AN ABSTRACT OF THE THESIS OF

__Douglas M. Gomez__ for the degree of __Master of Science__ in
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Title: Small Mammal and Herpetofauna Abundance in Riparian and Upslope
Areas of Five Forest Conditions

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I compared species composition and relative abundance of small

mammals and herpetofauna between riparian and upslope habitats among 5

forest types. Riparian- and upslope- associated species were identified

based on capture frequency. Small mammal species richness was similar

between stream and upslope habitats and among the 5 forest types. There

were differences (P<0.05) in the abundances of 9 small mammal species

among forest types. The total captures of small mammals was highest in

deciduous stands and progressively lower from shrub to old-growth

coniferous forests. Neurotrichus gibbsii, Sorex bendirii, Sorex

pacificus, Microtus longicaudus, Microtus townsendii, Phenacomys

albipes, and Zapus trinotatus were captured in higher numbers in

riparian than in upslope habitats; Sorex pacificus, Microtus

longicaudus, and Phenacomys albipes may be considered riparian

associated species; and S. bendirii may an obligate of riparian

habitat. In contrast, Clethrionomys californicus showed a strong

association with upslope habitats.

Herpetofauna species richness was similar among forest types but

slightly greater in the shrub stands. The abundances of 3 of

herpetofauna species differed among forest types. Total captures of

herpetofauna was highest in deciduous forests, intermediate in the

mature conifer forests, and lowest in the 2 younger forest types.

Herpetofauna species richness was similar between stream and upslope

habitats, however captures of this group were higher in riparian than upslope habitat. _Ascaphus truei_, _Plethodon dunni_, _Taricha granulosa_, _Dicamptodon tenebrosus_ and _Rana aurora_ had higher captures in riparian than upslope habitats; _Taricha granulosa_ and _Dicamptodon tenebrosus_ may be considered riparian associated species; and _Ascaphus truei_ and _Plethodon dunni_ may be obligates of riparian habitat. _E. eschscholtzi_ was associated with upslope habitats.

I described riparian microhabitat components important to capture of small mammals and herpetofauna. _S. bendirii_ was found only associated with intermittent streams in upslope habitats, and _A. truei_ was positively correlated with stream depth, additional evidence that these 2 species were associated with riparian habitat. _S. pacificus_, _N. gibbsii_, _P. albipes_, _M. longicaudus_, and _Z. trinotatus_ were associated with deciduous vegetation. In addition, _M. longicaudus_ was positively correlated with the number of logs. The high abundance of _Z. trinotatus_ along streams was associated with herbaceous vegetation. This is supported by it's high abundance in shrub stands where herbaceous cover is high. _C. californicus_ was captured most frequently in mature and old-growth forests, it was associated with deep litter and abundant snags.

The results suggested that small (second- third- and fourth-order) riparian systems and adjacent upslope areas may provide important habitat to some small mammals and herpetofauna on the Oregon Coast Ranges. It is vital that these systems be considered in management plans which include the protection of at least some of these areas from timber harvest.

SMALL-MAMMAL AND HERPETOFAUNA ABUNDANCE IN RIPARIAN
AND UPSLOPE AREAS OF FIVE FOREST CONDITIONS.

By

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Finally, and most important, I thank all the individual animals that participated in this study. I hope that these species and all others for which the information is applicable benefit from the results never to be forgotten again in management.

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INTRODUCTION

Riparian areas in forests of Western Oregon and Washington are known as some of the most productive and diverse habitats available to wildlife (Thomas et al. 1979, Oakley et al. 1985). However, information on wildlife use of riparian areas is limited in the Pacific Northwest despite the abundance of moist forests and stream habitat in this area. Without proper forest management of riparian habitat, the status of many species' populations might be affected, functional riparian communities lost, and the overall biotic potential of the riparian ecosystem limited (Kauffman 1988).

The purpose of this study was to assess the influence of forest type, and riparian and upslope habitat on relative abundance of small mammals and herpetofauna, and describe habitat relationships of riparian associates in watersheds of the Oregon Coast Ranges. My objectives were to:

1. Compare species composition and relative abundance of small mammals and herpetofauna between riparian and upslope habitats among five riparian forest types.

2. Identify species with riparian associations.

3. Describe specific microhabitat relationships of the species that show strong riparian or upslope associations.

In the first two papers, species composition and relative abundance of small mammals and herpetofauna are presented, respectively. Capture frequencies among forest types, between riparian and upslope habitats, and along a transriparian gradient are compared. In the third paper, microhabitat relationships of stream and upslope associates are described.

SMALL-MAMMAL ABUNDANCE IN RIPARIAN AND UPSLOPE
AREAS OF FIVE FOREST CONDITIONS

INTRODUCTION

The high species diversity, density, and productivity of wildlife has been noted for riparian habitat in Western Oregon, and the impact of silvicultural practices on wildlife use has made riparian areas a critical issue (Anthony et al. 1987b). The importance of maintaining riparian forest vegetation for the benefit of fish populations has been recognized for years (Brazier and Brown 1973, Meehan et al. 1977, Sedell et al. 1981); however the importance to other animals is less clear. The importance of riparian areas to birds was described by Bottorf (1974), Stevens et al. (1977), Bull (1978), Hehnke and Stone (1978), Stauffer and Best (1980), Koster (1984), Knopf (1985) and Knight (1988). They concluded that riparian areas usually support greater diversity of bird species per unit area than other habitats. However, in contrast McGarigal and McComb (In Press) found mean bird species diversity, richness, and total bird abundance greater in upslope areas than along streams on the Oregon Coast Ranges. The significance of riparian areas to large mammal species was described by Oakley et al. (1985) and Raedeke et al. (1988). However, few studies have been conducted on small mammals in riparian areas in Pacific Northwest. Despite the large proportion of the vertebrate community which is comprised of these species (approximately 100 small-mammal species (Bury 1988)), the importance of small mammals in riparian areas is not well known. Additionally, many of the studies on wildlife populations in riparian habitat have been conducted in arid regions

where the riparian influence is often more distinct (Johnson 1981), thus the results of those studies are not directly applicable to mesic regions of Western Oregon.

Many definitions of "riparian systems" have been proposed to describe the specific characteristics of these areas and delineate the important habitat features to wildlife. However, the significance of riparian habitats to wildlife is often overlooked, because of the small amount (less than 1% of Western United States, Knopf et al. 1988) and linear nature of these systems. Kauffman (1988) suggested riparian habitats may be used by large numbers of wildlife species, and they play a significant and often essential role in the maintenance of wildlife communities in the adjacent upland habitats (Hirsch and Segelquist 1978). The transition zone between riparian and upland habitat also is important to both the timber industry and wildlife (Cross 1985). The differences in composition and structure of vegetation and the variability in soil moisture in riparian areas, may influence many species of wildlife by providing food and other essential resources. Thomas et al. (1979) suggested that riparian habitat provides a source of cover, food, and water to small mammals migrating to different habitats. Campbell and Franklin (1979) were able to identify distinct plant communities within riparian and upslope areas using a gradient approach.

Although most plant ecologists recognize the significance of moisture gradients in structuring plant communities, there is a need for similar investigations on animal responses along these gradients. Hirsch and Segelquist (1978) and Hair (1988) cited the urgency of preservation of remaining riparian habitat, with an estimated 70-90% of

all natural areas already lost in the Eastern United States. Rochelle et al. (1988) suggested that specific wildlife goals for riparian areas in the Pacific Northwest should include the maintenance or enhancement of critical riparian species, maintenance of important habitat features (down logs, snags, etc.), enhancement of cover conditions, and optimum species diversity. Human disturbance of natural communities including timber harvesting, grazing of livestock, road building, channeling and dam building has increased (Hall 1988). Changes in stream morphology, water quality, and vegetation often result from these disturbances, followed by a decrease in the productivity of aquatic systems and the terrestrial vertebrate community (Kauffman 1988). Ultimately, these changes produce a shift in dominance to the more adaptable species, which are associated with disturbed habitats (Kauffman 1988). However, even in their natural state riparian areas are subject to natural disturbances (i.e. flooding), cyclic geomorphology, and biotic interactions which produce habitats of mixed vegetation combined with different forest types. There are 69 species of riparian associated plants and animals listed as threatened or endangered by the Department of Interior, many a result of dramatic habitat alterations (Hirsch and Segelquist 1978).

Studies on small mammals in riparian areas of the Pacific Northwest have been limited in scope and type. Anthony et al. (1987a) compared small-mammal abundance along streamside versus riparian fringe habitats in the Oregon Cascades and found higher species richness but lower abundance of small mammals along the streamside habitat. In addition, they suggested that mammalian insectivores could be particularly sensitive to alterations in riparian habitats in parts of

the Cascade mountains. Cross (1985) also found that riparian zones had higher species richness of small mammals than the transition and upland habitats in four mixed conifer sites in southwest Oregon. However, the species composition of small mammals was similar between riparian buffer strips and riparian zones in uncut forest. According to Cross (1985) use of riparian habitat was not restricted to obligate species; some rodents with larger home ranges utilized riparian components for only part of their daily and seasonal activity. Deer mice (<u>Peromyscus maniculatus</u>), Pacific shrews (<u>Sorex pacificus</u>), shrew moles (<u>Neurotricus gibbsii</u>), and Pacific jumping mice (<u>Zapus trinotatus</u>) were found in greater abundance in the riparian zones than in upland or transition zones (Cross 1985). Simons (1985) found similar small-mammal communities between old-growth and logged riparian areas in the Siskiyou Range of Northern California. Doyle (1990) using Sherman traps in the Oregon Cascades found species richness greater along the stream in 1981 and 1982, but equal with upslope in 1983. She also found higher average adult body weights and higher percentages of reproductively active adults in riparian zones compared to upland forests. Trowbridge shrews (<u>Sorex trowbridgii</u>), dusky shrews (<u>S. monticolis</u>), <u>N. gibbsii</u>, <u>P. maniculatus</u>, <u>Z. trinotatus</u>, Oregon creeping voles (<u>Microtus oregoni</u>), and the ermine (<u>Mustela erminea</u>) had higher relative abundance along small permanent streams than in the upland habitat (Doyle 1990). Based on available life history data (Whitaker and Maser 1976, Maser and Johnson 1967), Anthony et al.(1987b) suggested that the Pacific water shrew (<u>Sorex bendirii</u>) and the white-footed vole (<u>Phenacomys albipes</u>) are riparian obligate species in western Oregon.

The purpose of this study was to describe differences in species composition and relative abundance of small mammals between riparian and upslope habitats among five forest types. My goal was to identify species with riparian or upslope associations. I suggest special management for the survival and success of certain species.

METHODS

Study Sites

Fifteen study sites were located within five watersheds in the Central Coast Ranges of Oregon along second-, third-, and fourth-order streams (Horton 1945) (Strahler 1957) (Figure 1.1). The Figure 1.1. Map of study site locations in Oregon Coast Ranges. Coast Ranges is influenced by the maritime climate of Western Oregon, with mild-wet winters and cool-dry summers (Brown and Curtis 1985). The annual precipitation ranges from 64 cm in the interior valleys to 305 cm on the western slopes of the coastal mountains (Brown and Curtis 1985). Franklin and Dyrness (1973:31-32) described the Coast Ranges as a narrower zone not including the interior valleys, which receives 170-300 cm of precipitation a year. They suggested that the average temperatures in these areas seldom drop below 0°C in the winter and never exceed 27°C in the summer. The upland soils of these areas consist largely of silt loams and clays (of sedimentary origin) and finer textured clay loams which are igneous (Maser et al. 1981). Organic matter content is high and acidity is medium (Franklin and Dyrness 1973: 9-10). There may be substantial differences in soil types which occur locally as topography changes, with shallow, poorly developed soils on steep slopes and deep soils on gradual slopes

Figure 1.1. Map of study site locations in Oregon Coast Ranges.

(Maser et al. 1981). The elevation of the study sites ranges from 110-378 m and slope is from 28 to 68% (Appendix A).

I described five forest types (Hall et al. 1985) including: (1) shrub-conifer forests; 5-10 years old, trees <3 m tall, dbh <2.5 cm, <40% crown cover with grass-forb condition intermittent, dominate tree species Douglas-fir (Pseudotsuga menziesii) (2) open sapling-pole conifer forests; 20-35 years old, trees usually >3 m tall, 2.5-10 cm dbh, <60% crown cover, dominate tree species Douglas-fir (3) large sawtimber conifer forests; 110-200 years old, trees usually >30 m tall, dbh >53 cm, 60-80% crown, dominate tree species Douglas-fir and 4) old-growth conifer forests; 200+ years old, multilayered vertical structure, 60-80% crown cover, dominate tree species Douglas-fir and western hemlock (Tsuga heterophylla) 5) deciduous; >70% cover, dominate tree species red alder (Alnus rubra) and bigleaf maple (Acer macrophyllum. I sampled three replicates of each forest type (= 15 total stands). Sites were only selected which had the respective forest type on both sides of the stream, and in areas large enough to include the transects with additional area (>100m) to reduce edge effects. Aerial photos and field reconnaissance were used to locate the sites.

Trapping Design and Method

The trapping design on each study site consisted of two 200-m transriparian, one 350-m riparian, and one 350-m upslope transect in a rectangular arrangement (Figure 1.2). Eight trap stations with two pitfall traps/station were located at 50-m intervals along the riparian and upslope transects and nine trap stations at 25-m intervals along
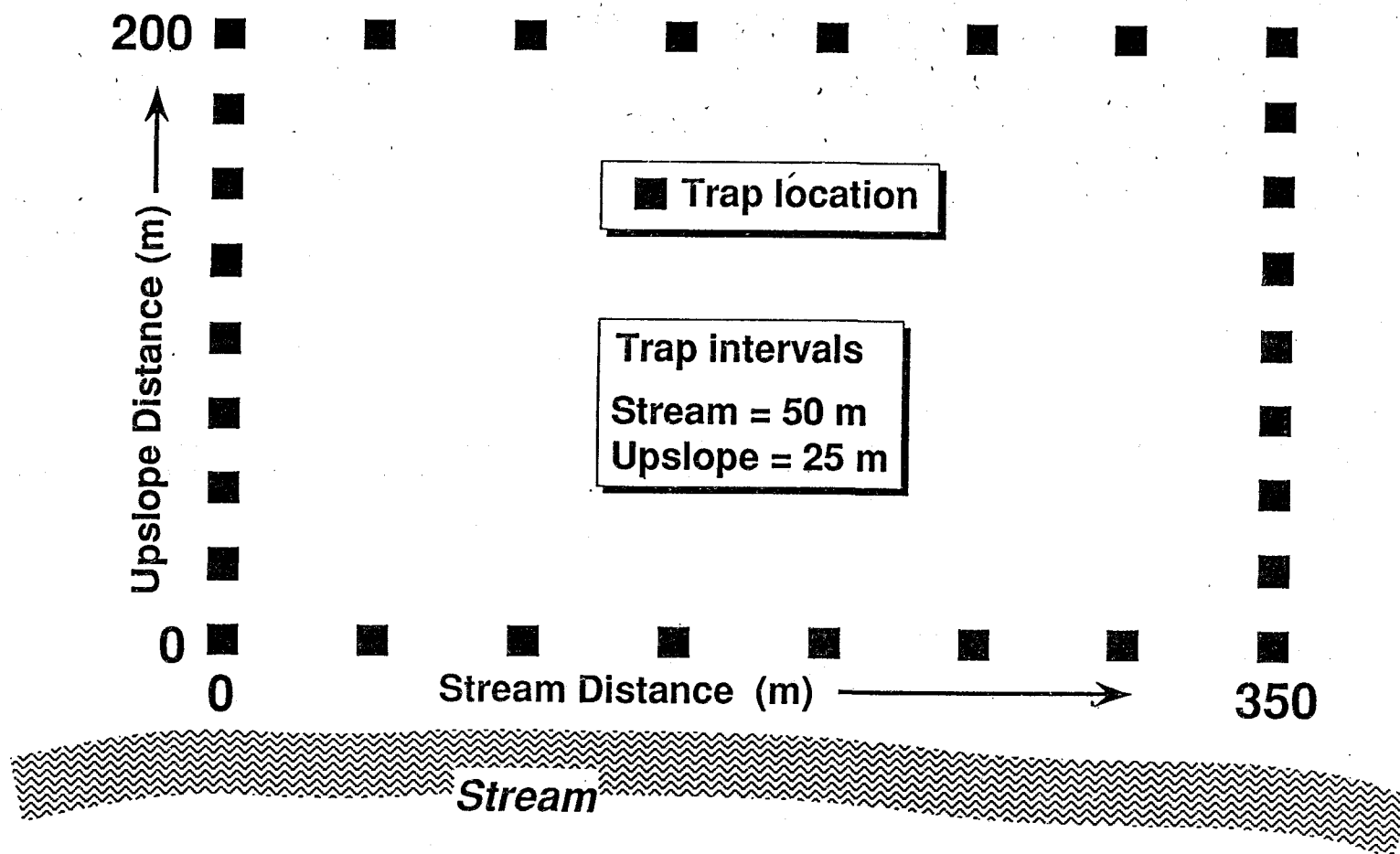
Figure 1.2. Study site design.

the transriparian transects. There were 60 pitfall traps per stand and a total 900 traps for all stands combined. Multiple traps were used perstation to increase the capture rates. Transect lengths and trap spacing were modified from McComb et al. (1991) to maximize the efficiency of the study design and obtain a representative sample of the population. The traps were constructed by attaching two #10 sized cans together, and placing them in holes so that the top of the can was flush with the ground. Traps were located within a 10 m radius of the station center to allow for subjectivity in trap placement. Traps were located along fallen logs, stumps, live trees, rocks, or slope breaks, which acted as natural drift fences. Kill trapping methods Figure 1.2. Study site design.were used in this study because of poor accessibility to the sites and time constraints.

The study included four 28-day trapping periods during the spring (cool, wet season) and summer (hot, dry season) of 1989 and 1990 and resulted in 100,800 trap nights. Traps were opened in May and August, and each trap was checked weekly, which allowed me to measure seasonal variations in abundance or trap response. Dead animals were taken from the field to freezers where they were stored for positive identification. Live animals were identified and released in similar habitats outside the study sites.

Pitfall trapping is a cost-effective and accurate technique for sampling the full array of small mammals and herpetofauna (Smith et al. 1975, Bury and Corn 1987). Bury and Corn (1987) found pitfall trapping to be the most desireable for sampling both small mammals and herpetofauna. Briese and Smith (1974) suggested that larger individuals or species may escape from shallow pitfalls, but pitfalls usually

capture a greater diversity of small mammals than obtained from live trapping or snap trapping. Based on available data (Hudson and Solf 1959, Aulak 1967, Brown 1967, Pacek 1969), Briese and Smith suggested pitfall traps to be more effective than live traps for shrews. In addition, results of McComb et al. (1991) suggested that the single, most efficient technique for quantifying the forest-floor vertebrate community was pitfall trapping. Relative abundance of each species was measured by pitfall trapping and capture rate (capture rate = abundance when used in the text) was used as an indice for relative abundance in my study.

Habitat Variables

Habitat variables were measured at each trapping station. Habitat variables were carefully chosen for accuracy, precision, and speed in sampling; for which minimal fluctuation occurs during a field season; and on the basis of their potential importance to influence particular wildlife species (Dueser and Shugart 1978).

Vegetation sampled included: herbaceous (forb, fern, grass), evergreen shrub (usually low shrubs 0 - 1.3 meters), deciduous shrub (usually tall shrubs 1.3 - 4 meters) and canopy cover (total, deciduous, and evergreen). Coverage of shrubs and trees by species were estimated (Appendix B). All vegetative and habitat sampling was within 10 m of each trapping station. Logs and snags were placed into size classes (small= 10-19 cm, medium= 20-49 cm, large >49 cm) and numbers were counted accordingly. In addition, the total number of stumps >10 cm diameter were tallied at each station. The percent slash cover, aspect, slope, basal area, mountain beaver (Aplodontia rufa) activity,

litter depth, pitfall orientation to and distance from nearest object, distance to stand edge and closest intermittent stream were measured (Table 1). In addition to the general habitat attributes, stations along the stream were characterized by stream gradient, aspect, width, depth, alluvial flood plain, beaver (<u>Castor canadensis</u>) activity, and presence of beaver dams. The vegetation sampling was conducted from June to September 1990.

Data Analysis

All data analysis was conducted using the SAS software system. Relative abundance of each species was compared among forest types using one-way Analysis of Variance (ANOVA) and the Student-Newman-Kuels (SNK) mean comparison tests. Relative abundance of each species was compared between stream and upslope habitats among forest types, and stations along the transriparian gradient among forest types using two-way ANOVA and the Student-Newman-Kuels (SNK) mean comparison tests. SNK was choosen for it's power in declaring significant differences and because it works well with equal sample sizes. The transect by forest type interaction and station by forest type interaction were used to test the transect effect and station effect along the transriparian gradient, respectively. Site within forest type was used as an error term when the interaction between transect and forest type (or station and forest type) was insignificant. When the mean square for site within forest type was less than the mean square for transect by site within forest type, the site within forest type error term was dropped and it became a completely randomized design. This procedure allowed me to separate the effects due to differences among forest types and sites

Table 1. Description of habitat attributes measured in riparian and upslope areas of 5 stand conditions in the Oregon Coast Ranges. 1990.

VARIABLE	DESCRIPTION
Aspect	Degrees
Slope	Percent
Basal area conifers	Meters/Hectare
Basal area deciduous	Meters/Hectare
Mountain beaver	0=absent; 1=present but not active; 2=active
Mountain beaver activity	Closest distance from plot center-meters
Litter depth	1Centimeters-measured at 5 points; station center, and 5 meters north, south, east and west of station center
Pit distance to object	Closest object within 1 meter (1-6; slope break, log>2m, log<2m, rock, stump, tree)
distance to stand edge	Distance <100 meters, or >100 meters
Distance to intermitant stream	Distance <100 meters, or >100 meters
Logs	Small (10-19 cm), medium (20-49 cm), large (>49 cm), and total # / 314 m^2
Snags	Small (10-19 cm), medium (20-49 cm), large (>49 cm), and total # / 314 m^2
Stumps	Total # / 314 m^2 plot
Slash	Percent cover / 314 m^2 plot
Stream habitat:	
Pit distance to stream	Meters
Stream gradient	Percent slope-degrees
Stream aspect	Degrees
Stream width	Meters
Stream depth	Meters
Alluvial flood plain	Width-meters
Beaver activity	0=absent; 1=present but not active; 2=active
Beaver dam	0=absent; 1=active

from differences between and within transects. When necessary, variables were transformed [log10 (x+1) and arc sine square-root for percent cover] to correct for non-normality or to obtain homogeneous variances. In some cases transformations were unsuccessful, but similar P-values from rank transformations suggested that nonnormality of data did not effect this assumption. Capture probabilities differed among species, so comparisons were restricted to among habitats and between transects for each species individually. Results for some species were not included, because small sample sizes (N<20) made interpretations tenuous.

RESULTS

Stand Characteristics

Forbs, deciduous shrubs, medium sized logs and deciduous tree coverage was greater (P<0.01) in riparian than in the upslope habitat (Table 2). Although grass coverage also was greater in riparian habitat (P<0.01), these results were not consistent among the forest types (Figure 1.3). Red elderberry (Sambucus racemosa), salmonberry (Rubus spectabilis) and stinking currant (Ribes bracteosum) were deciduous shrub species with higher percent cover (P<0.01) in the riparian than upslope habitat (Table 3), although, salmonberry and red elderberry varied among the forest types within these transects (Figure 1.4). The tree with the highest percent cover in riparian areas was red alder (Alnus rubra). Although not as common as in the upland areas, salal (Gaultheria shallon) had the highest percent cover among the evergreen shrubs along the streams. Cover of evergreen shrubs and evergreen trees, and litter depth were greater in upslope than in

Table 2. Average habitat characteristics along 15 streamside and 15 upslope transects in 5 stand conditions, Oregon Coast Ranges, 1989-90.

Variable[c]	Stream (n=15)		Upslope (n=15)		
	X	SE	X	SE	P
Slash cover (%)*	12.3	0.8	13.6	1.0	0.4282
Litter depth (cm)	1.6	0.2	4.1	0.3	0.0001
Logs / 314 m^2					
10-19 cm diameter	7.3	0.5	6.4	0.5	0.2911
20-50 cm diameter**	11.4	0.8	7.2	0.6	0.0036
50+ cm diameter	3.0	0.2	2.2	0.2	0.1214
Total*	21.7	1.3	15.8	1.0	0.0251
Snags / 314 m					
10-19 cm diameter	0.1	0.0	0.2	0.1	0.3068
20-49 cm diameter**	0.1	0.0	0.5	0.1	0.0273
50+ cm diameter**	0.2	0.0	0.3	0.1	0.3462
Basal area (m^2/ha) Deciduous**	11.4	1.7	5.1	1.1	0.0038
Cover (%) Forb	37.3	1.6	16.6	1.7	0.0001
Evergreen shrub	3.3	0.7	28.6	2.4	0.0006
Deciduous shrub	51.2	2.1	25.3	2.1	0.0003
Deciduous tree	41.0	3.5	22.0	3.2	0.0035
Evergreen tree	28.8	3.1	64.4	3.7	0.0002

*Variable was arc sine square-root transformed.
**Variable was Log10 + 1 transformed.

[c] Some variables were not included in this table because of significant differences among stand conditions within transects. Refer to figure 1.3.
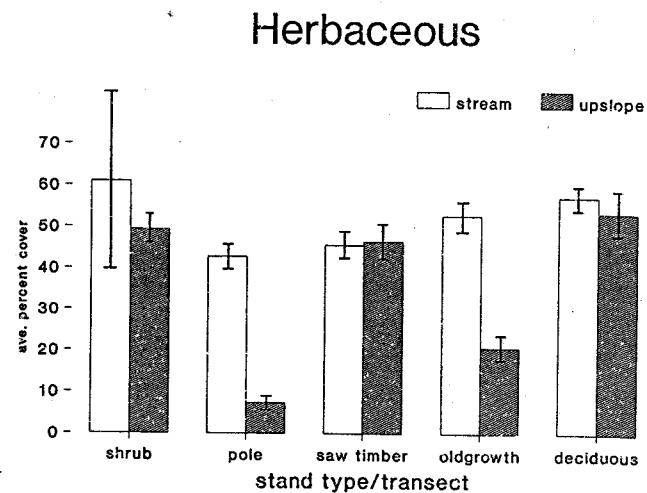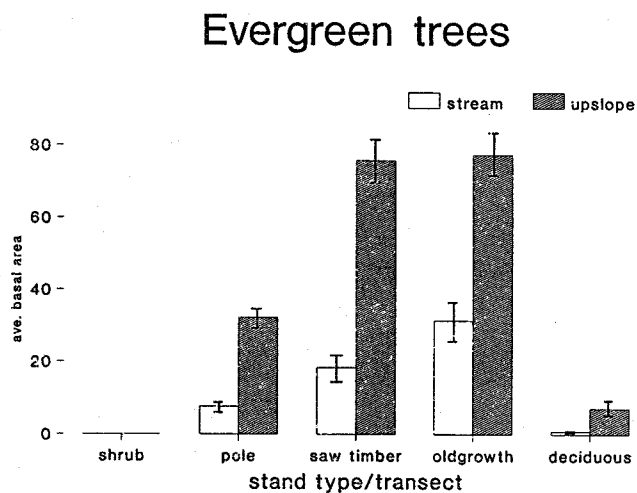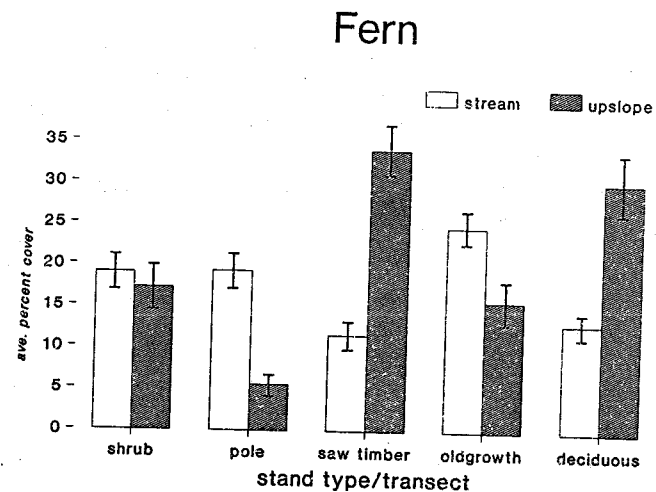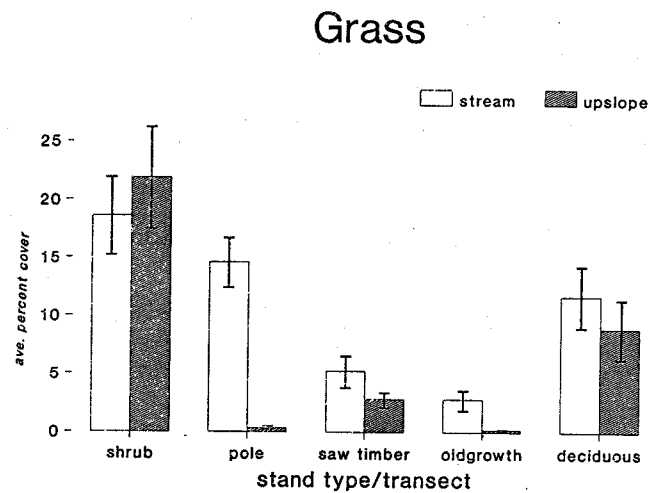
Figure 1.3. Average vegetation cover estimates among five stand conditions within stream (n=3) and upslope (n=3) transects (±standard error) in the Oregon Coast Ranges, 1990.

Table 3. Average vegetation cover estimates along 15 streamside and 15 upslope transects in 5 stand conditions, Oregon Coast Ranges, 1990.

Variable[a]	TRANSECT				P
	Stream (n=15)		Upslope (n=15)		
	X	SE	X	SE	
Douglas Fir	12.9	1.7	46.2	3.0	0.0001
Western hemlock[b]	10.6	1.9	14.8	2.3	0.4620
Western red cedar	4.8	1.1	3.4	1.2	0.6510
Red alder	36.7	3.4	17.0	2.8	0.0079
Vine maple[b]	6.9	1.0	9.7	1.7	0.8841
Red elderberry[b]	2.1	0.4	0.2	0.1	0.0034
Redstem ceanothus	0.0	0.0	0.1	0.1	0.1975
Salmonberry	34.8	2.2	3.7	0.9	0.0001
Huckleberry[b]	1.6	0.3	5.8	0.7	0.0029
Stinking current	9.8	1.2	0.0	0.0	0.0051
Salal[b]	2.2	0.6	17.6	2.1	0.0019
Oregon-grape	0.3	0.2	11.5	1.3	0.0006

[a]Some variables were not included in this table because of significant differences among forest types within transects. Refer to figures 1.3 & 1.4.

[b]Variable was arc-sine square-root transformed.
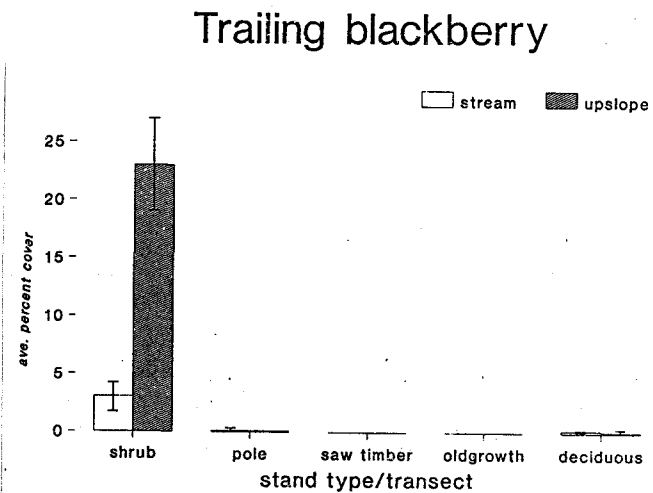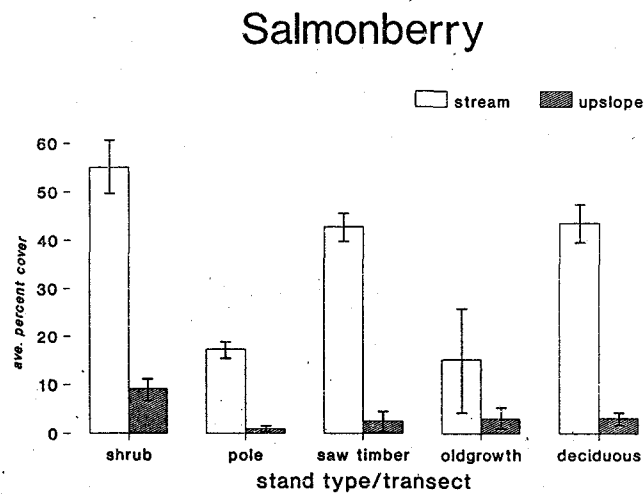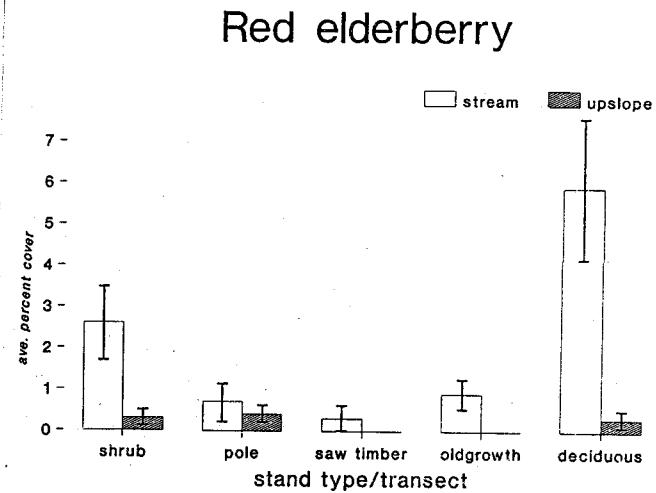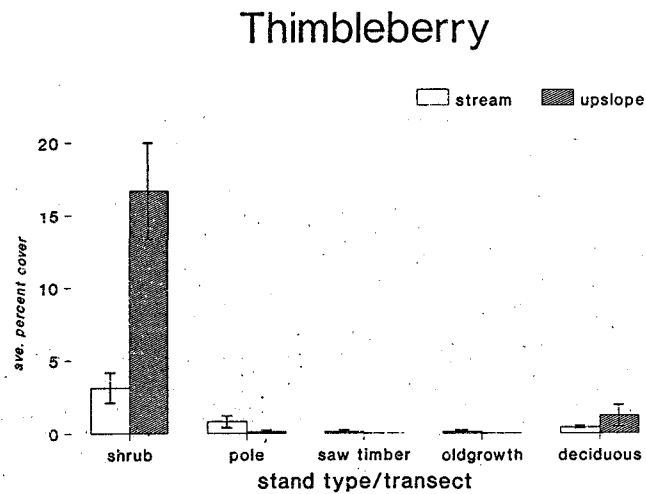
Figure 1.4. Average vegetation cover estimates among five forest types within stream (n=3) and upslope (n=3) transects (±standard error) in the Oregon Coast Ranges, 1990.

riparian areas (P<0.01) (Table 2). Basal area of evergreen trees, herbaceous coverage, and fern coverage differed among the forestupslope transects (Figure 1.3). Salal and Oregon-grape (Berberis nervosa) were the most frequently occurring evergreen shrubs in the upland habitat (Table 3). The predominant tree species (% cover) found in the upland areas of the conifer stands were Douglas-fir (Pseudotsuga menziesii) and western hemlock (Tsuga heterophylla). The deciduous shrubs with the highest percent cover in the upland habitat were vine maple (Acer circinatum) and red huckleberry (Vaccinium parvifolium). Thimbleberry (Rubus parviflorus) and trailing blackberry (Rubus ursinus) percent cover varied among the forest types within stream and upslope transects, and they were predominant shrub species in the upland areas of the shrub forest type (Figure 1.4). In addition, the density of stumps was higher in the upslope habitat (P<0.001) and total number of logs was greater along the stream (P<0.01).

Abundance and Species Richness

A total of 9723 small mammals including 20 different species were captured. Small mammal species richness among the forest types was greatest in the shrub habitat (20 species) and lowest in old-growth (15 species). In addition, the total captures of small mammals was progressively lower from young shrub stands to the older mature coniferous forests and highest in the deciduous habitat (Table 4). Species richness was similar between stream (18 species) and upslope habitats (17 species) (Table 5). There were 400 more captures along the stream than along the upslope transects.

Table 4. Distribution of small-mammal species captures among the five different stand types in the Oregon Coast Ranges, 1989-1990.

SMALL MAMMALS	STAND-TYPE[a]										Total Captures	p[b]
	S (n=3)		P (n=3)		L (n=3)		O (n=3)		D (n=3)			
	X	SE	X	SE	X	SE	X	SE	X	SE		
Insectivores:												
Neurotrichus gibbsii	14.7	2.7b	15.3	1.3b	26.7	8.7ab	27.0	3.5ab	35.7	4.7a	358	0.0247*
Scapanus orarius	1.3	0.7	5.0	2.0	5.3	1.2	7.7	2.7	8.7	4.6	84	0.3838
Scapanus townsendii	5.3	1.7a	0.3	0.3b	1.0	0.6b	0.7	0.7b	2.3	1.3ab	29	0.0382
Sorex bendirii	22.7	7.2	22.3	4.1	51.0	10.3	23.0	7.2	27.3	0.9	439	0.0556
Sorex pacificus	115.7	25.3	141.7	23.6	114.3	27.4	77.7	6.8	122.0	19.7	1714	0.3389
Sorex trowbridgii	208.0	59.5b	403.7	23.7a	290.0	17.1b	275.0	15.9b	468.3	50.5a	5016	0.0030
Sorex vagrans	33.0	6.1a	0.6	0.3c	3.0	1.5bc	3.7	2.7bc	10.7	2.0ab	153	0.0017*
Subtotals	1202		1848		1474		1244		2025		7793	
Rodents:												
Aplodontia rufra	4.7	1.7	3.0	1.7	3.7	0.9	0.3	0.3	1.7	0.9	40	0.1226*
Clethrionomys californicus	21.3	15.2	18.7	2.7	45.3	16.8	56.0	20.1	4.0	3.1	436	0.0549*
Microtus longicaudus	3.7	1.5	1.3	0.3	2.3	1.9	3.3	3.3	1.3	1.3	36	0.8627*
Microtus oregoni	75.7	29.8a	5.7	1.5b	3.7	1.2b	2.3	0.7b	8.3	4.9b	287	0.0061*
Microtus townsendii	5.3	3.2	0.7	0.7	0.3	0.3	0.0	0.0	1.0	0.6	22	0.2006*
Peromyscus maniculatus	61.3	13.2a	7.3	2.7b	7.7	2.4b	5.0	1.2b	20.7	1.5b	306	0.0007*
Phenacomys albipes	5.3	2.7	4.7	1.7	1.3	0.9	2.3	1.2	6.0	2.3	59	0.4827*
Phenacomys longicaudus	0.7	0.3b	0.3	0.3b	1.3	0.3b	5.3	2.4a	0.0	0.0b	23	0.0033*
Zapus trinotatus	147.0	26.3a	20.7	4.5b	23.0	9.3b	10.0	6.2b	33.3	10.4b	702	0.0096*
Subtotals	975		187		266		254		229		1911	
TOTAL CAPTURES[c]	2191		2036		1741		1498		2257		9723	

*Variable was Log10 + 1 transformed.

[a]S=shrub, P=pole, L=large saw timer, O=oldgrowth, D=deciduous.

[b]2-way ANOVA with site as block and error term to test for stand-type effect.

[c]Not including non-target species and the specimens which were in too poor condition to identify.

Table 5. Frequency of small-mammal captures along stream and upslope transects in five forest types in the Oregon Coast Ranges, 1989-90.

| | TRANSECT | | | | | |
| | STREAM (n-15) | | UPSLOPE (N=15) | | | |
SMALL MAMMALS	$\bar{X}$	SE	$\bar{X}$	SE	TOTAL	P[b]
Insectivores:						
Scapanus orarius	1.5	0.4	1.7	0.4	47	0.6495
Scapanus townsendii	0.3	0.1	0.1	0.1	6	0.4238
Sorex bendirii	24.2	3.3	1.3	0.4	383	0.0001*
Sorex pacificus	40.6	3.6	26.0	3.4	997	0.0007
Sorex trowbridgii	83.7	6.7	100.3	11.9	2760	0.1884*
Subtotals	2419		2112		4531	
Rodents:						
Aplodontia rufra	0.9	0.3	0.5	0.2	20	0.2845*
Clethrionomys californicus	2.4	1.3	14.4	3.3	253	0.0009
Microtus longicaudus	2.4	0.8	0.0	0.0	36	0.0066*
Microtus oregoni	3.4	1.4	7.6	4.5	165	0.3663*
Microtus townsendii	1.3	0.8	0.0	0.0	20	0.0457*
Peromyscus maniculatus	5.1	1.7	6.1	1.8	167	0.2843*
Phenacomys albipes	2.1	0.6	0.4	0.2	38	0.0113*
Phenacomys longicaudus	0.4	0.3	0.5	0.2	38	0.0113*
Zapus trinotatus	24.9	6.1	6.9	3.7	477	0.0001*
Subtotals	644		545		1089	
TOTAL CAPTURES[c]	3066		2662		5728	

*Variable was log10 + 1 tranformed.

[a] N. gibbsii and S. vagrans were not included because of significant differences among stand conditions between stream and upslope transects for these species. Refer to figure 1.5.

[b]2-way ANOVA with transect by forest type interaction used to test for transect effect and site within forest type used as an error term.

[c]Not including non-target species and the specimens which were in too poor condition to identify.

Insectivores- There was a total of 7793 (almost 80% of all captures) insectivores captured, which included three mole and four shrew species. Sorex trowbridgii and Sorex pacificus together accounted for 86% of the insectivores and 69% of all small mammals captured. S. trowbridgii was captured more frequently in pole and deciduous forest types (P<0.01), but it was abundant in all of the forest types (Table 4). S. trowbridgii was 1.2 X more abundant along the upslope than stream transect (Table 5). Sorex vagrans was 3 X more abundant in the shrub stand-type (P<0.01) than in any of the other forest types (Table 4). The capture rate of S. vagrans along the stream and upslope transects varied among stand-types (P<0.05) (Figure 1.5). Sorex pacificus and Sorex bendirii were more abundant (P<0.001) along the stream than upslope transects (Table 5). In addition, both species capture rates along transriparian transects were higher near streams than further away (P<.001)(Figure 1.6). S. bendirii also wascaptured more than 1.8 X more often in the large sawtimber forest type than in all other types (Table 4). Scapanus townsendii was more abundant in the shrub and in the deciduous forest type (P<0.05) (Table 4). Neurotrichus gibbsii was the most abundant member of the mole group, representing 76% of the moles, 5% of insectivores and 4% of all small mammals captured. The capture rate of N. gibbsii was greatest (1.3X)(P<0.05) in the deciduous forest type (Table 4), and the capture rate along the stream and upslope transects was different among the forest types (P<0.05)(Figure 1.5).

There was significant variation in capture rates between seasons in the stream and upslope transects for N. gibbsii, S. pacificus, and S. trowbridgii (Figure 1.7), however because of significant interaction
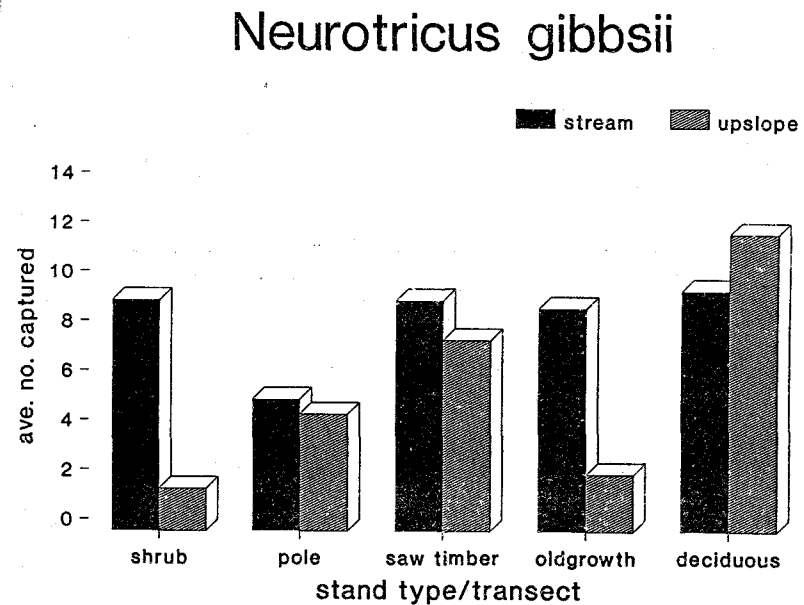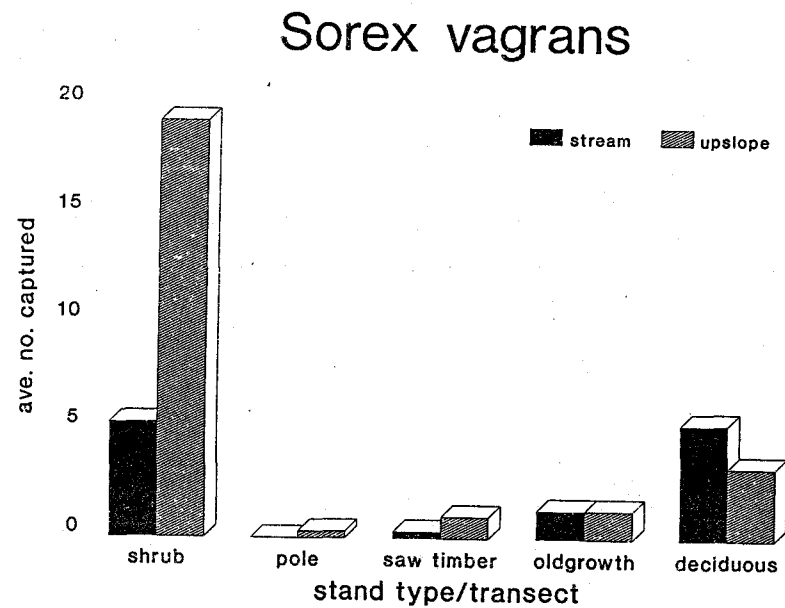
Figure 1.5. Average number of S. vagrans and N. gibbsii captured among five forest types along stream (n=3) and upslope (n=3) transects in the Oregon Coast Ranges, 1989-90.

Sorex pacificus
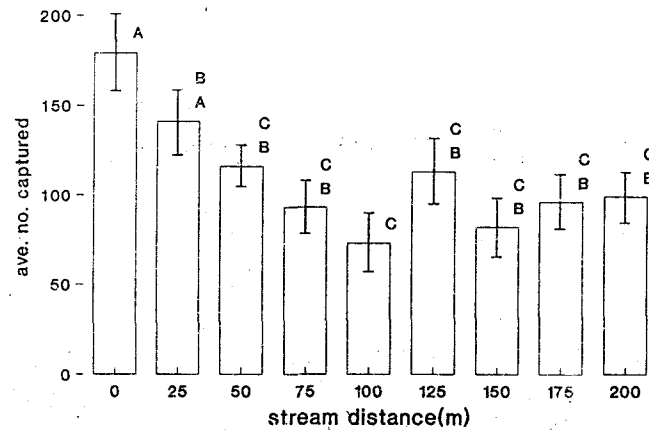
Sorex bendirii
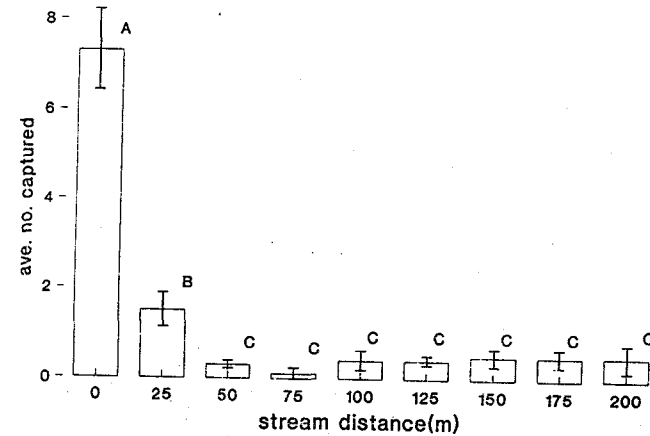
Zapus trinotatus
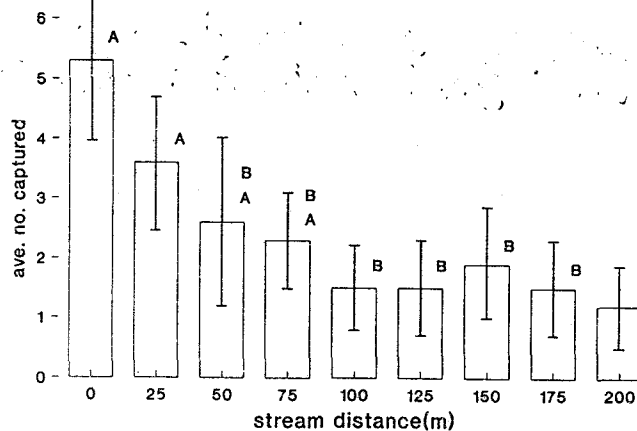
Clethrionomys californicus
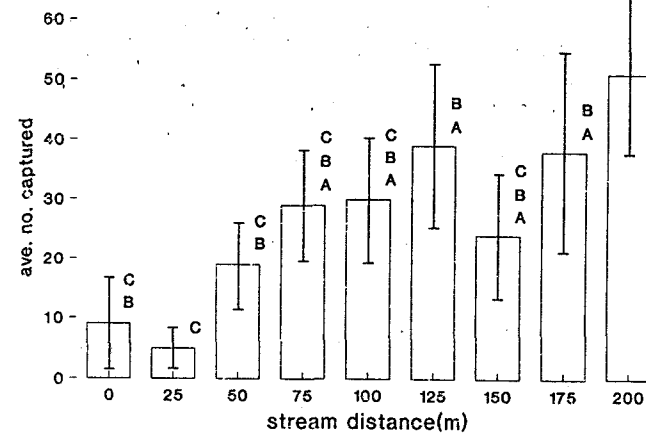
Figure 1.6. Average number of S. pacificus, S. bendirii, Z. trinotatus, and C. californicus captured (±standard error) along transriparian transects (n=15) in the Oregon Coast Ranges, 1989-90.

Neurotricus gibbsii

stream ☐ upslope ▨

ave. no. captured

10 –
8 –
6 –
4 –
2 –
0 –

cool-wet · hot-dry

transect/season

Sorex pacificus

stream ☐ upslope ▨

ave. no. captured

35 –
30 –
25 –
20 –
15 –
10 –
5 –
0 –

cool-wet · hot-dry

transect/season

Sorex trowbridgii

stream ☐ upslope ▨

ave. no. captured

80 –
60 –
40 –
20 –
0 –

cool-wet · hot-dry

transect/season

Zapus trinotatus

stream ☐ upslope ▨

ave. no. captured

20 –
15 –
10 –
5 –
0 –

cool-wet · hot-dry
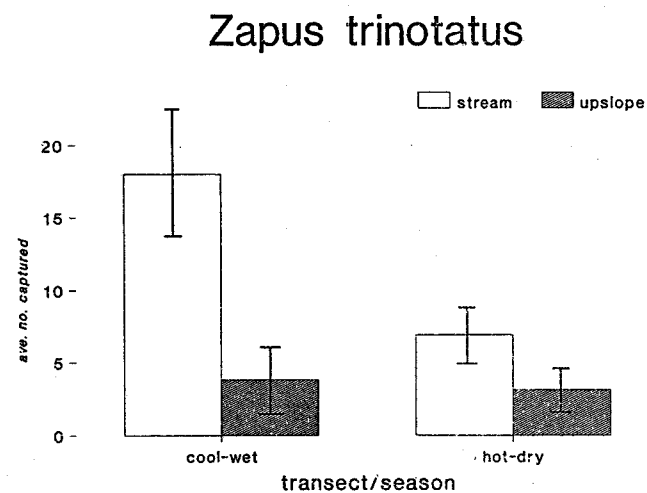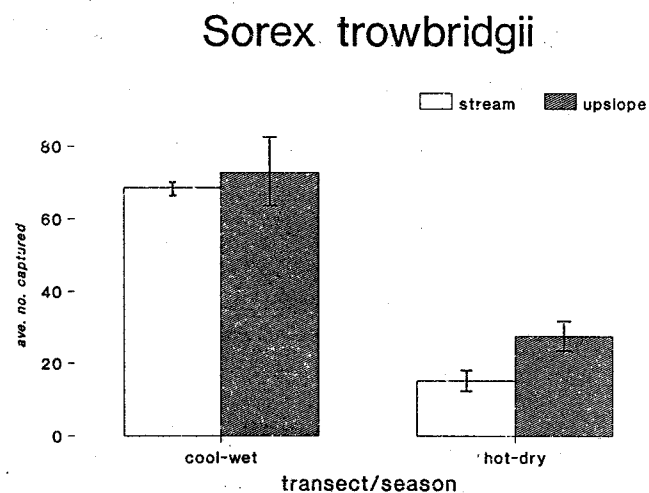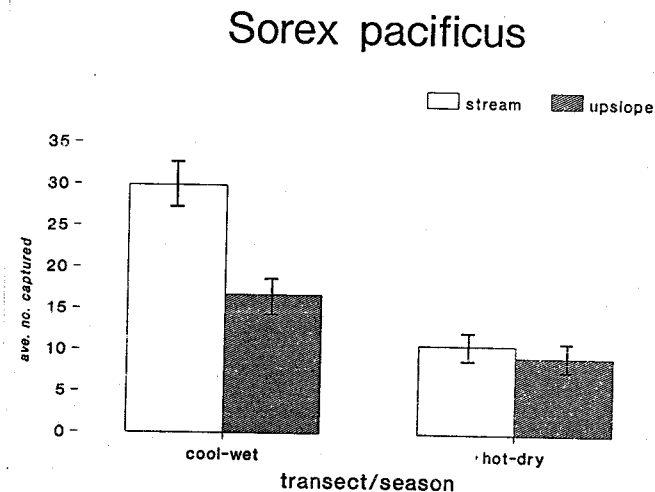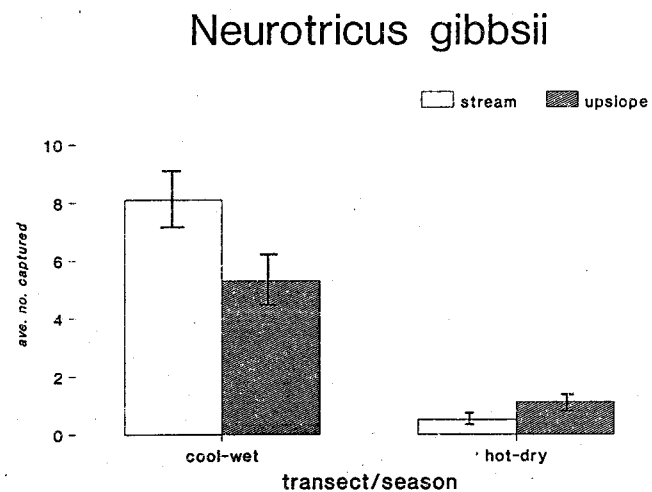
transect/season

Figure 1.7. Average number of N. gibbsii, S. pacificus, S. trowbridgii, and Z. trinotatus captured (±standard error) in riparian (n=15) and upslope (n=15) areas during different seasons in the Oregon Coast Ranges, 1989-90.

between season and transect in this analysis and because of variation due to removal of individuals in subsequent seasons, these results are difficult to interpret. The distribution of captures within seasons changed from 1.5 X more individuals along the stream in the spring (P<0.01) to 2.2 X more individuals upslope in the summer for N. gibbsii (Figure 1.7). There were 1.8 X more captures of S. pacificus along the stream versus upslope (P<0.01) in the spring compared to only 1.1 more captures in the stream versus upslope in the summer. Although there was not a significant difference between stream and upslope captures of S. trowbridgii during the cool-moist season, there were 1.8 X more individuals captured in the upslope during the hot-dry season (P<0.01)(Figure 1.7).

Rodents- A total of 1914 rodents was captured, which included 11 species; six were microtines. Zapus trinotatus, Clethrionomys californicus, Peromyscus maniculatus and Microtus oregoni together accounted for over 90% of the total rodents and 18% of all small mammals captured. P. maniculatus and M. oregoni were at least 3 X more abundant (P<0.01) in the shrub forest type than in the other habitats (Table 4). In addition, P. maniculatus and M. oregoni were more abundant along the upslope than stream transects. Z. trinotatus was 4.4 X more abundant in the shrub type (P<0.01) than in the other forest types (Table 4). It was also captured 3.6 X more in the riparian than upslope habitats (P<0.001) (Table 5) and was more abundant near the stream than upslope along transriparian transects (P<0.001) (Figure 1.6).

There were three microtine species that were captured 5 X more often (P<0.05) in riparian than upslope habitats (Table 5). Microtus

longicaudus was captured exclusively in riparian habitat; Microtus townsendii also was captured almost entirely near the stream; and captures of Phenacomys albipes were significantly greater in riparian than upslope habitats. In contrast, C. californicus was captured (P<0.001) more frequently (6 X more frequently) in the upslope habitat (Table 5). It was also unique, being the only small mammal significantlymore abundant at distances further from stream transects (Figure 1.6). It was found at least 2.1 X more frequently in large sawtimber and old-growth conifer stands than the other three forest types (Table 4). There were only 23 captures of Phenacomys longicaudus, but it was captured more frequently (P<0.01) (Table 4) in old-growth forests than in each of the other forest types.

Z. trinotatus was the only rodent species with significantly higher captures between seasons on the stream and upslope transects. It was captured 2.2 X more often in the cool-wet season (P<0.01) along the stream and upslope transects (Figure 1.7). In addition, Z. trinotatus was 4.7 X more abundant along the stream versus upslope transects in the spring, but only 2.7 X more abundant along the stream in the summer.

DISCUSSION

Species Richness

In the Oregon Cascades using Sherman traps, Doyle (1990) found species richness greater along the stream in 1981 and 1982, but equal with upslope in 1983. This decrease in species richness was probably the result of emigration, mortality and/or trap avoidance by some less abundant species from the previous two years. She also captured 1.5

times more small mammal individuals in riparian habitat. Small mammal abundance was similar between riparian and transriparian habitats but was approximately twice as great as in upslope areas along these transects in southwestern Oregon (Cross 1985). Cross (1985) also found higher species richness in riparian areas, intermediate in transriparian areas, and lowest in upslope habitats. In addition, there were higher numbers of small mammals in clearcut riparian areas, than in forested riparian habitat, while species richness was higher in the forested riparian habitats (Cross 1985).

Abundance

S. trowbridgii and S. pacificus together accounted for a majority of the small mammal captures in my study. Doyle (1987) also found S. trowbridgii to be the most abundant small mammal captured using Sherman traps in the Cascades, and Maser et al.(1981) captured it more frequently than other shrews on the Oregon coast. S. trowbridgii was captured more frequently in the pole and deciduous stands in this study. There also was a significant difference in abundance of S. trowbridgii between seasons along the stream and upslope transects. In contrast, the abundance of S. trowbridgii was significantly greater in riparian than upland habitat in Oregon Cascades (Doyle 1990). Doyle (1990) also found mean adult weights, minimum survival time, percent of adult males breeding, and the length of the male breeding season were higher along the stream than upslope habitats for S. trowbridgii. In addition, Doyle found greater abundance of S. trowbridgii in sites dominated by deciduous tree cover, similar to the higher abundances of this shrew in the deciduous stands in this study. Gashwiler (1970)

suggested that S. trowbridgii abundance was usually low in old-growth, Douglas-fir forests when litter and shrub cover were limited. In addition, abundance of S. trowbridgii declines following clearcutting as a result of a decrease in available food and cover (Gashwiler 1970). Ingles (1965) and Christenson and Larrison (1982) suggested that S. trowbridgii preferred coniferous forests (immature and mature) (Maser et al. 1981) in Western Oregon. However, Ingles (1965) and Maser et al. (1981) found that the species may occupy a wide range of other habitats including wet areas in riparian habitat and dry areas away from streams. My study supports these conclusions.

S. vagrans was significantly more abundant in the shrub stands than the other forest types and had greater abundance in the upslope versus stream transect in the shrub stands of this study. S. vagrans is found in a variety of habitats including; lowland grasses, open brush, woods, moist meadows, headland shrub and prairie, tideland river habitats and dry uplands (Bailey 1936, Maser et al. 1981, and Christenson and Larrison 1982). It is typically associated with herbaceous vegetation.

S. townsendii was captured significantly more often in the shrub and in the deciduous stands in my study. Others have suggested that S. townsendii occupies open habitat, mostly in wet pastureland and agricultural fields of lowland valleys (Bailey 1936, Maser et al. 1981, and Christenson and Larrison 1982). These habitat preferences might have limited numbers of captures in this study, although Maser et al. (1981) suggested that this species is sometimes found in headland prairie and shrub habitats. The fossorial habits of moles also may

limit the captures of this group even when drift fences are used with pitfalls (Briese and Smith 1974).

N. gibbsii was significantly more abundant in the deciduous stands than all the other forest types, in large sawtimber and old-growth than the young conifer stands, and along the stream versus the upslope transect. The abundance of N. gibbsii differed between seasons along the stream and upslope transects in my study. There were more individuals captured during the cool-moist season and there was a change in abundance of captures from stream to upslope during the hot-dry season. Doyle (1990) also reported it to be the most abundant mole species and captured it 1.6 times more often along the stream than upslope transects. Cross (1985) also suggested that N. gibbsii frequented riparian habitats. N. gibbsii has been found in a variety of habitats including immature and mature coniferous forests and riparian hardwoods; however they are most abundant in alder/salmonberry and riparian alder habitats in the Oregon Coast (Maser et al. 1981, this study).

S. pacificus and S. bendirii were more abundant along stream than upslope transects and at distances closer to the streams along transriparian transects. The association of S. bendirii with riparian habitat was particularly strong. There also was a significant difference in abundance of S. pacificus between seasons along the stream and upslope transects in my study. S. pacificus was captured more often along stream and upslope transects during the cool-moist season than in the hot-dry season. S. bendirii is endemic to Coastal Pacific Northwest and Northern California. It is mostly found in or near water; including lowland bogs, marshes, and ponds (Christenson and

Larrison 1982) and along small streams in red alder habitat on the Oregon Coast (Maser et al. 1981). Hooven and Black (1969) suggested S. bendirii was dependent on the abundant grass and herbaceous cover typical of many riparian areas. However, this does not explain the high capture rates of S. bendirii in the large sawtimber forest type of my study. Bailey (1936) suggested that S. bendirii might be more dependent on moist muddy habitats for food than on a open water source.

S. pacificus is restricted to Coastal Oregon and the Northern Coast of California. Bailey (1936) and Christenson and Larrison (1982) suggested that S. pacificus is most abundant in moist, marshy, brushy places in Southern Coastal Oregon. In addition, Maser et al. (1981) reported that S. pacificus was found less frequently in conifer forests and prefers riparian alder habitat. Although the abundance of S. pacificus did not vary significantly among the forest types in my study, the results support an association of S. pacificus with riparian habitat.

P. maniculatus and M. oregoni were significantly more abundant in the shrub stands than in the other habitats. In addition, both species were captured more often along the upslope versus stream transects. The same rodent species that were dominant in my study accounted for the majority of captures in the Oregon Cascades by Doyle (1990). In contrast, Doyle (1990) found M. oregoni and P. maniculatus to be more abundant in riparian than upslope habitat; she also found higher mean adult weights, survival rates, and breeding activity for these species in riparian versus upslope habitats. M. oregoni is one of 30 microtine species in North America, 13 occur in Pacific Northwest (including Northern California) including seven endemic species. M. oregoni is

often found in coniferous forests, in riparian areas with alder (Maser et al. 1981) and might be associated with moist Douglas-fir forests (Goertz 1964). Although my results varied from these studies they are in agreement with Bailey (1936) and Whitaker (1980), who suggested that M. oregoni often preferred open upland areas and dry slopes. Results from this study also agree with Cross (1985) who found M. oregoni more abundant in clearcut areas than in forested areas. P. maniculatus is a ubiquitous species throughout North America and is found in a multitude of habitats because of its adaptability in these areas (Bailey 1936, Ingles 1965, Maser et al. 1981, Christenson and Larrison 1982). Although it was found in all habitats in my study, the results suggest an affiliation with the shrub stands. Cross (1985) also found P. maniculatus more frequently in the riparian and upslope areas in clearcuts than in forests.

Z. trinotatus is endemic to Coastal Pacific Northwest and the coast of Northern California. It was significantly more abundant in the shrub stands than in the other forest types, along riparian than upslope transects, and close to streams in this study. There also was a significant difference in abundance of Z. trinotatus between seasons along the stream and upslope transects. Z. trinotatus is found on the entire Oregon Coast Ranges in riparian areas of deciduous forests, in meadows, and in brushy successional stages of Douglas fir and mixed-coniferous forests (Hooper 1944, Maser et al. 1981 and Gannon 1988). Doyle (1990) found Z. trinotatus to be more abundant along the streams than upslope areas. Mean adult weights, survival rates and breeding activity of Z. trinotatus also were higher in riparian versus upland habitats in her study. Maser et al. (1981) suggested a riparian

association for Z. trinotatus and Cross (1985) found it almost entirely in the riparian areas of forests, but even more frequently in the riparian areas of clearcuts. Ingles (1965) found it affiliated more with grassy moist areas of meadows located in coniferous forests. My data suggest an association with herbaceous vegetation with greater abundances in riparian habitats of all the stand types, and throughout the shrub stands.

Microtus longicaudus was captured exclusively in riparian habitat. Others have reported it in riparian habitat; including streamside brush (Ingles 1965), and riparian alder and willow/sedge marsh habitats (Maser et al. 1981). M. longicaudus is a microtine found throughout the western portions of the United States and Canada with the exception of Southern California and the Willamette Valley.

M. townsendii is an endemic microtine to Coastal Pacific Northwest and on the coast of Northern California. It was significantly more abundant along the stream versus upslope transect. The primary habitat of M. townsendii is marsh and meadows of lowlands (Bailey 1936, Christenson and Larrison 1982) and deflation plains, willow/sedge marsh, wet pastureland, and tideland water habitats on the Oregon Coast (Maser et al. 1981).

The distribution of Phenacomys albipes is restricted to Coastal Oregon and the northern coast of California. P. albipes was captured more frequently in riparian than upslope habitats in my study. Maser and Johnson (1967) suggested an association with small streams, and Maser et al. (1981) indicated an association with alder habitats along small streams, which is similar to the higher capture rates of this species in deciduous stands in my study. Contrary to some of these

studies, P. albipes was found in all of the forest types compared in this study; however, it was least abundant in the large sawtimber and old-growth forest types. It is considered a sensitive species by the U.S. Fish and Wildlife Service and may be a proposed candidate for the threatened or endangered species list.

P. longicaudus was significantly more abundant in the old-growth forests in this study. Its distribution is restricted to coastal Oregon and the northern coast of California. P. longicaudus is a microtine found in coniferous forests of Western Oregon, usually in the limbs or crown of Douglas firs (Maser et al. 1981, Christenson and Larrison 1982). Bailey (1936), Ingles (1965) and Maser et al. (1981) suggested that abundance estimates based on trapping will always be low for P. longicaudus because of it's arboreal nesting habits. Maser et al. (1981) stated that populations of P. longicaudus are becoming scattered and eventually disappearing from some areas as a result of logging and land development. However, in my study it was found in all the different forest types except deciduous.

Clethrionomys californicus is a microtine endemic to the south coast of Washington, coastal portions of Oregon, and the coast of Northern California. It was significantly more abundant in the upslope versus the stream habitat and at distances farther from streams in this study. Doyle (1990) also found C. californicus predominantly in the upslope areas and found their average breeding season was longer in the upslope. Percent females and males in breeding condition, mean adult weight and minimum survival time for C. californicus were greater in riparian areas in Doyle's study. In addition, abundance was correlated positively with abundance of evergreen shrubs and trees, and negatively

with deciduous tree cover (Doyle 1990). Macnab and Dirks (1941) and Maser et al. (1981) suggested that <u>C. californicus</u> was found primarily and often restricted to coniferous forest types along the Oregon Coast. Cross (1985) found it in abundance in mixed-conifer forests but absent from clearcut areas in Southwestern Oregon. Results from my study indicated that <u>C. californicus</u> was at least 4.6 X more abundant in each of the four conifer- dominated forest types than in the deciduous forests, and 2.1 X more abundant in large sawtimber and old-growth stands than in younger stands.

Riparian Associates

Many of the small mammals on the Oregon Coast may depend on riparian habitat for at least part of their life requirements, including <u>N. gibbsii</u>, <u>S. bendirii</u>, <u>S. pacificus</u>, <u>M. longicaudus</u>, <u>M. townsendii</u>, <u>P. albipes</u>, and <u>Z. trinotatus</u>. <u>S. pacificus</u> and <u>Z. trinotatus</u> had a stronger association with riparian habitats although <u>Z. trinotatus</u> was found in the upslope in the shrub forest type and <u>S. pacificus</u> was present in the upslope in all the forest types. Although my results seem to suggest a strong riparian association for <u>M. longicaudus</u> on the Oregon Coast Ranges, it has been found associated with open grassland habitats in other parts of it's range. Only <u>S. bendirii</u> may be considered an obligate of riparian habitat and require a riparian influence for survival on the Central Oregon Coast. <u>C. californicus</u> was unique among the small mammals captured because of its' abundance in the mature conifer forests and the strong association with upslope habitats. This might help support a conclusion that this

species prefers older contiguous stands of large sawtimber or old-growth forests.

I suggest that small riparian systems are important habitat for some small mammals on the Oregon Coast Ranges. It is vital that riparian and upslope systems be considered in management plans for S. bendirii and C. californicus. Results from my study would suggest that management which includes protection of at least some of these areas from logging may be necessary. Many of the small mammal species have limited geographic ranges which includes only portions of the Pacific Northwest. This makes the protection of these areas and species even more critical. Although it was ubiquitous among the forest types in my study, P. albipes is one species which is naturally rare and considered sensitive in Oregon. The importance of monitoring and maintaining populations of sensitive species is obvious. However, I suggest the populations of P. albipes might be higher and found in more vegetative types than previous estimates. Further investigation is necessary before conclusions may be made about this species.

The results of my study support a conclusion that warrants closer investigation of riparian and upslope habitat and the wildlife species associated with these areas. In addition, data on capture frequencies along transriparian transects for riparian (S. bendirii, S. pacificus and Z. trinotatus) associates allow me to suggest zones along riparian areas for management of these species. There was a significant decline in captures of these species at 50-100 meters away from streams. Consequently, riparian management zones should be at least 75-100 m on each side of the stream to include riparian habitat features and the areas of highest abundance of all of these species. Management for

upslope/old forest associates (<u>C.</u> <u>californicus</u>) may be equally as important as for riparian species. Many of the distinct structural features which make large sawtimber and old-growth conifer forests important to wildlife (large trees, snags, and logs) require centuries for development. Without proper management these forests will continue to become fragmented and soon the distinct microhabitats and unique wildlife they support will become less common.

HERPETOFAUNA ABUNDANCE IN RIPARIAN AND UPSLOPE
AREAS IN FIVE FOREST CONDITIONS

INTRODUCTION

Much of the riparian management in the Pacific Northwest has been focused on protection of fish habitat along larger streams (Meehan et al. 1977 and Sedell et al. 1981). There are 69 species of riparian associated plants and animals listed as threatened or endangered by the Department of Interior. The status of many may be as a result of dramatic habitat alterations (Hirsch and Segelquist 1978). Timber harvesting, road construction, and recreation facilities have altered important riparian areas which support many wildlife species. Leopold et al. (1964) estimated that 85 % of the total length of running waters are first to third order streams. Bilby (1988) suggested that the alterations along the smaller streams have a much more dramatic effect than on larger streams, because they shift the primary source of organic matter from land to the stream. These changes may alter the structure and productivity at higher levels of the food chain (Murphy and Hall 1981, Hawkins et al 1983).

Intergradation of riparian vegetation with the adjacent upland habitat provides increased structural diversity for wildlife (Thomas et al. 1979), and amphibians and other nongame species have an important role in the food chain in these ecosystems (Bury et al. 1980, Brode and Bury 1981). The cool-moist microclimate found in riparian habitats may be essential for some herpetofauna, and it undoubtedly offers limited resources to others during at least part of the year (Brode and Bury 1981). According to Bury (1988), riparian habitat is used by many

amphibians for cover and/or breeding habitat. Alterations in these components caused by changes in the forest can be detrimental to many species, including salamanders (Bury et al. 1980). Bury (1968) and Noble and Putnam (1931) hypothesized that increased temperatures of the exposed stream-bed, as a result of timber removal, may lead to the disappearance of the tailed frog (Ascaphus truei). Bury and Corn (1988) found that canopy removal may dramatically effect the tadpole population of tailed frogs by increasing water temperatures and altering the food base. Brode and Bury (1981) found that populations of Olympic salamanders (Rhyacotriton olympicus), which are often associated with cool ravines and rivulets, were eliminated by logging in Northwestern California. Although the numbers of herpetofauna species in the Pacific Northwest is comparatively lower than birds and mammals, their ecological significance as measured by density and biomass is high (Bury 1988). Thomas et al. (1979) suggested that the vertebrates which feed and/or reproduce in water are usually dependent on riparian habitat, but some amphibians have a less direct association with water and are more general in their habitat requirements. These species, including the plethodontid salamanders and the red-legged frog (Rana aurora), might not have the ability to adapt or compete with invading exotic species, following habitat changes (Brode and Bury 1981).

Life history information is available for some herpetofauna in the Oregon Coast Ranges (Nussbuam et al. 1983). Ten of 24 native species of herpetofauna in the Oregon Coast Ranges often are found in riparian habitat (Marshall 1986). A list of potential obligates of riparian habitat in the Oregon Coast Ranges (Anthony et al. 1987b)

included Pacific giant salamander (<u>Dicamptodon</u> <u>ensatus</u>), Olympic
salamander (<u>Rhyacotriton</u> <u>olympicus</u>), Dunn's salamander (<u>Plethodon</u>
<u>dunni</u>), tailed frog (<u>Ascaphus</u> <u>truei</u>), red-legged frog (<u>Rana</u> <u>aurora</u>),
spotted frog (<u>Rana</u> <u>pretiosa</u>), Foothill yellow-legged frog (<u>Rana</u>
<u>boylei</u>), Western toad (<u>Bufo</u> <u>boreas</u>) and Western aquatic garter snake
(<u>Thamnophis</u> <u>couchi</u>). Additionally, Bury (1988) stated that the
northwestern salamander (<u>Ambystoma</u> <u>gracile</u>) and the roughskin newt
(<u>Taricha</u> <u>granulosa</u>) require water (preferably slow moving) for
breeding. He also stated that the northern alligator lizard (<u>Elgaria</u>
<u>coerulea</u>) may be more abundant along the streams, but does not require
riparian habitat for survival. Bury (1988) concluded that none of the
herpetofauna of the Oregon Coast or Northern California appear to be
riparian obligates, because none of them are dependent on riparian
habitat alone for both breeding and cover. His statement left some
doubt about the occurrence of riparian obligate herpetofauna in the
Oregon Coast Ranges.

The purpose of this study was to describe differences in species
composition and relative abundance of herpetofauna between riparian and
upslope habitats among five forest types. My ultimate goal was to
identify any species with riparian or upslope associations and suggest
management strategies for certain species in riparian and adjacent
habitats.

METHODS

Study Sites

Fifteen study sites were located in the Central Coast Ranges of
Oregon along second-, third-, and fourth-order streams (Horton 1945)

(Strahler 1957) (refer to Figure 1.1). The Coast Ranges is influenced by the maritime climate of Western Oregon, with mild-wet winters and cool-dry summers (Brown and Curtis 1985). The annual precipitation ranges from 64 cm in the interior valleys to 305 cm on the western slopes of the coastal mountains (Brown and Curtis 1985). Franklin and Dyrness (1973:31-32) described the Coast Ranges as a narrower zone not including the interior valleys, which receives 170-300 cm of precipitation a year. They suggested that the average temperatures in these areas seldom drop below 0 C in the winter and never exceed 27 C in the summer. The upland soils of these areas consist largely of silt loams and clays (of sedimentary origin) and finer textured clay loams which are igneous (Maser et al. 1981). Organic matter content is high and acidity is medium (Franklin and Dyrness 1973:9-10). There may be substantial differences in soil types which occur locally as topography changes, with shallow, poorly developed soils on steep slopes and deep soils on gradual slopes (Maser et al. 1981).

I described five forest types (Hall et al. 1985) including: (1) shrub-conifer forests; 5-10 years old, trees <3 m tall, dbh <2.5 cm, <40% crown cover with grass-forb condition intermittent, dominate tree species Douglas-fir (Pseudotsuga menziesii) (2) open sapling-pole conifer forests; 20-35 years old, trees usually >3 m tall, 2.5-10 cm dbh, <60% crown cover, dominate tree species Douglas-fir (3) large sawtimber conifer forests; 110-200 years old, trees usually >30 m tall, dbh >53 cm, 60-80% crown, dominate tree species Douglas-fir and 4) old-growth conifer forests; 200+ years old, multilayered vertical structure, 60-80% crown cover, dominate tree species Douglas-fir and western hemlock (Tsuga heterophylla) 5) deciduous; >70% cover, dominate

tree species red alder (<u>Alnus</u> <u>rubra</u>) and bigleaf maple (<u>Acer</u> <u>macrophyllum</u>. I sampled three replicates of each forest type (= 15 total stands). Sites were only selected which had the respective forest type on both sides of the stream, and in areas large enough to include the transects with additional area (>100m) to reduce the edge effects. Aerial photos and field reconnaissance were used to locate the sites. The elevation of the study sites ranged from 110-378 m and slope is from 28 to 68% (Appendix A).

Trapping Design and Method

The trapping design on each study site consisted of two 200-m transriparian, one 350-m riparian, and one 350-m upslope transect in a rectangular arrangement (refer to Figure 1.2). Eight trap stations with two pitfall traps/station were located at 50-m intervals along the riparian and upslope transects and nine trap stations at 25-m intervals along the transriparian transects. There were 60 pitfall traps per stand and a total 900 traps for all stands combined. Multiple traps were used per station to increase the capture rates. Transect lengths and trap spacing were modified from the results of McComb et al. (1991) to maximize the efficiency of the study design and obtain a representative sample of the population. The traps were constructed by attaching two #10 sized cans together, and placing them in holes so that the top of the can was flush with the ground. Traps were located within a 10 m radius of the station center to allow for subjectivity in trap placement. Traps were located along fallen logs, stumps, live trees, rocks, or slope breaks, which acted as natural drift fences.

Kill trapping methods were used in this study because of poor accessibility to the sites and time constraints.

The study included four 28-day trapping periods during the spring (cool, wet season) and summer (hot, dry season) of 1989 and 1990 and resulted in 100,800 trap nights. Traps were opened in May and August, and each trap was checked weekly. Dead animals were taken from the field to freezers where they were stored for positive identification. Live animals were identified and released in similar habitats outside the study sites.

Pitfall trapping is a cost-effective and accurate technique for sampling the full array of small mammals and herpetofauna (Smith et al. 1975, Bury and Corn 1987). Bury and Corn (1987) found pitfall trapping to be the most desireable for sampling both small mammals and herpetofauna. In addition, results of McComb et al. (1991) suggested that the single, most efficient technique for quantifying the forest-floor vertebrate community was pitfall trapping.

Relative abundance of each species was measured by pitfall trapping and capture rate (capture rate = abundance when used in the text) was used as an indice for relative abundance in my study.

Habitat Variables

Habitat variables were measured at each trapping station. Habitat variables were carefully chosen for accuracy, precision, and speed in sampling; for which minimal fluctuation occurs during a field season; and on the basis of their potential importance to influence particular wildlife species (Dueser and Shugart 1978).

Vegetation sampled included: herbaceous (forb, fern, grass), evergreen shrub (usually low shrubs 0 - 1.3 meters), deciduous shrub (usually tall shrubs 1.3 - 4 meters) and canopy cover (total, deciduous, and evergreen). Coverage of shrubs and trees by species were estimated (Appendix B). All vegetative and habitat sampling was within 10 m of each trapping station. Logs and snags were placed into size classes (small= 10-19 cm, medium= 20-49 cm, large >49 cm) and counted accordingly. In addition, the total number of stumps >10 cm diameter were tallied at each station. The percent slash cover, aspect, slope, basal area, mountain beaver (Aplodontia rufa) activity, litter depth, pitfall orientation to and distance from nearest object, distance to stand edge and closest intermittent stream were measured (see Table 1). In addition to the general habitat attributes, stations along the stream were characterized by stream gradient, aspect, width, depth, alluvial flood plain, beaver (Castor canadensis) activity, and presence of beaver dams. The vegetation sampling was conducted from June to September 1990.

Data Analysis

All data analysis was conducted using the SAS software system. Relative abundance of each species was compared among forest types using one-way Analysis of Variance (ANOVA) and the Student-Newman-Kuels (SNK) mean comparison tests. Relative abundance of each species was compared between stream and upslope habitats among forest types, and stations along the transriparian gradient among forest types using two-way ANOVA and the Student-Newman-Kuels (SNK) mean comparison tests. SNK was choosen for it's power in declaring significant differences and

because it works well with equal sample sizes. The transect by forest type interaction and station by forest type interaction were used to test the transect effect and station effect along the transriparian gradient, respectively. Site within forest type was used as an error term when the interaction between transect and forest type (or station and forest type) was insignificant. When the mean square for site within forest type was less than the mean square for transect by site within forest type, the site within forest type error term was dropped and it became a completely randomized design. This procedure allowed me to separate the effects due to differences among forest types and sites, from differences between and within transects. When necessary, variables were transformed [$log10 (x+1)$ and arc sine square-root for percent cover] to correct for non-normality or to obtain homogeneous variances. In some cases transformations were unsuccessful, but similar P-values from rank transformations suggested that nonnormality of data did not effect this assumption. Capture probabilities differed among species, so comparisons were restricted to among habitats and between transects for each species individually. Results for some species were not included, because small sample sizes ($N<20$) made interpretations tenuous.

RESULTS

Abundance and Species Richness

A total of 917 herpetofauna was captured during 100,800 trap nights, including nine species of amphibians and three species of reptiles (Table 6). Herpetofauna species richness was greatest in the shrub habitat (11 species) and slightly lower in the older forest types

Table 6. Distribution of herpetofauna species captures among the five different stant types in the Oregon Coast Ranges, 1989-90.

HERPETOFAUNA	S (n=3) X	SE	P (n=3) X	SE	L (n=3) X	SE	O (n=3) X	SE	D (n=3) X	SE	TOTAL CAPTURES	P[b]
Amphibians:												
Ambystoma gracile	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0.0	1.0	1.0	5	---
Acaphus truei	1.0	0.6	2.0	1.0	29.7	3.5	25.0	21.6	9.3	5.2	201	0.0573*
Dicamptodon ensatus	0.3	0.3b	1.3	1.3ab	6.0	1.5a	4.7	2.7ab	1.0	0.0ab	40	0.0424*
Ensatina eschscholtzi	2.3	0.7	4.3	1.7	4.7	0.9	5.0	2.6	5.7	1.5	66	0.6709*
Plethodon dunni	0.3	0.3	2.0	0.6	2.0	0.6	2.3	1.2	2.0	1.5	26	0.4833*
Plethodon vehiculum	10.7	4.8ab	6.0	1.5b	12.3	4.5ab	9.7	2.4ab	27.7	6.1a	199	0.0355
Rana aurora	1.3	1.3	0.3	0.3	0.0	0.0	0.0	0.0	3.7	3.2	16	0.4026*
Rhyacotriton olympicus	0.7	0.7	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.0	4	---
Taricha granulosa	1.0	0.6b	7.0	3.6ab	10.7	5.8ab	17.7	11.8ab	64.0	22.5a	301	0.0620*
Subtotals	53		72		197		193		343		858	
Reptiles:												
Elgaria coerulea	14.3	3.8a	1.7	0.9b	0.3	0.3b	0.3	0.3b	0.0	0.0b	50	0.0002*
Thamnophis ordinoides	1.7	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5	---
Thamnophis sirtalis	1.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4	---
Subtotals	52		5		1		1		0		59	
TOTAL CAPTURES[c]	105		77		198		194		343		917	

*Variable was Log10 + 1 transformed.

[a]S=shrub, P=pole, L=large saw timeber, O=oldgrowth, D=deciduous.

[b]2-way ANOVa with site as block and error term to test for stand-type effect. Letters represent specific differences identified by the multiple comparisons test.

[c]Not including non-target species and the specimens which were in too poor condition to identify.

with seven different species in the old-growth forest type. Herpetofauna abundance was highest in the deciduous forest type, intermediate in large sawtimber and old-growth forest types, and lowest in the two younger conifer forest types. The species richness was the same in stream and upslope habitats with 11 species (Table 7). However, herpetofaunal abundance was 1.7 X greater in the riparian than upslope habitats.

Amphibians- There was a total of 858 amphibians captured, which included seven salamander and two frog species. $T.$ granulosa, $A.$ truei and western redback salamander ($Plethodon$ $vehiculum$) together made up 82% of the amphibians and 76% of the total herpetofauna (Table 6). $D.$ tenebrosus was captured at least 3.5 X more often ($P<0.05$) in the large sawtimber and old-growth stands than in the other three forest types (Table 6) and was 3.4 X more abundant along the riparian than upslope transects (Table 7).

$T.$ granulosa was the most abundant salamander in this study representing about 5% of the sample. $T.$ granulosa accounted for 86% of the 350 Salamandrids captured and was captured more often (2.4 X) ($P<0.01$) along stream than upslope habitat (Table 7). There was more captures at some stations along the transriparian transects closer to the stream than further away ($P<0.05$) (Figure 2.1). There were progressively fewer captures of $T.$ granulosa from old to younger coniferous forests; however $T.$ granulosa was more than 3.6 X abundant in the deciduous forest type than in any of the other forest types (Table 6).

$P.$ dunni was 4 X more abundant ($P<0.05$) in riparian than upslope It also was more abundant ($P<0.05$) at stream stations than stations

Table 7. Frequency of herpetofauna captures among the stream and upslope transects in five forest types in the Oregon Coast Ranges, 1989-90.

| | TRANSECT | | | | | |
| | STREAM (n=15) | | UPSLOPE (n=15) | | | |
HERPETOFAUNA	$\bar{X}$	SE	$\bar{X}$	SE	TOTAL	p[b]
Amphibians:						
Ambystoma gracile	0.1	0.1	0.1	0.1	2	----
Ascaphus truei	6.6	2.3	1.6	0.7	123	0.0033*
Dicamptodon ensatus	1.0	0.4	0.3	0.2	22	0.1211*
Ensatina eschscholtzi	0.0	0.0	2.0	0.4	30	0.0003*
Plethodon dunni	1.1	0.3	0.3	0.1	20	0.0355*
Plethodon vehiculum	3.2	0.6	3.4	0.9	99	0.6007*
Rana aurora	0.8	0.6	0.1	0.1	14	0.0828*
Rhyacotriton olympicus	0.2	0.1	0.1	0.1	4	----
Taricha granulosa	7.3	2.6	2.9	1.2	153	0.0041*
Subtotals	305		162		467	
Reptiles:						
Elgaria coerulea	0.3	0.3	1.1	0.6	21	0.0619*
Thamnophis ordinoides	0.1	0.1	0.0	0.0	1	----
Thamnophis sirtalis	0.1	0.1	0.1	0.1	3	----
Subtotals	8		17		25	
TOTAL CAPTURES[b]	313		179		492	

*Variable was Log10 + 1 transformed.

[a]2-way ANOVA with transect by forest type interaction used to test for transect effect and sity within forest type used as error term.

[b]Not including non-target species and the specimens which were in too poor condition to identify.
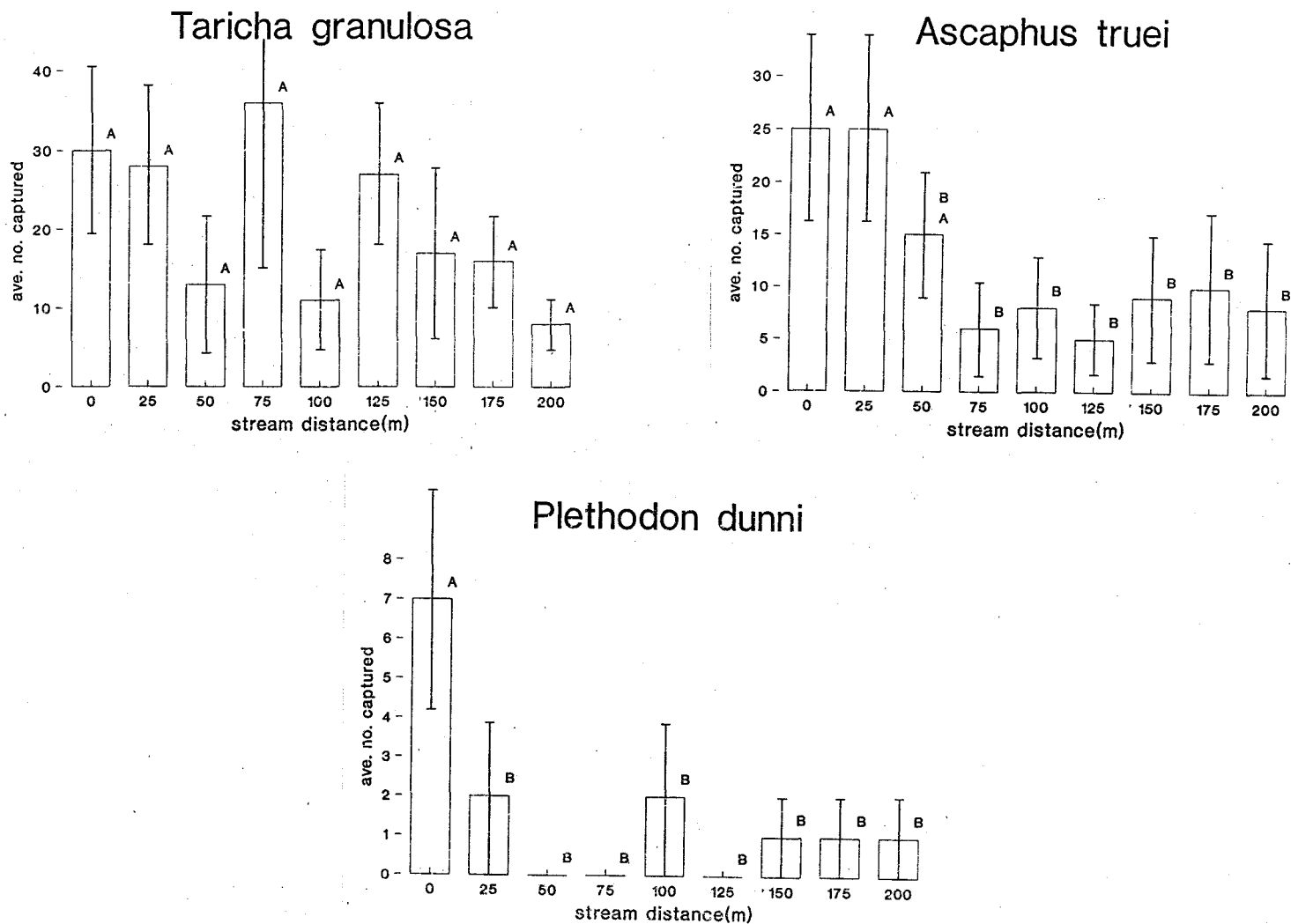
Figure 2.1. Average number of T. granulosa, P. dunni, and A. truei captured (±standard error) along transriparian transects (n=15) in the Oregon Coast Ranges, 1989-90.habitat (Table 7).

away from the stream along the transriparian transects (Figure 2.1). P. dunni had a similar capture rate in all the forest types with the exception of the shrub stands where there was only one capture (Table 6).

P. vehiculum was approximately 2.2 X more abundant in the deciduous forests than in the other forest types and 4.6 X more abundant than in the pole forest type (Table 6). It was the most abundant of the Plethodontids and comprised 68% of the total family.

E. eschscholtzi was more abundant (P<0.001) in the upslope than riparian habitats (Table 7). In fact, there were no captures of this species in the riparian habitat in my study.

Ascaphus truei was one of two frog species that I captured. It was 4.1 X more abundant (P<0.01) in the riparian than upslope habitats (Table 6) and was captured more frequently (P<0.001) at stations closer to the stream than those further away (Figure 2.1). A. truei was found in all forest types in this study; however, it was significantly more (2.6 X) abundant in the large sawtimber and old-growth forest types than the other forest types (Table 6).

R. aurora was represented only by 16 individuals. It was approximately 2.8 X more abundant in the deciduous stands than the other forest types and 6 X more frequent in the riparian than upslope transects in this study.

Reptiles- There were only 59 reptiles captured in my study representing two snakes and one lizard species. Elgaria coerulea accounted for 85% of the reptiles but only 5% of all the herpetofauna. E. coerulea was more abundant (P<0.001) in the shrub forest type than the other forest types. There were no captures in the deciduous forests and only one

capture in the large sawtimber and old-growth forests (Table 6). It was also 3.2 X more abundant in the upslope than stream habitat (Table 7).

Herpetofauna species capture rate was similar between seasons along riparian and upslope transects; there were no significant differences in capture rates between wet and dry seasons for any species. However, low numbers of captures precluded any powerful statistical comparisons.

DISCUSSION

Dicamptodon is a genus endemic to the Pacific Northwest. _D. tenebrosus_ was one of two species of Dicamptodontid salamanders captured, and only three species representatives occur in the Pacific Northwest. All members of this family possess a larval stage; however the degree to which these species depend on aquatic environments is variable among the family (Nussbaum et al. 1983). _D. tenebrosus_ depend on the stream for breeding and paedogenic forms require stream habitat for life. However, transformed adults may be found on the forest floor under woody debris or fully exposed, especially during the rainy season (Nussbaum et al. 1983). Nussbaum et al. (1983) suggested that the preferred habitat of _D. tenebrosus_ is moist coniferous forests. _D. tenebrosus_ was significantly more abundant in large sawtimber and old-growth forests than in the other three forest types and was more abundant along the riparian than upslope transects. Similar to this study, Raphael (1984), Bury and Corn (In press) found _D. tenebrosus_ to be more abundant in mature coniferous forests than in young coniferous forests and Bury (1983) compared logged and unlogged redwood forests and found _D. tenebrosus_ absent from the former.

The genus _Taricha_ (Family: Salamandridae) is the only newt genus in western North America, and _T. granulosa_ is the only newt found in the Pacific Northwest. Salamandrids are primarily an old world family with two genera and six species occurring in North America (Nussbaum 1983). _T. granulosa_ is the most common salamander in the Pacific Northwest and may be found in numerous habitats including coniferous and hardwood forests, open valleys and farmlands (Nussbaum et al. 1983). _T. granulosa_ was the most abundant salamander in this study. It was captured more often in the stream than upslope habitat, and there were differences in number of captures at stations along the transriparian gradient. There were progressively fewer captures of _T. granulosa_ from old- to younger coniferous forests; however _T. granulosa_ was more abundant in the deciduous forest type than in each of the other forest types in this study. This species may be restricted to low gradient sections of creeks and streams during breeding (Bury and Corn in press). However, Nussbaum et al. (1983) suggested they may also be found in lakes, ponds, and on land. Similar to this study, Corn and Bury (1990) found _T. granulosa_ more frequently in old-growth than in younger conifer stands and Raphael (1984) found greater abundance of _T. granulosa_ in mature conifer stands than in younger (<150) and older (>250) conifer forests.

P. dunni is a lungless salamander (Family: Plethodontidae) and it does not require moving water to breed (Nussbaum et al. 1983). It is one of 28 species from the genus in North America; six of these species are endemic to the Pacific Northwest. _P. dunni_ was significantly more abundant in riparian than upslope habitat in this study. The riparian influence was also evident along the transriparian gradient with more

captures at stream stations than stations away from the stream. In addition, the capture rate of P. dunni was similar among the forest types with the exception of the shrub forests where there was only one individual captured. The species has been found more associated with aquatic habitats than other members of the Plethodon genus (Nussbaum et al. 1983, Bury and Corn 1990); my results support that conclusion. Nussbaum et al. (1983) suggested that the preferred habitat of P. vehiculum is the dryer sections of dense coniferous forests. It was the only other member of the genus Plethodon captured in my study. Although it was found equally abundant between stream and upslope habitats, it was captured in greater numbers in deciduous stands than other forest types.

E. eschscholtzi is restricted to the coast of the Pacific Northwest and Coastal Northern California. It is another lungless salamander (Family: Plethodontidae) (Nussbaum et al. 1983). Ensatina eschscholtzi was the only amphibian which was more abundant in the upslope than riparian habitats. Nussbaum et al. (1983) suggested that E. eschscholtzi usually preferred forested areas but have been found in clearings in the Pacific Northwest. Raphael (1984) found greater numbers of E. eschscholtzi in older Douglas-fir forests than in younger forest types in Northern California and Bury (1983) found it more abundant in old-growth forests than in logged stands. The results from my study were similar to their findings; E. eschscholtzi was less abundant in the shrub forest type especially in the upland areas.

There are only six families (six genera, 14 species) of anurans which occur in the Pacific Northwest. Ascaphus is one of two genera from the family Leiopelmatidae (Nussbaum et al. 1983); A. truei is an

endemic of the Pacific Northwest. <u>A. truei</u> was significantly more abundant in riparian than upslope transects and at stations closer to the stream than those further away. It was found mostly in cooler sections of streams by Nussbaum et al. 1983 and Bury and Corn (in press). It requires permanent drainages often with a dense canopy cover for optimal temperatures (Noble and Putnam 1931, Nussbaum et al. 1983, Bury and Corn in press). However, <u>A. truei</u> (especially the juveniles) have been found at long distances from permanent streams in forested areas (Corn and Bury 1990). Noble and Putnam (1931) found adult <u>A. truei</u> at greater distances away from the stream during the wet season and with higher abundances along the stream during dryer times. Noble and Putnam (1931) and Metter (1964) have suggested that habitat loss caused by logging and/or fire has resulted in the disappearance of <u>A. truei</u>. My results conflict with their hypothesis, <u>A. truei</u> was more abundant in the large sawtimber and old-growth forest types than the younger forest types but was found in all forest types in this study. Nevertheless, it is currently listed in Oregon as a sensitive species by the Fish and Wildlife Service. Bury (1968) suggested that the effect of timber removal on stream microclimate and <u>A. truei</u> populations is dependent on the geography of the area. He found <u>A. truei</u> in recently logged locations of coastal Humboldt county where the maritime climate reduces the temperatures of the exposed stream bed.

<u>R. aurora</u> is restricted to the Pacific Northwest Coast and the coast of Northern California. It is considered a sensitive species in Oregon by the U. S. Fish and Wildlife Service. It is one of eight species from the family Ranidae which occur in the Pacific Northwest. Nussbaum et al. (1983) suggested that <u>R. aurora</u> may be found in moist

forests of valley riparian areas in the Pacific Northwest. They are
dependent on water for breeding; however, adults are semi-aquatic to
terrestrial (Nussbaum et al. 1983). R. aurora individuals can be found
up to 300 m away from standing water. R. aurora was more abundant in
the deciduous forest type than in each of the other forest types, and
more abundant in the riparian than upslope transects in this study.
Although R. aurora was more abundant along the stream, there also were
two individuals found along the upslope transect in this study. Bury
and Corn (In press) suggested that R. aurora may prefer creeks and
streams with low gradients for breeding.

Elgaria coerulea is an endemic species to the Pacific Northwest
and Northern California and is the only lizard which occupies the coast
of Northern Oregon and Washington (Nussbaum et al. 1983). It is one of
11 lizard species found in the Pacific Northwest. E. coerulea accounted
for the majority of the reptile captures but only 5% of all the
herpetofauna captured in my study. It was more abundant in the shrub
forest type than in all other forest types, and in the upslope versus
stream transect. Raphael (1984) found E. coerulea abundance decreased
with stand age in Douglas-fir forests in Northwestern California. Bury
and Corn (1990) found no reptiles in young (>40 years), mature and old-
growth forest sites in Pacific Northwest and suggested that the closed
canopy and lack of suitable open areas in these sites probably did not
produce the necessary habitat requirements for this group. The lack of
abundance of reptiles in forest types of my study, with the exception
of the shrub forest type, supports their theory. Nussbaum et al.
(1983) suggested E. coerulea is more abundant along coniferous forest
edges often in disturbed or cut-over areas. In this study, E. coerulea

was more abundant in the shrub stands than in all other forest types, with no captures in the deciduous forest, and only one in the large sawtimber and old-growth forest interior.

Riparian Associates

Three amphibians (A. truei, P. dunni, and T. granulosa) were more abundant in riparian than upslope habitats, and at distances closer to the stream than further away along the transriparian transects. These species may be considered riparian associates. In addition, D. tenebrosus and R. aurora were captured more often along the stream transect than upslope and may depend on riparian habitat for at least part of their life requirements. In contrast, E. eschscholtzi was significantly more abundant in the upslope than in the stream habitat.

These results suggest that small riparian systems provide important habitat for A. truei and P. dunni on the Oregon Coast Ranges. It is vital that these systems be considered in management plans which include the protection of at least some of the areas from timber harvest. Many of these herpetofauna species have limited geographic ranges which includes only portions of the Pacific Northwest. This makes the protection of these areas and species even more critical. A. truei is a species which is already considered sensitive in Oregon. The importance of maintaining habitat and populations of this species is obvious. The investigation of riparian habitat and the wildlife species associated with these areas warrants further study.

MICROHABITAT RELATIONSHIPS OF SELECTED SPECIES OF

SMALL MAMMALS AND HERPETOFAUNA

INTRODUCTION

There are many factors that limit the local distribution of organisms including interactions with other organisms, temperature, moisture, and other physical and chemical factors (Krebs 1978: 17-22). The distribution and abundance of animals depends to a large degree on the vegetative characteristics of an area. What microhabitat components are important to a species and which play a larger role in their distribution and abundance are questions which are important in understanding the ecology of a species. The differences in composition and structure of vegetation and the variability in soil moisture, both a result of increased water in riparian areas, may influence many species of wildlife by providing food and other essential resources. Thomas et al. (1979) suggested that riparian habitat provides a source of cover, food, and water to small mammals migrating to different habitats. They suggested that the increased humidity, rate of transpiration, shade, and air movement typical of riparian habitats, provides a unique microclimate which many wildlife species prefer. Campbell and Franklin (1979) were able to identify distinct plant communities within riparian and upslope areas using a gradient approach. Doyle (1990) indicated that greater abundances of food (fruits, herbs, deciduous shrubs and mast) and water produces habitat that is more suitable to several small mammals.

Oregon Coastal regions have historically been altered by wildfire, but changes associated with timber harvests have more recently become

the major cause of habitat alterations. The long term impacts of logging on a stream ecosystem is dependent on forest and streambed alterations (Murphy and Hall 1981). Murphy and Hall (1981) found that primary production increased after clearcutting and suggested that animal production would follow; however these higher rates of production decreased in 10-20 years as a result of shading from riparian vegetation. Although habitat changes may be beneficial to some species, they are usually detrimental to others. Geier and Best (1980) stressed the importance of knowing the habitat needs of small mammals, so that the effects of habitat alterations on their populations might be predicted. The microhabitats available to salamanders may be limited by the composition and structure of the vegetation that effect the temperature and moisture regimes of the forest floor (Heatwole 1962; Heatwole and Lim 1961). Clearcutting drastically alters the microclimate by increasing surface temperatures on the ground and in the water (Thomas et al. 1979). Thus, changes in plant communities may alter small mammal and herpetofauna communities.

The increased understory vegetation following a clearcut might provide cover and allow some microtines a better chance for free movement; however such changes might be detrimental to some shrew species (Hooven 1969). Later when the forest matures to open sapling-pole, Hooven (1969) speculated that mice and shrew population increases might be triggered by abundances of insects. Hawkins et al. (1983) found the numbers of fish and salamanders in streams of Pacific Northwest were strongly correlated with invertebrate abundance. Borror et al. (1981) found invertebrates more abundant in stream habitats, and Doyle (1990) suggested insectivore abundance in riparian areas might be

correlated with insect abundance. Tevis (1956) and Cross (1985) found Western red-back voles, northern flying squirrels (Glaucomys sabrinus) and shrew moles in forested areas, but absent to rare in clearcuts. The Pacific water shrew also was absent from most of the clearcut plots with the exception of the riparian zone in these studies. In contrast, the association that deer mice, creeping voles, and jumping mice have with herbaceous vegetation enabled them to benefit from clearcutting (Cross 1985). Campbell and Clark (1980) found a drop in red-back vole abundance 9-12 months following clearcutting, and they hypothesized that the decline was caused by soil xerification. The reduction in species numbers that occurs following a clearcut are probably the result of drying conditions (Hooven 1969). Hooven (1969) suggested that the disappearance of red-backed voles in clearcuts is caused by it's preference for cool mature conifer forests. He also found a temporary decrease in the abundance of shrews, which were found only among the woody debris near the forest edge. However, he suggested that many small mammals rely on herbs and shrubs for food which don't normally grow within a closed canopy mature conifer forest.

Coarse woody debris in Western Oregon streams dramatically influences the morphology of streams and ultimately creates different microhabitats (Swanson et al. 1976, Meehan et al. 1977). The loss of large, woody debris from streams following a disturbance, decreases the long-term productivity in addition to increasing sediment transfer rates downstream (Swanson et al. 1976). Geier and Best (1980) predicted that deciduous tree removal in Iowa riparian areas could have an adverse effect on two to six small-mammal species and the removal of woody plant debris would negatively effect four small mammals including

two insectivores. Woody debris which is present prior to the disturbance often provide habitat for reproduction and other activities of amphibians and reptiles (Thomas et al. 1979).

The smaller and narrower the stream, the easier it is affected by disturbance (Thomas et al 1979); however, all riparian areas are characterized as corridors for natural disturbance caused by frequent flooding (Agee 1987). Boehne and House (1983) recommended that some first- and second-order streams should be left undisturbed, because of their dramatic influence on temperature and sediment transport downstream, which ultimately affects habitat structure and productivity for fish. These streams supply larger streams with a partially prepared food source (Franklin et al 1981); however, it is these streams that are usually neglected in management strategies because of the absence of salmonids in them. According to Bury (1988), amphibians are often found in small permanent side channels and seeps of main tributaries. Bury (1988) suggested that differences in stream width often produce enough structural variation for amphibians and reptiles to respond to, but larger streams generally have fewer species than the intermediate sized streams. Bury and Corn (1988) suggested that the tailed frog, Pacific giant salamander, Olympic salamander, and Dunn's salamander are often dependent on the smaller streams in Oregon Coast Ranges, and in general most amphibians are more abundant in these areas. My results are in agreement for Ascaphus truei and Plethodon dunni; however, Dicaptodon tenebrosus and Rhyacotriton olympicus were poorly represented in my study. In contrast, I found some amphibian species more abundant in upslope areas. Bury and Corn (1988) also found that increased sedimentation and exposure resulting from logging had a

severe impact on these species in the smaller coastal streams of Oregon. However, the effects of habitat alterations on herpetofauna have been emphasized less than small mammals. Some essential microhabitat components for salamanders include the density of understory vegetation and leaf litter depth. The closed canopy and multilayered structure that are characteristic of coniferous forests in Pacific Northwest produce cool, moist microclimates in riparian and upland habitats (Bury 1988). Alterations in these components caused by changes in forest structure and composition can be detrimental to many species, including salamanders (Bury et al. 1980). Bury (1968) and Noble and Putnam (1931) hypothesized that increased temperatures of the exposed stream-bed as a result of timber removal may lead to the disappearance of the tailed frog (Ascaphus truei). However, Bury (1968) suggested that the degree that clearcutting affects tailed frog populations might not be as severe in cool, moist climates. Nevertheless, Bury and Corn (1988) concluded that canopy removal may dramatically affect the tadpole stage of tailed frogs by altering temperatures and it's food base. They suggested that the tailed frog would be negatively affected by multiple factors following clearcutting in riparian habitat, which would lead to their reduction and possibly extinction on the Oregon Coast Ranges and in Northern California. Brode and Bury (1981) found that populations of Olympic salamanders (Rhyacotriton olympicus), which are often associated with cool ravines and rivulets, were eliminated by logging in Northwestern California.

The purpose of this study was to identify microhabitat relationships of small mammal and herpetofauna species. Hopefully, this information will provide some insight on the influence of habitat alterations on these species.

METHODS

Study Sites

Fifteen study sites were located within five watersheds in the Central Coast Ranges of Oregon along second-, third-, and fourth-order streams (Horton 1945) (Strahler 1957) (see Figure 1.1). The Coast Ranges is influenced by the maritime climate of Western Oregon, with mild-wet winters and cool-dry summers (Brown and Curtis 1985). The annual precipitation ranges from 64 cm in the interior valleys to 305 cm on the western slopes of the coastal mountains (Brown and Curtis 1985). Franklin and Dyrness: (1973:31-32) described the Coast Ranges as a narrower zone not including the interior valleys, which receives 170-300 cm of precipitation a year. They suggested that the average temperatures in these areas seldom drop below 0 C in the winter and never exceed 27 C in the summer. The upland soils of these areas consist largely of silt loams and clays (of sedimentary origin) and finer textured clay loams which are igneous (Maser et al. 1981). Organic matter content is high and acidity is medium (Franklin and Dyrness: 1973:9-10). There may be substantial differences in soil types which occur locally as topography changes, with shallow, poorly developed soils on steep slopes and deep soils on gradual slopes (Maser et al. 1981). The elevation of the study sites ranged from 110-378 m and slope is from 28 to 68% (Appendix A).

I described five forest types (Hall et al. 1985) including: (1) shrub-conifer forests; 5-10 years old, trees <3 m tall, dbh <2.5 cm, <40% crown cover with grass-forb condition intermittent, dominate tree species Douglas-fir (Pseudotsuga menziesii) (2) open sapling-pole conifer forests; 20-35 years old, trees usually >3 m tall, 2.5-10 cm dbh, <60% crown cover, dominate tree species Douglas-fir (3) large sawtimber conifer forests; 110-200 years old, trees usually >30 m tall, dbh >53 cm, 60-80% crown, dominate tree species Douglas-fir and 4) old-growth conifer forests; 200+ years old, multilayered vertical structure, 60-80% crown cover, dominate tree species Douglas-fir and western hemlock (Tsuga heterophylla) 5) deciduous; >70% cover, dominate tree species red alder (Alnus rubra) and bigleaf maple (Acer macrophyllum. I sampled three replicates of each forest type (= 15 total stands). Sites were only selected which had the respective forest type on both sides of the stream, and in areas large enough to include the transects with additional area (>100m) to reduce edge effects. Aerial photos and field reconnaissance were used to locate the sites.

Trapping Design and Method

The trapping design on each study site consisted of two 200-m transriparian, one 350-m riparian, and one 350-m upslope transect in a rectangular arrangement (refer to Figure 1.2). Eight trap stations with two pitfall traps/station were located at 50-m intervals along the riparian and upslope transects and nine trap stations at 25-m intervals along the transriparian transects. There were 60 pitfall traps per study site and a total 900 traps for the sites combined. Multiple traps were used per station to increase the capture rates. Transect lengths

and trap spacing were modified from McComb et al. (1991) to maximize the efficiency of the study design and obtain a representative sample of the population.

The study included four 28-day trapping periods during the spring (cool, wet season) and summer (hot, dry season) of 1989 and 1990 and resulted in 100,800 trap nights. Traps were opened in May and August, and each trap was checked weekly. Dead animals were taken from the field to freezers where they were stored for positive identification. Live animals were identified and released in similar habitats outside the study sites.

The traps were constructed by attaching two #10 sized cans together, and placing them in holes so that the top of the can was flush with the ground. Traps were located within a 10 m radius of the station center to allow for subjectivity in trap placement. Traps were located along fallen logs, stumps, live trees, rocks, or even slope breaks, which acted as natural drift fences. Kill trapping methods were used in this study because of poor accessibility to the sites and time constraints.

Habitat Variables

Habitat variables were sampled at all trapping stations at each study site to identify microhabitat components that riparian and upslope affiliated species may be associated with. Habitat variables were carefully chosen for accuracy, precision, and speed in sampling; for which minimal fluctuation occurs during a field season; and on the basis of their potential importance to influence particular wildlife species (Dueser and Shugart 1978).

Vegetation sampled included: herbaceous (forb, fern, grass), evergreen shrub (usually low shrubs 0 - 1.3 meters), deciduous shrub (usually tall shrubs 1.3 - 4 meters) and canopy cover (total, deciduous, and evergreen). Coverage by shrubs and trees by species were estimated (Appendix B). All vegetative and habitat sampling was within 10 m of each trapping station. Logs and snags were placed into size classes (small= 10-19 cm, medium= 20-49 cm, large >49 cm) and counted accordingly. In addition, the total number of stumps >10 cm diameter were tallied at each station. The percent slash cover, aspect, slope, basal area, mountain beaver (Aplodontia rufa) activity, litter depth, pitfall orientation to and distance from nearest object, distance to stand edge and closest intermittent stream were measured (refer to Table 1). In addition to the general habitat attributes, stations along the stream were characterized by stream gradient, aspect, width, depth, alluvial flood plain, beaver (Castor canadensis) activity, and presence of beaver dams. The vegetation sampling was conducted from June to September 1990. Habitat characteristics were measured to determine if there were correlations with the relative abundance of small mammals and herpetofauna.

Data Analysis

Average habitat characteristics were compared among forest types using one-way analysis of variance and Student-Newman-Kuels mean comparison tests. Spearman rank correlation coefficients were used to assess significant correlations ($P<.01$) between small mammal and herpetofauna capture frequencies and average vegetative characteristics per study site for selected species. Spearman rank correlations also

were used to identify any associations (P<.01) between selected species capture rates and average vegetative characteristics in riparian and upslope transects. The riparian affiliated species were included in the analysis of upslope areas (and upslope affiliates in the riparian habitat analysis) to determine if a habitat component existed which individuals were attracted to in these areas, believed to be outside the species preferred habitat.

Stepwise discriminant function analysis was used to compare stations with captures of selected species to stations with no captures of the species, and to identify variables that a species may be associated with. This analysis was conducted only for those species which were thought to be riparian and upslope associated, as described in the two previous chapters. This analysis was also limited to the species which had N >50 captures. Discriminant function analysis is a multivariate procedure which separates groups based on a set of measured independent variables (Johnson 1981). Results from discriminant analysis provide a test for determining the significance of a function and a means of assessing the value that each of the independent variables has in discriminating between groups (Dueser and Shugart 1978).

Prior to DFA, separate data sets were created for each species which included an equal number of capture and noncapture stations. The noncapture stations were randomly selected (using a SAS computer program). Each habitat variable was tested univariately for normality based on estimates of skewness and kurtosis (Sokal and Rohlf 1981). Kruskal-Wallis nonparametric tests were then conducted because of nonnormal population distributions. Stepwise DFA was performed to

obtain a reduced list of variables, which were prioritized by the order of selection. When two habitat variables were correlated (r>.70) one was dropped and the other retained based on a subjective view of their biological importance. Variables were included in the stepwise procedure when P<.25; however only those with P<.05 were actually retained. Total canonical structure coefficients were used to measure the simple linear correlation between each independent variable and the discriminant function. Structure coefficients or discriminant loadings are considered more valid than discriminant weights for determining the relative contribution of each independent variable to the discriminant function (Hair et al. 1987). The discriminating power of each discriminant function was evaluated using the jackknife reclassification procedure. The jackknife procedure measures the validity of functions as predictors by separating the impact of individual subsets of data on the estimate, taken from the sample as a whole (Hair et al. 1987). The kappa statistic (Cohen 1960) was provided to assess the performance of each discriminant model over chance alone. This procedure removes the affects attributed by chance and provides a chance-corrected classification rate (Titus et al. 1984). Squared canonical correlations were used to determine the amount of variation between capture and noncapture stations explained by the discriminant function. In addition to the presence-absence comparisons, habitat characteristics between stations with low (1-3), medium (4-6) and high (>6) captures of selected species were compared.

Results from normality comparisons of discriminant scores indicated departures to be minimal. However, in most cases the assumption of homogeneity of variance covariance matrices for each

species was violated. Williams (1981) suggested that in most field studies the assumption of homogeneity of variance-covariance matrices is seldom met. Consequently, the multivariate representations of species in sample space will vary in size or shape regardless of differences or similarities in position (Dueser and Shugart 1979). Green (1974) suggested that regardless of this violation, discriminant functions may be biologically significant if they can be interpreted ecologically and account more for the separation of the groups than other discriminant functions, and if they contribute significantly to the group separation. However, the interpretations of the data should not be considered conclusive and instead the results should be used for descriptive purposes (Williams 1981, Rexstad et al. 1988).

RESULTS

Differences Among Stand Types

Canopy cover was significantly lower (P<0.001) in the shrub stands than in the other forest types and highest in the deciduous stands (Table 8). Deciduous tree cover in the shrub stands ranked second after the deciduous sites and was lowest in the pole forest types. Evergreen tree cover was significantly lower (P<0.01) in the shrub and deciduous stands, and highest in the old-growth forest type. The deciduous basal area was significantly higher (P<0.001) in the deciduous stands and conifer basal area was higher (P<0.001) in the large sawtimber and old-growth forest types. Small, medium, and total logs, and stumps were more abundant (P<0.01) in the pole forest type and intermediate in the shrub forest type. Forb, fern, and herbaceous cover were significantly lower (P<0.05) in the pole forest type than in others. Grass cover was

Table 8. Average habitat characteristics among five stand-types in the Oregon Coast Ranges, 1990.

| | FOREST TYPE | | | | | | | | | | |
| Variable | Shrub | | Pole | | Saw timber | | Oldgrowth | | Deciduous | | p^a |
	X	SE	X	SE	X	SE	X	SE	X	SE	
Slash cover (%)	8.8	0.9	16.6	1.2	8.0	0.5	11.9	0.9	18.6	1.2	0.1772
Litter depth (cm)	1.7	0.2b	3.6	0.4ab	2.3	0.2b	4.7	0.4a	2.3	0.2b	0.0304
Logs / 314 m²:											
10-19 cm diameter	7.0	0.6ab	11.5	0.6a	5.0	0.4b	4.9	0.4b	4.2	0.4b	0.0092
20-49 cm diameter	8.9	0.7ab	17.1	0.9a	7.3	0.6b	5.0	0.4b	5.1	0.5b	0.0021
50+ cm diameter	1.6	0.2	3.0	0.3	2.3	0.2	2.8	0.2	2.3	0.2	0.4516
Total	17.5	1.2a	31.7	1.3ab	14.6	0.8a	12.8	0.7a	11.6	0.9ab	0.0040
Snags / 314 m²:											
10-19 cm diameter	0.0	0.0b	0.2	0.1b	0.2	0.1b	0.1	0.0b	0.4	0.1a	0.0037
20-49 cm diameter*	0.1	0.0	0.1	0.0	0.9	0.1	0.3	0.1	0.1	0.0	0.0697
50+ cm diameter	0.0	0.0b	0.0	0.0b	0.4	0.1a	0.5	0.1a	0.1	0.0b	0.0019
Stumps / 314 m²:											
>10 cm diameter*	3.0	0.3b	7.6	0.6a	1.1	0.2c	1.4	0.2bc	1.4	0.2bc	0.0001
Basal area (m²/ha):											
Deciduous	0.0	0.0b	1.7	0.7b	3.9	0.9b	3.6	1.0b	27.2	2.2a	0.0001
Evergreen	0.0	0.0c	23.1	1.7b	50.2	4.0a	60.8	3.9a	5.3	1.1c	0.0001
Fern cover (%)	18.3b	1.1ab	13.4	1.3b	25.4	1.6a	19.1	1.3ab	23.7	1.6a	0.0110
Forb cover (%)*	28.1	2.0a	8.9	1.4b	30.8	2.0a	18.7	2.0ab	31.4	2.2a	0.0242
Grass cover (%)	20.2	2.0a	4.2	0.9b	4.0	0.5ab	1.1	0.3b	6.4	1.1ab	0.0219
Herbacous cover (%)	51.3	1.8a	21.5	2.1b	48.2	1.8a	33.3	2.4ab	51.3	2.1a	0.0113
Shrub cover (%):											
Evergreen*	26.5	2.6a	32.1	2.8a	8.8	1.3ab	25.7	3.1ab	5.4	1.2b	0.0808
Deciduous*	50.6	2.6a	21.1	1.8b	36.7	3.1ab	32.7	2.6ab	47.6	2.6ab	0.0939
Canopy cover (%)	22.6	2.3c	75.0	2.0ab	67.6	2.6b	77.2	2.1ab	86.0	1.9a	0.0001
Tree cover (%):											
Deciduous*	18.7	2.5b	7.4	2.1c	14.4	2.3bc	15.5	2.7bc	82.5	2.6a	0.0001
Evergreen	26.0	2.5b	68.6	2.7a	65.4	4.2a	82.7	4.8a	15.8	2.9b	0.0024
Distance to:											
Intermittent* stream (m)	45.7	1.2	44.2	1.4	47.4	1.0a	48.1	0.9	44.2	1.4	0.8978

*Variable was Log10 + 1 transformed.

[a]1-way ANOVA with site within forest type used as an error term. Means with different letters identify significant differences among the forest types determined by the multiple comparisons test.

significantly higher (P<0.05) in the shrub forest type than in the other forest types, and litter depth was significantly higher (P<0.05) in the old-growth forests, with the exception of the pole forest type. Small snag abundance was significantly higher in the deciduous stands, and large snags were more abundant in the large sawtimber and old-growth stands (P<0.01).

Salmonberry (<u>Rubus</u> <u>spectabilis</u>), thimbleberry (<u>Rubus</u> <u>parviflorus</u>) and trailing blackberry (<u>Rubus</u> <u>ursinus</u>) were most abundant in the shrub stands (Table 9). However, salmonberry also was abundant in the deciduous and sawtimber stands. Trailing blackberry dominated the shrub stands. The predominant tree species in all the forest types, with the exception of the deciduous replicates, was Douglas-fir (<u>Psuedotsuga</u> <u>menziessi</u>). Red alder (<u>Alnus</u> <u>rubra</u>) was the tree most frequently found in the deciduous sites.

Relationship of Relative Abundance to Stand Characteristics

The insectivore species captured in this study included three moles: <u>Scapanus</u> <u>orarius</u>, <u>Scapanus</u> <u>townsendii</u> and <u>Neurotrichus</u> <u>gibbsii</u>, and four shrews: <u>Sorex</u> <u>bendirii</u>, <u>Sorex</u> <u>pacificus</u>, <u>Sorex</u> <u>trowbridgii</u> and <u>Sorex</u> <u>vagrans</u>. The frequency of captures of <u>S.</u> <u>orarius</u> was positively correlated with the number of large logs and negatively with percent slope (Table 10). Captures of <u>S.</u> <u>townsendii</u> were positively correlated with percent cover of thimbleberry, and forbs and grasses, and negatively correlated with number of large logs, conifer basal area, percent cover of devil's club, western hemlock and total evergreen tree cover. <u>N.</u> <u>gibbsii</u> was negatively correlated with number of medium logs and slope. <u>S.</u> <u>bendirii</u> was positively correlated with stream aspect.

Table 9. Average vegetative cover (%) of plant species among five stand-types in the Oregon Coast Ranges, 1990.

	STAND-TYPE										
Variable	Shrub		Pole		Saw timber		Old-growth		Deciduous		P-value
	X	SE	X	SE	X	SE	X	SE	X	SE	
Douglas fir*	25.9	2.5ab	48.1	2.5a	48.0	3.4a	39.8	3.6a	4.4	1.3b	0.0008
Western hemlock	0.1	0.1	18.8	1.9	10.7	1.9	31.0	3.6	8.1	2.1	0.2812
Western red cedar	0.0	0.0	1.7	0.5	6.5	1.6	10.6	2.0	3.3	1.0	0.4220
Red alder	14.1	2.3a	7.1	2.1b	13.6	2.3b	11.6	2.3b	71.1	3.2b	0.0001
Bitter cherry*	0.4	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.9	0.5	0.1691
Vine maple*	6.1	1.0	2.5	0.7	13.0	2.6	16.6	2.6	24.0	2.6	0.3682
Pacific dogwood*	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.6	0.3	0.2	0.4562
Devil's club*	0.0	0.0	1.9	0.5	0.9	0.3	0.8	0.3	0.3	0.2	0.1073
Thimbleberry*	13.9	1.7a	0.3	0.1b	0.1	0.0b	0.1	0.1b	2.0	0.7b	0.0026
Salmonberry	26.0	3.0a	5.1	0.9b	14.8	2.3ab	8.8	1.7b	18.2	2.3ab	0.0381
Trailing blackberry*	16.7	1.7a	0.6	0.3b	0.1	0.0b	0.0	0.0b	0.1	0.0b	0.0001
Salal	12.7	2.5	26.6	2.6	3.1	0.8	15.7	2.3	2.1	1.0	0.2063
Oregon grape	5.5	1.2	8.1	1.2	5.9	1.0	14.0	1.7	3.2	0.8	0.2566

*Variable was arc sine square-root transformed.

[a]1-way ANOVA with site withing forest type used as an error term. Means with different letters identify significant differences among the forest types determined by the multiple comparisons test.

Table 10. Spearman's rank correlations (P<0.01) between insectivore abundance and average habitat variables per stand (n=15)[a], Oregon Coast Ranges, 1989-90.

Habitat variable	Species[b]						
	SCOR	SCTO	NEGI	SOBE	SOPA	SOTR	SOVA
Western hemlock cover	+	-.68*	+	+	-	-	-.83**
Evergreen tree cover	+	-.71*	-	+	-	-	-.87**
Deciduous tree cover	+	+	+	+	+	+	.68*
Devil's club cover	-	-.55	-	+	+	+	-.79**
Thimbleberry cover	-	.72*	-	-	+	+	.73*
Forb-grass cover	-	.70*	-	+	-	-	.64
Slope	-.75*	+	-.59	+	+	-	+
Basel area conifers (m/ha)	+	-.59	+	+	-	-	-.68*
# of medium logs	-	-	-.67*	-	+	+	-
# of large logs	.53	- .79**	+	-	-	+	-.57
Stream aspect	-	+	-	.74*	-	-	+

S. vagrans abundance was positively correlated with cover of deciduous trees, thimbleberry, and forbs and grasses, and negatively correlated with number of large logs, basal area of conifers, percent cover of devil's club, percent cover of western hemlock (Tsuga heterophylla) and evergreen trees collectively. There were no significant correlations between abundance of S. pacificus and S. trowbridgii and average habitat characteristics in the stands.

The nine more common rodent species captured were Aplodontia rufra, Clethrionomys californicus, Microtus longicaudus, Microtus oregoni, Microtus townsendii, Peromyscus maniculatus, Phenacomys albipes, Phenacomys longicaudus and Zapus trinotatus. The relative abundance of A. rufra was positively correlated with grass cover and negatively correlated with cover of western hemlock, Pacific dogwood, and litter depth (Table 11). C. californicus abundance was positively correlated with percent cover of Douglas-fir, all evergreen trees, basal area of conifers, number of large snags and litter depth, and negatively with bitter cherry cover. Captures of M. longicaudus were positively correlated with percent cover of thimbleberry, and negatively with vine maple and Pacific dogwood cover. M. oregoni abundance was positively correlated with percent cover of thimbleberry, trailing blackberry, mallow ninebark, and grass; and negatively with percent cover of all evergreen trees, western hemlock and western redcedar cover, basal area of conifers, number of large logs, and number of snags. M. townsendii abundance was positively correlated with bitter cherry cover and stream depth, and negatively with western redcedar cover, basal area of conifers, and number of medium snags. Abundance of P. maniculatus was positively correlated with percent

Table 11. Spearman's rank correlations (P<0.01) between rodent species captures (>20) and average habitat variables per stand (N=15).

Habitat variable	APRU	CLCA	MILO	MIOR	MITO	PEMA	PHAL	PHLO	ZATR
Evergreen tree cover	+	.51	-	-.63	-	-.87**	-	.53	-.78*
Douglas fir cover	+	.69*	-	-	-	-	-	+	-
Western hemlock cover	-.53	+	-	-.73*	-	-.83**	-	+	-.79**
Western red cedar cover	-	+	-	-.87**	-.55	-.69*	-	+	-.67*
Bitter cherry cover	+	-.71*	-	+	.55	.55	+	-.55	+
Vine maple cover	-	+	-.74*	-	+	+	-	-	-
Pacific dogwood cover	-.64*	+	-.59	-	-	-	+	+	-.56
Mallow ninebark cover	+	-	+	.65*	+	.56	+	-	.56
Devil's club cover	+	+	+	-	-	-.69*	-	-	-
Thimbleberry cover	+	-	.52	.74*	+	.73*	+	-	.90**
Trailing blackberry cover	+	-	+	.58	+	.74*	+	-	.84**
Grass cover	.57	-	+	.84**	+	.69**	+	-.60	.75*
Basal area conifers (m/ha)	-	.63	-	-.71*	-.57	-.84**	-	.66*	-.78**
# of large logs	-	+	-	-.61	-	-.53	+	+	-.70*
# of medium snags	-	+	-	-.63	-.59	-.76**	-.61	.61	-.65*
# of large snags	-	.56	-	-.57	-	-.66*	-.67*	.57	-.77**
Total # of snags	-	+	-	-.69*	-	-.64*	-.52	+	-.67*
Litter depth (cm)	-.53	.58	-	-	-	-.65*	-	+	-.65*
Stream depth (m)	+	+	+	-	.65*	-	-	+	-
Beaver dam (0-1)	+	+	+	+	.66*	.55	+	+	.59

[a]Positive and negative symbols indicate direction of nonsignificant correlations; P<.05; *P<.01; **P<.001.

[b]APRU=Aplodontia rufra, MIOR=Microtus oregoni, PEMA=Peromyscus maniculatus, PHAL=Phenacomys albipes, PHLO=Phenacomys longicaudus, ZATR=Zapus trinotatus.

cover of bitter cherry, thimbleberry cover, trailing blackberry and grass cover, and negatively with cover of all evergreen tree species, western hemlock cover, western redcedar cover, devil's club cover, basal area of conifers, litter depth, number of large logs, and number of snags. _P. albipes_ abundance was negatively correlated with the number of medium- and large-sized snags. _P. longicaudus_ abundance was positively correlated with evergreen tree cover, basal area of conifers, number of medium and large snags, and negatively with bitter cherry and grass cover. Finally, captures of _Z. trinotatus_ were positively correlated with thimbleberry cover, trailing blackberry cover and grass cover, and negatively with evergreen tree cover, western hemlock cover, western red cedar cover, pacific dogwood cover, basal area of conifers, litter depth, number of large logs, and number of snags.

The more common herpetofauna species captured in this study were _Ascaphus truei_, _Dicamptodon ensatus_, _Ensatina eschscholtzi_, _Elgaria coerulea_, _Plethodon dunni_, _Plethodon vehiculum_ and _Taricha granulosa_. The abundance of _A. truei_ was positively correlated with stream depth (Table 12). _D. ensatus_ abundance was positively correlated with basal area of conifers, stream depth, and number of snags. _E. coerulea_ abundance was positively correlated with trailing blackberry cover, and negatively with canopy cover and total number of snags. _P. dunni_ abundance was positively correlated with stream depth, and _P. vehiculum_ abundance was negatively correlated with evergreen shrub cover. _T. granulosa_ and _E. eschscholtzi_ were not significantly correlated with any habitat characteristics at the stand level in this study.

Table 12. Spearman's rank correlations (P<0.01) between herpetofauna species captures (>20) and average habitat variables per site (N=15), Oregon Coast Ranges, 1989-90[a].

Habitat variable	Species[b]						
	ASTR	DIEN	ENES	ELCO	PLDU	PLVE	TAGR
Canopy cover	+	+	+	-.67*	+	+	+
Redstem ceanothus cover	-	-	-	.64*	-	+	-
Evergreen shrub cover	-	-	+	+	-	-.65*	-
Trailing blackberry	-	-	+	.74*	-	-	-
Basal area conifer (m/ha)	+	.68*	+	-	+	-	+
Stream depth (m)	.60	.53	-	-	.69*	+	-
# of medium snags	+	.72*	-	-	+	-	-
Total # of snags	+	.70*	+	-.62	+	+	+

[a]Positive and negative symbols indicate direction of nonsignificant correclations; P<.05; *P<.01; **P<.001.

[b]ASTR=Ascaphus truei, DITE=Dicamptodon tenebrosus, ENES=Ensatina eschscholtzi, ELCO=Elgaria coerulea, PLDU=Plethodon dunni, PLVE=Plethodon vehiculum, TAGR=Taricha granulosa.

Riparian and Upslope Associates and Habitat Characteristics

For the three riparian-associated herpetofauna species (A. truei, P. dunni, and T. granulosa), T. granulosa was the only species for which captures were significantly correlated with more than one habitat characteristic along the stream transects. Captures of this species were positively correlated with canopy cover, deciduous tree cover and vine maple cover (Table 13). However, A. truei abundance was positively correlated with fern cover, number of medium snags and total number of snags, and negatively correlated with salal and trailing blackberry cover along the upslope transect (Table 14). Abundance of E. coerulea (an upslope associate) was positively correlated with percent cover red elderberry, thimbleberry cover, and trailing blackberry cover, and negatively with basal area of conifers and litter depth along the upslope transect.

N. gibbsii abundance was positively correlated with vine maple cover at stations along the stream transect (Table 13). Abundance of S. pacificus was negatively correlated with evergreen tree cover, western hemlock cover and western redcedar cover at stations along the stream transect. S. bendirii abundance was negatively correlated with salal cover and distance to intermittent streams at stations along the upslope transect (Table 14).

There were four riparian (M. longicaudus, M. townsendii, P. albipes, Z. trinotatus) and one upslope (C. californicus) associated rodent species. M. longicaudus captures were negatively correlated with number of large snags, percent canopy cover, vine maple cover, and Oregon grape cover in riparian areas (Table 13). M. townsendii

Table 13. Spearman's rank correlations between captures of selected species of amphibians and small-mammals and average habitat variables along stream transects, Oregon Coast Ranges, 1989-90[a].

Habitat variable	Species										
	Herpetofauna			Insectivores			Rodents				[b]
	ASTR	PLDU	TAGR	NEGI	SOBE	SOPA	MILO	MITO	PHAL	ZATR	CLCA
Canopy cover	+	+	.72*	+	-	-	-.52	-	+	-	+
Evergreen tree cover	+	+	-	-	-	-.52	-	-.60	-	-.76*	+
Western hemlock cover	+	+	-	-	-	-.65*	-	-.60	-	-.80**	+
Western red cedar cover	-	-	-	-	+	-.74*	-	-.60	-	-.82**	+
Deciduous tree cover	-	-	.66*	+	-	+	-	+	+	+	-
Vine maple cover	-	-	.57	.79**	-	+	-.62	+	-	-	.55
Oregon grape cover	-	+	+	+	-	-	-.59	-	-	-.70*	.58
Grass cover	-	-	-	-	-	+	+	+	-	.76*	-
Basal area conifer (m/ha)	+	+	-	-	+	-	-	-	-	-.85**	+
# of large snags	+	+	+	+	-	+	-.70*	-	-	-	.78**

[a]Positive and negative symbols indicate direction of nonsignificant correlations; P<.05; *P<.01; **P<.001.

[b]ASTR=Acaphus truei, PLDU=Plethodon dunni, TAGR=Taricha granulosa, NEGI=Neurotrichus gibbsii, SOBE=Sorex bendirii, SOPA=Sorex pacificus, MILO=Microtus longicaudus, MITO=Microtus townsendii, PHAL=Phenacomys albipes, ZATR=Zapus trinotatus, CLCA=Clethrionomys californicus.

[c]CLCA only upslope associate included.

Table 14. Spearman's rank correlations between captures of selected species of amphibians and small-mammals and average habitat variables along upslope transects, Oregon Coast Ranges, 1989-90[a].

Habitat variable	Species[b]								
	Herpetofauna				Insectivores			Rodents	
	ASTR	TAGR	ENES[c]	ELCO[c]	NEGI	SOBE	SOPA	ZATR	CLCA[c]
Evergreen tree cover	+	-	+	-	-	-	-	-.73*	.59
Douglas fir cover	-	-	+	-	-	-	+	-.59	.67*
Red elderberry cover	-	-	-	.65*	-	+	+	+	-
Thimbleberry cover	-	-	-	.68*	-	-	+	.83**	-
Redstem ceanothus cover	-	-	-	.69*	-	+	-	.63	-
Salal cover	-.53	+	+	+	-	-.64*	+	-	+
Oregon grape cover	-	-	+	-	-	-	-	-	.66*
Trailing blackberry	-.52	-	-	.83**	-	-	+	.58	-
Fern cover	.64*	+	-	-	+	+	+	+	+
Grass cover	-	-	-	+	-	+	+	.66*	-
Basal area conifers (m/ha)	+	+	+	-.68*	+	-	-	-.86**	.72*
# of medium snags	.72*	+	-	-	+	+	-	-	.64*
# of large snags	+	+	-	-	+	+	-	-.64	+
Total # of snags	.68*	+	-	-	+	+	-	-.67*	.54
Litter depth (cm)	-	+	+	-.64*	+	-	+	-.76**	+
Distance to intermittent stream (m)	-	+	+	-	+	-.75*	-	+	+

[a]Positive and negative symbols indicate direction of nonsignificant correlations; P<.05; *P<.01; **P<.001.

[b]ASTR=Acaphus truei, TAGR=Taricha granulosa, ENES=Ensatina eschscholtzi, ELCO=Elgaria coerulea, CLCA=Clethrionomys californicus, ZATR=Zapus trinotatus, NEGI=Neurotrichus gibbsii, SOBE=Sorex bendirii, SOPA=Sorex pacificus.

[c]CLCA only upslope associate included.

abundance was negatively correlated with percent cover of evergreen tree species, western hemlock, and red cedar in riparian habitat. Z. trinotatus abundance was positively correlated with grass cover, and negatively correlated with basal area of conifers, percent cover of evergreen trees, western hemlock, western red cedar and Oregon grape along the stream transect. In addition, Z. trinotatus was positively correlated with percent cover of thimbleberry, trailing blackberry and grasses, and negatively correlated with evergreen tree percent cover, Douglas-fir cover, basal area of conifers, litter depth, number of large snags and total number of snags, along the upslope transect. Finally, C. californicus captures were positively correlated with evergreen tree cover, Douglas fir cover, Oregon grape cover, basal area of conifers, and number of snags along the upslope transect.

Characterization of Capture Locations

Litter depth and evergreen shrub cover were the most important variables for separating capture locations of M. longicaudus from those where the species was not captured (Table 15A). Litter depth and percent evergreen shrub cover were both significantly lower (P<0.001) at capture stations than noncapture stations. Additionally, deciduous shrub cover and number of medium logs were significantly higher (P<0.05) at capture stations versus noncapture stations. Over 50% of the variation in the discriminant function was explained by this model, 85% of the trap stations were classified correctly, and the classification was 70% better than chance.

Table 15. Summary of stepwise discriminant analysis used to differentiate between microhabitats at stations with small mammal captures vs. stations without captures in the Oregon Coast Ranges, 1989-90.

A. Long-tailed vole (_Microtus longicaudus_)

Habitat variable	Capture areas (n=27) X	SE	Non-capture areas (n=27) X	SE	Univariate P-value[a]	Canonical structure
Litter depth (cm)	1.1	0.2	3.1	0.5	.0006	-.686
Evergreen shrub cover	1.4	1.0	18.5	4.5	.0001	-.642
Deciduous shrub cover	53.5	3.3	37.7	5.1	.0073	.549
Number of medium logs	10.8	1.4	7.1	1.1	.0308	.391

Group explained variation
(sq. canonical correlation)   =   .512

Total jackknife
classification rate   =   .852 (.704)[b]

B. Red-backed vole (_Clethrionomys californicus_)

Habitat variable	Capture areas (n=161) X	SE	Non-capture areas (n=161) X	SE	Univariate P-value[a]	Canonical structure
Evergreen shrub cover	34.0	2.2	9.7	1.3	.0001	.739
Basal area conifers(m/ha)	48.2	3.2	16.8	2.0	.0001	.668
Liter depth (cm)	4.4	0.3	1.9	0.1	.0001	.665
Distance to intermittent stream (m)	48.6	0.5	44.0	1.1	.0001	.323

Group explained variation
(sq. canonical correlation)   =   .401

Total jackknife
classification rate   =   .795 (.590)[b]

[a]Based on Kruskal-Wallis nonparametric tests.

[b]Chance-corrected classification rate.

Evergreen shrub cover, basal area of conifers, litter depth, and distance to intermittent stream were significantly greater (P<0.001) at capture than noncapture locations of C. californicus (Table 15B). This model explained 40% of the variation between capture and noncapture locations and the discriminant function correctly classified 80% of the trap stations for C. californicus, which was 59% better than chance.

Deciduous tree cover and deciduous shrub cover were significantly higher (P<0.01) at capture stations for P. albipes (Table 16A). The amount of variation explained in this model was 16%, and 65% of the observations were classified correctly in this analysis, which was 30% better than chance. Small sample size (46 total captures) affected analysis for this species.

Basal area of conifers, forb-grass cover, and deciduous shrub cover were the best discriminators of capture locations of Z. trinotatus (Table 16B). Conifer basal area was significantly lower (P<0.001) at capture stations, and forb-grass cover and deciduous shrub percent cover were significantly higher (P<0.001). Other variables included in this analysis were number of large logs and distance to edge which were greater at noncapture stations, and deciduous tree cover which was greater at capture stations. Thirty seven percent of the variation in the data set was explained by the model, 77% of the trap locations were classified correctly by the discriminant function, and 54% were classified better than chance.

The variables that characterized capture locations of S. bendirii were evergreen shrub cover, evergreen tree cover, and distance to stand edge (Table 17A). These variables were all significantly lower (P<0.001) at capture stations than in noncapture stations. The

Table 16.   Summary of stepwise discriminant analysis used to differentiate between microhabitats at stations with small captures vs. stations without captures in the Oregon Coast Ranges, 1989-90.

A. White-footed vole (_Phenacomys albipes_)

Habitat variable	Capture areas (n=46) X	SE	Non-capture areas (n=46) X	SE	Univariate P-value[a]	Canonical structure
Deciduous tree cover*	48.0	6.0	22.5	4.9	.0011	.872
Deciduous shrub cover*	48.6	3.7	33.1	3.8	.0037	.731

Group explained variation
(sq. canonical correlation)   =   .160

Total jackknife
classification rate   =   .652 (.304)[b]

B. Pacific jumping mouse (_Zapus trinotatus_)

Habitat variable	Capture areas (n=184) X	SE	Non-capture areas (n=184) X	SE	Univariate P-value[a]	Canonical structure
Basal area conifers(m/ha)	8.8	1.5	43.2	2.8	.0001	-.816
Forb-grass cover	45.5	2.0	21.7	1.6	.0001	.709
Deciduous shrub cover	46.9	1.8	30.5	1.9	.0001	.503
Number of large logs	2.0	0.2	2.7	0.2	.0113	-.228
Deciduous tree cover	35.0	2.6	23.1	2.6	.0001	.273
Distance to edge (m)	88.8	1.6	96.1	1.0	.0001	-.327

Group explained variation
(sq. canonical correlation)   =   .372

Total jackknife
classification rate   =   .772 (.543)[b]

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*Variable was arc sine square-root transformed.

[a]Based on Kruskal-Wallis nonparametric tests.

[b]Chance-corrected classification rate.

Table 17. Summary of stepwise discriminant analysis used to differentiate beween microhabitats at stations with small mammal captures vs. stations without captures in the Oregon Coast Ranges, 1989-90.

A. Pacific water shrew (Sorex bendirii)

Habitat variable	Capture areas (n=165)		Non-capture areas (n=165)		Univariate P-value[a]	Canonical structure
	X	SE	X	SE		
Evergreen shrub cover	7.5	1.3	27.3	2.0	.0001	-.712
Evergreen tree cover	34.9	3.0	67.9	3.4	.0001	-.642
Distance to stand edge(m)	85.7	2.0	97.4	0.8	.0001	-.501
Number of large logs	3.0	0.2	2.3	0.2	.0140	.243
Litter depth (cm)	1.9	0.2	3.9	0.3	.0001	-.576
Slope (%)	35.7	2.4	47.8	2.1	.0001	-.352
Basal area deciduous(m/ha)	10.8	1.3	5.4	1.1	.0002	.295

Group explained variation
(sq. canonical correlation)   =   .342

Total jackknife
classification rate   =   .773 (.546)[b]

B. Pacific shrew (Sorex pacificus)

Habitat variable	Capture areas (n=48)		Non-capture areas (n=48)		Univariate P-value[a]	Canonical structure
	X	SE	X	SE		
Deciduous tree cover*	36.4	5.7	11.0	3.3	.0015	.838
Deciduous shrub cover*	41.2	3.8	25.2	3.0	.0023	.779

Group explained variation
(sq. canonical correlation)   =   .174

Total jackknife
classification rate   =   .698 (.396)[b]

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*Variable was arc sine square-root transformed.

[a]Based on Kruskal-Wallis nonparametric tests.

[b]Chance-corrected classification rate.

discriminant function also included number of large logs and basal area of deciduous trees which were greater at capture stations: litter depth and slope which were lower at capture stations. The model explained 34% of the variation in the dependent variables, 77% of the observations were classified correctly by the model, and 55% were classified better than chance.

The discriminant analysis included only deciduous tree cover and evergreen shrub cover in the model for S. pacificus (Table 17B). Both variables were significantly greater (P<0.01) at capture stations than noncapture stations. The model explained 17% of the variation in the data set, 70% of the observations were correctly classified, and 40% were classified better than chance.

Deciduous tree cover was the best discriminating variable between capture and noncapture sites for N. gibbsii, followed by slope and distance to intermittent stream (Table 18). Deciduous tree cover was significantly greater (P<0.001) at capture stations and percent slope was significantly greater at noncapture stations (P<0.01). Only 7% of the variation was accounted for by this model and 59% of the observations were correctly classified, which was only 18% better than chance. The poor discriminating ability of this model may reflect a generalist mode of habitat selection for this species.

Evergreen shrub cover was the best discriminating variable between capture and noncapture stations of A. truei (Table 19A). The next variable chosen was evergreen tree cover, followed by litter depth, distance to edge, slash percent cover, and distance to intermittent stream. Evergreen shrub cover, litter depth and slash cover were all significantly lower (P<0.01) at capture stations. The amount of

Table 18. Summary of stepwise discriminant analysis used to differentiate between microhabitats at stations with small mammal captures vs. stations without captures in the Oregon Coast Ranges, 1989-90.

Shrew-mole (*Neurotrichus gibbsii*)

Habitat variable	Capture areas (n=200) X	SE	Non-capture areas (n=200) X	SE	Univariate P-value[a]	Canonical structure
Deciduous tree cover	37.0	2.7	20.9	2.3	.0001	.824
Slope (%)	41.6	2.2	50.7	2.1	.0015	-.556
Distance to intermittent stream (m)	47.1	0.7	45.0	0.9	.0648	.340

Group explained variation
(sq. canonical correlation)   =   .072

Total jackknife
classification rate   =   .590 (.180)[b]

[a]Based on Kruskal-Wallis nonparametric tests.

[b]Chance-corrected classification rate.

Table 19. Summary of stepwise discriminant analysis used to differentiate between microhabitats at stations with herpetofauna captures vs. stations without captures in the Oregon Coast Ranges, 1989-90.

A. Tailed Frog (_Ascaphus truei_)

Habitat variable	Capture areas (n=95) X	SE	Non-capture areas (n=95) X	SE	Univariate P-value[a]	Canonical structure
Evergreen shrub cover	3.7	0.8	21.8	2.4	.0001	-.759
Evergreen tree cover	58.3	5.0	50.3	4.6	.4731	.139
Liter depth (cm)	2.0	0.2	3.7	0.4	.0003	-.453
Distance to edge (m)	91.1	2.2	95.8	1.3	.5198	-.220
Slash cover	9.8	0.7	14.1	1.1	.0048	-.372
Distance to intermittent stream (m)	46.7	1.1	45.0	1.3	.2145	.121

Group explained variation
(sq. canonical correlation)   =   .382

Total jackknife
classification rate   =   .737 (.474)[b]

B. Ensatina (_Ensatina eschscholtzi_)

Habitat variable	Capture areas (n=56) X	SE	Non-capture areas (n=56) X	SE	Univariate P-value[a]	Canonical structure
Number of small logs*	5.1	0.5	7.1	0.6	.0358	-.657
Evergreen tree cover**	73.6	5.9	56.9	509	.0399	.633

Group explained variation
(sq. canonical correlation)   =   .097

Total jackknife
classification rate   =   .571 (.143)[b]

*Variable was square-root + (square-root+1) transformed.
**Variable was arc sine square-root transformed.

[a]Based on Kruskal-Wallis nonparametric tests.

[b]Chance-corrected classification rate.

variation that was explained by the model was 38%, 74% of the observations were correctly classified, and 47% were classified better than chance.

Two variables that were included in the discriminant analysis for E. eschscholtzi were the number of small logs and evergreen tree cover (Table 19B). The number of small logs was significantly lower (P<0.05) and the percent evergreen tree cover was significantly higher (P<0.05) at capture stations. Twenty percent of the variation was accounted for by the model, 57% of the observations were classified correctly, and only 14% were classified better than chance. The model was not very useful in discriminating capture from noncapture stations.

Stepwise discriminant function analysis was used to differentiate between microhabitat at stations with low, medium and high captures of riparian and upslope associated species. Evergreen shrub cover, fern cover, and total number of snags were the three variables included in the discriminant function for C. californicus (Table 20A). Evergreen shrub cover was the highest at stations with greater than six captures, and fern cover and number of snags were greatest at stations with four to six captures. 16% of the variation in the model was explained by differences in means among low, medium and high capture sites. The analysis correctly classified 76% of the observations in the data set, which was 30% better than chance.

There were only two variables included in the analysis for S. pacificus (Table 20B). Basal area of conifers and distance to stand edge were greatest at stations with one to three captures. The amount of variation explained by this model was only 5% and 51% of the cases were correctly classified, only 6% better than chance, so this model

Table 20. Summary of stepwise discriminant analysis used to differentiate between microhabitats at stations with low (1-3) medium (4-6) and high (>6) captures of red-backed voles and Pacific shrews in the Oregon Coast Ranges, 1989-90.

A. Red-backed vole (Clethrionomys californicus)

	CAPTURE AREAS						
Habitat variable	Low (n=119)		Medium (n=33)		High (n=9)		Canonical stucture
	$\overline{X}$ SE		$\overline{X}$ SE		$\overline{X}$ SE		
Evergreen shrub cover	30.9	2.5	41.7	5.0	46.4	6.5	.452
Fern cover	18.8	1.3	25.6	2.8	20.8	5.0	.463
Total number of snags	0.8	0.1	1.5	0.4	1.0	0.6	.423

Group explained variation
(sq. canonical correlation) = .158

Total jackknife
classification rate = .758 (.300)[a]

B. Pacific shrew (Sorex pacificus)

	CAPTURE AREAS						
Habitat variable	Low (n=203)		Medium (n=123)		High (n=76)		Canonical stucture
	$\overline{X}$ SE		$\overline{X}$ SE		$\overline{X}$ SE		
Basal area conifers(m/ha)	31.8	2.6	21.0	2.5	17.0	2.8	-.864
Distance to edge (m)	93.5	1.2	93.4	1.5	85.3	3.1	-.672

Group explained variation
(sq. canonical correlation) = .045

Total jackknife
classification rate = .508 (.065)[a]

[a]Chance-corrected classification rate.

performed no better than what one would expect from chance for characterizing habitat for this species.

The first two discriminating variables chosen in this stepwise procedure for _Z. trinotatus_ were deciduous shrub cover and forb-grass cover (Table 21). Deciduous shrub cover was highest at stations with greater than six captures, and forb-grass cover was greatest at stations with four to six captures. Basal area of deciduous trees, distance to edge, basal area of conifer trees, and litter depth were all greatest at stations with one to three captures. Distance to intermittent stream was the final variable included in this model and was highest at stations with four to six captures. Thirty percent of the variation in the discriminant function was accounted for by the model, 52% of the observations in the data set were classified correctly, and 25% were classified better than chance.

DISCUSSION

Microhabitat relationships were identified for species using discriminant function and correlation analysis. Both were effective in characterizing habitat for some species. Other species either had more general habitat requirements or analyses were restricted because of small sample sizes. The important habitat variables were similar for the rodents, insectivores, and amphibians including litter depth, shrub cover, tree cover and abundance of logs. The co-existence of similar small- mammal species occurs where they inhabit structurally distinct microhabitats (Rosenzweig and Winakur 1969). Substrate moisture, microclimate, food availability, amount and type of cover (debris and

Table 21. Summary of stepwise discriminant analysis used to differentiate between microhabitats at stations with low (1-3) medium (4-6) and high (>6) captures of Pacific jumping mice in the Oregon Coast Ranges, 1989-90.

Pacific jumping mouse (<u>Zapus</u> <u>trinotatus</u>)

CAPTURE AREAS

Habitat variable	Low (n=112)		Medium (n=41)		High (n=31)		Canonical stucture
	X	SE	X	SE	X	SE	
Deciduous shrub cover	40.9	2.2	52.6	4.0	61.0	4.0	.576
Forb-grass cover	40.8	2.5	54.7	4.5	50.5	4.8	.377
Basal area deciduous(m/ha)	11.2	1.7	7.2	1.9	2.3	1.3	-.361
Distance to edge (m)	92.0	1.8	88.7	3.2	77.6	4.8	-.376
Basal area conifer(m/ha)	13.8	2.3	1.5	0.7	0.6	0.4	-.569
Litter depth (cm)	2.1	0.2	0.9	0.1	1.6	0.4	-.401
Distance to intermittent stream (m)	44.3	1.3	47.3	1.5	43.7	2.7	.072

Group explained variation
(sq. canonical correlation)   =   .299

Total jackknife
classification rate   =   .522 (.247)[a]

[a]Chance-corrected classification rate.

vegetation) and interspecific competition all have been found to influence the distribution of small-mammals in forests (Miller and Getz 1977). Geier and Best (1980) found five of nine small-mammal species with significant positive correlations to forb cover andseven of nine significant negative correlations between small mammal abundance and plant species richness. In addition, they found that all correlations between small-mammal abundance and woody debris abundance were positive. Maser et al. (1979) suggested that logs are important microhabitat components for lookouts, feeding, reproduction, protection and cover, sources and storage of food, and bedding for vertebrates.

Rodents

Maser et al (1981) suggested most voles are burrowers; however Ingles (1965) cited the long-tailed vole as an exception among the group. Maser et al. (1978b) suggest that _M. longicaudus_ is found more often near streams in the early successional stages of coniferous forests where it feeds on a variety of plants and some fungi. It is often found in riparian alder and willow/sedge marsh habitats; however it probably has more general habitat requirements (Maser et al. 1981). Typical _M. longicaudus_ habitat includes shrub or forest edge areas (Dalquest 1948, Rickard 1960, Brown 1967). In this study, _M. longicaudus_ was found in microhabitats with low litter depth and low percent cover of evergreen shrub. It also used areas that were high in percent cover of deciduous shrubs and greater numbers of medium logs. Conley (1976) and Randall (1978) suggested that _M. longicaudus_ might be pushed into less desirable shrubby areas by competition from other _Microtus_. Van Horne (1982) suggests that _Microtus_ spp. distribution is

related to food and cover availability. She found berries to be important for juvenile survival and growth, and forbs were a necessary component for winter survival of M. longicaudus. She also suggested that M. longicaudus abundance was highly correlated with log cover. My results support her findings. In addition, all of the M. longicaudus captured in my study were along riparian transects, which suggests an affiliation with streamside microclimate.

The usual habitat of C. californicus is moist, dense coniferous forests (Bailey 1936, Macnab and Dirks 1941). Maser et al. (1981) suggested that C. californicus may be found in a variety of coniferous forest types in Western Oregon, and Tevis (1956) reported a preference for virgin coniferous forests. In my study, microhabitats used by C. californicus had greater evergreen shrub cover, basal area of conifers, litter depth, and greater distance to intermittent streams. Captures were also positively correlated with the number of medium snags and percent cover of Douglas fir along the upslope transects. In addition, more individuals choose microhabitats with high evergreen shrub cover, fern cover, and total number of snags. Doyle (1990) also found C. californicus abundance to be positively correlated with number of snags, distance to creek, and percent cover of evergreen shrubs and trees. In addition, Doyle (1987) found C. californicus to use sites with more highly decayed logs and greater percent cover of lichens. Maser et al. (1981) also suggested that C. californicus abundance is correlated with the number of decaying logs. Decay classes of logs and lichen cover were not measured in my study. However, litter depth was a measure of the depth of decayed material and may reflect a legacy of decayed logs from the past. C. californicus was found 6 X more often in

upslope than riparian habitat, and at least 2.1 X more frequently in large sawtimber and old-growth forest types than the other three forest types. Maser et al. (1978b) suggests that the higher abundances of C. californicus in older conifer forest types is a result of a dependence on hypogeous fungi for food, and Ure and Maser (1982) suggest that C. californicus is restricted to coniferous forest in the west because of this dependence. Hayes et al. (1986) suggested that C. californicus may expedite reforestation in logged areas through spore dispersal. Hypogeous mycorrhizal fungi require a conifer host in order to fruit (Maser et al. 1978b), and their densities are high in the dead wood of these trees (Maser et al. 1978a). Tevis (1956) found that the few C. californicus present in clearcuts were found in close association with logs and suggested that removal of these logs would make the area completely unsuitable to the species. The close association of C. californicus to logs may also be for cover when breeding or for protection from predators (Macnab and Dirks 1941, Gashwiler 1959, Doyle 1987). Gashwiler (1970) and Campbell and Clark (1980) also found a decrease in abundance of C. californicus in clearcut areas, but Gashwiler suggested that loss of ground cover and increase in surface temperatures were the cause, while Campbell and Clark attributed the reduction in abundance to soil xerification. In contrast, Ure and Maser (1982) found C. californicus in forests with few logs and no undergrowth and suggested that the presence of this species was more dependent on available food and water which it obtains from hypogeous fungi. The association of C. californicus to litter depth and snag abundance in my study may reflect its dependence on hypogeous fungi. Maser et al. 1978b suggested that coexistence between C. californicus

and M. oregoni was possible through food partitioning, because M.
oregoni has a much more general diet than C. californicus. Although
there was distributional overlap between these species in my study, all
habitat correlations were contrasting (Table 11), which suggests
habitat partitioning by these two species.

P. albipes is naturally rare and classified as a sensitive species
in Oregon. It is currently a proposed candidate species for the USFWS
threatened and endangered species list. It is considered the rarest
microtine in North America; consequently information on this species is
lacking (Maser and Johnson 1967, Maser et al. 1981). Nevertheless, P.
albipes was captured in all the forest types in my study. Maser and
Johnson (1967) suggested that P. albipes is associated with small
streams as a terrestrial species. More specifically it frequents the
banks of small permanent drainages dominated by red alder with a dense
deciduous understory (Maser et al. 1981). Maser and Johnson (1967) and
Maser et al. (1981) suggested that historically, green herbaceous
plants are known as primary dietary components of this species. In my
study, many of the P. albipes individuals captured had teeth stained
green with vegetation, which would support their results. P. albipes
was captured in areas with high abundance of deciduous trees and
shrubs, and captures were negatively correlated with number of snags in
my study. It also was captured more frequently in riparian (82%) than
upslope (18%) habitats. My study indicates that this species is
associated with deciduous riparian vegetation. In addition, there may
be some competitive exclusion occurring between P. albipes and C.
californicus, because most correlations with habitat characteristics

for these species were opposite and there was essentially no overlap in their capture locations.

In my study, Z. trinotatus was associated with high forb-grass cover, deciduous shrub cover, deciduous tree cover, and wild blackberry cover; and low basal area of conifers, number of large logs, and number of medium and large snags. In addition, a greater number of individuals were found at stations with high cover of deciduous shrubs and herbaceous vegetation. Lower abundances were found at stations with high basal area of deciduous and coniferous trees, and greater litter depths. Z. trinotatus abundance was negatively correlated with western hemlock, western red cedar and Oregon grape cover in riparian habitats, and positively correlated with thimbleberry cover. Doyle (1990) also found abundance of Z. trinotatus to be positively correlated with deciduous shrubs and trees and negatively correlated with evergreen trees. In addition, she found Z. trinotatus abundance associated with plant species richness, deciduous herb cover, and negatively with evergreen tree cover. Morrison and Anthony (1989) found Z. trinotatus at trap sites where grass and tree cover were significantly higher, and evergreen shrub cover significantly lower than in non-capture sites. Z. trinotatus was most abundant in riparian habitat and in the shrub stands in my study. This was a result of an association with herbaceous vegetation, deciduous shrubs (salmonberry and thimbleberry) and blackberry cover. Ingles (1965) and Morrison and Anthony (1988) suggest Z. trinotatus prefers moist-grassy habitats on the Oregon Coast. The low abundance of Z. trinotatus in coniferous forests and high abundances in the shrub stands plus the correlation with herbs and shrubs in my study supports their suggestions. Results from my study

may also support M'Closkey's (1976) who suggested that variability of shrub size is one of the most important variables separating rodent microhabitats. In my study, M. longicaudus and C. californicus were associated with habitats with high cover of low shrubs, while Z. trinotatus and P. albipes were associated with habitats with high cover of tall shrub species. The significance of these results might be related to the basic differences between evergreen and deciduous shrubs. Miller and Getz (1977) found that small-mammal species diversity was positively correlated with diversity of trees and shrubs in forests of Northeastern U.S. and suggested that this correlation reflected the importance of food diversity to these species.

Insectivores

Maser et al. (1981) suggest that S. bendirii is found along small permanent streams in the Oregon Coast Ranges, mostly in red alder forests dominated by salmonberry and other deciduous shrubs. They are found also in moist muddy areas often under logs or other available cover (Bailey 1936). Maser et al. (1981) report that S. bendirii feeds on aquatic insects as well as a variety of terrestrial invertebrates. Aquatic insects account for a major portion of the marsh shrew's diet (Pattie 1973), often greater than 25% (Whitaker and Maser 1976). In my study, stepwise DFA selected evergreen shrub cover, evergreen tree cover, distance to stand edge, number of large logs, litter depth, percent slope, and basal area of deciduous trees to distinguish capture from noncapture stations of S. bendirii. Number of large logs and the basal area of deciduous trees were greater around capture stations than noncapture stations. S. bendirii was found more (18 X) abundant in

riparian habitat than upslope areas and more (1.8 X) in the large sawtimber forest type. <u>S.</u> <u>bendirii</u> captures in upslope habitats were close to intermittent streams. This species is probably more dependent on the cool, moist microclimates and associated food resources that riparian habitats provide, rather than on specific vegetative characteristics.

<u>S.</u> <u>pacificus</u> may be found in red alder stands with high deciduous shrub cover along intermittent and more permanent streams, as well as in skunkcabbage marshes in forests and valley clearings in the Oregon Coast Ranges (Maser et al. 1981). They are often captured under old logs and stumps in brushy-marshy habitats (Bailey 1936). <u>S.</u> <u>pacificus</u> feeds primarily on invertebrates (Bailey 1936, Whitaker and Maser 1976, Maser et al. 1981). In addition to the invertebrates, Whitaker and Maser (1976) found <u>S.</u> <u>pacificus</u> to feed on small amphibians (including <u>E.</u> <u>eschscholtzi</u>), fungi, and some vegetation. In my study, <u>S.</u> <u>pacificus</u> selected microhabitats with high percent cover of deciduous trees and deciduous shrubs; but the strength of this association was low. Abundance of <u>S.</u> <u>pacificus</u> also was negatively correlated with western hemlock and western redcedar along the stream transect. In addition, fewer individuals selected microhabitats with high basal area of conifers and greater distance to edge. <u>S.</u> <u>pacificus</u> was about 1.5 X more abundant in riparian than upslope habitat. Abundance of this species seems to be associated with the microclimates found in riparian habitats and/or deciduous vegetation.

Maser et al. (1981) suggested that the preferred habitat of <u>N.</u> <u>gibbsii</u> (like <u>S.</u> <u>pacificus</u> <u>and</u> <u>S.</u> <u>bendirii</u>) is in red alder forests found along intermittent and permanent streams on the Oregon Coast.

Although the marsh shrew is semiaquatic and the shrew-mole more fossorial, all three species are often active on the surface, but only in close conjunction with some kind of protective cover (eg. logs or vegetation). When adequate cover is not available, Pacific shrews often burrow and share similar plant community types with a minimal amount of direct competitive interaction by dividing available microhabitat and food (Whitaker and Maser 1976). Maser et al. (1981) reported however, that N. gibbsii may be found in variety of other habitats, including young and old coniferous forests. Tevis (1956) found N. gibbsii in virgin forest and concluded it decreases in numbers following logging. The diet of N. gibbsii consists of a variety of invertebrates including earthworms, centipedes and insects (Bailey 1936, Maser et al. 1981). In my study, N. gibbsii was captured at stations with high deciduous tree cover and low slope. Captures also were negatively correlated with the number of medium logs and positively correlated with vine maple cover along the stream. N. gibbsii was 1.3 X more abundant along the stream transect than upslope and 1.3 X more abundant in the deciduous stands than the other forest types. Maser et al. (1981) also reports N. gibbsii to prefer areas with high percent cover of deciduous shrubs, particularly salmonberry. In contrast, Doyle (1990) found N. gibbsii at sites with low percent cover of lichen and few snags in the Oregon Cascades, and Whitaker et al. (1979) found it associated with large decayed logs. Habitat selection by this species is probably influenced more by cool microclimates in riparian areas and the presence of deciduous vegetation.

Amphibians

The larval forms of salamanders and frogs differ, the former being herbivorous and the later carnivorous (Nussbaum et al 1983). In the first phase of their biphasic life cycle, A. truei requires a water substrate for existence. As adults, both E. eschscholtzi and A. truei feed on a variety of terrestrial invertebrates, however A. truei also feeds in the water (Nussbaum et al. 1983). Although the A. truei requires permanent streams for existence, usually in densely forested areas where the temperatures remain cool year around, during the cooler rainy season they often have been reported to venture (>25 meters [Nussbaum et al. 1983]) from the stream (Noble and Putman 1931). Putman and Noble (1931) suggested that both the adults and larval forms of A. truei prefer shallow mountain streams. Nussbaum et al. (1983) suggested that A. truei larvae feed on diatoms and conifer pollens, while adults feed on insects as well as a variety of other invertebrates. In my study, A. truei was found at stations with low cover of evergreen shrubs, high evergreen tree cover, low litter depth, closer to edges, and low slash cover. Abundance of A. truei was positively correlated with stream depth, fern cover, and number of snags in the upslope habitat. A. truei captures were 4.1 X higher in riparian than upslope habitats and 2.6 X higher in the sawtimber and old-growth forest types. A. truei is found in streams with minimal amounts of decaying vegetation and where there is a supply of exposed rocks for protection from predators (Noble and Putman 1931). They suggest that A. truei often is restricted to smaller mountain streams because of fish predators. My results support the conclusion that A. truei is dependent

on the cool microclimates found in most riparian areas especially in
older forests.

Nussbaum et al. (1983) suggested that _E. eschscholtzi_ occur in
forested areas of Western Oregon. Ensatina uses the cover of litter and
other debris to find cooler temperatures and it copes with the hot, dry
summer climate by retreating further beneath the ground (Nussbaum et al
1983). They also suggested that _E. eschscholtzi_ feed on a variety of
terrestrial invertebrates. In my study, captures of _E. eschscholtzi_
were higher where the number of small logs was lower and the evergreen
tree cover was high. This species was not found along the stream
transect and almost half (30 individuals) were found in the upslope
habitat. Nevertheless, the low classification rates and few habitat
variables which correlate with captures of this species, suggest that
it might be more general in habitat selection.

GENERAL DISCUSSION

The degree to which each species depends on riparian habitat
surely varies, just as the particular habitat features that they depend
on will vary. Some of the species may depend on the unique microclimate
that riparian areas offer, which is dependent on the topography, water
availability, and on vegetation characteristics of an area (Raedeke et
al.1988).

S. bendirii and _A. truei_ were strongly associated with riparian
habitat. _S. bendirii_ was found along the upslope only associated with
intermittent streams, and _A. truei_ was positively correlated with
stream depth; this is additional evidence of a strong riparian
association. Their lack of association with other habitat variables

might suggest a dependence on the cool, moist microclimate and associated foods of riparian areas rather than any specific vegetative characteristics. This may also be true for other species in my study including D. ensatus and P. dunni. S. pacificus, N. gibbsii, P. albipes, M. longicaudus, and Z. trinotatus were associated with deciduous vegetation, which they may require for food, and/or cover from predators, or for cooling. In addition, M. longicaudus was positively correlated with the number of logs which may also be important for cover. The high abundance of Z. trinotatus along streams was associated with herbaceous vegetation which it might use for cover and food. This is supported by it's high abundance in shrub stands where herbaceous cover is high. The high abundance of C. californicus in the large sawtimber and old-growth forest types, along with the correlation it has with litter depth and snag abundance reflects it's association with characteristics of older forests and use of hypogeous fungi for food.

Microhabitat differences between similar taxa might be a result of competitive interaction or could reflect differences in food preferences, other species (predators and competitors), and/or different environmental tolerances. C. californicus, M. oregoni, M. longicaudus, and P. albipes are sympatric microtine rodents with similar morphology and life histories, opposite correlations among them and habitat characteristics, along with the small amount of overlap in their capture locations, demonstrates possible competitive interaction between these species. In contrast, differences in microhabitat between P. albipes and P. longicaudus are probably a result of niche segregation (terrestrial v.s. arboreal). Variability in shrub size or

type (deciduous v.s. conifer) might play an important role in microhabitat separation of rodents in this study.

Divergence in body size between similar species may reduce competition and allow coexistence (M'Closkey 1976). The three riparian associated insectivores, for example, range in size from _N. gibbsii_ (smallest), _S. pacificus_ (intermediate) to _S. bendirii_ (largest). These differences in body size may promote variability in size preference of food. Differences in foraging behavior and location also allows similar species to coexist, another example of niche segregation. Much of the diet of _S. bendirii_ is aquatic insects while the other insectivores feed on terrestrial foods. Divergence in body size and foraging behavior also might be important for the coexistence of riparian associated rodents.

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APPENDICES

Appendix A. Location, aspect, slope, and elevation of study sites in the Suislaw National Forest, Oregon, 1989-1990.

Stand	County	Creek[a]	Location[b]	Aspect	Slope	Elevation
Shrub #1	Lincoln	Horse	12S-10W-9-S	SW	34	760
Shrub #2	Benton	Wilkinson	14S-9W-26-NE	W	61	360
Shrub #3	Lincoln	Cow	14S-9W-11-NE	W	68	500
Pole #1	Lincoln	Drift	12S-9W-31-NE	NW	57	1160
Pole #2	Lincoln	Drift	13S-92-9-center	SE	48	1240
Pole #3	Lincoln	Meadow	12S-10W-23-SE	SW	40	600
Sawtimber #1	Lincoln	Gold	13S-10W-2-S	SW	45	940
Sawtimber #2	Lincoln	Boulder	13S-10W-14-NE	SW	54	950
Sawtimber #3	Lincoln	Nettle	12S-92-28-SE	S	45	1000
Oldgrowth #1	Benton	S.F.Rock	12S-7W-23-NE	NW	27	640
Oldgrowth #2	Benton	S.F.Alsea	A4S-7W-27-NE	W	38	1100
Oldgrowth #3	Lincoln	Boulder	13S-10W-10-S	S	53	480
Deciduous #1	Lincoln	Bull Run	13S-9W-10-S	SW	65	760
Deciduous #2	Lincoln	Johnson	12S-8W-10-NE	SW	42	540
Deciduous #3	Benton	Honey Grove	14S-72-4-NW	E	26	500

[a]May be tributary or main creek

[b]Township-range-section-quadrat

Appendix A. Location, aspect, slope, and elevation of study sites in the Suislaw National Forest, Oregon, 1989-1990.

Stand	County	Creek[a]	Location[b]	Aspect	Slope	Elevation
Shrub #1	Lincoln	Horse	12S-10W-9-S	SW	34	760
Shrub #2	Benton	Wilkinson	14S-9W-26-NE	W	61	360
Shrub #3	Lincoln	Cow	14S-9W-11-NE	W	68	500
Pole #1	Lincoln	Drift	12S-9W-31-NE	NW	57	1160
Pole #2	Lincoln	Drift	13S-92-9-center	SE	48	1240
Pole #3	Lincoln	Meadow	12S-10W-23-SE	SW	40	600
Sawtimber #1	Lincoln	Gold	13S-10W-2-S	SW	45	940
Sawtimber #2	Lincoln	Boulder	13S-10W-14-NE	SW	54	950
Sawtimber #3	Lincoln	Nettle	12S-92-28-SE	S	45	1000
Oldgrowth #1	Benton	S.F.Rock	12S-7W-23-NE	NW	27	640
Oldgrowth #2	Benton	S.F.Alsea	A4S-7W-27-NE	W	38	1100
Oldgrowth #3	Lincoln	Boulder	13S-10W-10-S	S	53	480
Deciduous #1	Lincoln	Bull Run	13S-9W-10-S	SW	65	760
Deciduous #2	Lincoln	Johnson	12S-8W-10-NE	SW	42	540
Deciduous #3	Benton	Honey Grove	14S-72-4-NW	E	26	500

[a]May be tributary or main creek

[b]Township-range-section-quadrat

Appendix B. Vegetation cover estimates measured at stations in each of the five forest types in the Oregon Coast Ranges, 1990.

HERBACOUS

FORB

FERN

GRASS

LOW SHRUB

SALAL (*Gaultheria shallon*)

OREGON-GRAPE (*Berberis nervosa*)

WILD BLACKBERRY (*Rubus ursinus*)

TALL SHRUB

RED HUCKLEBERRY (*Vaccinium parvifolium*)

VINE MAPLE (*Acer circinatum*)

SALMONBERRY (*Rubus spectabilis*)

STINKING CURRENT (*Ribes bracteosun*)

DEVIL'S CLUB (*Oplopanax horridum*)

OCEAN-SPRAY (*Holodiscus discolor*)

PACIFIC DOGWOOD (*Cornus nuttallii*)

INDIAN PLUM (*Oemleria cerasiformis*)

CALIFORNIA HAZEL (*Corylus cornuta*)

RED ELDERBERRY (*Sambucus racemosa*)

THIMBLEBERRY (*Rubus parviflorus*)

LITTLE WOOD ROSE (*Rosa gymnoocarpa*)

MALLOW NINEBARK (Physocarpus malvaceus)

Appendix B. Continued.

BLUEBERRY (Rubus sp.)

RUSTY MENZIESIA (Menziesia ferruginea)

RED-FLOWERING CURRENT (Ribes sanguineum)

REDSTEM CEANOTHUS (Ceanothus sanguineus)

SCOTCH BROOM (Cytisus scoparius)

CASCARA BUCKTHORN (Rhamnus purshiana)

CANAPY

DOFI=DOUGLAS FIR (Pseudotsuga menziesii)

WEHE=WESTERN HEMLOCK (Tsuga heterophylla)

WECE=WESTERN RED CEDAR (Thuja plicata)

FISP=NOBLE FIR (Abies procera)

PYEW=PACIFIC YEW (Taxus brevifolia)

MADR=MADRONE (Arbutus menziesii)

EVERGREEN TREE COVER=DOFI+WEHE+WECE+FISP+PYEW+PYEW

REAL=RED ALDER (Alnus rubra)

BIMA=BIGLEAF MAPLE (Acer macrophyllum)

WISP=WILLOW (Salix sp.)

GOCH=GOLDEN CHINQUAPIN (Castanopsis chrysophylla)

BICH=BITTER CHERRY (Prunus emarginata)

WHAL=WHITE ALDER (Alnus rhombifolia)

DECIDUOUS TREE COVER=REAL+BIMA+WISP+GOCH+BICH+WHAL