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Response of terrestrial small mammals to varying amounts and patterns of green-tree retention in Pacific Northwest forests

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Abstract

To sustain native species in managed forests, landowners need silvicultural strategies that retain habitat elements often eliminated during traditional harvests such as clearcut logging. One alternative is green-tree or variable retention. We investigated the response of terrestrial small mammals to experimental harvests that retained large live trees in varying amounts (approximately 100, 75, 40, and 15% of original basal area) and patterns (aggregated versus dispersed) in mature coniferous forests of western Oregon and Washington. Treatments were applied in 36, 13-ha experimental units. We used pitfall traps to sample small mammals for 4 weeks each autumn during 2 years before and 2 years after treatments. We captured 21,351 individuals of 32 species. We analyzed effects of treatments on relative abundance of 12 species. As level of retention declined, we expected species associated with closed-canopy forests to decrease (*Sorex trowbridgii*, *Neurotrichus gibbsii*, *Peromyscus keeni*, *Myodes* [*Clethrionomys*] *californicus*, and *M. gapperi*); species associated with early successional habitats to increase (*S. vagrans*, *P. maniculatus*, *Microtus longicaudus*, and *Microtus oregoni*); and habitat generalists to show little response (*S. monticolus*, *S. pacificus*, and *S. sonomae*). As expected, *M. californicus* declined after harvest, and *P. maniculatus* and *M. longicaudus* increased. *Sorex sonomae* showed an unpredicted decrease. Other species did not show consistent changes. Responses of *S. monticolus*, *S. sonomae*, and *M. gapperi* varied among study areas. For *M. gapperi*, this variation was not explained by differences in habitat structure among areas. For all species, capture rates were similar in dispersed- and aggregated-retention units. Similarity in species composition between harvested sites and controls decreased with decreasing retention. Future sampling of these treatments is needed to assess long-term responses. Based on our initial results, green-tree retention strategies need to be sensitive to regional variation in environmental characteristics and small mammal community composition.

Keywords: Structural retention; Timber harvest; Shrews; Rodents; Forest management

1. Introduction

Forest managers worldwide seek to sustain native species while extracting timber. In many temperate and boreal regions, managers have adopted green-tree retention (Franklin et al., 1997) as an alternative to clearcut logging. Retention of large live trees in small aggregates or dispersed across a harvest unit may help sustain larger populations of forest species than would occur after clearcut harvesting. Green-tree retention may enable breeding populations of closed-canopy species to persist during the period between harvest and subsequent canopy closure. If so, green-tree retention would greatly increase connectivity of local populations for species with low dispersal ability (Matveinen-Huju et al., 2006). Compared to even-aged management, green-tree retention also may increase structural complexity and functional diversity of regenerating forests (Franklin et al., 2002). In time, these forests may support larger populations of mature-forest species and a more diverse fauna, thereby enhancing the ability of "working forests" to sustain native species (Carey et al., 1999; Lindenmayer et al., 2006). Studies from many forest ecosystems are testing these hypotheses (Sullivan et al., 2001; Vanha-Majamaa and Jalonen, 2001; Koivula, 2002; Hyvärinen et al., 2005; Vergara and Schlatter, 2006).

Because of these potential ecological benefits, green-tree retention is now required in harvest units on U.S. federal lands

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within the range of the Northern Spotted Owl (western Oregon and Washington, and northern California; USDA and USDI, 1994a). In the Pacific Northwest, researchers and forest managers collaborated to design the Demonstration of Ecosystem Management Options (DEMO) experiment to examine effects of retention amount (proportion of original basal area; 15–100%) and spatial distribution (aggregated or dispersed) on persistence and recovery of forest organisms (Aubry et al., 1999; Franklin et al., 1999). In this paper, we examine effects of DEMO treatments on insectivores and small rodents.

In Pacific Northwest forests, numerous studies have addressed habitat associations of small mammals (e.g., Aubry et al., 1991; Carey and Johnson, 1995) and their comparative abundances in clearcuts versus mature forests (Gashwiler, 1970; Hooven and Black, 1976; Sullivan, 1980; Morrison and Anthony, 1989; Cole et al., 1998). The western Cascades and coastal ranges support a group of species most abundant in closed-canopy forests, a group most abundant in recent clearcuts and riparian areas, and generalists that can be equally abundant across successional stages (Lehmkuhl et al., 1999). As in other forest systems, small mammals of this region respond strongly to changes in the abundance of logs; litter cover and depth; density and composition of herbaceous vegetation and shrubs; and abundance of fruits, seeds, and fungal fruiting bodies (e.g., Carey and Johnson, 1995; Carey et al., 1999).

Previous studies in this region addressed responses of small mammals to partial disturbances such as thinning or shelterwood harvests (Waters and Zabel, 1998; Wilson and Carey, 2000; Suzuki and Hayes, 2003). However, few studies have explicitly examined responses across a range of harvest intensities or to different spatial patterns of overstory removal. Moreover, responses to green-tree retention may differ from responses to other partial-harvest methods, which emphasize silvicultural objectives (tree growth and regeneration). Green-tree retention emphasizes ecological objectives; i.e., managers retain large live trees to maintain forest species and habitat structure. Our study addresses these gaps in knowledge. To our knowledge, this is the first study of green-tree retention to examine effects of both retention amount and pattern on small mammals across multiple forest types and structural conditions.

We predicted that small mammal species associated with closed-canopy forests, early successional species, and habitat generalists would show different responses to retention amount and pattern in the first 2 years after harvest (Lehmkuhl et al., 1999). We anticipated that small mammals would show variable responses among our study areas due to variation in post-harvest habitat conditions. To clarify potential causes of these responses, we quantified treatment effects on key habitat elements. We addressed the following hypotheses:

Hypothesis 1. Closed-canopy species (Trowbridge's shrew, *Sorex trowbridgii*; shrew-mole, *Neurotrichus gibbsii*; Keen's mouse, *Peromyscus keeni*; western red-backed vole, *Myodes* [*Clethrionomys*] *californicus*; southern red-backed vole, *M. gapperi*) would decrease along the retention gradient (from 100 to 15% retention).

Hypothesis 2. Early successional species (vagrant shrew, *S. vagrans*; deer mouse, *P. maniculatus*; long-tailed vole, *Microtus longicaudus*; creeping vole, *Microtus oregoni*) would respond positively to lower levels of retention.

Hypothesis 3. Habitat generalists (montane shrew, *S. monticolus*; Pacific shrew, *S. pacificus*; fog shrew, *S. sonomae*) would show weak or no response to harvest.

Hypothesis 4. The magnitude of response by each species would vary among locations. This variation would be caused by among-location differences in post-harvest habitat conditions.

Hypothesis 5. Pattern of retention (aggregated versus dispersed) would not affect responses.

Hypothesis 6. Small mammal community composition would differ between intact forests (controls) and harvest treatments. Differences would be greatest at the lowest level of retention.

2. Methods

2.1. Experimental design and treatment implementation

The DEMO experiment is a randomized complete-block design with six treatments randomly assigned to six 13-ha experimental units at each of six locations (blocks; Fig. 1). Blocks are located in the southern Oregon Cascades (Watson Falls [WF] and Dog Prairie [DP]); in the southern Washington Cascades (Butte [BU], Little White Salmon [LW], and Paradise Hills [PH]); and in western Washington at the edge of the Coast Range (Capitol Forest [CF]). Before harvest, all blocks supported mature forests (age 65–170 years) dominated by Douglas-fir (*Pseudotsuga menziesii*). Elevations range from 210 to 275 m at CF to 1710 m at DP, with little snow accumulation at CF and snowpack lasting until May or early June at BU and PH. Study sites and vegetation responses to treatment are described by Aubry et al. (1999), Halpern et al. (1999, 2005), Halpern and McKenzie (2001), and Maguire et al. (2006, 2007).

Treatments include four levels of basal-area retention and two retention patterns. These treatments are (1) control (100% retention); (2) 75% aggregated (75%A), with three, 1-ha circular gaps; (3) 40% dispersed (40%D); (4) 40% aggregated (40%A), with five, 1-ha circular aggregates; (5) 15% dispersed (15%D); (6) 15% aggregated (15%A), with two, 1-ha aggregates (Fig. 1). In aggregated-retention treatments, all trees were retained within aggregates; trees >18-cm DBH were removed from harvest areas. In 40%D and 15%D, dominant and co-dominant trees were retained evenly across harvest units. Harvests were completed in autumn 1997 (BU and PH), spring 1998 (CF), or autumn 1998 (WF, DP, and LW). Logs were yarded with helicopters (DP, BU, and LW), suspension cables (CF), or ground-based equipment (WF, PH, and small sections of CF; Halpern and McKenzie, 2001). At four of six blocks, boles were yarded with tree canopies attached to reduce slash accumulation. At WF, some slash was piled on skid paths and burned.