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Associations of Small Mammals and Amphibians with Beaver-occupied Streams in the Oregon Coast Range

Abstract

We examined the association between stream reach and riparian conditions influenced by beavers with capture rates of small mammals and amphibians. We compared vegetation structure and capture rates of small mammals and amphibians between stream reaches occupied by beaver and unoccupied reaches in 5 streams in the Oregon Coast Range. Percent cover by stinking currant and all shrubs combined was lower at occupied than unoccupied reaches. Cover by elderberry, grasses, and sedges was higher at occupied than unoccupied reaches. Capture rates of individual species of small mammals and amphibians did not differ between beaver-occupied and unoccupied reaches ($P > 0.1$). However, capture rates of species typically found in either early successional stages or ponds were higher in beaver-occupied areas. For instance, combined capture rates for 3 species of microtine voles were consistently higher at occupied than at unoccupied reaches ($P < 0.1$). Further, variability in capture rates was higher among occupied than unoccupied reaches for 5 species of small mammals ($P < 0.1$). We hypothesize that the high variability in capture rates is associated with more diverse vegetative and physical characteristics at beaver-occupied reaches. We also hypothesize that analyses conducted at larger spatial scales, including whole watersheds, may reveal contributions of beaver to riparian area heterogeneity and vertebrate diversity.

Introduction

Beaver (*Castor canadensis*) alter riparian areas through cutting woody plants and building dams (Naiman et al. 1988). Beaver dams modify stream hydrology, accumulate sediments, and increase wetted surface area of the channel (Gard 1961, Naiman et al. 1986). Beaver dams form pools that often benefit trout (*Salmo* spp.; Gard 1961) and coho salmon (*Oncorhynchus kisutch*; Bruner et al. 1992). Streamside areas flooded by beaver often function as wetlands that provide habitat for waterfowl (Beard 1953, Renouf 1972), furbearers (Beard 1953, Rutherford 1955), and non-game birds (Hair et al. 1978). Herbivory by beaver can reduce biomass and change the structure and composition of riparian forests (Johnston and Naiman 1990).

Despite the well-documented influence of beaver on a wide variety of vertebrates, little is known regarding how beaver influence habitat for small mammals and amphibians (Medin and Clary 1991). We are not aware of any published studies that assessed associations between beaver activities and amphibians. Streamsides generally support more small mammals (McComb et al. 1993) and amphibians (Gomez and Anthony 1996) and more diverse small mammal communities (McComb et. al 1993) than upslope areas in the Oregon Coast Range. Deciduous riparian forests support a particularly diverse small mammal community in the Oregon Coast Range (Gomez and Anthony 1996, Gomez and Anthony 1998). Beaver are often associated with deciduous riparian forests and they preferentially forage on deciduous trees and shrubs (Jenkins 1979, Bruner 1990). Consequently, the disturbances caused by beaver may influence habitat quality for small mammals and amphibians. For instance, changes in stream hydrology and rates of sedimentation caused by beaver might influence the abundance of amphibian species that require either clear-flowing streams or ponds for reproduction. Furthermore, small mammal species that are primarily associated with early seral plant communities might be positively influenced by openings created by beaver (Medin and Clary 1991). On the other hand, intense beaver herbivory might negatively influence the abundance and habitat quality of those species that are primarily associated with dense riparian forests.

Our objectives were 1) to compare vegetative and geophysical structure of habitat between

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beaver-occupied and unoccupied reaches and 2) to compare relative abundance and community structure of small mammals and amphibians between beaver-occupied and unoccupied reaches.

Study Area and Methods

Our study was conducted in 5 perennial 1st- and 2nd-order streams in the western slope of the Oregon Coast Range, Lincoln County, Oregon (Figure 1). Streams pass through steep and deeply cut mountain valleys; elevation ranges from near sea level to 860 m. The climate of the Oregon Coast Range is maritime characterized by wet, mild winters and cool, relatively dry summers; annual temperature averages 10°C and precipitation averages 250 cm (Franklin and Dyrness 1988:38-42). The study area lies within the western hemlock (*Tsuga heterophylla*) vegetation zone (Franklin and Dyrness 1988:70-88). Forest stands adjacent to 2 streams were 10-30 years old; the other 3 streams were adjacent to young stands on 1 side and stands 100-140 years old on the other side. Red alder (*Alnus rubra*) was the most dominant tree species along the 5 streams. Douglas-fir (*Pseudotsuga menziesii*) was present but usually found >30 m away from the stream. Understory vegetation was dominated by salmonberry (*Rubus spectabilis*).

Within each stream, we subjectively selected a pair of beaver-occupied and beaver-unoccupied reaches (Figure 1). Each pair of reaches was similar in stream order (1st or 2nd order), stream gradient (< 5%), and stand age. Within each reach, we established a 180-m transect parallel to and 8 m from the stream on each side of the stream. We also established a 180-m riparian-fringe transect approximately 20 m from 1 of the streamside transects at each reach. Trapping stations were established every 20 m along each transect. One pitfall trap (double-deep No. 10 tin can) and 2 Museum Special traps were placed at each trapping station. The Museum Specials were baited with rolled oats and peanut butter. No bait was used in the pitfall traps. The pitfall traps were activated on the second week of September, 1989 and remained open for 30 days. After 30 days of intermission, we

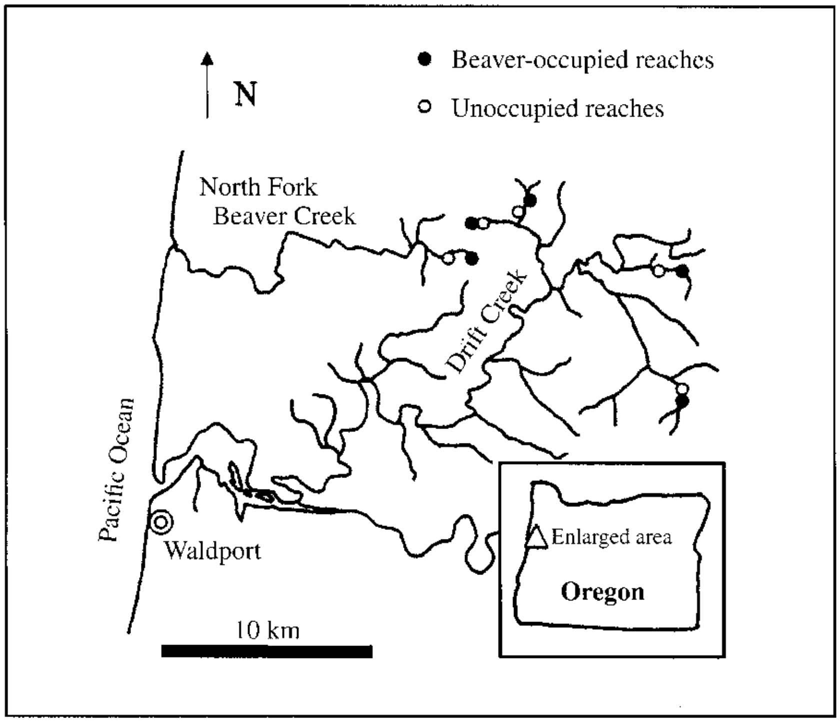

Figure 1. Location of study sites in the central Oregon Coast Range, Lincoln County, Oregon.

reactivated the pitfall traps on the second week of November, 1989 and kept them open for another 30 days. The Museum Specials were operated for 3 consecutive days during September, 1989. The pitfall traps were checked weekly and the Museum Specials were checked daily. We measured 28 variables that characterized floristics, vegetation structure, downed wood, and geomorphology at a 10-m radius plot centered on each pitfall trap (Suzuki 1992:41-43). We measured habitat variables from August-September 1989.

We compared captures per 100 trap nights (TN) of small mammal and amphibian species with > 20 total captures between beaver-occupied and unoccupied reaches with Wilcoxon signed-rank tests (SAS Institute 1990:626). We tested for equality of variances in capture rates of vertebrates between beaver-occupied and unoccupied reaches with F-tests; F was the ratio of the larger to the smaller sample variance in capture rates between beaver-occupied and unoccupied reaches (Steel and Torrie 1980:111-112). We compared habitat variables between beaver-occupied and unoccupied reaches with paired t-tests. In cases where habitat variables were not normally distributed we used appropriate transformations (log e or square-root) to improve the distribution of variables in the paired t-tests. We considered results with $P < 0.1$ as statistically significant in all analyses.

Results and Discussion

Beaver-occupied reaches had lower percent cover by total shrubs, tall shrubs, and stinking currants (*Ribes bracteosum*) than unoccupied reaches (Table 1). In contrast, percent cover by grasses, sedges, and elderberries (*Sambucus racemosa*) were higher along occupied reaches than at unoccupied reaches. Beaver alter species composition of riparian plant communities by selectively removing preferred species and by indirectly stimulating the growth of avoided species (Barnes and Dibble 1988, Johnston and Naiman 1990). In the Oregon Coast Range, beaver most often cut red alder, salmonberry, and vine maple (*Acer circinatum*) stems 2-9 cm in diameter (Bruner 1990). Therefore, the selective foraging by beaver probably decreased cover of preferred shrub species, especially in the tall shrub layer (1.4-3.9 m in height) and indirectly stimulated the growth of unbrowsed species, such as elderberry. The high percent cover by grasses and sedges at beaver-occupied reaches may be a result of removal of tall shrubs by beaver and increased soil moisture due to the high water table (Taylor 1970, Beier and Barrett 1987).

We captured 838 individuals of 16 species of small mammals and 131 individuals of 9 species of amphibian at beaver-occupied reaches. Fewer individuals (693) and species (15) of small mammals and comparable numbers (133) and species (8) of amphibians were captured on unoccupied reaches compared to occupied reaches. Some beaver-occupied reaches supported high abundances for pond-breeding amphibians (i.e., rough-skinned newts [*Taricha granulosa*] and northwestern salamanders [*Ambystoma gracile*] and several species of small mammals that are associated with herbaceous riparian or early-seral vegetation (Figures 2 and 3), but no species of small mammal or amphibian differed significantly in capture rates between beaver-occupied reaches and unoccupied reaches ($P > 0.1$). Nonetheless, given the observed differences in vegetation structure and composition between occupied and unoccupied stream reaches, we hypothesized that the following species collectively should have higher capture rates at occupied reaches: creeping voles ((*Microtus oregoni*, Goerts 1964), Townsend's voles ((*M. townsendii*, Goerts 1964), long-tailed voles (*M. longicaudus*, Maser et al. 1981:210), vagrant shrews (*Sorex vagrans*, Hooven et al. 1975, Borrecco et al. 1979), Pacific jumping mice ((*Zapus trinotatus*, Borrecco et al. 1979), deer mice (*Peromyscus maniculatus*, Gashwiler 1970, Hooven and Black 1976, Cross 1985), northwestern salamanders (Leonard et al. 1993:24), and rough-skinned newts (Leonard et al. 1993:56). Average capture rates collectively among these species was higher at occupied ($\bar{x}$ = 6.89 captures per 100TN) than at unoccupied ($\bar{x}$ = 4.06 captures per 100 TN) stream reaches. For instance, capture rates for 3 *Microtus* species combined (creeping vole, Townsend's vole, and long-tailed vole) was higher at beaver occupied reaches than at unoccupied reaches ($P = 0.063$). The consistently high capture rates for *Microtus* at beaver-occupied reaches probably was related to the presence of the dense cover of grasses and sedges near the water. Graminoid vegetation, which provides food and cover, and the presence of water are the primary factors that influence distributions and abundance of *Microtus* (Getz 1985:288).

There was inconsistency in capture rates among beaver-occupied reaches. Indeed, variability in capture rates was higher among beaver-occupied

TABLE 1. Vegetative and geomorphic characteristics of 5 pairs of beaver-occupied and unoccupied sites in the Oregon Coast Range, Lincoln County Oregon, 1989.

Characteristic	Mean (SE) Occupied	Mean (SE) Unoccupied	P[a]
Vegetative Cover (%)			
Red alder	23.6 (4.5)	34.3 (9.7)	0.205
Douglas-fir	12.3 (3.2)	9.7 (3.4)	0.664
Salmonberry	42.2 (4.3)	54.9 (7.6)	0.168
Vine maple	7.7 (3.5)	7.1 (1.9)	0.873
Elderberry	7.6 (2.7)	1.8 (0.8)	0.079 *
Red huckleberry			
(*Vaccinium parvifolium*)	2.0 (0.9)	2.1 (1.2)	0.872
Stinking currant	1.3 (0.4)	5.4 (2.2)	0.002 ***
Thimbleberry (*Rubus parviflorus*)	4.9 (2.1)	5.9 (3.1)	0.618
Total shrub	46.3 (4.7)	58.2 (6.3)	<0.001 ****
Grass	28.1 (6.7)	17.0 (6.4)	0.023 **
Sedge	11.7 (4.0)	3.4 (1.9)	0.060 *
Forb	33.6 (3.9)	32.4 (5.7)	0.780
Fern	16.6 (3.4)	20.3 (5.9)	0.896
Moss	13.9 (3.5)	20.6 (2.8)	0.224
Bare ground	13.0 (3.1)	8.5 (1.6)	0.177
Cover by Vertical Strata (%)			
Overstory tree (≥ 20 m in height)	22.5 (5.2)	35.0 (9.4)	0.112
Midstory tree (4-19 m)	24.9 (1.9)	24.9 (3.9)	0.990
Tall shrub (1.4-3.9 m)	38.2 (6.7)	54.4 (8.1)	0.091 *
Low shrub (0-1.3 m)	32.5 (2.2)	25.9 (3.0)	0.211
Herb	58.2 (5.0)	52.0 (3.9)	0.101
Tree Density (no./ha)			
Red alder	86.8 (21.9)	99.7 (35.7)	0.522
Douglas-fir	59.2 (13.0)	51.4 (21.5)	0.782
Log Density (no./ha)			
Total logs (all diameter classes)	130.9 (16.0)	158.1 (36.9)	0.411
Small logs (10-19 cm)	22.3 (5.4)	31.4 (8.2)	0.228
Medium logs (20-49 cm)	82.1 (9.1)	95.1 (28.1)	0.653
Large logs (≥ 50 cm)	26.5 (8.0)	31.6 (11.1)	0.426
Other Variables			
Litter depth (mm)	27.5 (2.7)	31.8 (2.3)	0.323
Bank Slope (%)	33.8 (5.6)	37.2 (6.0)	0.640

[a] *P*-values from paired *t*-tests comparing means between beaver-occupied and unoccupied sites (* $P < 0.1$, ** $P < 0.05$, *** $P < 0.01$, **** $P < 0.001$).

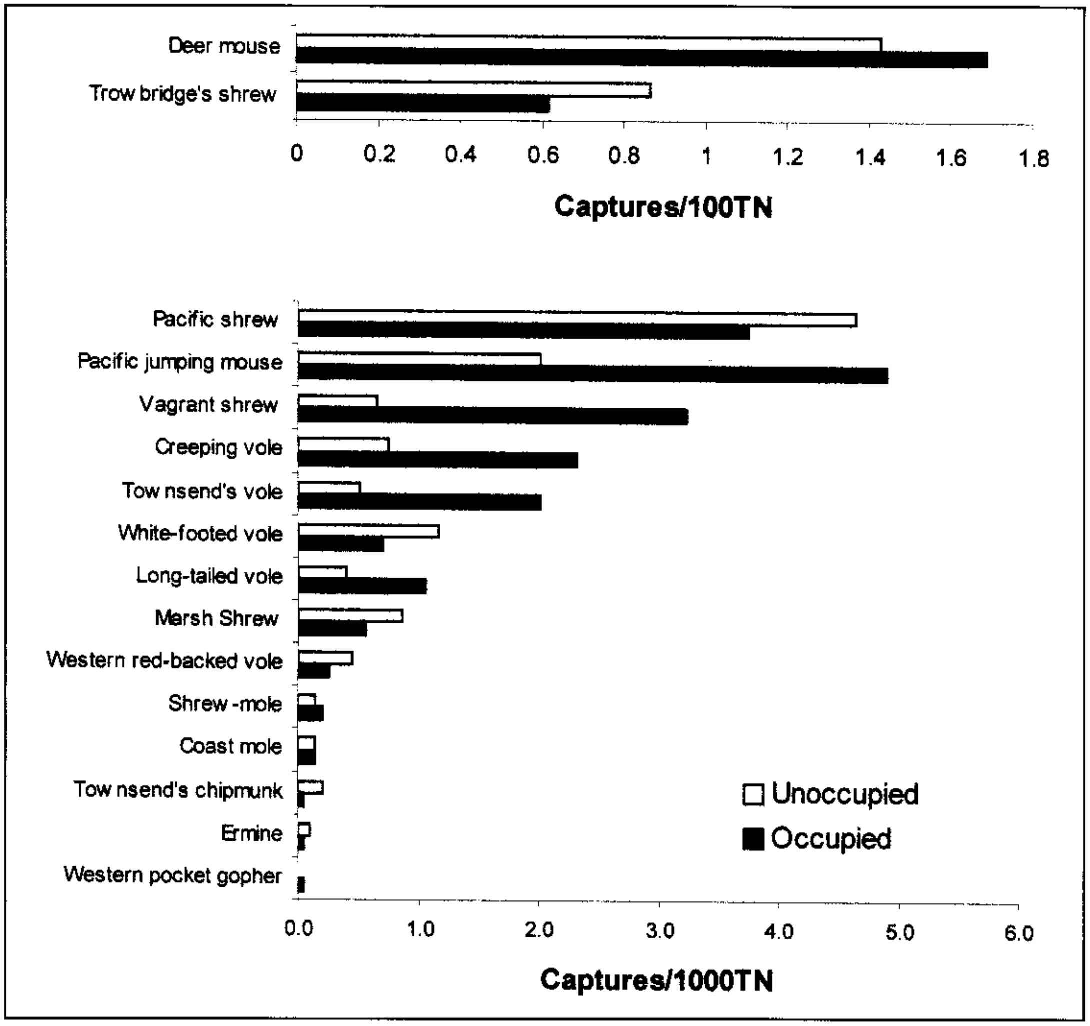

Figure 2. Associations of small mammal species (captures per 100 or 1000 trap nights) with beaver-occupied and unoccupied reaches in 5 perennial 1st- to 2nd-order streams in the Oregon Coast Range, Lincoln County, Oregon, 1989. Scientific names of species not mentioned in the text: marsh shrew (*Sorex bendirii*), Pacific shrew (*S. pacificus*), Trowbridge's shrew (*S. trowbridgii*), white-footed vole (*Arborimus albipes*), western red-backed vole (*Clethrionomys californicus*), shrew-mole (*Neurotrichus gibbsii*), coast mole (*Scapanus orarius*), Townsend's chipmunk (*Tamias townsendii*), western pocket gopher (*Thomomys mazama*), and ermine (*Mustela erminea*).

reaches than among unoccupied reaches for the following species: Pacific jumping mice ($F_{4,4}$ = 17.24, P = 0.009), creeping vole ($F_{4,4}$ = 8.56, P = 0.031), Townsend's vole ($F_{4,4}$ = 8.18, P = 0.033), long-tailed voles ($F_{4,4}$ = 15.94, P = 0.010), and vagrant shrews ($F_{4,4}$ = 40.98, P = 0.002). The high variability in capture rates may reflect a diversity of vegetative conditions among the beaver-occupied reaches. Vegetation at beaver-occupied reaches can be highly variable for many reasons. For example, differences in geomorphology can contribute to variability in foraging patterns, as well as shape and size of beaver ponds (Johnston and Naiman 1987). Variability in vegetation structure and composition also can occur because of the differences in initial vegetation type, successional stage of the pond, and hydrology among occupied reaches (Naiman et al. 1988). In California, there are at least the following 4 successional stages of beaver ponds: unsilted ponds, shallow sedge-marsh, grass-sedge

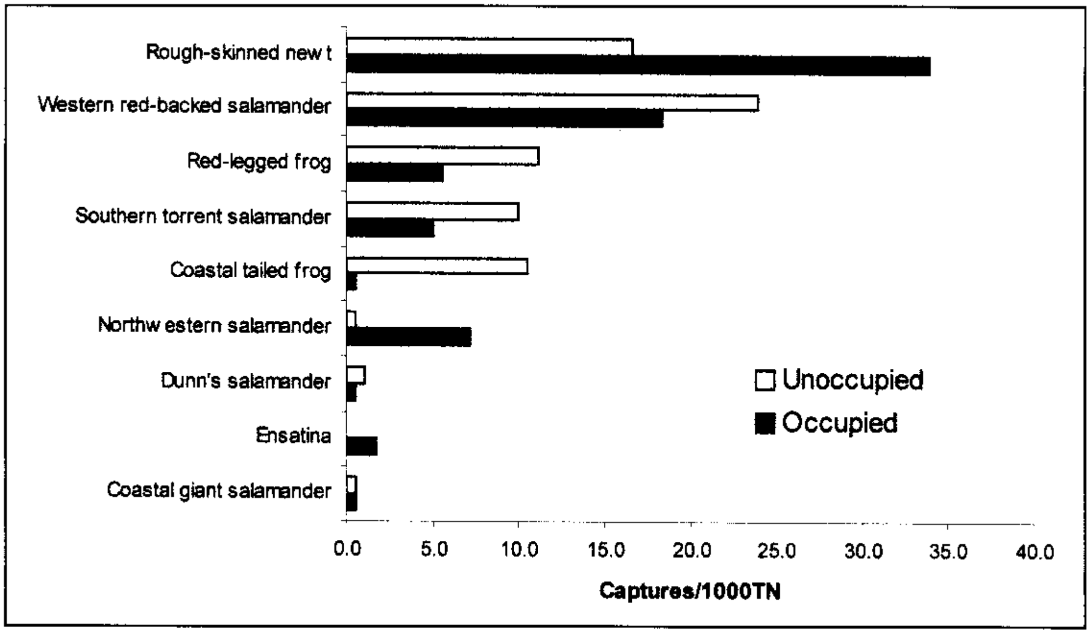

Figure 3. Associations of amphibian species (captures per 1000 trap nights) with beaver-occupied and unoccupied reaches in 5 perennial 1st- to 2nd-order streams in the Oregon Coast Range, Lincoln County, Oregon, 1989. Scientific names of species not mentioned in the text: southern torrent salamander (*Rhyacotriton variegatus*), western red-backed salamander (*Plethodon vehiculum*), coastal tailed frog (*Ascaphus truei*), red-legged frog (*Rana aurora*), ensatina (*Ensatina eschscholtzii*), coastal giant salamander (*Dicamptodon tenebrosus*), and Dunn's salamander (*Plethodon dunni*).

meadow, and dry grass meadow (Taylor 1970). In boreal forest, 32 wetland vegetation types are associated with beaver ponds, and general successional stages of ponds include emergent marsh, bogs, forested wetlands, and open water ponds (Naiman et al. 1988). Indeed, a study that examines animal community relationships with successional stages of beaver pond development may reveal a series of species associated with various seral stages. On a scale of an entire drainage basin over a long period of time, the various ecological conditions provided by beaver activities might contribute to a diversity of vegetative conditions and associated diversity of small mammal and amphibian communities in much the same way that landscape complexity is associated with small mammal and amphibian diversity (Martin and McComb 2002, 2003).

Scope and Limitations

We identified the scope and limitations of our study to ensure the appropriate use of the research results and to suggest improvement of study design and future areas of research. First, the geographical scope of this study was 1st- to 2nd-order mountain streams of the central Oregon Coast Range occupied by beaver. Because influences of beaver could be different in regions of arid climate or gentle topography, the results may not be applicable to other regions. Second, we compared only 5 pairs of beaver-occupied and unoccupied reaches. Considering the high variability of ecological conditions among beaver-occupied reaches, we feel that our sample size may not have adequate statistical power to reject the null hypothesis at $\alpha = 0.1$. Third, we sampled vertebrates during only one year. Consequently, we could not account for variability between years in the analysis and did not address long-term population trends of vertebrates between beaver-occupied and unoccupied reaches. Fourth, small mammals and amphibians were collected in fall; therefore, we were not able to address seasonal variability in abundance of small mammals and amphibians. Although differences in hydrology and vegetation may be most pronounced in the fall after a prolonged dry period, many species breed in spring, so different results might be expected if sampling were conducted in spring. Fifth, we consider the influence of beaver at the scale of stream reach and did not consider relationships at watershed scales. We might detect differences in abundance of small mammals and amphibians if watersheds with high beaver populations were compared to watersheds with low populations. Further study is necessary to understand the influence of beaver on small mammals and amphibians among seral stages and over larger spatial scales.

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