The Riparian Ecosystem Management Study: Response of Small Mammals to Streamside Buffers in Western Washington

Martin G. Raphael and Randall J. Wilk

Abstract

One of the fundamental concepts behind the conservation strategy in the U.S. federal Northwest Forest Plan is the importance of habitat buffers in providing functional stream and streamside ecosystems. To better understand the importance of riparian buffers in providing habitat for associated organisms, we investigated responses of small mammals to various streamside management options in western Washington forests. First, we conducted a retrospective study at 49 first- to third-order streams on state, federal, and private lands on the Olympic Peninsula, Washington. Streams represented six forest and stream-buffer conditions ranging from unlogged control to young second growth with no buffers. Because of high variability among sites within each condition, we found few differences in responses of mammals to site conditions; however there were species-specific associations with stream size, gradient, and site elevation. In hopes of reducing site variability, we subsequently undertook an experimental study on state lands in western Washington along 23 first- and second-order headwater streams to evaluate small mammal populations both before and after riparian and upland forest treatment. The four treatments, grouped within blocks of adjacent catchments, included an unlogged control, and continuously buffered streams, patch-buffered streams, and unbuffered streams within upland clearcuts. We sampled small mammals in 2003 before logging and then for two years following logging. We found significant changes in abundance of most common species following logging, including a decline in abundance of Keen's Mouse (*Peromyscus keeni*) in all treatments relative to controls, and increases in abundance of the Creeping Vole (*Microtus oregoni*), Southern Red-backed Vole (*Myodes gapperi*), and Townsend's Chipmunk (*Tamias townsendii*). We found capture rates of some of the more specialized species were too low to allow conclusions about treatment effects. For these rarer species, more focused autoecological studies will be needed to better evaluate their habitat relationships along headwater streams and their potential responses to streamside buffer treatments.

Keywords: Riparian buffers, small mammals, streamside management.

Introduction

Management of streamside vegetation is a major component of the Northwest Forest Plan for federally managed lands in western California, Oregon, and Washington (FEMAT 1993). One of the fundamental concepts behind the conservation strategy in the Northwest Forest Plan is the importance of riparian habitat buffers in providing functional stream and streamside ecosystems. These buffers, as proposed by the Scientific Analysis Team (Thomas et al. 1993) and FEMAT (1993) are meant to conserve habitat conditions not only for at-risk stocks of

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fish but also a diverse range of riparian-associated organisms including lichens, liverworts, fungi, vascular plants, invertebrates, and vertebrates (USDA and USDI 1994). The size of these buffers, and their placement on all stream orders including headwater and intermittent streams, has resulted in the reservation of a large portion of the landscape, ranging from 30 percent to 70 percent of the federal land base (USDA and USDI 1994). Although the size of these buffers was determined from a thorough review of existing literature, very few field data were available comparing the efficacy of alternative buffer designs at the time of their conceptual development. Understanding relationships between biodiversity and watershed function and watershed condition may lead to opportunities to better balance commodity production and protection of streamside habitat.

Much attention has focused on the role of buffers in conserving spawning habitat for salmonids and in providing habitat for streamside and aquatic amphibians. Less attention has focused on the efficacy of these buffers for conservation of small mammals. In a recent review, Anthony et al. (2003) noted that 95 of the 147 mammal species of Oregon and Washington use riparian zones to varying degrees. They classified the degree of association for each of these 95 species and found that 9 are riparian obligates (they require free water or riparian vegetation for some aspect of their natural history); 33 are riparian associates (they are found at statistically greater abundance in riparian habitats compared with uplands); 5 are early-seral species that use recently cut-over forest along streams, and 52 are non-riparian species that use riparian ecosystems but whose abundance in riparian habitats does not differ from abundance in upland habitats. Given that a large number of mammalian species use riparian forest, we undertook retrospective and experimental studies to investigate how small mammals respond to riparian buffers retained during upland forest harvest practices in western Washington.

Retrospective Study

As a preliminary effort toward better understanding the importance of riparian buffers in providing habitat of associated organisms, we initiated a retrospective study of responses of aquatic and terrestrial organisms to various streamside management options (Raphael et al. 2002). Experimental manipulation of riparian systems, evaluated both before and after treatment, is a preferable approach, but such treatments were not possible on federally managed lands during development of our study in the mid-1990s in western Washington. We gained insights using our retrospective approach of past management practices to more effectively develop a later manipulative study, detailed below.

Using a retrospective approach, sixty-two study sites were located on the west and south sides of the Olympic Peninsula, Washington, on state, federal, and private lands outside the Olympic National Park. A study site included a 300-m stream reach plus the adjacent forest area. We chose 300 m as our standard because we suspected that a shorter reach would likely reflect the effects of upstream influences rather than the channel and adjacent stands. Streams were usually first- to third-order, and <3 m across the wetted portion. We selected sites representing six forest conditions:

1. Old forest: unmanaged with intact forest on both sides of the stream;
2. Buffered old forest: old forest with adjacent clearcuts leaving buffers of 10 to 30 m;
3. Young forest: 35- to 100-year-old forest with no adjacent harvest;
4. Thinned young forest: 35- to 100-year-old forest with commercial thinning extending to the stream;
5. Buffered young forest: 35- to 100-year-old forest with adjacent clearcuts leaving 10- to 30-m-wide buffers of young forest adjacent to the stream; and

6. Early regeneration forest: 0- to 35-year-old forest on recent clearcuts with no intact buffer.

Stand types were not equally distributed across the study area because of differing ownerships and management practice histories.

Our approach was a retrospective analysis that examined existing forest condition resulting from past management practices with different intervals since logging, with and without streamside buffers. Raphael et al. (2002) sampled mammals along transects that ran parallel to the stream. We established two transects along each stream reach, one close to the stream (generally within 20 m) and one upslope, spaced 100 m apart. Raphael et al. (2002) reported results from only the near-stream transect, and those are the findings reported here because they pertain more directly to the riparian buffer portion of the study. Small mammals were trapped with Sherman live-traps. Pairs of traps were placed at 10-m intervals along transects for a total of 62 traps per transect.

Total small mammal captures averaged 5.9 individuals per 100 trap-nights; mean numbers of captures did not vary significantly among stand conditions (fig. 1). Raphael et al. (2002) found significant differences in relative abundance of the Pacific Jumping Mouse (*Zapus trinotatus*) among stand conditions, with greater abundance in younger stands than older stands regardless of buffer type. Abundance of the four other more common species did not differ significantly among sites. Capture rates of four of the five species were correlated with physical stream features. Keen's Mouse (*Peromyscus keeni*) was more abundant in smaller streams at lower elevations. The Deer Mouse (*P. maniculatus*) was also more abundant in smaller streams, but its abundance was not correlated with elevation or stream gradient. The Dusky Shrew (*Sorex monticolus*) was more abundant at higher elevations in steeper streams. Abundance of the Pacific Jumping Mouse increased with lower elevations. Abundance of Trowbridge's Shrew (*S. trowbridgii*) did not vary significantly with any of the physical attributes

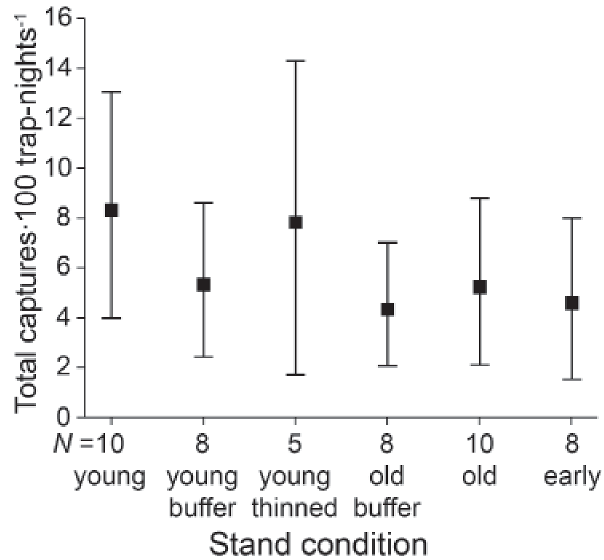

Figure 1—Mean number of captures of small mammals per 100 trap-nights in a retrospective study of existing site conditions on the Olympic Peninsula, Washington (from Raphael et al. 2002).

of streams. O'Connell et al. (2000), in their study of riparian sites in managed forests of the Cascade Range of Washington, found that total abundance and species richness of birds and small mammals using areas close to streams before any timber harvest were comparable to the number and kinds after harvest. At the species level, O'Connell et al. (2000) found that abundance of Pacific Jumping Mouse increased in buffers along streams following harvest; our data, while not conclusive, are consistent with their observation.

Experimental Study

In hopes of reducing the confounding effects of site variability, we subsequently undertook an experimental study on state lands in western Washington along 23 first- and second-order headwater streams to evaluate conditions both before and after treatment (Wilk et al. 2010). The four treatments, grouped within blocks of adjacent catchments to reduce variation in stream size, gradient, and elevation, included unlogged control streams, continuously buffered streams (strips), patch-buffered streams, and unbuffered streams within upland cut-over

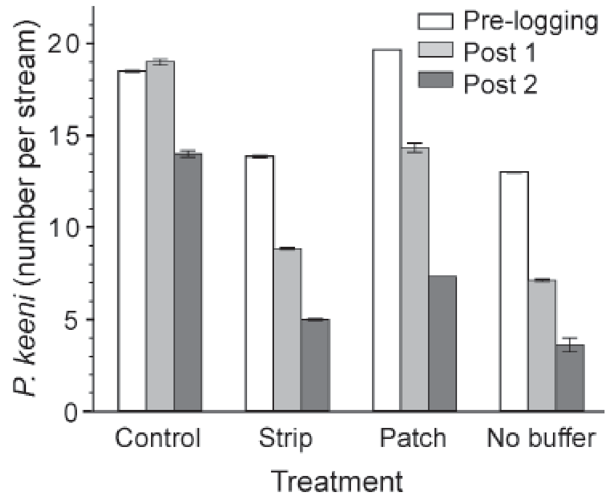

Figure 2—Mean number of Keen's Mice (*Peromyscus keeni*) captured per stream reach before and after treatment in four different stream buffer treatment types (from Wilk et al. 2010). Error bars represent 90 percent confidence interval.

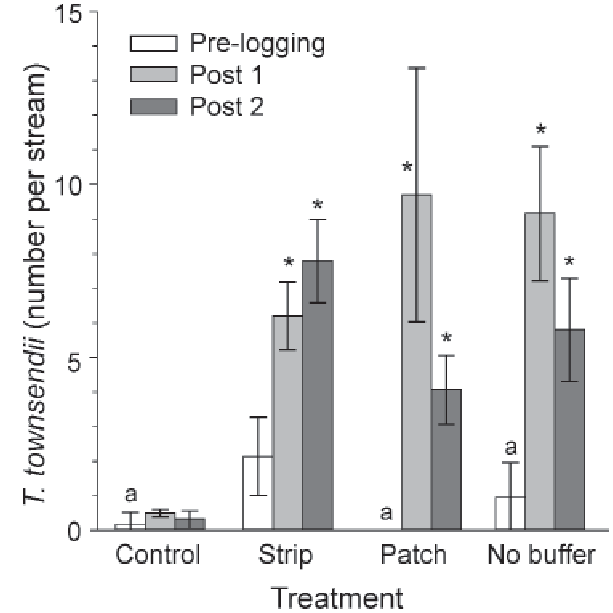

Figure 3—Mean number of Townsend's Chipmunks (*Tamias townsendii*) captured per stream reach before and after treatment in four different stream buffer treatment types (from Wilk et al. 2010). Error bars represent 90 percent confidence interval. Asterisks indicate differences in abundance between pre- and post-treatments; letters indicate a difference between treatment and control within years.

stands. We sampled small mammals in 2003 before logging and then for 2 years following logging. We sampled by using 36 live traps (half on each side of stream) spaced at 5-m intervals within 2 m of the stream. We checked traps daily over 3 successive nights in 5 bouts that were 2 to 3 weeks apart. Among all taxa with sufficient numbers of captures for analysis, we found significant changes in abundance of each species following logging, including a larger decline in abundance of Keen's Mouse in all treatments relative to controls (fig. 2), and increases in abundance of the Creeping Vole (*Microtus oregoni*), the Southern Red-backed Vole (*Myodes gapperi*), and Townsend's Chipmunk (fig. 3). We also observed increases in abundance for the Deer Mouse in continuous buffers and no buffers, and the Pacific Jumping Mouse in patch buffers. The Shrew-mole (*Neurotrichus gibbsii*) decreased in the streams with no buffers. Relative to controls, diversity of small mammals (including total captures, species richness, and species evenness) did not change significantly following logging in any of the treatments (fig. 4). Variation among sites was large, making differences among species in each treatment difficult to detect (example:

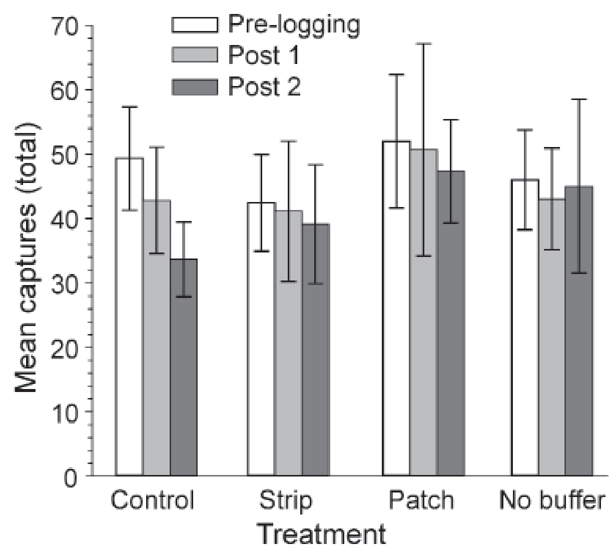

Figure 4—Mean total number of captures of small mammals per 100 trap-nights in an experimental study of stream buffer treatments on state lands in western Washington (from Wilk et al. 2010). Error bars represent 90 percent confidence interval.

Trowbridge's Shrew and Dusky Shrew that had high abundance but large SE). Differences we observed could be due to change in forest cover, not riparian influences per se. Overall, we observed that total abundance of small mammals did not differ much among treatments, but that species composition did change (fig. 5). We also found that capture rates of some of the more specialized species such as Water Shrews (*Sorex palustris*) and Marsh Shrews (*S. bendirii*)] were too low to allow conclusions about treatment effects. For these rarer species, more focused autoecological studies will be needed to better evaluate their habitat relationships along headwater streams and their potential responses to streamside buffer treatments.

Although we observed significant effects of alternative buffer designs on abundance of most of the more common small mammal species in our study, the experimental approach was challenging to implement consistently among sites. These challenges need to be acknowledged, because they may have affected results and constrain the scope of inference of our findings.

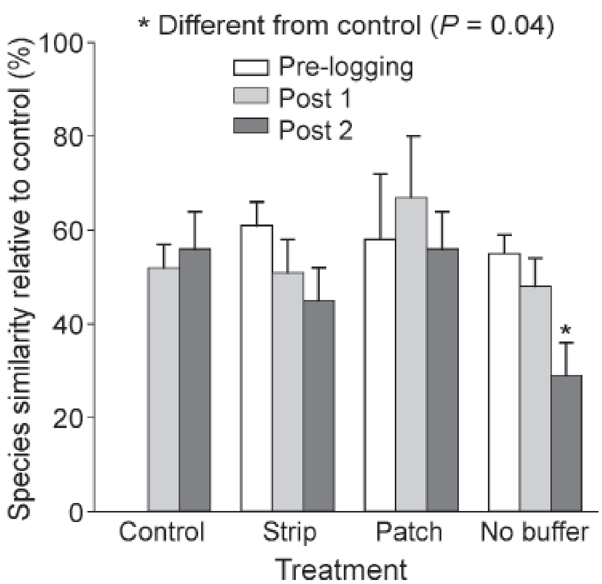

Figure 5—Changes in species composition of small mammals (percent similarity with control sites) before and after logging to create alternative buffer designs on state lands in western Washington (after Wilk et al. 2010). Error bars represent ± SE.

Treatments were not assigned randomly and the design was not balanced (not all treatments occurred in all blocks) owing to logistical constraints associated with roads and anticipated costs of treatments. Furthermore, treatments did not occur when originally planned, due to realities of timber markets driving the timing of timber sales. Implementation of timber harvest among years introduces potential time effects on small mammal populations that were not controlled among sites. Such a time effect may be reflected in our single pre-treatment year of data collection as well. Implementation of buffer design, especially strip buffers, varied noticeably, from dense shading to narrow and open. Finally, windstorms caused blowdown of trees within buffers on many of the treated sites, causing changes in habitat structure that obscured some differences among treatments. Despite these challenges, stand-scale forest experimental studies are valuable for the insights they can provide us regarding responses to anthropogenic disturbances under conditions that are largely controlled. Our mammal responses to combined riparian buffers and upland cut-over area provide such insights that can be tested elsewhere.

Overall, our results demonstrate that populations of the more common species of small mammals in our study changed following logging along streams. Changes in abundance we observed were species-specific, with some species abundances increasing and some decreasing following harvest. The changes we observed seemed to reflect change in amount of preferred forest habitat, either early-seral or late-seral, depending on species. We could not show that these changes were due to retention of streamside buffers per se. Furthermore, none of the common species we were able to sample adequately included riparian obligates as identified in Anthony et al. (2003). Our results do not mean that riparian buffers are not important for small mammals. Retention of suitable habitat along streams will contribute to the total amount and connectivity of habitat at broader scales, and thus should contribute to conservation of these species in managed landscapes. The potential role of riparian buffers could include enhanced opportunities for dispersal of populations of small mammals (e.g., Doyle 1990), but our sampling was not designed to evaluate dispersal rates. Future studies should include an explicit investigation of the role of riparian buffers as dispersal corridors, as well as more detailed investigation of population fitness of selected species in relation to buffer design.

Acknowledgments

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