Appendix A Table 14). The golden-mantled ground squirrel was found to be more abundant in areas with lower vertical cover of forest litter up to and above 1m (Table 5). This makes sense when considering that the species is known to prefer more open forests. Bartels and Thompson (1993) reported that this species prefers open pine forest with light brush, high densities of stumps and logs, and rocky areas.

Meadow vole relative abundance was not associated with any of the habitat type classes, or VGS's tested (Fig. 12, and Appendix A Table 14). Several habitat variables which could influence meadow vole abundance were identified by the Kruskal-Wallis test (Table 5). Meadow vole relative abundance was significantly lower in stands with higher large tree bole heights, and greater canopy closures. This makes sense, because meadow voles are known to prefer forests with more open understories (Burt and Grossenheider 1980). Reich (1981) found meadow vole abundance to be higher in areas with higher cover of herbaceous vegetation.

Herptiles

The long-toed salamander showed no association with habitat type classes (Fig. 15). There is some support however for the long-toed salamander being more abundant in the dry Douglas-fir small tree VGS. The Kruskal-Wallis test detected a significant difference in long-toed salamander relative abundance between the 2 VGS's during 1 of the 3 trapping sessions in which salamanders were caught (Fig. 17, and Appendix A Table 15). The GLM for repeated measures also detected a significant difference in salamander relative abundance between the VGS's. Though not significant, it is interesting to note that mean long-toed salamander relative abundance was highest in the small tree VGS during all 3 trapping sessions in which they were caught. This support for an association between long-toed salamanders and the small tree dry Douglas-fir VGS is somewhat limited, and thus unclear. Perhaps obtaining larger sample sizes in future investigations could clarify this potential relationship. The percent vertical cover of woody vegetation in the 1st meter above the ground was significantly lower in the small tree VGS (Table 3), and was also lower for both the 1st meter above the ground and above 1m in the higher long-toed salamander relative abundance groups (Table 6). Also the percent litter cover at ground level was lower in the small tree VGS, and the percent litter cover in the 1st meter above the ground was lower in the higher relative abundance group. Having these 2 variables in common between the preferred VGS, and the higher relative abundance group, provides further support for an association between long-toed salamanders and the dry Douglas-fir small tree VGS, and seem to indicate that the long-toed salamander prefers more open forest conditions.

Long-toed salamanders may be associated with other habitat variables that were not identified by more than one testing format. In dry Douglas-fir small tree stands, coarse woody debris tended to be longer and larger in diameter (Table 3). Larger volume pieces of decaying coarse woody debris would maintain cool moist conditions in their interiors better than smaller pieces. Long-toed salamanders are known to spend much of their time in decaying logs and stumps, especially during the drier periods of the year (Behler 1979, Nussbaum et al. 1983). Aspect was also found to be significantly different between VGS's, with small tree stands found on more southerly facing sites. Also relative abundance was higher at lower elevations (Table 6). These warmer south-facing low elevation sites may have afforded longer periods of proper temperature conditions for long-toed salamanders to feed and move about the landscape. Howard and Wallace (1985) found that long-toed salamanders at lower elevations produced more eggs and metamorphosed at earlier ages. This could account for there being more salamanders captured at lower elevation sites. Snag and large tree density were inversely related to salamander abundance. This could be related to a preference for more open forest stands, though I could find nothing in the literature to support such a preference.

The western toad was not associated with either habitat type classes or VGS's (Fig. 16, and Appendix A Table 15), though several habitat characteristics that may be important to western toads were identified (Table 6). Stump densities were greater in the higher relative abundance groups. Decaying stumps hold moisture during dry periods and may provide good micro climate conditions for western toads (Nussbaum et al. 1983). Decaying stumps also leave macropores into the soil when their roots rot away, these macro-pores are often used by herptiles to access the better microconditions below the surface (Jones 1986).

Bats

No associations of bat species with habitat type classes or VGS's were identified in the analysis. Potential reasons for the lack of associations between bat species and habitat type classes could have been the limited range of habitat type classes that were investigated. Krusic et al. (1996) found differences in bat activity between forest types in White Mountain National Forest, New Hampshire. But Krusic et al. (1996) were testing between spruce-fir, and northern hardwood forests. Perhaps if habitat type classes that were more distinctly different in nature were investigated in the future some associations could be found. Huff et al. (1993) found stand age to be the best indicator of bat activity. In addition, Krusic et al. (1996) found that within stand bat activity was greatest in overmature stands (> 119 yrs.), and in regenerating stands (0-9 yrs.). The lack of bat species associations with VGS's may simply have been due to the use of too fine of a temporal scale for bats.

Ecosystem Diversity Matrix

One of the purposes for trying to identify species associations with different habitat type classes, and vegetative growth stages was to determine if the ecosystem diversity matrix, which these classifications came from, is capable of representing the diversity of species and the habitat components that they are dependent upon on the landscape. If the EDM is capable of representing this diversity through its ELU's, ecosystem management approaches based on the use of this tool could be a viable option for planning forest management activities. The big question is, can the EDM represent the diversity of all indigenous species and their requirements on the planning landscape. By identifying species associations with habitat type classes, and VGS's, more support is given to the ability of the EDM to represent this diversity.

Results of this study indicate that there is some potential for the EDM to represent the diversity of species on the landscape, based on species associations with the ecological units of the EDM. Several potential species associations with both habitat type classes, and VGS's were identified. Three of the associations of species found with habitat type classes have fairly good support. The red-backed vole, masked shrew, and northern pocket gopher had relative abundances that were significantly different between habitat type classes in 2 of the 4 trapping sessions, and the GLM for repeated measures used for all trapping sessions together lent further support for this. Some habitat variables that differed significantly among habitat type classes also varied significantly with the relative abundance of these species, and could potentially explain those associations. Fairly strong support also exists for the deer mouse's association with the dry Douglas-fir medium tree VGS. This species showed significant differences in relative abundance between the 2 VGS's in all 4 trapping sessions, and with the GLM for repeated measures used for all trapping sessions together lent further support. The dwarf shrew and deer mouse showed potential associations with habitat type classes, but with less strong support. The red-backed vole and long-toed salamander also showed potential associations with one of the dry Douglas-fir VGS's, but with less strong support.

These species associations lend further support to the usefulness of the EDM for representing the diversity of species and their habitat requirements on the landscape, when a few other factors are considered. First, trapping of species, and testing for differences in relative abundances between habitat type classes was only done for 3 of the 11 habitat type classes represented in the matrix. These 3 habitat type classes were also located beside each other on the matrix, indicating that they were more similar to each other than many other habitat type classes of the matrix. Had the study investigated species associations in more widely separated, or more habitat type classes in the EDM, more associations between species and habitat type classes could potentially have been found. Statistical tests for differences in small mammal and herptile relative abundance were only done for 2 of the 14 VGS's of the matrix, and only in one habitat type class. Had more and/or more widely separated VGS's in additional habitat type classes (ELU's) been investigated, it is very likely that more species associations would have been found.

Much more research involving many more species and cells of the EDM will be necessary to prove that the EDM can represent the full indigenous range of biodiversity on the planning landscape. Only the most common and easily captured members of the small mammal, and herptile communities were investigated. While these species may give a hint as to the usefulness of the EDM for representing the diversity and habitat requirements of small mammal and herptile species, small mammals and herptiles only comprise a very small portion of the biota that ecosystem management strives to represent. However, it is my opinion that the results of this study in conjunction with its previously mentioned limitations does give some support to the usefulness the EDM as a viable tool for representing the diversity of indigenous species, and their habitat requirements, in ecosystem management.

CONCLUSIONS

The results of this research indicate that several species were associated with different habitat type classes. The red-backed vole, masked shrew, and northern pocket gopher showed relatively strong support for an association with a habitat type class, and the dwarf shrew and deer mouse showed less strong support for an association with a habitat type class. These associations indicate that, at least for the species investigated, the habitat type classes of the EDM are properly chosen to represent the diversity of species and their needs on the landscape.

Several associations of species with VGS's were identified. There was strong support for an association between the deer mouse and the medium tree dry Douglas-fir VGS, and less strong support for an association between both the red-backed vole and long-toed salamander with the small tree dry Douglas-fir VGS. These associations indicate that the vegetative growth stages of the EDM were properly chosen to represent the diversity and habitat needs of the diversity of species across the landscape.

Some site and vegetation characteristics were identified as important to different species. Some of these relationships were useful in explaining the reasons for species associations with different habitat type classes and VGS's, others were not. Due to the high variability of site and vegetation characteristics within stands, and small sample sizes, much of this vegetation analysis is not strongly supported by our biological knowledge of these species. The high variability of conditions within stands may have made it more difficult to identify important site and vegetation characteristics than if the stands had been more uniform. More research with larger sample sizes will be necessary to sort these relationships out.

More research on a wider variety of species will be needed to strengthen the support, provided by this research, for the EDM's usefulness as an ecosystem management tool. Future research will also need to include more cells of the EDM. However, given the species associations with both habitat type classes and VGS's identified in this research, there is support for the usefulness of the EDM as an ecosystem management tool for representing the diversity of species and their habitat needs across the landscape.

LITERATURE CITED

LITERATURE CITED

Anderson, S. H. 1985. Managing our wildlife resources. 2nd ed. Prentice Hall Inc., Englewood Cliffs, N.J. 492pp.

Arno, S. F. 1980. Forest fire history in the northern rockies. J. For. 78:460-465.

_____, and T. D. Peterson. 1983. Variation in estimates of fire intervals: a closer look at fire history on the Bitterroot National Forest. USDA For. Serv. Res. Pap. INT-301. Intermountain For. Range Exp. Stn., Ogden UT. 1-8pp.

Bartels, M. A., and D. P. Thompson. 1993. *Spermophilus lateralis*. Mammal. Species. No. 440 1-8pp.

Behler, J. S. 1979. The Audubon Society field guide to North American reptiles and amphibians. Alfred A. Knopf Inc. Press, New York, NY 743pp.

Belk, M. C., H. D. Smith, and J. Lawson. 1988. Use and partitioning of montane habitat by small mammals. J. Mammal. 69:689-695.

_____, C. L. Pritchett, and H. D. Smith. 1990. Patterns of microhabitat use by *Sorex monticolus* in summer. Great Basin Nat. 71:387-389.

Brown, L. N. 1967. Ecological distribution of six species of shrews and comparison of sampling methods in the central Rocky Mountains. J. Mammal. 48:617-623.

Burt, W. H., and R. P. Grossenheider 1980. A field guide to the mammals of North America north of Mexico. Houghton Mifflin Co. Boston, MA. 289pp.

Bury, R. B., and P. S. Corn. 1987. Evaluation of pitfall trapping in northwestern forests: trap arrays with drift fences. J. Wildl. Manage. 51:112-119.

Cook, J. G., T. W. Stutzman, C. W. Bowers, K. A. Brenner, and L. L. Irwin. 1995. Spherical densiometers produce biased estimates of forest canopy cover. Wildl. Soc. Bull. 23:711-717.

Corben, C. 1994. Anabat5 software. Titley Electronics, Balina, N.S.W., Australia. 28pp.

Craighead, F. 1979. Track of the grizzly. Sierra Club Books, San Francisco, CA. 210pp.

Daubenmire, R. 1968. Plant communities: a textbook of plant synecology. Harper and Row, New York, NY. 300pp.

DeGraaf, R. M., D. P. Snyder, and B. J. Hill. 1991. Small mammal habitat associations in poletimber and sawtimber stands of four forest cover types. For. Ecol. and Manage. 46:227-243.

de Vries, P. G. 1986. Sampling theory for forest inventory. Springer-Verlag Publ. New York, NY. 450pp.

Fenton, M. B., and G. P. Bell. 1981. Recognition of species of insectivorous bats by their echolocation calls. J. Mammal. 62:233-243.

_____, H. G. Merriam, and G. L. Holroyd. 1983. Bats of Kootenay, Glacier, and Mount Revelstoke national parks in Canada: identification by echolocation calls, distribution, and biology. Can. J. Zool. 61:2502-2508.

Franklin, J. F. 1993. Preserving biodiversity: species, ecosystems, or landscapes? Ecol. Appl. 3:202-205.

Grumbine, R. E. 1994. What is ecosystem management? Conserv. Biol. 8:27-38.

Haufler, J. B. 1990. Static management of forest ecosystems. Pages 123-130 *in* J. M. Sweeney, ed. Management of dynamic ecosystems. North Cent. Sect., The Wildl. Soc., West Lafayette, Ind.

_____. 1994. An ecological framework for planning for forest health. J. Sustainable For. 2:307-316.

_____, C. A. Mehl, and G. J. Roloff. 1996. Using a coarse-filter approach with species assessment for ecosystem management. Wildl. Soc. Bull. 24:200-208.

Hays, J. P., and S. P. Cross. 1987. Characteristics of logs used by the red-backed vole (*Clethrionomys californicus)* and deer mice (*Peromyscus maniculatus*). Can. Field-Nat. 101:543-546.

Hays, R. L., C. Summers, and W. Seitz. 1981. Estimating wildlife habitat variables. U.S.D.I. Fish and Wildl. Serv. FWS/OBS-81/47. 111pp.

Higgins, K. F., J. S. Oldemeyer, K. J. Jenikins, G. K. Clambey, and R. F. Harlow. 1994. Vegetation sampling and measurement. Pages 567-591 in T. A. Bookhout, ed. Research and management techniques for wildlife and habitats. Fifth ed. The Wildlife Society, Bethesda, Md.

Hoffmann, R. S., and J. G. Owen. 1980. *Sorex tenellus* and *Sorex nanus*. Mammal. Species. No. 131 1-4pp.

Howard, J. H., and R. L. Wallace. 1985. Life history characteristics of populations of the long-toed salamander (*Ambystoma macrodactylum*) for different altitudes. Am. Midl. Nat. 113:361-373.

Huff, M. H., J. F. Lehmkuhl, and J. A. Young. 1993. Linking bat activity with landscape-level attributes using GIS. Northwest Sci. 67:131 (abstract only).

Hunter, M. S. JR. 1990. Wildlife forests and forestry: principles of managing forests for biological diversity. Prentice-Hall, Inc., Englewood Cliffs, NJ. 370pp.

Jones, K. B. 1981. Effects of grazing on lizard abundance and diversity in western Arizona. Southwest. Naturl. 26:107-115.

_____. 1986. Amphibians and reptiles. Pages 267-290. in Cooperrider, A. Y., R. J. Boyd, and H. R. Stuart, ed. 1986. Inventory and monitoring of wildlife habitat. U.S. Dept. Inter., Bur. Land Manage. Service Center. Denver, Co. Xviii, 858pp.

Junge, J. A., and R. S. Hoffmann. 1981. An annotated key to the long-tailed shrews (Genus *Sorex*) of the United States and Canada, with notes on middle American *Sorex*. Occas. Pap. Mus. Nat. Hist. University of Kansas. 94:1-48.

Koeln, G. T., L. M. Cowardin, and L. L. Strong. 1994. Geographic information systems. Pages 540-566 in T. A. Bookhout, ed. Research and management techniques for wildlife and habitats. Fifth ed. The Wildlife Society, Bethesda, Md.

Krusic, R. A., M. Yamasaki, C. D. Neefus, and P. J. Pekins. 1996. Bat Habitat use in White Mountain National Forest. J. Wildl. Manage. 60:625-631.

Leopold, A. 1949. A sand county almanac. Oxford University Press, New York. 295pp.

MacCracken, J. G., D. W. Uresk, and R. M. Hansen. 1985. Habitat used by shrews in southeastern Montana. Northwest Sci. 59:24-27.

Mardia, K. V. 1972. Statistics of directional data. Academic Press. New York, NY. 200pp.

Meffe, G. K., and C. R. Carroll. 1994. Principles of conservation biology. Sinauer Associates Inc., Sunderland, MA. 600pp.

Miller, R. G. Jr. 1985. Simultaneous statistical inference. 2nd ed. Springer-Verlag, Inc. New York, NY. 265pp.

Moris, D. W. 1996. Coexistence of specialist and generalist rodents via habitat selection. Ecology 77:2352-2364.

Nudds, T. D. 1977. Quantifying the vegetative structure of wildlife cover. Wildl. Soc. Bull. 5:113-117.

Nussbaum, R. A., E. D. Brodie, and R. M. Storm. 1983. Amphibians & reptiles of the Pacific Northwest. University of Idaho Press, Moscow, ID. 332pp.

Ott, R. L. 1993. An introduction to statistical methods and data analysis. 4th ed. Duxbury Press, Belmont, Ca. 1051pp.

Patterson, B. D., P. L. Meserve, and B. K. Lang. 1990. Quantitative habitat associations of small mammals along an elevational transect in temperate rainforests of Chile. J. Mammal. 71:620-630.

Perkins, M. 1976. A survey of bat populations and their habitat preferences in southern Oregon. Unpublished Student Originated Studies Project Report. University of Portland, Portland, OR. 89pp.

Reich, L. M. 1981. *Microtus pennsylvanicus*. Mammal. Species. No. 159 1-8pp.

Rohlf, D. J. 1991. Six biological reasons why the Endangered Species Act doesn't work - and what to do about it. Conserv. Biol. 5:273-282.

Roloff, G. J., and J. B. Haufler. 1993. Forest planning in Michigan using a GIS approach. Proc. Internat. Union of Game Biol. 21:364-369.

Samuel, M. D., and M. R. Fuller. 1994. Wildlife radiotelemetry. Pages 370-418 in T. A. Bookhout, ed. Research and management techniques for wildlife and habitats. Fifth ed. The Wildlife Society, Bethesda, Md.

SAS Institute Inc. 1989. SAS/STAT User's Guide, Release 6.0 Edition., Volumes 1 and 2. Cary, NC: SAS Institute Inc., 1028pp.

Schowalter, T. D. 1989. Canopy arthropod community structure and herbivory in old-growth and regenerating forests in western Oregon. Can. J. For. Res. 19:318-322.

Scrivner, J. H., and H. D. Smith. 1981. Pocket gophers (*Thomomys talpoides*) in successional stages of spruce fir forest in Idaho. Great Basin Nat. 41:362-367.

Siegel, S., and N. J. Castellan Jr. 1988. Nonparametric statistics for the behavioral sciences. 2nd ed. McGraw-Hill Book Inc. New York, NY. 399pp.

Smith, M. E., and M. C. Belk. 1996. *Sorex monticolus*. Mamm. Species. No. 528 1-5pp.

Sharples, F. E. 1983. Habitat use by sympatric species of *Eutamias*. J. Mammal. 64:572-579.

Shelford, V. E. 1933. Ecological Society of America: a nature sanctuary plan unanimously adopted by the society, December 28, 1932. Ecol. 14:240-245.

Steele, R., R. D. Pfister, R. A. Ryker, and J. A. Kittams. 1981. Forest habitat types of central Idaho. USDA For. Serv. Gen. Tech. Rep. INT-144, Intermt. For. and Range Exp. Stn., Ogden, UT. 138pp.

Sutton, D. A. 1992. *Tamias amoenus*. Mammal. Species. No. 390 1-8pp.

Szaro, R. C. 1988 The management of amphibians, reptiles, and small mammals in North America: Historical perspective and objectives. Pages 1-3 in Szaro, R.C., E.E. Severson, and D.R. Patton, ed. Management of amphibians, reptiles, and small mammals in North America. USDA For. Serv. Gen. Tech. Rept. RM-166.

Terry, C. J. 1981. Habitat differentiation among three species of *Sorex*, and *Neurotrichus gibsi* in Washington, Am. Midl. Nat. 106:119-125.

Thomas, D. W., G. P. Bell, and M. B. Fenton. 1987. Variation in echolocation call frequencies recorded from North American vespertillonid bats: a cautionary note. J. Mammal. 68:842-847.

_____, and S. D. West. 1989. Sampling methods for bats. Gen. Tech. Rep. PNW-GTR-243. Portland, OR: USDA, For. Serv., Pac. Northwest Res. Stn. 20pp.

Thomas, J. W., and J. Verner. 1986. Forests. Pages 73-91. in Cooperrider, A. Y., R. J. Boyd, and H. R. Stuart, ed. 1986. Inventory and monitoring of wildlife habitat. U.S. Dept. Inter., Bur. Land Manage. Service Center. Denver, Co. Xviii, 858pp.

_____, and M. Dombeck. 1996. Ecosystem management in the interior Columbia river basin. Wildl. Soc. Bull. 24:180-186.

Toothaker, L. E. 1991. Multiple comparisons for researchers. SAGE Publications, Inc. Newbury Park, CA. 168pp.

Tummlison, R., G. R. Cline, and P. Zwank. 1990. Surface Habitat associations of the Oklahoma salamander (*Eurycea tynerensis*). Herpetol. 44:169-175.

Wackenhut, M., and M. McGraw. 1996. Idaho's bats: description, habitats, & conservation. Nongame Leaflet #11. Idaho Fish and Game, Boise, ID. 24pp.

Walters, B. B. 1991. Small mammals in a subalpine old growth forest and clearcuts. Northwest Sci. 65:27-31.

Whitaker, J. O., R. Elman, and C. Nehring. 1980. The Audubon Society field guide to North American mammals. Alfred A. Knopf Inc. Press, New York, NY. 745pp.

Williams, D. F., and S. E. Braun. 1983. Comparison of pitfall and conventional traps for sampling small mammal populations. J. Wildl. Manage. 47:841-845.

Wright, G. M., and B. Thompson. 1935. Fauna of the national parks of the US. USDA Dep. of Inter., Washington, D.C. 310pp.

Wrigley, R. E., J. E. Dubois, and H. W. R. Copland. 1979. Habitat abundance, and distribution of six species of shrews in Manitoba. J. Mammal. 60:505-520.

Wywialowski, A. P., and G. W. Smith. 1988. Selection of microhabitat by the red-backed vole, *Clethrinomys gapperi*. Great Basin Nat. 48:216-223.

Yahner, R. H. 1995 Eastern deciduous forest: ecology and wildlife conservation. University of Minnesota Press, Minneapolis, MN. 220pp.

APPENDIX A

Appendix A Table 1. Species encountered, and number caught in each field season.

Common Name	Scientific Name	*1995	*1996
	Small Mammal Species		
Yellow-pine Chipmunk	*Eutamias amoenus*	266	296
Deer Mouse	*Peromyscus maniculatus*	159	277
Northern Red-backed Vole	*Clethrionomys gapperi*	98	59
Dusky Shrew	*Sorex monticolus*	49	84
Masked Shrew	*Sorex cinereus*	38	49
Meadow Vole	*Microtus pennsylvanicus*	15	5
Vagrant Shrew	*Sorex vagrans*	9	21
Dwarf Shrew	*Sorex nanus*	7	7
Northern Pocket Gopher	*Thomomys talpoides*	7	18
Golden-mantled Ground Squirre	*Spermophilus lateralis*	6	27
Western Jumping Mouse	*Zapus princeps*	4	2
Long-tailed Weasel	*Mustela frenata*	4	0
Columbian Ground Squirrel	*Spermophilus columbianus*	3	4
Red Squirrel	*Tamiasciurus hudsonicus*	1	2
Bushy-tailed Wood Rat	*Neotoma cinerea*	0	1
Northern Flying Squirrel	*Glaucomys sabrinus*	0	1
Water Shrew	*Sorex palustris*	0	2
	Herptiles		
Long-toed Salamander	*Ambystoma macrodactylum*	19	14
Pacific Tree Frog	*Pseudacris regilla*	5	5
Striped Chorus Frog	*Pseudacris triseriata*	2	0
Western Toad	*Bufo boreas*	1	32
Common Garter Snake	*Thamnophis sirtalis*	1	2
Rubber Boa	*Charina bottae*	0	1
	Bats		
Big Brown Bat	*Eptesicus fuscus*	220	554
Long-eared Myotis	*Myotis evotis*	34	83
Myotis Species Group	*Myotis sp.*	469	820
Hoary Bat	*Lasiurus cinereus*	283	80
Silver-haired Bat	*Lasionycteris noctivagans*	30	103
Townsend's Big-eared Bat	*Plecotus townsendii*	30	53

type class, successional

Appendix A Table 3. Number of deer mice, *Peromyscus maniculatus,* captured, organized by habitat type class, successional stage, and stand ID.

Habitat Type	Stage	Stand #	# Caught Trap Session 1			# Caught Trap Session 2			# Caught Trap Session 3			# Caught Trap Session 4		
Cool-moist	1	9	8	Mean=	4.00	8	Mean=	7.00	.			.		
Grand Fir	1	41	4	Std. Error	0.76	14	Std. Error	1.69	7	Mean=	8.20	6	Mean=	11.20
400's	1	B	3	C.I.=	1.24	10	C.I.=	2.78	18	Std. Error	2.33	11	Std. Error	1.77
	1	11	3			4			7	C.I.=	3.84	18	C.I.=	2.90
	1	12	3			3			6			10		
	1	E	3			3			3			11		
	2	13	2			3			9			18		
Dry	1	27	0	Mean=	2.40	3	Mean=	4.00	4	Mean=	3.17	5	Mean=	7.83
Grand Fir	1	F	5	Std. Error	0.87	6	Std. Error	1.05	5	Std. Error	0.70	8	Std. Error	4.17
300's	1	26	3	C.I.=	1.52	7	C.I.=	1.75	4	C.I.=	1.16	28	C.I.=	6.87
	1	D	3			2			1			1		
	2	6	1			2			4			1		
	2	G	.			.			1			4		
Dry	1	17	0	Mean=	5.50	0	Mean=	3.83	1	Mean=	3.83	4	Mean=	10.67
Douglas-fir	1	18	1	Std. Error	2.23	0	Std. Error	1.54	3	Std. Error	0.95	8	Std. Error	2.12
	1	A	2	C.I.=	3.67	3	C.I.=	2.53	2	C.I.=	1.56	7	C.I.=	3.49
200's	2	19	13			5			7			14		
	2	C	6			5			4			13		
	2	2	11			10			6			18		

Stage represents successional stage, stage 1 = small tree, stage 2 = medium tree. Missing values are represented by a (.).

Appendix A Table 8. Number of dwarf shrews, *Sorex nanus*, captured, organized by habitat type class, successional stage, and stand ID.

Habitat Type	Stage	Stand #	# Caught Trap Session 1			# Caught Trap Session 2			# Caught Trap Session 3			# Caught Trap Session 4		
Cool-moist	1	9	0	Mean=	0.71	0	Mean=	0.00	.			.		
Grand Fir	1	41	1	Std. Error	0.29	0	Std. Error	0.00	1	Mean=	0.33	1	Mean=	0.67
400's	1	B	2	C.I.=	0.47	0	C.I.=	0.00	1	Std. Error	0.21	2	Std. Error	0.33
	1	11	0			0			0	C.I.=	0.35	0	C.I.=	0.55
	1	12	1			0			0			1		
	1	E	1			0			0			0		
	2	13	0			0			0			0		
Dry	1	27	0	Mean=	0.00	0	Mean=	0.00	0	Mean=	0.00	0	Mean=	0.17
Grand Fir	1	F	0	Std. Error	0.00	0	Std. Error	0.00	0	Std. Error	0.00	0	Std. Error	0.17
300's	1	26	0	C.I.=	0.00	0	C.I.=	0.00	0	C.I.=	0.00	0	C.I.=	0.27
	1	D	0			0			0			0		
	2	6	0			0			0			0		
	2	G	.			.			0			1		
Dry	1	17	0	Mean=	0.17	1	Mean=	0.17	0	Mean=	0.00	0	Mean=	0.00
Douglas-fir	1	18	0	Std. Error	0.17	0	Std. Error	0.17	0	Std. Error	0.00	0	Std. Error	0.00
200's	1	A	0	C.I.=	0.27	0	C.I.=	0.27	0	C.I.=	0.00	0	C.I.=	0.00
	2	19	0			0			0			0		
	2	C	1			0			0			0		
	2	2	0			0			0			0		

Stage represents successional stage, stage 1 = small tree, stage 2 = medium tree. Missing values are represented by a (.).

Appendix A Table 10. Number of northern pocket gophers, *Thomomys talpoides*, captured, organized by habitat type class, successional stage, and stand ID.

abitat Type	Stage	Stand #	# Caught Trap Session 1			# Caught Trap Session 2			# Caught Trap Session			# Caught Trap Session 4		
Cool-moist	1	9	1	Mean=	0.71	0	Mean=	0.00	.			.		
Grand Fir	1	41	0	Std. Error	0.36	0	Std. Error	0.00	0	Mean=	1.17	3	Mean=	1.17
400's	1	B	2	C.I.=	0.59	0	C.I.=	0.00	3	Std. Error	0.48	2	Std. Error	0.48
	1	11	2			0			0	C.I.=	0.79	1	C.I.=	0.79
	1	12	0			0			1			0		
	1	E	0			0			2			0		
	2	13	0			0			1			1		
Dry	1	27	0	Mean=	0.20	0	Mean=	0.00	0	Mean=	0.00	0	Mean=	0.50
Grand Fir	1	F	1	Std. Error	0.20	0	Std. Error	0.00	0	Std. Error	0.00	1	Std. Error	0.34
300's	1	26	0	C.I.=	0.33	0	C.I.=	0.00	0	C.I.=	0.00	0	C.I.=	0.56
	1	D	0			0			0			2		
	2	6	0			0			0			0		
	2	G	.			.			0			0		
Dry	1	17	0	Mean=	0.17	0	Mean=	0.00	0	Mean=	0.17	0	Mean=	0.00
Douglas-fir	1	18	0	Std. Error	0.17	0	Std. Error	0.00	0	Std. Error	0.17	0	Std. Error	0.00
200's	1	A	0	C.I.=	0.27	0	C.I.=	0.00	0	C.I.=	0.27	0	C.I.=	0.00
	2	19	1			0			0			0		
	2	C	0			0			0			0		
	2	2	0			0			1			0		

Stage represents successional stage, stage 1 = small tree, stage 2 = medium tree. Missing values are represented by a (.).

Appendix A Table 11. Number of meadow voles, *Microtus pennsylvanicus,* captured, organized by habitat type class, successional stage, and stand ID.

Habitat Type	Stage	Stand	# Caught Trap Session 1			# Caught Trap Session 2			# Caught Trap Session 3			# Caught Trap Session 4		
Cool-moist	1	9	1	Mean=	0.71	1	Mean=	0.14	.			.		
Grand Fir	1	41	3	Std. Error	0.42	0	Std. Error	0.14	0	Mean=	0.00	0	Mean=	0.33
400's	1	B	0	C.I.=	0.69	0	C.I.=	0.23	0	Std. Error	0.00	0	Std. Error	0.21
	1	11	0			0			0	C.I.=	0.00	1	C.I.=	0.35
	1	12	0			0			0			0		
	1	E	1			0			0			1		
	2	13	0			0			0			0		
Dry	1	27	1	Mean=	0.40	1	Mean=	0.60	0	Mean=	0.00	0	Mean=	0.50
Grand Fir	1	F	1	Std. Error	0.24	0	Std. Error	0.40	0	Std. Error	0.00	2	Std. Error	0.34
300's	1	26	0	C.I.=	0.40	0	C.I.=	0.66	0	C.I.=	0.00	0	C.I.=	0.56
	1	D	0			2			0			0		
	2	6	0			0			0			0		
	2	G	.			.			0			1		
Dry	1	17	1	Mean=	0.33	0	Mean=	0.33	0	Mean=	0.00	0	Mean=	0.00
Douglas-fir	1	18	1	Std. Error	0.21	0	Std. Error	0.33	0	Std. Error	0.00	0	Std. Error	0.00
200's	1	A	0	C.I.=	0.35	0	C.I.=	0.55	0	C.I.=	0.00	0	C.I.=	0.00
	2	19	0			0			0			0		
	2	C	0			0			0			0		
	2	2	0			2			0			0		

Stage represents successional stage, stage 1 = small tree, stage 2 = medium tree. Missing values are represented by a (.).

Appendix A Table 12. Number of long-toed salamanders, *Ambystoma macrodactylum,* captured, organized by habitat type class, successional stage, and stand ID.

Habitat Type	Stage	Stand #	# Caught Trap Session 1			# Caught Trap Session 2			# Caught Trap Session 3			# Caught Trap Session 4		
Cool-moist	1	9	0	Mean=	0.00	0	Mean=	0.14	.			.		
Grand Fir	1	41	0	Std. Error	0.00	1	Std. Error	0.14	0	Mean=	0.17	1	Mean=	0.17
400's	1	B	0	C.I.=	0.00	0	C.I.=	0.23	0	Std. Error	0.17	0	Std. Error	0.17
	1	11	0			0			0	C.I.=	0.27	0	C.I.=	0.27
	1	12	0			0			0			0		
	1	E	0			0			1			0		
	2	13	0			0			0			0		
Dry	1	27	0	Mean=	0.20	0	Mean=	1.40	0	Mean=	0.67	0	Mean=	0.00
Grand Fir	1	F	1	Std. Error	0.20	0	Std. Error	1.40	0	Std. Error	0.49	0	Std. Error	0.00
300's	1	26	0	C.I.=	0.33	7	C.I.=	2.30	0	C.I.=	0.81	0	C.I.=	0.00
	1	D	0			0			0			0		
	2	6	0			0			3			0		
	2	G	.			.			1			0		
Dry	1	17	0	Mean=	0.00	2	Mean=	1.67	1	Mean=	0.67	4	Mean=	0.67
Douglas-fir	1	18	0	Std. Error	0.00	3	Std. Error	0.56	1	Std. Error	0.21	0	Std. Error	0.67
200's	1	A	0	C.I.=	0.00	3	C.I.=	0.92	1	C.I.=	0.35	0	C.I.=	1.10
	2	19	0			0			0			0		
	2	C	0			0			0			0		
	2	2	0			2			1			0		

Stage represents successional stage, stage 1 = small tree, stage 2 = medium tree. Missing values are represented by a (.).

Appendix A Table 13. Number of western toads, *Bufo boreas,* captured, organized by habitat type class, successional stage, and stand ID.

abitat Type	Stage	Stand #	# Caught Trap Session 1			# Caught Trap Session 2			# Caught Trap Session 3			# Caught Trap Session 4		
Cool-moist	1	9	0	Mean=	0.00	0	Mean=	0.00	.			.		
Grand Fir	1	41	0	Std. Error	0.00	0	Std. Error	0.00	7	Mean=	2.67	0	Mean=	0.50
400's	1	B	0	C.I.=	0.00	0	C.I.=	0.00	3	Std. Error	1.09	2	Std. Error	0.34
	1	11	0			0			0	C.I.=	1.79	0	C.I.=	0.56
	1	12	0			0			2			0		
	1	E	0			0			4			1		
	2	13	0			0			0			0		
Dry	1	27	0	Mean=	0.00	0	Mean=	0.00	0	Mean=	1.33	0	Mean=	0.33
Grand Fir	1	F	0	Std. Error	0.00	0	Std. Error	0.00	4	Std. Error	0.61	2	Std. Error	0.33
300's	1	26	0	C.I.=	0.00	0	C.I.=	0.00	1	C.I.=	1.01	0	C.I.=	0.55
	1	D	0			0			0			0		
	2	6	0			0			1			0		
	2	G	.			.			2			0		
Dry	1	17	0	Mean=	0.00	1	Mean=	0.17	2	Mean=	0.33	0	Mean=	0.17
Douglas-fir	1	18	0	Std. Error	0.00	0	Std. Error	0.17	0	Std. Error	0.33	0	Std. Error	0.17
200's	1	A	0	C.I.=	0.00	0	C.I.=	0.27	0	C.I.=	0.55	0	C.I.=	0.27
	2	19	0			0			0			1		
	2	C	0			0			0			0		
	2	2	0			0			0			0		

Stage represents successional stage, stage 1 = small tree, stage 2 = medium tree. Missing values are represented by a (.).

Appendix A Table 14. Results of tests for differences in small mammal species relati abundance between dry Douglas-fir vegetative growth stages by trapping session.

	Probability of > F			
Species	Trap 1	Trap 2	Trap 3	Trap 4
Yellow-pine Chipmunk	0.71	0.14	1.00	0.57
Deer Mouse	0.02	0.01	0.02	0.02
Red-backed Vole	0.12	0.00	0.83	1.00
Dusky Shrew	0.12	0.41	0.85	0.44
Masked Shrew	.	.	.	0.37
Vagrant Shrew	0.13	.	0.12	.
Golden-mantled Ground Squir	0.83	.	0.83	0.84
Northern Pocket Gopher	0.37	.	0.37	.
Meadow Vole	0.12	0.37	.	.
Dwarf Shrew	0.37	0.37	.	.

(.) indicates no captures, so no test was run.

All probabilities of > F from Kruskal-Wallis Test (Ott 1993).

Appendix A Table 15. Results of tests for differences in herptile species relative abundance between dry Douglas-fir vegetative growth stages by trapping session.

	Probability of > F			
Species	Trap 1	Trap 2	Trap 3	Trap 4
Long-toed Salamander	.	0.05	0.12	0.37
Western Toad	.	0.37	0.37	0.37

(.) indicates no captures, so no test was run.

All probabilities of > F from Kruskal-Wallis Test (Ott 1993).

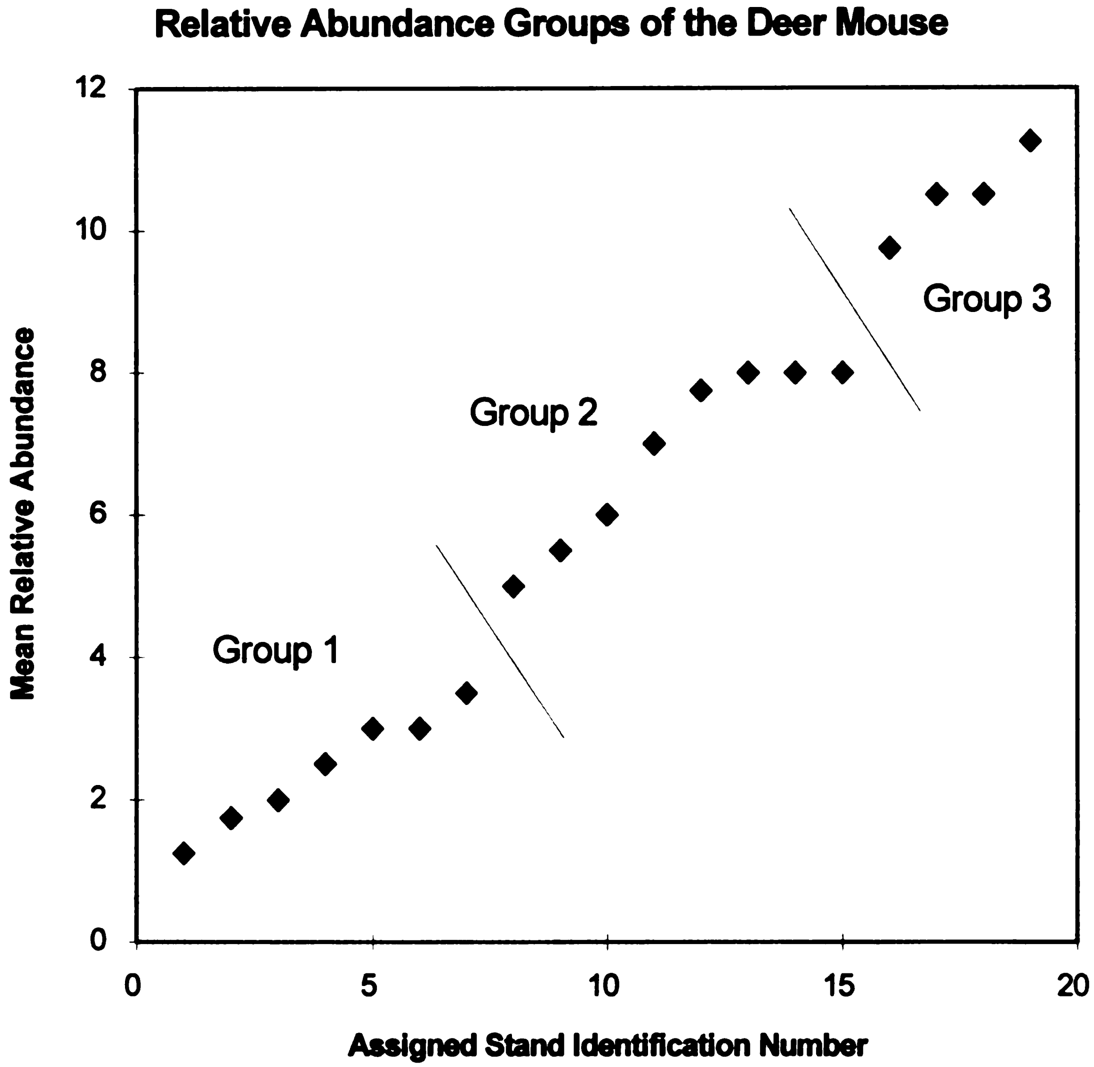
APPENDIX B

APPENDIX B

Relative Abundance Group Delineation

To aid in identifying habitat variables that played a role in the presence and abundance of individual species, mean capture rates for the 4 trapping sessions within stands were broken into relative abundance groups, based on natural breaks in the data. This was done by sorting the stands in ascending order of mean relative abundances, of all trapping sessions, for one individual species. Stands were then numbered 1-19 based on lowest to highest mean relative abundance. The data for the individual species were then plotted with mean relative abundance on the Y axis and the assigned number on the X axis. Natural gaps in the data were chosen as dividing points between the relative abundance groups. The stands were divided into a minimum of 2, to at most 4 relative abundance groups. Relative abundance groups were required to have a minimum of 3 stands, to make them useful for analysis. Though natural breaks in the data were important to use, if possible, groups were kept to a relatively similar range of relative abundance, based on the total range of mean relative abundance for that species (i.e. 0-2, 2-4, 4-6). Given the opportunity, group sizes were kept as similar as possible as well. Extremely different group sizes can cause the joint ranks multiple comparison test to be unable to distinguish between groups when the Kruskal-Wallis test detected an overall difference. The mean relative abundance data for some species lent itself to this way of grouping stands. However, other species data did not conform as well to being divided into groups in this manner. To clarify this, several examples will be given.

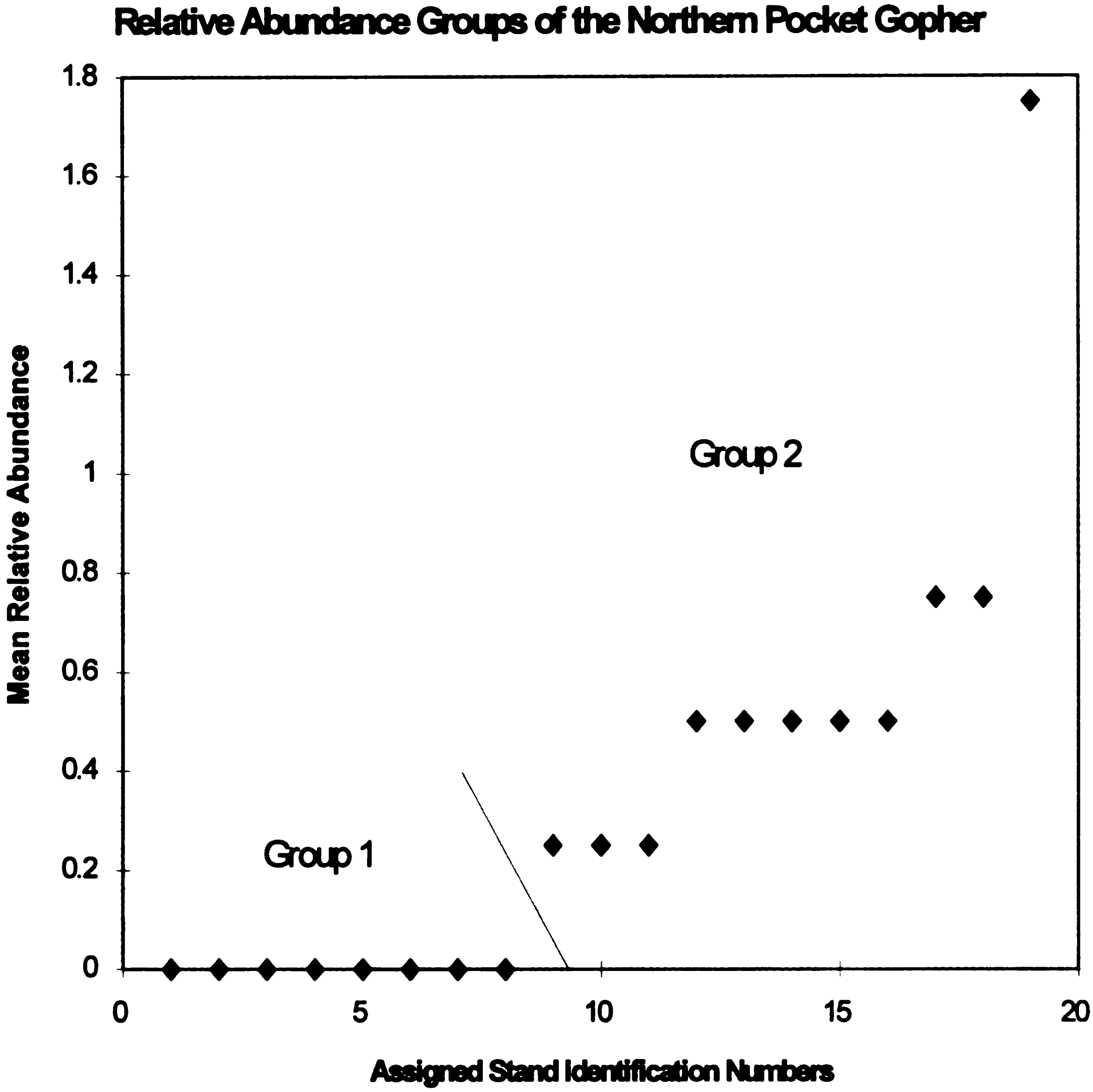
The deer mouse is a good example of the data breaking nicely into 3 relative abundance groups, with relatively even ranges, and sizes (Appendix B Fig. 1). Deer



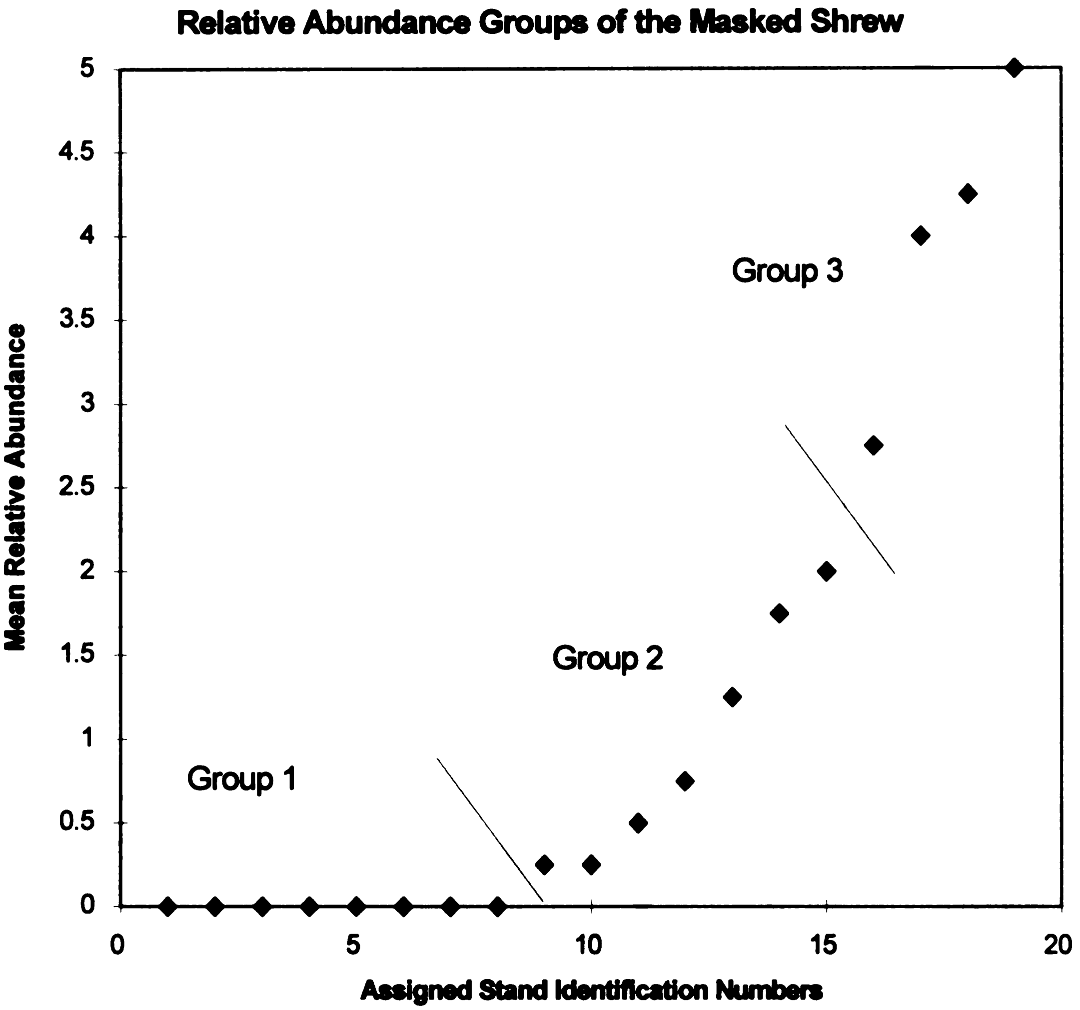
Appendix B Figure 1. Deer mouse relative abundance groups, based on the mean of relative abundance in each stand during the 4 trapping sessions in Valley County Idaho during 1995, and 1996. Arbitrary stand identification numbers were assigned in ascending order of mean relative abundance.

mouse mean relative abundance in these groups was separated by gaps in mean relative abundance of approximately 1.5-1.75, ranged from 0-4, 4-8, and 8-12, and contained 7, 8, and 4 stands respectively. Some less commonly captured species such as the pocket gopher (Appendix B Fig. 2) had a very small range of mean relative abundance (18 of 19 stands having a mean relative abundance of 0-0.75) , and could only be broken into 2 groups (presence, and absence). Another good example is the masked shrew (Appendix B Fig. 3), which was broken into 3 relative abundance groups with mean relative abundances of 0, 0-2 and 2-5. While the break between the 2nd and 3rd group could have been made 1 stand higher on the scale, at a bigger gap, the gap used to separate groups was the largest gap encountered thus far and a compromise with group size was made.

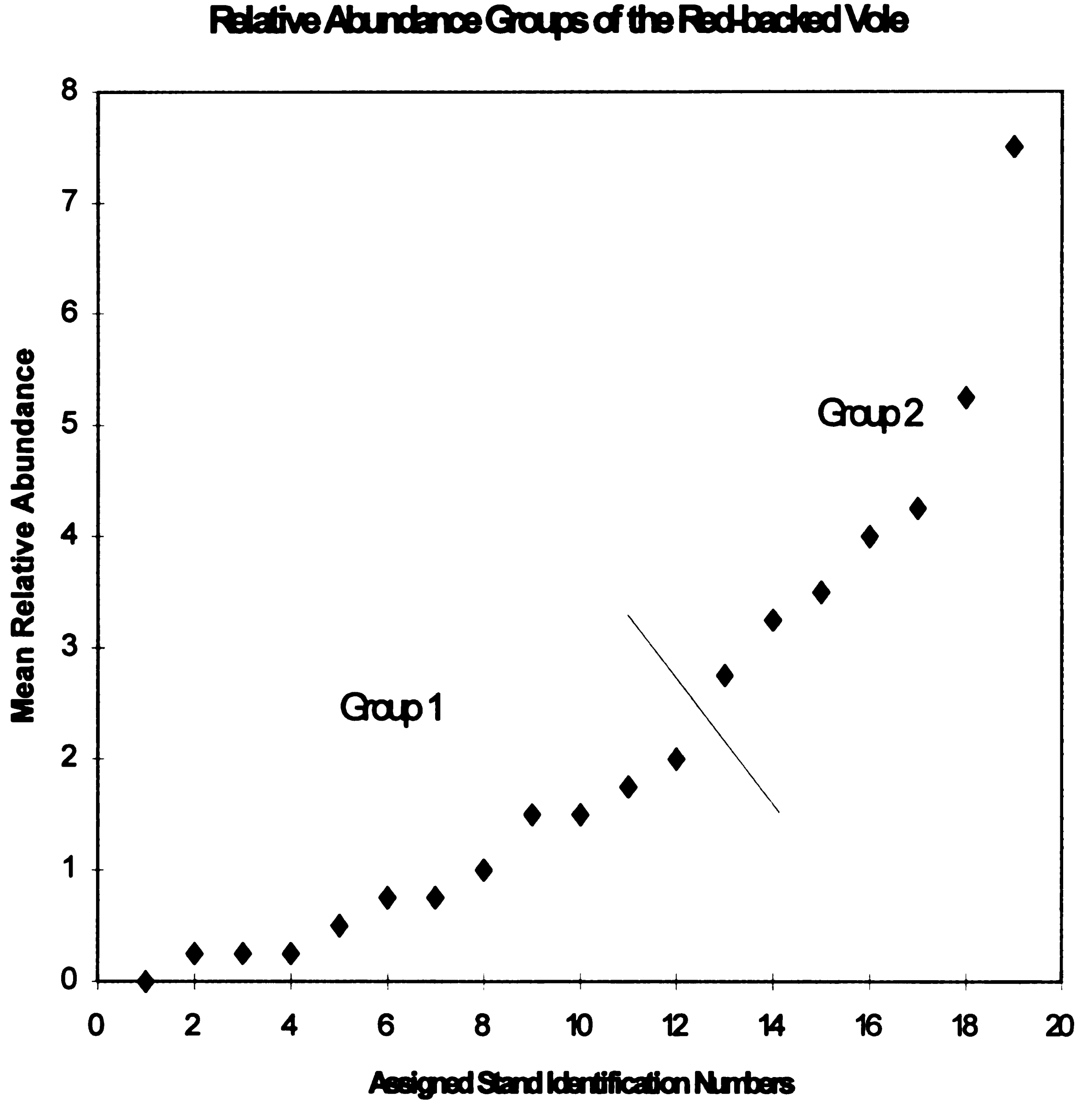
Some species did not show large natural breaks in mean relative abundance at which to separate the groups. The red-backed vole is a good example of this (Appendix B Fig. 4). For the red-backed vole, the stands were ultimately broken into 2 groups at the largest available gap which gave an acceptable compromise between relative abundance ranges and group sizes. Another good example of a species that was not well suited to being broken into groups was the yellow-pine chipmunk (Appendix B Fig. 5). Relatively large gaps in relative abundance were only present at the 2 extremes of the graph. This would only have given 2 small groups, with one relatively large group in between, covering a much wider range of relative abundance than the other 2 groups. To reach a reasonable compromise between the ranges of relative abundance within groups, and group sizes, the largest gap available, as close to the center of the larger middle group as possible, was used to make another break in the data. This gave a total of 4 relative abundance groups for the Yellow-pine chipmunk.



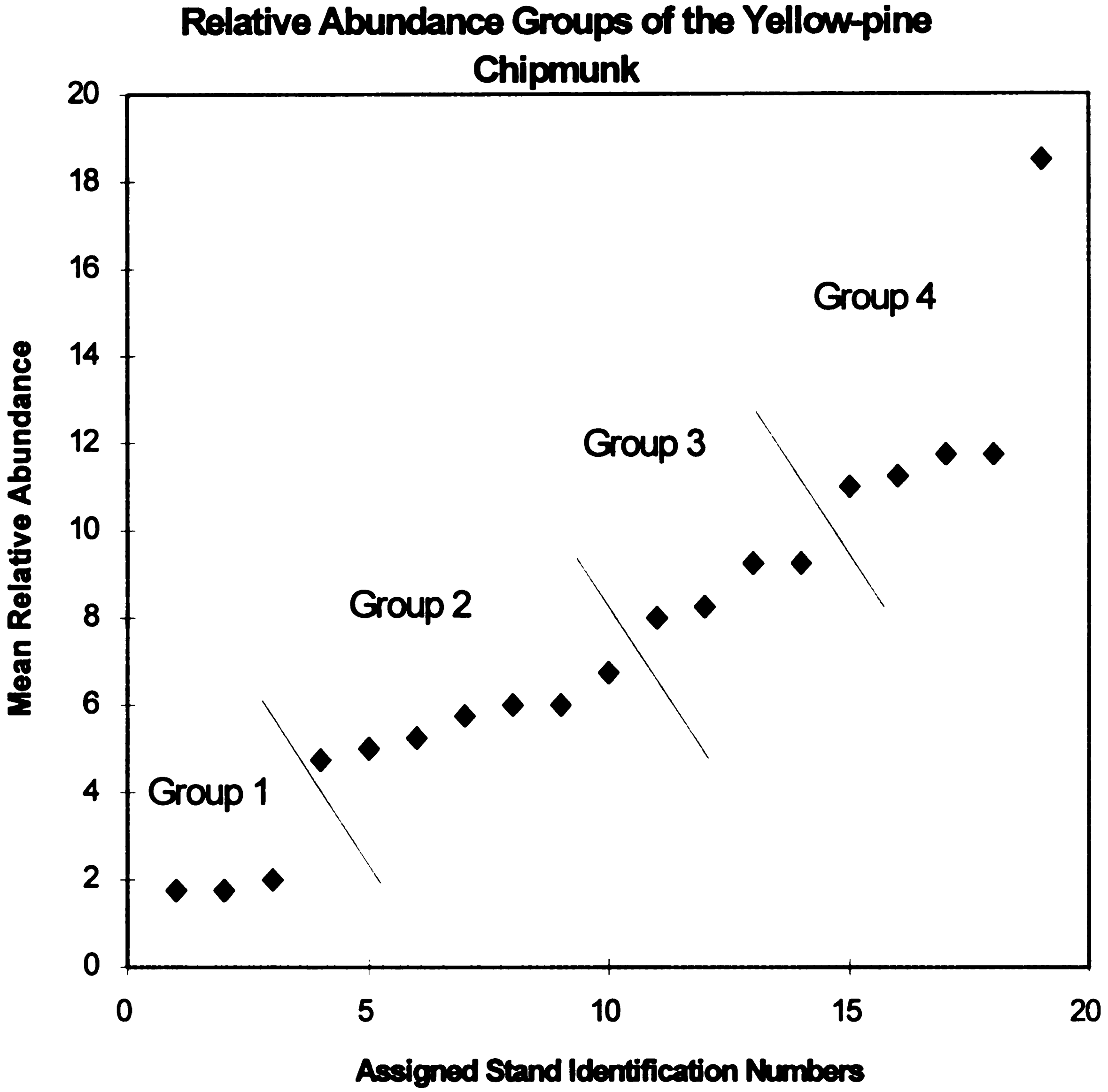
Appendix B Figure 2. Northern Pocket Gopher relative abundance groups, based on the mean of relative abundance in each stand during the 4 trapping sessions in Valley County Idaho during 1995, and 1996. Arbitrary stand identification numbers were assigned in ascending order of mean relative abundance.



Appendix B Figure 3. Masked shrew relative abundance groups, based on the mean of relative abundance in each stand during the 4 trapping sessions in Valley County Idaho during 1995, and 1996. Arbitrary stand identification numbers were assigned in ascending order of mean relative abundance.



Appendix B Figure 4. Red-backed vole relative abundance groups, based on the mean of relative abundance in each stand during the 4 trapping sessions in Valley County Idaho during 1995, and 1996. Arbitrary stand identification numbers were assigned in ascending order of mean relative abundance.



Appendix B Figure 5. Yellow-pine chipmunk relative abundance groups, based on the mean of relative abundance in each stand during the 4 trapping sessions in Valley County Idaho during 1995, and 1996. Arbitrary stand identification numbers were assigned in ascending order of mean relative abundance.

Having broken stands into groups, based on natural breaks in the relative abundance of each species, the Kruskal-Wallis test was used to identify significant differences ($P < 0.10$) in individual habitat variables among the relative abundance groups. Since the Kruskal-Wallis test works on the ranks of the data, extreme values should not have had a great influence on the results. Significant differences in habitat variables among the relative abundance groups indicated a potential relationship between the variable and the species whose relative abundance was used to form those groups. The number of significant differences, among the 29 variables, ranged from 2 to 7 for different species. For 3 species, the number of groups the data was broken into was changed from 4 to 2, and from 4 to 3, with changes in detected relationships not changing appreciably in 2 of the 3 species. This indicates that group membership should not have had a major influence on the relationships that were detected. Relative abundance groups were numbered from lowest relative abundances (group 1) to highest relative abundances (groups 2, 3, or 4). When the results of the joint ranks multiple comparison test (multiple comparison test) are listed, they will always be given with the group with the highest mean value for that variable 1st, and the next group with a mean value that is significantly different 2nd. Any group listed as not being significantly different from the group with the highest mean will have a mean between the 2 significantly different groups.

Small Mammals and Habitat Variables

The yellow-pine chipmunk had only 2 variables with significant differences detected among relative abundance groups by the Kruskal-Wallis test (Table 4). A significant difference was detected in the density of snags between 2 of the 4 relative abundance groups (P = 0.06). The multiple comparison test only detected a significant difference between relative abundance groups 3 and 1. Snag densities in relative abundance groups 4 and 2 were not significantly different from any of the other groups. This minimal number of relationships, and the disorder of relative abundance groups may imply that no true relationship exists. The Kruskal-Wallis test also detected a difference in the percent vertical cover of forest litter more than 1m from the ground (P = 0.04). The multiple comparison test was too conservative, or not sensitive enough, to detect any significant differences among the 4 relative abundance groups at the α=0.10 level.

The Kruskal-Wallis test detected significant differences in 3 habitat variables for the 3 groups based on the relative abundance of the deer mouse (see Table 4). Coarse woody debris densities were significantly different among deer mouse relative abundance groups (P = 0.05). The multiple comparison test detected a significant difference between the 3rd and 2nd relative abundance groups, but not between the 1st relative abundance group and either of the other 2 groups. The Kruskal-Wallis test also detected a significant difference in percent canopy closure (P = 0.08) between deer mouse relative abundance groups. The 3rd relative abundance group had a different canopy closure from the 1st group, but not from the 2nd, according to the results of the multiple comparison test. The 3rd variable to show a significant difference between deer mouse relative abundance groups was the percent vertical cover of herbaceous vegetation greater than 1m above the ground (P= 0.04). The multiple comparison test was too conservative to detect the difference in this variable.

Several habitat variables differed significantly between the relative abundance groups of the red-backed vole. Percent slope differed significantly between relative abundance groups of the red-backed vole ($P = 0.09$), with steeper slopes corresponding to higher relative abundances. The percent vertical cover of herbaceous foliage in the 1st meter above the ground also differed significantly between red-backed vole relative abundance groups ($P = 0.09$), with the lower relative abundance group corresponding to higher coverages of herbaceous vegetation. The final difference detected between relative abundance groups by the Kruskal-Wallis test was the percent vertical cover of herbaceous vegetation above 1m from the ground ($P = 0.06$), with group 2 having the higher mean values.

Several habitat variables were found to be significantly different among the relative abundance groups of the masked shrew. Large tree bole height was found to be significantly different between the relative abundance groups of the masked shrew by the Kruskal-Wallis test ($P = 0.03$). The multiple comparison test found group 1 to have significantly higher mean bole heights than group 2, but not than group 3. Relative abundance group 3 was also not found to have different bole heights than group 2. Snag dbh differed significantly among the relative abundance groups of the masked shrew ($P = 0.01$). The multiple comparison test showed a significant difference between groups 2 and 1, with group 2 having the higher mean value. No difference was detected between group 3 and either of the other 2 groups for snag dbh. The Kruskal-Wallis test also detected a significant difference in the percent vertical cover of herbaceous vegetation above 1m ($P = 0.04$) among the relative abundance groups of the masked shrew.

However, the multiple comparison test was unable to separate out any significantly different relative abundance groups for this variable.

The vagrant shrew showed potential relationships with several site and vegetation variables. Snag density was significantly higher in relative abundance group 2 for the vagrant shrew (P = 0.06). Aspect was significantly different between the relative abundance groups as well (P = 0.04), with group 1 having the higher mean value. The percent vertical cover of woody vegetation in the 1st meter above the ground was significantly higher in relative abundance group 1 (P = 0.09) for the vagrant shrew. Percent of vertical cover of herbaceous vegetation above the 1st meter from the ground was also found to be significantly different between the relative abundance groups (P = 0.03), with group 2 having the highest mean values. Lastly, the percent of vertical cover of forest litter above the 1st meter from the ground was also significantly higher in the 2nd relative abundance group for the vagrant shrew (P = 0.002), according to the results of the Kruskal-Wallis test.

Several site and vegetation variables differed significantly between the relative abundance groups of the golden-mantled ground squirrel. Coarse woody debris diameter was significantly larger in the 2nd relative abundance group for the golden-mantled ground squirrel (P = 0.05). The Kruskal-Wallis test also found a significant difference in aspect between the 2 groups (P = 0.04), with group 2 having a more westerly aspect.

The Kruskal-Wallis test only detected significant differences in 2 habitat variables between the 2 relative abundance groups of the pocket gopher (Table 5). Small tree height differed significantly between the 2 groups (P = 0.099). Mean small tree height was greatest for relative abundance group 2. Stump diameter was also found to be significantly larger in relative abundance group 2 for the pocket gopher (P = 0.099).

Several vegetation variables differed significantly between the relative abundance groups of the meadow vole. The Kruskal-Wallis test showed a significant difference in coarse woody debris diameter (P = 0.099), with relative abundance group 2 of the meadow vole having the largest mean diameters. Small tree height was greater in relative abundance group 2 (P = 0.01) for the meadow vole.

The Kruskal-Wallis test detected significant differences between the 2 relative abundance groups of the dwarf shrew in 2 habitat variables (Table 5). The 1st relative abundance group of the dwarf shrew had significantly higher large tree densities than the 2nd group (P = 0.07). The Kruskal-Wallis test also detected a significant difference in the percent ground cover of woody vegetation (P = 0.003) for the relative abundance groups of the dwarf shrew, with the higher mean coverage in group 1.

Herptiles and Habitat Variables

The western toad had several habitat variables differ significantly among its 3 relative abundance groups. Coarse woody debris diameter differed significantly among relative abundance groups of the western toad (P = 0.09). However, the multiple comparison test was too conservative to detect differences among any of the 3 groups for this variable. The Kruskal-Wallis test showed large tree bole height to be significantly different among the relative abundance groups (P = 0.01). The multiple comparison test showed relative abundance group 2 of the western toad to have significantly higher large tree bole heights than both groups 1 and 3, which did not differ significantly. Small tree height differed significantly among the relative abundance groups, according to the Kruskal-Wallis test (P = 0.08), but no differences were detected by the multiple comparison test. The Kruskal-Wallis test also found the percent vertical coverage of woody vegetation above 1m to differ significantly between the relative groups of the western toad (P = 0.05). The multiple comparison test identified relative abundance group 1 as having significantly greater vertical cover of woody vegetation above 1m than group 2. Relative abundance group 3 did not differ significantly from either of the other groups in this variable.

Discussion

Small Mammals and Habitat Variables

Twenty-nine habitat variables were tested for differences among the relative abundance groups of each species. Of these 29 tests per species, up to 3 Type 1 errors could have occurred. However, just because a certain number of Type 1 errors could occur does not mean that they did occur. And, there are ways to help identify some of the spurious results. Habitat variables that differed significantly among the relative abundance groups of species but were poorly supported biologically and in the literature are discussed in this section.

Several habitat variables that differed significantly between the relative abundance groups of the red-backed vole are not well supported. The cool moist grand fir habitat types, that the red-back vole was associated with, tended to have steeper slopes (Table 2). The higher relative abundance of red-backed voles on sites with steeper slopes may just be an artifact of the location of the moister sites. Snag densities and elevation were greater in the cool moist grand fir habitat type class (Table 2). These don't appear related to red-backed vole abundance. The small tree VGS that the vole was more abundant in had more southerly aspects, lower ground cover of litter, and lower coverage of woody vegetation (Table 3). The lower percent cover of woody vegetation may be a spurious result, because other authors have found the opposite result (Belk et al. 1988, Walters 1991, Wywialowski and Smith 1988). These authors all hypothesized that higher shrub covers in the 1st meter above the ground were creating the more preferred mesic conditions, and higher food abundance for the red-backed vole. These variables may influence red-backed vole relative abundance, or could be related to the mesic conditions which the vole was selecting, and should be considered in future investigations. Percent vertical cover of herbaceous vegetation in the 1st meter above the ground was negatively related to red-backed vole relative abundance, while above 1m it was positively related to red-backed vole relative abundance (Table 4). Since you can not have higher densities of herbaceous vegetation above 1m with lower density of herbaceous vegetation below 1m, one of these results must be spurious, possibly due to Type 1 error, or small sample size. Since the percent of vegetative cover in the 1st meter above the ground was found positively related to red-backed vole abundance in several studies (Belk 1988, Walters 1991, Wywialowski and Smith 1988), and since green vegetation is its primary food source, I would consider the negative relationship with percent cover of herbaceous vegetation in the 1st meter above the ground to be the spurious result.

One habitat variable that shows a potential relationships with masked shrew abundance, through the association with the grand fir habitat type classes, is snag density

(Table 2). Higher densities of snags could provide more nesting area, with greater protection from predators. This source of decaying woody material may also afford hunting areas with larger densities of bugs, the masked shrews primary food source (Whitaker et al. 1980), with greater protection from other predators. Snag diameter was also significantly larger in higher masked shrew relative abundance groups (Table 3). In the comparison of relative abundance groups with habitat variables, large tree bole height showed a significant difference between relative abundance groups. However the multiple comparison test showed the lowest relative abundance group to be significantly different than the middle relative abundance group, but not than the highest group, which I can not explain. There could be a relationship, but it could also be Type 1 error. The percent cover of herbaceous vegetation above 1m was also found to be significantly different among relative abundance groups. The multiple comparison test was unable to distinguish between the groups, but the higher mean values were in the 2nd and 3rd groups respectively. Higher coverages of herbaceous vegetation would provide a moister microhabitat and higher bug densities, but I can not explain why this relationship would not have shown up with herbaceous vegetation densities in lower strata as well.

Habitat variables that are potentially important to the northern pocket gopher, due to their mutual relationship with the different habitat type classes, include large tree dbh, snag density, elevation, and percent slope (Table 2). The cool moist grand fir habitat type class had significantly smaller large tree dbh's than the other 2 habitat type classes. The high densities of large woody roots in areas with larger trees may make digging more difficult for pocket gophers, thereby limiting their presence (Scrivner and Smith 1981).

This may indicate a more open, earlier successional condition, where plant productivity is higher, providing a greater abundance of palatable roots and tubers for the pocket gopher to consume, is preferred by pocket gophers. The moister conditions in the cool grand fir habitat types, due to the higher elevations, may create conditions more conducive to pocket gopher digging and feeding. It has been shown that pocket gophers prefer moister soil conditions for digging in (Whitaker et al. 1980, Scrivner and Smith 1981). These moister conditions may provide more productive plant communities which are rich in palatable roots and tubers as well (Scrivner and Smith 1981). I can provide no explanation why higher snag densities, and steeper slopes would positively influence pocket gopher abundance. These variables may just be coincidental with the cool moist grand fir habitat type class, and not influence pocket gopher abundance at all, and may be Type 1 errors. Small trees were significantly taller in the higher pocket gopher relative abundance group (Table 5). I can not explain this relationship either, and it may be a spurious result.

Two habitat variables were shown to be negatively related to dwarf shrew relative abundance by the Kruskal-Wallis test (Table 5). Large tree densities were highest in the lower relative abundance group. High densities of large trees could possibly reduce the productivity of the understory in stands, thereby reducing the availability of insect prey. Percent vertical cover of woody vegetation at ground level was highest in the lower relative abundance group for the dwarf shrew (Table 5). MacCracken et al. (1985) found dwarf shrews in Montana to be more abundant in areas of high brush and litter cover, hypothesizing that this created better moisture conditions. I can think of no reason for dwarf shrews to avoid areas of high shrub cover, and would consider it to be a spurious result. The low density at which dwarf shrews exist caused capture rates to be very low. This in conjunction with small sample sizes may be masking relationships between the dwarf shrew and habitat variables. Obtaining larger sample sizes in future investigations could help to clarify dwarf shrew habitat type class associations and habitat relationships.

Several habitat variables could potentially influence deer mouse relative abundance based on its association with the dry Douglas-fir medium tree VGS (Table 3). The medium tree VGS tends to be on more westerly aspects, with higher ground coverages of litter, and higher percent vertical coverages of woody vegetation in the 1st meter above the ground. More westerly aspects are moister, potentially producing the higher shrub densities. Belk et al. (1988) found deer mice to prefer areas with higher shrub densities. Walters (1991) found deer mice to prefer areas with high densities of forest litter, stumps and logs. The primary food of the deer mouse is seeds and nuts (Whitaker et al. 1980) which could be more abundant under these conditions. Higher shrub densities and litter coverages could also provide more hiding cover, for protection from predators. Deer mouse relative abundance was lower in areas with higher coarse woody debris lengths and diameters. This contradicts the findings of both Belk et al. (1988), and Walters (1991). This relationship is also contradicted by the density of coarse woody debris being highest in the stands composing the deer mouse's highest relative abundance group. But, the higher coarse woody debris densities are in the lowest relative abundance group, which was not shown to be significantly different than that in the highest relative abundance group. No clear interpretation can be made of this situation, and these may just be a spurious results. Larger sample sizes might allow future investigators to clarify this. Canopy closure was also significantly greater in the higher relative abundance groups. It is possible that the higher canopy closures of some sites raised moisture levels to the point where higher densities of food and cover providing shrubs could grow, but differences in mean canopy closure don't appear large enough to support this. Mean canopy closure was only 37% in the small tree VGS, 46% in the medium tree VGS, and had a mean of 42% in the dry Douglas-fir habitat type class, which was the highest of all habitat type classes. The percent vertical cover of herbaceous vegetation above 1m was highest in the 2nd relative abundance group, and lowest in the 3rd relative abundance group. I can not explain why this would be and expect that it is a spurious result.

Two habitat variables that could potentially influence yellow-pine chipmunk relative abundance were detected by the Kruskal-Wallis test (Table 4). Yellow-pine chipmunk relative abundance was higher in areas with greater percent cover of litter above 1m. Forest litter at this level would be composed mostly of dead brush. This species is known to inhabit open forests with brush. Both Sharples (1983) and Sutton (1992) found the yellow-pine chipmunk to prefer open forest with brush composing the understory. Snag density was greater in the higher relative abundance groups for the yellow-pine chipmunk. The yellow-pine chipmunk is a generalist species (Moris 1996) and may not have a true relationship with these variables. Both these variables are not very easily explained, and may have been found significantly different due to type 1 error. Larger sample sizes in future investigations may help to sort out the uncertainty associated with these variables.

Several habitat variables that differed significantly between the relative abundance groups of the vagrant shrew are difficult to support biologically. Vagrant shrews showed a negative relationship with percent vertical cover of woody vegetation up to 1m above the ground. Perhaps this woody vegetation had a negative effect on the density of herbaceous cover. However, percent cover of forest liter above 1m from the ground was also higher in the 2nd relative abundance group for the vagrant shrew. Forest litter in this height strata would primarily be composed of dead brush, or litter suspended on brush, which contradicts the inverse relationship with woody cover in the 1st meter above the ground. One of these findings is apparently incorrect. Larger sample sizes may have been needed to clarify this. Mean snag density was greater in the higher vagrant shrew relative abundance group. This is probably a spurious result, but could be because vagrant shrews nest in decaying woody material (Burt and Grossenheider 1980), and snags may provide for a larger insect food source as well.

Two habitat variables that differed significantly between the relative abundance groups of the golden-mantled ground squirrel were coarse woody debris density, and aspect. Coarse woody debris density was found to be significantly higher in the 2nd relative abundance group for the golden-mantled ground squirrel. This relationship could potentially be supported by the fact that golden-mantled ground squirrels usually have their dens under or near downed logs and stumps, or brush (Burt and Grossenheider 1980). Golden-mantled ground squirrel relative abundance was found to be higher in stands with more northerly aspects. This contradicts what would be expected, because northerly aspects usually support denser forests. The relationship identified with aspect, is probably therefore be a spurious result, due to Type 1 error.

The meadow vole showed 2 potential vegetation relationships that are difficult to support biologically. Meadow vole relative abundance was higher in stands with larger diameter pieces of coarse woody debris. Small tree height was greater in the higher meadow vole relative abundance group. No explanation for either of these findings could be found.

Herptiles and Habitat Variables

Several habitat characteristics that may be important to western toads were identified (Table 6). Percent cover of woody vegetation above 1m was lowest in relative abundance groups 2 and 3 respectively. The Kruskal-Wallis test showed a significant difference in coarse woody debris diameter between relative abundance groups. The multiple comparison test was too conservative to separate the groups out (Miller 1985), but mean values appear to be inversely related to relative abundance. The opposite relationship would be expected, and I have no feasible explanation. This may simply be one of the expected spurious results. Large tree bole height was highest in relative abundance group 2, with the lowest mean value being in group 3. I can not explain this order and this may be another potentially spurious result. Small tree height was greatest in relative abundance group 3, and 2nd highest in group 2. Again, I can not explain this. The confused relationship of large tree bole height, and small tree height may indicate these as spurious results due to Type 1 error. Larger sample sizes in future investigations could possibly aid in sorting these relationships out.