SMALL MAMMAL POPULATIONS IN RIPARIAN ZONES OF DIFFERENT-AGED CONIFEROUS FORESTS

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ABSTRACT—Small mammals were trapped in riparian zones in young, mature, and old-growth coniferous forests during spring and summer of 1983. *Peromyscus maniculatus* was the most abundant species and comprised 76% and 83% of the total captures during spring and summer, respectively. More species, but fewer individuals, were captured on the streamside transects in comparison to the riparian fringe transects, which were 15–20 m from the stream. Six species of Insectivora, including five species of *Sorex*, were captured in these riparian zones. No species was solely dependent on riparian zones in old-growth forests; however, additional studies are needed to define the specific habitat requirements of *Sorex bendirii, Sorex palustris, Neurotrichus gibbsii, Phenacomys albipes,* and *Microtus richardsoni.*

Riparian zones recently have been recognized for their uniqueness and intrinsic value as wildlife habitat. To date, much attention has been focused on the most conspicuous riparian zones, such as those found in semiarid lands or along major rivers and streams (Johnson and Jones 1977, Thomas et al. 1979). Studies on wildlife populations in riparian zones dominated by coniferous forests are less numerous (Swanson et al. 1982), although riparian zones along low-order (second-, third-, and fourth-order streams at the head of watersheds) mountain streams are an integral part of the forest ecosystem (Swanson et al. 1982).

Harvest of old-growth forests has become a major forestry-wildlife issue, because these forests provide unique wildlife habitat and they are rapidly being logged (Meslow et al. 1981). Recent studies have indicated that many species of wildlife may find optimum habitat in old-growth forests (Meslow 1978; Thomas 1979; Mannan 1980, 1982; Verner and Boss 1980; Franklin et al. 1981; Anthony et al. 1982; Forsman et al. 1984). However, most of these studies have been on avian species in upland areas, and small mammal populations in riparian zones of old-growth forests have received less attention.

Herein, we compare small mammal populations inhabiting low-order riparian zones in three age-classes of forests (young, mature, old growth) and contrast species composition of streamside versus riparian fringe transects.

STUDY AREA

This study was conducted at 12 sites in the western hemlock (*Tsuga heterophylla*)/Douglas-fir (*Pseudotsuga menziesii*) zone on the west slope of the Cascade Range. All 12 sites were located in the Blue River or McKenzie River Ranger Districts of Willamette National Forest, Lane County, Oregon, and most sites were within the H. J. Andrews Experimental Forest. They were located in riparian zones of second- and third-order streams within young (25–50 yrs), mature (130–200 yrs), and old-growth (400–450 yrs) forest stands. Old-growth and mature stands were virgin forests, and young stands originated from clear-cut logging. Because the study sites were located along small headwater streams, they contained few deciduous trees. The study sites ranged in elevation from 500–975 m and varied in slope and aspect. Annual precipitation in the area is approximately 180 cm.

Douglas-fir dominated the forest in all successional stages. Western hemlock and western red cedar (*Thuja plicata*) contributed to the old-growth canopy, and red alder (*Alnus rubra*) was present in the young stands. The shrub layer included salmonberry (*Rubus spectabilis*), huckleberry (*Vaccinium* spp.), vine maple (*Acer circinatum*), salal (*Gaultheria shallon*), Pacific rhododendron (*Rhododendron*

macrophyllum), Oregon grape (*Berberis repens*), western swordfern (*Polystichum munitum*), and common bracken fern (*Pteridium aquilinum*). Young stands had the lowest shrub cover because of a dense overstory of young Douglas-fir and western red cedar; however, early seral species such as willow (*Salix* sp.) and snowbrush ceanothus (*Ceanothus velutinus*) were common.

METHODS

Field

Five old-growth, five mature, and two young forest stands were selected for trapping and comparison. Paired (Calhoun) traplines were located within the riparian zones, with one line placed within ~1 m of the stream (streamside) and the other placed along the riparian fringe (15–25 m from the stream) between the upland forest and the riparian zone. Each line consisted of 25 trap stations spaced at 15-m intervals, with two museum specials and one Victor® rat trap at each station. Traps were baited with rolled oats and peanut butter. Each line was operated for three consecutive nights (=450 trapnights) during spring (May 1983) and summer (August and September 1983). Traplines were shifted either upstream or downstream within the riparian zone during the summer to avoid areas previously trapped during spring.

Diurnal sciurids (primarily *Tamias townsendii* and *Tamiasciurus douglasii*) were counted using the variable circular plot method (Reynolds et al. 1980) during June and July. Five plots, spaced 200 m apart, were established along the riparian zone of each of the 12 stands. Each plot was sampled during the morning hours approximately once per week. Diurnal sciurids were detected visually or audibly during a 10-min sample period, and the distance from the animal to the plot center was estimated. Counts were repeated five to seven times per stand.

Data Analysis

Diversity (H′) and evenness (J) of small mammal communities were calculated (Shannon and Weaver 1963), and richness (S) was the number of species captured in each forest stand. Mean differences in diversity, evenness, and richness between age-classes were tested for significance by a nonparametric *t*-test. Chi-square tests were used to compare efficiency of rat traps with that of museum specials, total captures between forest age-classes, and total captures of individual species on streamside versus riparian transects. Expected values for chi-square tests were derived by assuming equality of captures. Densities of diurnal sciurids censused by variable circular plot were estimated by a cumulative distance algorithm (Emlen 1971, Ramsey and Scott 1981). Differences in densities of diurnal sciurids between forest age-classes were tested by an analysis of variance with Duncan's new multiple-range test for mean separation (Steel and Torrie 1980:187). All differences were judged significant at the 0.05 level.

Populations of *Peromyscus maniculatus* were initially estimated by program CAPTURE (Otis et al. 1978) and the Zippin (1958) removal method. However, data collected were not sufficient in many circumstances to provide reliable population estimates with the removal method, and weather also had an influence on capture rates and the reliability of estimates. Therefore, the number of individuals captured was used as an index to abundance.

The taxonomy of mammals for this paper follows Verts and Carraway (1984), and more specifically, the taxonomy of the genus *Sorex* is according to Junge and Hoffmann (1981). Because the taxonomy of the *S. pacificus*/*S. monticolus* group has not been resolved, the mammals we trapped were deposited in the Oregon State University Department of Fisheries and Wildlife Mammal Collection for future reference.

RESULTS

Species Composition

A total 936 individuals of 16 species of small mammals was captured in 10,800 trapnights during the study (Tables 1, 2). All 16 species were captured in spring, whereas 13 were captured during summer. *Tamiasciurus douglasii, Sorex monticolus,* and *Neurotrichus gibbsii* were not captured during summer. More individuals were captured during the spring (600) than the summer (336). *Peromyscus maniculatus* totaled 76 and 83% of the spring and summer captures, respectively (Tables 1, 2). *Sorex pacificus* (8 and 6%), *Sorex trowbridgii* (4

TABLE 1. Number of individuals of each mammal species captured in three age-classes of forests in riparian areas in the Cascade Mountains, western Oregon, during May 1983.

Species	Old growth[a]					Mature[a]					Young[a]		Total captures	Percent of total captures
	MC	MCT	LC	LLT	ULT	HC	ELK	CC	EF	KC	SW	SPR		
Peromyscus maniculatus	37	60	68	44	93	31	11	19	12	27	15	37	454	75.8
Sorex pacificus	1		5	1	4	14	5	1	4	1	10		46	7.7
Sorex trowbridgii		2	4			6	6	2	1	2	1	2	26	4.3
Tamias townsendii	1	1		4	2		1		1	1	9	2	22	3.7
Clethrionomys californicus	4	3	3			1			5			1	17	1.8
Microtus richardsoni					6	3	1					1	11	1.8
Tamiasciurus douglasii	1											1	2	1.2
Zapus trinotatus						1				1		4	6	1.0
Sorex bendirii	1				2		1				1		5	0.8
Sorex monticolus					1								1	0.2
Microtus oregoni					1								1	0.2
Glaucomys sabrinus							1			1	1		3	0.5
Sorex palustris	1									1			2	0.3
Neurotrichus gibbsii					1								1	0.2
Neotoma cinerea			1										1	0.2
Phenacomys albipes					1	1							2	0.3
Total Captures	46	66	81	49	111	57	26	22	23	34	37	48	600	100.0
No. species	7	4	5	3	9	7	7	3	5	7	6	7		

[a] MC = Mack Creek, MCT = Mack Creek Tributary, LC = Lookout Creek, LLT = Lower Lookout Creek Tributary, ULT = Upper Lookout Creek Tributary, HC = Hogan Creek, ELK = Elk Creek, CC = Cougar Creek, EF = East Fork Creek, KC = King Creek, SW = Swamp Creek, SPR = Spring Creek.

TABLE 2. Number of individuals of each mammal species captured in three age-classes of forests in riparian areas in the Cascade Mountains, western Oregon, during August and September 1983.

Species	Old growth[a]					Mature[a]					Young[a]		Total captures	Percent of total captures
	MC	MCT	LC	LLT	ULT	HC	ELK	CC	EF	KC	SW	SPR		
Peromyscus maniculatus	38	37	47	37	31	17	13	5	9	1	15	28	278	82.7
Sorex pacificus	1	1		4	4		2	2	2		2	2	20	5.9
Sorex trowbridgii				2			1	2	2	3	1		11	3.3
Tamias townsendii	1		1		2								4	1.2
Clethrionomys californicus		1		1				1	1		2		6	1.8
Microtus richardsoni		1											1	0.3
Zapus trinotatus			2				1				1	1	5	1.5
Sorex bendirii											1		1	0.3
Microtus oregoni			1										1	0.3
Glaucomys sabrinus							1			1	3	1	6	1.8
Sorex palustris		1											1	0.3
Neotoma cinerea	1												1	0.3
Phenacomys albipes										1			1	0.3
Total captures	41	41	51	44	37	17	18	10	14	6	25	32	336	100.0
No. species	4	5	4	4	3	1	5	4	4	4	7	4		

[a] MC = Mack Creek, MCT = Mack Creek Tributary, LC = Lookout Creek, LLT = Lower Lookout Creek Tributary, ULT = Upper Lookout Creek Tributary, HC = Hogan Creek, ELK = Elk Creek, CC = Cougar Creek, EF = East Fork Creek, KC = King Creek, SW = Swamp Creek, SPR = Spring Creek.

TABLE 3. Mean number of small mammals captured in three age-classes of forests in western Oregon, the Cascade Mountains, during spring and summer 1983.

	Young	Mature	Old growth	χ^2 values
		Spring		
All species	42.5	32.2	70.4	16.14[a]
Peromyscus maniculatus	26.0	20.0	60.4	26.77[a]
Sorex pacificus	5.0	5.0	2.4	1.10
Sorex spp.	7.0	8.8	4.2	1.60
		Summer		
All species	28.5	13.0	42.8	15.75[a]
Peromyscus maniculatus	21.5	9.0	38.0	18.56[a]
Sorex pacificus	2.0	1.2	2.0	0.25
Sorex spp.	3.0	2.8	2.6	0.29

[a] Denotes a significant ($p < 0.05$) difference between the number of captures in the three age-classes of forests as determined by a chi-square test.

and 3%), and *Tamias townsendii* (4 and 1%) comprised most of the remaining captures. These four species were captured in all forest stands during spring and summer. *Clethrionomys californicus, Tamiasciurus douglasii, Microtus richardsoni, Zapus trinotatus,* and *Sorex bendirii* each comprised less than 2% of the captures but were captured in all age-classes of forests. *Microtus oregoni, Phenacomys albipes, Neotoma cinerea, Sorex palustris, S. monticolus,* and *Neurotrichus gibbsii* were captured only in old-growth or mature forests, whereas *Glaucomys sabrinus* was captured only in mature and young forests. None of the species was captured exclusively in young stands during spring or summer.

Victor® rat traps were only 28% as efficient in capturing small mammals as museum special mouse traps. *Sorex pacificus, S. trowbridgii,* and *Peromyscus maniculatus* were captured by rat traps significantly ($p < 0.001$) less than in museum specials. Rat traps were more effective in capturing *Glaucomys sabrinus* ($p < 0.001$) than museum specials.

Abundance

Significant ($p < 0.05$) differences in small mammal captures occurred between the three forest age-classes for all species combined and for *Peromyscus maniculatus* during spring and summer (Table 3). Because *Peromyscus maniculatus* comprised most (76–83%) of the captures, differences in its abundance also accounted for differences in all species combined. Highest abundances of *Peromyscus maniculatus* occurred in the old-growth stands, and lowest abundances occurred in mature stands. Differences in capture rates for all *Sorex* combined and *S. pacificus* were not significantly ($p > 0.05$) different between the forest-age classes (Table 3). Captures for the other species were too low (Tables 1, 2) to warrant statistical comparisons of abundance.

The variable circular plot method resulted in a significantly greater number of observations of *Tamias townsendii* and *Tamiasciuris douglasii* (Table 4) than did snap-trapping (Tables 1, 2); therefore, this method was more reliable for estimating abundance of this group of mammals. Densities of *Tamias townsendii* were significantly ($p < 0.05$) different among all forest age-classes (Table 4). Densities in young stands averaged two times greater than in old-growth and five times greater than in mature forests. No significant ($p > 0.05$) differences in densities of *Tamiasciurus douglasii* were found among forest age-classes although the highest densities were observed in young stands.

Species Diversity, Evenness, Richness

Species diversity (H′) and evenness (J) were significantly ($p < 0.05$) lower for old-growth stands as compared to mature and young-aged stands during spring (Table 5).

TABLE 4. Mean densities (#/40 ha) of diurnal sciurids in three age-classes of forests in the Cascade Mountains, western Oregon, during summer 1983.

	Young		Mature		Old growth		
	$\bar{x}$	2 SE	$\bar{x}$	2 SE	$\bar{x}$	2 SE	*F*-value
Tamias townsendii	50.0	33.4	9.6	5.0	31.8	16.5	5.86[a]
Tamiasciurus douglasii	44.4	22.2	31.1	24.8	40.0	27.8	0.21

[a] Denotes a statistically significant ($p < 0.05$) difference between forest types as determined by an *F*-test.

However, mean species richness (S) did not differ significantly ($p > 0.05$) among forest age-classes for either season, so the lower diversity indices for the old-growth stands during spring and summer were a result of the relatively higher abundances of *Peromyscus maniculatus* in those stands (Table 3) which resulted in lower evenness. No significant ($p > 0.05$) difference in species diversity was detected for the summer trap period (Table 5), although the relative differences were similar to those for spring.

Streamside and Riparian Fringe

Fourteen species of small mammals were trapped in the streamside transects, whereas only nine species were captured along the riparian fringe transects (Table 6). *Microtus oregoni, M. richardsoni, Tamiasciurus douglasii, Phenacomys albipes, Sorex bendirii, S. palustris,* and *Neurotrichus gibbsii* were captured only along the streamside transects and not on the riparian fringe transects. Although fewer species were captured on the riparian fringe, significantly ($p < 0.05$) more individuals were captured there as compared to the streamside area. Captures of *Peromyscus maniculatus, Sorex pacificus, S. trowbridgii, Glaucomys sabrinus,* and *Clethrionomys californicus* were significantly ($p < 0.05$) greater in the riparian fringe, whereas *M. richardsoni, Zapus trinotatus,* and *Sorex bendirii* were captured more frequently ($p < 0.05$) in streamside traps (Table 6).

DISCUSSION

Our study did not identify any definitive dependence of small mammal species on low-order riparian areas in old-growth forests. However, *Sorex palustris, Neurotrichus gibbsii, Phenacomys abipes,* and *Microtus oregoni* were captured only along the streamside transects (versus riparian fringe) in old-growth and mature forests. In addition, *Sorex bendirii* and *Microtus richardsoni* were captured only along the streamside transects and are known to be associated with streams (Ingles 1965). Dalquest (1941) described the habitat of *Neurotrichus gibbsii* as dark, marshy, wooded areas; and Tevis (1956) indicated they were a virgin-forest inhabitant, although he made no reference to age of forests. Because captures were low for the six species mentioned above, no definitive statements

TABLE 5. Species diversity, evenness, and richness of small mammal communities in three age-classes of forests in western Oregon.

Community parameter	Age-class: Young	Mature	Old Growth
		Spring	
Species diversity (H')	1.14	1.07	0.59[a]
Evenness (J)	0.61	0.62	0.36[a]
Richness (S)	6.5	5.8	5.4
		Summer	
Species diversity (H')	0.93	0.89	0.46
Evenness (J)	0.53	0.78	0.34[a]
Richness (S)	5.5	3.6	4.0

[a] Denotes a statistically significant ($p < 0.05$) difference between forest types as determined by a nonparametric *t*-test.

TABLE 6. Number of captures of small mammals among streamside (SS) and riparian fringe (RF) areas in western Oregon during spring and summer 1983.

Species	Spring		Summer		Total	
	SS	RF	SS	RF	SS	RF
Peromyscus maniculatus	198	256	95	183	293	439[a]
Sorex pacificus	10	36	9	11	19	47[a]
Sorex trowbridgii	9	16	3	8	12	24[a]
Tamias townsendii	8	14	3	1	11	15
Clethrionomys californicus	3	14	0	6	3	20[a]
Microtus richardsoni	11	0	1	0	12	0[a]
Tamiasciurus douglasii	2	0	0	0	2	0
Microtus oregoni	1	0	1	0	2	0
Zapus trinotatus	5	1	4	1	9	2[a]
Glaucomys sabrinus	0	3	1	5	1	8[a]
Sorex palustris	2	0	1	0	3	0
Sorex bendirii	5	0	1	0	6	0[a]
Sorex monticolus	0	1	0	0	0	1
Phenacomys albipes	2	0	1	0	3	0
Neotoma cinerea	0	1	0	1	0	2
Neurotrichus gibbsii	1	0	0	0	1	0
Total captures	257	342	120	216	377	558[a]
No. species	13	8	11	8	14	9

[a] Denotes a significant ($p < 0.05$) difference in total captures between streamside and riparian fringe, as determined by a chi-square test.

can be made about dependencies on riparian areas in old-growth forests. Additional studies with more intensive sampling designs are needed to elucidate their habitat associations.

Species diversity was lowest in old-growth forests, but this difference was due to the significantly higher relative abundance (~lower evenness and lower species diversity) of *Peromyscus maniculatus* in these forests. More importantly, the number of species (richness) did not differ among forest age-classes. More species, but fewer individuals, were captured in streamside traps than in traps in the riparian fringe. The occurrence of more species along the streamside versus riparian fringe was an important finding of this study. Similarly, Cross (1985) found more diverse and generally more dense small mammal communities in riparian zones as compared to upland habitats. The lower abundance (capture rates) of individuals along streamside versus riparian fringe transects in our study was difficult to interpret because the stream and traps along the riparian fringe may have restricted accessibility of streamside traps to small mammals. Old-growth forests had the highest abundance of all mammal species combined in our study, and these differences may be important in influencing how and where predators forage.

Peromyscus maniculatus was the most commonly captured small mammal in our study. This is consistent with other studies conducted in Douglas-fir forests (Tevis 1956; Gashwiler 1959, 1970; Hooven 1969; Petticrew and Sadleir 1974; Hooven and Black 1976; Sullivan 1979). In contrast to other studies, we found *P. maniculatus* to be most abundant in the old-growth forests. Gashwiler (1970), Tevis (1956), and Hooven (1969) stated that mature or virgin forests were poor habitat and clearcuts were good habitat for *P. maniculatus.* However, their definitions of mature and virgin are ambiguous as they did not give the age of forests they sampled; therefore, comparisons are difficult.

Microtus oregoni was rare in the riparian habitats that we sampled. Geortz (1964) considered grassy clearcuts as optimum habitat for *M. oregoni*, and Hooven and Black (1976) found these voles to increase in density after clearcutting. In contrast, Gashwiler (1970) found this species to be more common in old-growth forests as compared to clearcuts. Anthony and Morrison (1985) found high abundances of this species in five- to sevenyear-old clearcuts. Based on the variety of different habitats this species occurs in, particularly recent clearcuts, it is obviously not dependent on riparian areas or old-growth forests.

Glaucomys sabrinus was captured only in mature and young forest types. These results are particularly peculiar as Forsman et al. (1984) documented the importance of this species in the diets of northern Spotted Owls (*Strix occidentalis*), which are highly dependent on old-growth forests. However, the methods employed in this study were not adequate to evaluate habitat relationships and abundance of *Glaucomys sabrinus* in different forest age-classes.

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