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Small Mammal and Amphibian Communities and Habitat Associations in Red Alder Stands, Central Oregon Coast Range

Abstract

Although red alder dominates many sites in the Oregon Coast Range, mammal and amphibian communities in these stands have not been described. We documented community structure and riparian area associations for small mammals and amphibians in three red alder stands. We sampled habitat, amphibians, and small mammals from 0 to 150 m from streams in three 40- to 50-year-old red alder stands in the central Oregon Coast Range. We did not detect differences ($P > 0.12$) between streamside and upland sites in 25 of 28 habitat characteristics, nor in capture rates for one amphibian species and four mammal species. Capture rates for Ensatina salamanders (*Ensatina eschscholtzi*) were higher in upland than in streamside habitats. Roughskin newts (*Taricha granulosa*) were the most common amphibian and the small mammal community was dominated by deer mice (*Peromyscus maniculatus*), Trowbridge's shrews (*Sorex trowbridgii*), Pacific shrews (*S. pacificus*), and Virginia opossums (*Didelphis virginiana*). Capture rates for five species were associated ($r > 0.7$) with the abundance of woody debris and/or vegetation on the sites. Nine species captured along streamsides and four species captured in uplands were not predicted by an existing wildlife habitat relationships model. Red alder stands should be considered important landscape components contributing to small mammal and amphibian diversity.

Introduction

Red alder (*Alnus rubra*) is a fast-growing, nitrogen-fixing tree that occupies over 1 million ha of the western United States (Tarrant *et al.* 1983). Alder has long been considered a weed species, but it is now receiving more attention as an economically valuable resource (DeBell *et al.* 1978). Although 3.7% of the timber harvest was composed of hardwoods in the 1980s, this will probably rise to 11.4% by the year 2000, mostly from red alder (Sessions 1989).

Despite the increasing economic importance and widespread occurrence of red alder in riparian and upland sites, only Gomez (1992) quantified small mammal or amphibian communities in the Oregon Coast Range. He found higher abundance of small mammals and amphibians in red alder than in old-growth Douglas-fir (*Pseudotsuga menziesii*) forests (Gomez 1992). The importance of streamside habitat for maintaining small mammal diversity and abundance in western coniferous forests has been described in southwest Oregon (Cross 1985), the Oregon Cascades (Anthony *et al.* 1987, Doyle 1990), and the central Oregon Coast Range (McComb et al. 1993, Gomez 1992). There is considerable geographic variation in responses of small mammals to riparian habitat (Raedeke 1988).

Managers need information on vertebrate use of streamside and upland habitats, including red alder stands, if they are to meet guidelines established by the National Forest Management Act and the Oregon Forest Practices Act (OFPA). The OFPA protects riparian vegetation along fish-bearing streams for anadromous fish and to reduce non-point source pollution (Brazier and Brown 1973). The effects of OFPA regulations on terrestrial vertebrates are unknown. However, Brown (1985: appendix 8) indicated that 97 species of terrestrial vertebrates would breed in closed sapling-pole red alder stands (the most mature stand condition he reported for red alder) and 114 species use this stand condition for feeding. Slightly higher use was predicted for closed sapling-pole hardwood and shrubby wetland stands (102 breeding, 140 feeding). Although the accuracy of these predictions has not been assessed, managers are widely using this information to make decisions.

Our objectives were to: 1) compare habitat characteristics and abundance of small mammals and amphibians between streamside and upland sites in 40- to 50-year-old red alder stands in the central Oregon Coast Range, 2) examine habitat relationships of small mammals and amphibians in these stands, and 3) compare the species that we detected in these stands to those predicted in a habitat relationships model (Brown 1985).

Study Area and Methods

We selected three 40- to 50-year-old red alder stands adjacent to or including second-order

Figure 1. Location of study areas in the central Coast Range, Oregon.

streams in the central Coast Range of Oregon (Fig. 1). All stands contained one or more first-order streams. Streams adjacent to and within the stands were 0.2-4.0 m wide, and 0.2-2.0 m deep. These stands are typical of human-induced (20-30 ha), unmanaged Coast Range alder forests. The northern stand (Fig. 1) was about 10 km west of Nashville (45°50′ lat., 124°, 40′ long.) resulting from secondary succession following abandonment of old fields. The other two stands, one about 15 km southwest of Alsea (45°40′ lat., 124°40′ long.) and about 3 km east of Sumner (43°30′ lat., 123°10′ long.) resulted from natural regeneration following harvest of Douglas-fir in the 1940-1950's. Although the overstory was dominated by red alder (basal area=26 m²/ha), scattered residual Douglas-fir and western redcedar (*Thuja plicata*) (basal area=5 m²/ha) were present in the stands. The shrub layer was dominated by salmonberry (*Rubus spectabilis*) and thimbleberry (*Rubus parviflorus*). Herbaceous vegetation was mostly sword fern (*Polystichum munitum*) and grasses.

We sampled the Nashville and Alsea stands in 1988 and the Sumner stand in 1989. We established three 10 x 10 sampling grids (135 x 135 m) in each stand such that second-order streams were adjacent to or included within each grid (Fig. 2). Points within grids were 15 m apart, lines of points were parallel to the stream, and they extended 60-135 m up the slope. Grids were >50 m from edges of adjacent stands. We determined the structure and composition of the habitat at each point by measuring habitat characteristics from the grid point (distances or basal area) or in a 5-m radius circle around the point (plant coverages, densities, and log lengths/79 m², Table 1). All foliage cover estimates were made prior to leaf fall.

We defined streamside habitat (74-142 sample points/stand) as <10 m of the high-water mark of any permanent stream, corresponding to the minimum OFPA buffer strip width for streams ≤4 m wide. Also, we included the full floodplain as streamside habitat on sites where the floodplain extended > 10 m from the stream (maximum = 35 m). Habitat ≥50 m from streams was considered

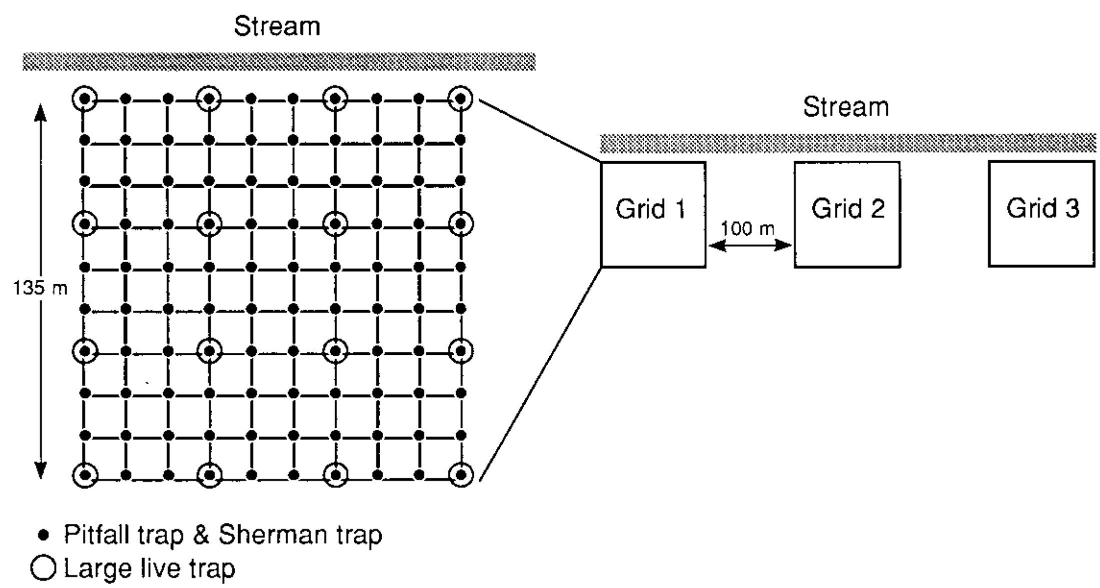

Figure 2. Schematic diagram of the sampling grid system used in the study.

TABLE 1. Average (SE) habitat characteristics among three habitat types in three red alder stands, Oregon Coast Range, 1988-89.

Characteristic	Streamside	Transition	Upland	P^1
Distance to water (m)	5.9 (2.7)	32.1 (2.5)	71.2 (1.8)	0.0495
Slope (%)[2]	41.5 (2.8)	43.7 (2.8)	48.8 (5.2)	0.2752
Rock cover (%)[3]	2.0 (1.3)	0.2 (0.1)	0.3 (0.2)	0.1266
Slash cover (%)[3]	1.7 (0.9)	1.0 (0.5)	1.5 (0.5)	0.8273
Litter depth (mm)[4]	4.6 (1.0)	6.4 (2.0)	7.0 (1.9)	0.2752
Logs (m/79 m²)				
10-19 cm diameter	16.5 (3.1)	16.5 (3.6)	15.9 (2.5)	0.8273
19-49 cm diameter	4.3 (1.7)	2.6 (0.9)	3.0 (1.0)	0.8273
50+ cm diameter	1.9 (1.0)	1.7 (0.9)	1.9 (1.1)	0.8273
Total	22.8 (4.9)	20.9 (5.0)	20.9 (3.6)	0.8273
Snags[5]/79 m²	0.5 (0.1)	0.7 (0.2)	0.8 (0.2)	0.2752
Stumps[6] >10 cm/79 m²	0.8 (0.3)	0.9 (0.2)	1.1 (0.3)	0.2752
Basal area (m²/ha)				
Deciduous	25.9 (1.2)	25.9 (0.7)	27.5 (3.9)	0.5127
Evergreen	3.2 (0.5)	4.9 (0.7)	8.2 (2.5)	0.1266
Total	29.1 (1.7)	30.8 (1.5)	35.7 (3.4)	0.0495
Woody plant cover (%)[3]				
Deciduous 0-1 m tall	6.6 (0.7)	3.0 (0.5)	2.7 (0.2)	0.1904
Deciduous 1.1-5 m tall	22.8 (1.5)	13.6 (1.3)	21.9 (0.8)	0.9999
Deciduous > 5 m tall	54.0 (1.4)	51.7 (1.3)	56.1 (0.8)	0.9999
Evergreen 0-1 m tall	0.1 (0.1)	0.1 (0.1)	1.2 (0.2)	0.3537
Evergreen 1.1-5 m tall	0.1 (0.1)	1.2 (0.3)	1.2 (0.2)	0.5066
Evergreen > 5 m tall	2.8 (0.7)	3.9 (0.8)	7.0 (0.6)	0.3827
Tree density/79 m²				
Deciduous 5-39 cm dbh	3.0 (0.8)	4.5 (0.3)	4.4 (0.2)	0.0495
Deciduous 40-79 cm dbh	0.4 (0.2)	0.3 (0.1)	0.4 (0.2)	0.8273
Deciduous >80 cm dbh	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.3758
Evergreen 5-39 cm dbh	0.1 (0.1)	0.3 (0.1)	0.8 (0.3)	0.1266
Evergreen 40-79 cm dbh	0.1 (0.1)	0.1 (0.1)	0.2 (0.1)	0.2752
Evergreen > 80 cm dbh	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.2752
Fern cover (%)[3]	23.2 (1.6)	33.4 (1.9)	36.7 (1.0)	0.1904
Forb cover (%)[3]	13.8 (1.1)	9.2 (0.8)	4.9 (0.3)	0.0809
Grass cover (%)[3]	3.3 (0.9)	3.1 (0.7)	1.6 (0.2)	0.6625

[1]Comparing streamside with upland, Wilcoxon sign-rank test.

[2]Measured with a clinometer 5 m upslope and downslope from plot center.

[3]Ocular estimate of coverage.

[4]Measured at 5 systematically arranged points within 5 m of plot center.

[5]Dead stems > 5 cm dbh. > 2 m tall.

[6]Dead stems > 5 cm dbh. < 2 m tall.

upland because McComb *et al.* (1993) found that capture rates for four small mammal species decreased dramatically beyond 50 m from streams in coniferous forests. All remaining habitat was considered transitional between streamside and upland.

We established one pitfall trap and one Sherman live trap within 2 m of each grid point. Pitfalls were number 10 tin cans, double deep, set flush with the surface of the ground along logs, rocks, slope breaks or other natural drift fences where they were available (Corn and Bury 1990). To keep pitfalls free of water accumulation, we put drain holes in the cans and placed a metal cover approximately 10-15 cm above each pitfall. We tried to keep animals alive by supplying both Sherman traps and pitfalls with polyester bedding, hamster chow, peanut butter and rolled oats as bait. Sixteen regularly-spaced grid points on each sampling area had wire cage traps (20 x 20 x 90 cm, Tomahawk) for sampling larger mammals. These traps were covered with polyethylene plastic for protection from rain and they were baited with sardines. Traps were set for eight consecutive nights in the early fall 23 August to 20 September, prior to most rains) and late fall (3-22 November, during consistent rains). All three sampling grids per stand were sampled simultaneously. Stands were sampled consecutively. Although capture rates for some species varied between sampling seasons, the distribution of captures among habitat types did not differ between seasons in this study, McComb *et al.* (1993), or (except for 3 small mammal species) Gomez (1992).

Animals that were captured alive were either ear-tagged or toe-clipped and released at the point of capture. Both living and dead animals were identified to species and the location of capture was recorded.

Statistical Analyses

Habitat characteristics and capture rates of species with >20 initial captures (recaptures were not considered) were compared between streamside and upland habitats with a Wilcoxon sign-rank test ($n=3$ stands). Stands were considered independent observations for these analyses. Populations were not estimated using standard mark-recapture methods because sampling grids were divided into habitat types for most analyses and because mortality of insectivores was too high (>30%).

We assessed habitat associations for species with >20 capture locations (8 species). We used Pearson product moment correlation to examine associations between captures per sampling grid and average habitat characteristics per sampling grid ($n=9$). These habitat analyses should be considered exploratory because grids within stands were probably more dependent on one another than were grids among stands. Hence, there is the potential for results to be confounded by stand effects.

Results and Discussion

Habitat characteristics

We were unable to detect differences between streamside and upland habitat in 25 of 28 characteristics (not including distance to water, Table 1). Deciduous trees 5-39 cm dbh were less abundant and total tree basal area was lower in streamside than upland habitats (Table 1). Cover by forbs was higher along streamsides than in uplands. There was a trend toward greater rock cover, evergreen basal area, and density of 5- to 39-cm dbh evergreens in streamside than in upland habitat ($P=0.13$).

Animal Abundance

Amphibians. We captured 228 amphibians (8 species) and 10 reptiles (1 species) during 14,400 pitfall trap-nights. Roughskin newts (*Taricha granulosa*) were the most common amphibian in both streamside and upland habitats. We could not detect differences between streamsides and upland habitats in the relative abundance of roughskin newts (Table 2). However, capture rates for Ensatina salamanders (*Ensatina eschschlotzi*) were higher in upland than in streamside habitat (Table 2). McComb *et al.* (1993) and Gomez (1992) also found Ensatina salamanders more strongly associated with upland than riparian habitat in Coast Range conifer forests. Although some amphibian species require free water for reproduction, total amphibian captures were not associated with streamside habitat in these red alder stands. Average capture rates of Pacific giant salamanders (*Dicamptodon tenebrosus*, 0.9-1.9/1,000 trapnights [TN]) and Ensatina salamanders (1.5-6.4/1,000 TN) were similar to rates reported by Corn and Bury (1991) in unmanaged Douglas-fir forests (0.4-0.5 and 4.5-5.1/1,000 TN, respectively). Gomez (1992) did not find differences between red alder-dominated and conifer-dominated stands in the relative abundance of Pacific giant salamanders or Ensatinas. However, roughskin newt capture rates were higher on our sites (6.5-7.2/1,000 TN) than in unmanaged Douglas-fir forests (0.3-1.1/1,000 TN, Corn and Bury 1991). Gomez (1992) also captured more roughskin newts in red alder than in seral Douglas-fir stands. Western redback salamander (*Plethodon vehiculum*) capture rates were lower on our sites (0.7-2.2/1,000 TN) than in Douglas-fir forests (4.9-8.1/1,000 TN, Corn and Bury 1991). Gomez (1992) captured more redback salamanders in red alder than in pole-stage Douglas-fir stands. Corn and Bury (1991) considered northwestern salamanders (*Ambystoma gracile*) rare in Douglas-fir forests, but they were as abundant as Pacific giant salamanders on our sites (Table 2) and on Gomez's (1992) sites.

Dunn's salamanders (*Plethodon dunni*) were found to be streamside associates by both Gomez

TABLE 2. Average (SE) mammal and amphibian captures/1,000 trap nights among three habitat types in three red alder stands, central Oregon Coast Range, August–November 1988, 1989.

Species	Trap Type[1]	*n*	Streamside	Transition	Upland	*P*[2]
Amphibians						
Roughskin newt	P	98	6.7 (4.4)	6.5 (3.9)	7.2 (5.5)	0.2752
Ensatina salamander	P	50	1.5 (0.4)	2.6 (1.8)	6.4 (2.9)	0.0459
western redback salamander	P	21	2.2 (1.5)	1.2 (0.8)	0.7 (0.4)	0.2752
Red-legged frog	P	19	2.1 (1.5)	1.2 (0.8)	0.7 (0.4)	
Pacific giant salamander	P	18	0.9 (0.7)	0.9 (0.5)	1.9 (1.5)	
northwestern salamander	P	13	0.9 (0.9)	1.4 (1.1)	1.3 (0.7)	
Other species [3]		9	0.4 (0.2)	0.5 (0.5)	0.3 (0.3)	
Total	P	228	15.1 (2.4)	14.6 (2.5)	18.1 (2.8)	0.4298
Mammals						
Deer mouse	S	562	36.0 (3.3)	33.5 (2.7)	39.5 (7.8)	0.5127
Trowbridge's shrew	P,S	263	9.1 (1.0)	9.5 (1.7)	9.8 (0.6)	0.5127
Pacific shrew	P,S	89	4.2 (1.7)	2.2 (0.9)	3.1 (1.4)	0.5127
Townsend's chipmunk	S	45	1.6 (0.6)	4.3 (1.4)	3.4 (1.8)	0.5127
Oregon vole	P,S	25	0.8 (0.6)	0.9 (0.3)	0.9 (0.9)	0.8166
Northern flying squirrel	T,S	14	0.0 (0.0)	0.2 (0.2)	2.4 (2.4)	
Virginia opossum	T	11	8.5 (4.1)	3.1 (1.3)	3.5 (1.8)	
Other species [3]		79	2.6 (0.7)	1.7 (0.4)	1.9 (0.8)	
Total		1088	36.0 (0.7)	33.4 (5.3)	38.7 (5.3)	0.5127

[1]Pitfall (P) trapnights=14,400; Sherman (S) trapnights=14,400; Tomahawk (T) trapnights=2,304. Captures/1000 trapnights are based on trapnights/trap type.

[2]Wilcoxon sign-rank test.

[3]Reptiles and amphibians with <10 captures along streamsides (S), upland (U), or both (B): tailed frog (U), Dunn's salamander (S), and common garter snake (S).

[4]Mammals with <10 captures along streamsides (S), upslope (U), or both (B): Mountain beaver (*Aplodontia rufa*, S), California red-backed vole (B), long-tailed vole (S), Townsend's vole (S), ermine (B), house mouse (*Mus musculus*, S), dusky-footed woodrat (*Neotoma cinereus*, B), shrew-mole (B), red tree vole (U), raccoon (*Procyon lotor*, S), black rat (*Rattus rattus*, S), Coast mole (U), Townsend's mole (S), marsh shrew (B), western spotted skunk (S), eastern cottontail (*Sylvilagus floridanus*, U), and Douglas squirrel (*Tamiasciurus douglasii*, B).

(1992) and McComb *et al.* (1993). Gomez (1992) also identified tailed frogs (*Ascaphus truei*), red-legged frogs (*Rana aurora*), Pacific giant salamander, and roughskin newts as streamside associates in the Oregon Coast Range.

Mammals. We captured 1,088 mammals (24 species) in 31,104 trap-nights (all three trap types). The mammal community was dominated by deer mice (*Peromyscus maniculatus*), Trowbridge's shrews (*Sorex trowbridgii*), Pacific shrews (*S. pacificus*), and Virginia opossums (*Didelphis virginiana*). We did not detect differences between streamside and upland habitats in the capture rates of four species with >20 captures, nor did total small mammal captures differ between streamside and upland habitats (Table 2). Capture rates of Pacific shrews (2.2-4.2/1,000 TN) and Trowbridge's shrews (9.5-9.8/1,000 TN) were lower in the red alder stands that we sampled than in conifer stands (2.5-6.0 and 13.5-19.1/1,000 TN, respectively, Corn and Bury 1991). Gomez (1992) did not detect differences between red alder and conifer stands in the relative abundance of Pacific shrews, but he found shrew-moles (*Neurotrichus gibbsii*) and Trowbridge's shrews more abundant in red alder than in Douglas-fir stands.

The affinity of various species for streamside habitat seems to vary geographically and from one plant community to another. Cross (1985) reported higher abundances of deer mice, Pacific shrews, shrew-moles, and Pacific jumping mice in streamside zones than in upland or transition zones in southwest Oregon. Doyle (1990) reported higher relative abundance in streamside than upland habitat for five of ten small-mammal species trapped on fourth- and fifth-order streams in the western Cascades, including 4 species found on our study sites: Trowbridge's shrew, deer mouse, Oregon vole

(*Microtus oregoni*), and ermine (*Mustela erminea*) (Doyle 1990). Doyle (1990) also found more California red-backed voles and Townsend's chipmunks (*Tamias townsendii*) in upland than riparian habitats. McComb *et al.* (1993) found no difference in total small mammal captures between upland and streamside habitats in coniferous forests. However, both McComb *et al.* (1993) and Gomez (1992) reported higher capture rates along streamsides for Pacific jumping mice (*Zapus trinotatus*), marsh shrews (*Sorex benderii*), long-tailed voles (*Microtus longicaudus*), and white-footed voles (*Phenacomys albipes*) and higher capture rates in upland habitats for California red-backed voles (*Clethrionomys californicus*). Gomez (1992) also found Pacific shrews and Townsend's voles (*M. townsendii*) associated with streamsides in the central Oregon Coast Range. Streamside habitat in the McComb *et al.* (1993) study was dominated by red alder and uplands were dominated by Douglas-fir, so some of these species may have been responding more to differences in tree communities than to proximity to free water.

There are at least three reasons why we were unable to detect differences between streamside and uplands habitats in capture rates for small mammals in our study. First, mammal community structure between streamside and upland habitats may be largely a function of differences in habitat structure and composition (Doyle 1990, McComb *et al.*, 1993). In our study, upland and streamside habitats were similar in structure and composition, and the capture rates of the common small mammals was similar between the two habitats as well. Second, McComb *et al.* (1993) found that although capture rates for marsh shrews, shrew-moles, deer mice and Pacific jumping mice declined beyond 50 m from the stream, capture rates for California red-backed voles and Trowbridge's shrews did not increase until > 200 m from a permanent stream in coniferous Coast Range forests. Thus, the upland red alder habitat that we sampled may have been too close to water to affect capture rates of some species. Finally, our sample sizes were small ($n=3$), so the power of our tests was low.

Habitat Relationships

The capture rates of five species were associated ($r > 0.7$, $P < 0.05$) with ≥1 habitat feature. Capture rates of roughskin newts and Oregon voles were positively associated with the length of logs > 19 cm in diameter ($r > 0.70$) and with the number stumps ($r > 0.78$), while Pacific shrew capture rates were negatively associated with these features ($r = -0.71$, logs; $r = -0.77$, stumps). Further, roughskin newt capture rates were associated with evergreen shrub cover ($r = 0.84$) and deciduous tree basal area ($r = -0.71$). Capture rates for Townsend's chipmunks were associated with deciduous shrub cover ($r = 0.87$) and fern cover ($r = -0.76$), and capture rates for Trowbridge's shrews were associated with grass and forb cover ($r = -0.88$). The habitat relationships for small mammals are generally consistent with observations made by Maser *et al.* (1981), but several (log associations with Oregon voles, evergreen shrubs with roughskin newts) were opposite of associations detected by Gomez (1992) among red alder and Douglas-fir stands. Roughskin newts that we captured were probably migratory individuals that sought cover during their movements.

Comparisons with a Wildlife Habitat Relationships Model

These data gave us the opportunity to test Brown's (1985) predictions of species occurrence in red alder stands. Two major types of errors exist with a wildlife habitat relationships model: 1) the species was found using a habitat type but use was not predicted by the model, 2) the species was not found using the habitat type but use was predicted by the model. Of these errors, the first type can be detected with the greatest confidence. The second type of error is more difficult to detect because the sampling strategy may be inappropriate for certain species, insufficient stands may have been sampled, or if the species was rare, it may have been missed by chance. More subtle errors occur in designation of habitat types as primary (a preferred or optimal habitat necessary for long-term population maintenance) vs. secondary (used by a species, but less suitable than primary habitat) (Brown 1985). Further, Brown (1985) designated habitats as secondary where data were insufficient to clearly identify it as primary.

Streamside Pole Stands.—Our streamside samples were most similar to the closed sapling-pole stand condition of the hardwood and shrubby wetland plant community described by Brown (1985). We caught 6 of 10 reptile and amphibian species and 12 of 20 mammal species that were predicted by Brown (1985) to use this habitat type for feeding, resting or breeding in this geographic region (within constraints of the sampling techniques). Western spotted skunks (*Spilogale gracilis*) were captured at two of the three sites and should be considered species that use streamside pole stands at least as secondary habitat. Six other species each were captured in only one stand: northwestern salamander, common garter snake (*Thamnophis sirtalis*), California red-backed vole, long-tailed vole, Townsend's mole (*Scapanus townsendii*), and coast mole (*Scapanus orarius*). Streamside pole stands may provide some habitat for these species, but these species should not be considered typical users of this habitat type.

Brown (1985) characterized closed-sapling pole riparian hardwood stands as being secondary habitat for western redback salamanders, deer mice, Trowbridge's shrews, Pacific shrews, and Townsend's chipmunks. These species were abundant in the streamside habitat that we sampled and they were consistently captured at all stands. Riparian hardwood closed-sapling pole stands probably should be considered primary habitat for these species.

Upland Pole Stands. Our upland samples were most similar to the closed sapling- pole stand condition of the red alder plant community described by Brown (1985). We caught 6 of 10 reptile and amphibian species and 13 of 17 mammal species that were predicted to use this habitat type for feeding, resting or breeding in this geographic region. California red-backed voles were captured at two of the three sites, so these stands may represent secondary habitat for this species. Tailed frogs, red tree voles (*Phenacomys longicaudus*), and Townsend's moles were each captured in only one stand. Upland pole stands may provide some habitat for these species, but they should not be considered typical users of this habitat type.

Brown (1985) characterized these upland pole stands as being secondary habitat for western redback salamanders, deer mice, Pacific shrews, Virginia opossums, and Townsend's chipmunks. These species were abundant in the upland habitat that we sampled and they were consistently captured at all stands. Red alder closed-canopy pole stands probably should be considered primary habitat for these species.

Management Implications

Oregon Forest Practices Act guidelines state that a riparian management area (RMA) shall be maintained on all fish-bearing streams. Its width is to average three times the stream width but it must not be <7.6 m, and need not be >30.3 m wide. Following harvest adjacent to the RMA, all preharvest logs, some live conifers, 50% of the preharvest shade level, and 75% of the shade over the aquatic zone must be retained. However, federal land management agencies sometimes maintain wider (30-50 m) RMA's to meet other needs, such as snag requirements. Timber harvest, usually clearcutting, may occur outside of RMA's. If RMA's extend >10 m on each side of the stream and maintain a strip of preharvest habitat for small mammals and amphibians, then most of the species that we sampled might find at least marginal habitat in RMA's prior to harvest of adjacent upland areas. We will be assessing the influence of harvesting adjacent upland areas on these species in the future. If any of these species are adversely affected by induced edges (sensu Temple 1986), then narrow RMA's may not even provide marginal habitat for such species.

The stands that we studied were probably more heterogeneous than stands managed for red alder timber production. The heterogeneity among our sampling grids allowed us to assess the potential value to five species of including certain structural features within alder stands. For example, if upland red alder stands are harvested and regenerated with red alder, then retaining logs $>$ 19 cm in diameter may provide cover for migrating roughskin newts and resident Oregon voles. Brown (1985) identified $>$ 150 species of vertebrates in western Oregon and Washington that use logs, so benefits of log retention or recruitment extend beyond these two species. Large logs would be unlikely to occur or persist in these alder stands unless conifers (especially Douglas-fir and western redcedar) are at least a minor component of the stand. Douglas-firs were a minor component of the naturally regenerated stands that we studied, but they were probably responsible for providing at least marginal habitat for red tree voles and California redbacked voles. We encourage land managers to consider managing alder stands that contain a minor component of Douglas-fir or western redcedar if enhancing vertebrate species richness is a goal.

Providing logs or conifers in small ($\sim$0.5-ha) patches could reduce interference with harvesting operations and intermediate treatments. Conifers grown in these patches would add compositional complexity and log recruitment to the stand. Capture rates of several species were associated with cover of either deciduous shrubs, primarily salmonberry and thimbleberry (also shrew-moles and Pacific jumping mice, Gomez 1992), or evergreen shrubs, predominantly salal (*Gaultheria shallon*), Oregon-grape (*Berberis* sp.), and huckleberry (*Vaccinium* sp.) (also tailed frogs and California red-backed voles, Gomez 1992). Hence, some effort should be made during site preparation and vegetation management to maintain a mixture of these species during stand development. Most of the deciduous shrubs in these stands reproduce vegetatively, so they may resprout after fire or mechanical site preparation. Patches of huckleberry and Oregon-grape may need some protection from site preparation to ensure their dominance in the developing stands. These recommendations represent hypotheses that should be tested by land managers.

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