# Fire Impacts to Small Mammals in Piedmont Oak-shelterwoods

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*Abstract:* Successful regeneration of oaks on better sites ($SI_{50}>60$) has proven difficult in recent decades due to competition from faster growing species and well-established advanced regeneration from more shade-tolerant species. The suppression of fire is thought to have played a critical role in allowing this largely fire-intolerant competition to dominate many upland hardwood forests at the expense of oaks. As part of a larger study examining the role of prescribed fire in regenerating upland oaks, seasonal prescribed burns were applied to first-stage shelterwood harvested stands on Horsepen WMA in the Virginia Piedmont in 1995. We surveyed small mammal communities in these stands to assess the impact of such fires on this component of the fauna. Over a combined 34,000 snap-trap and pitfall trapnights, we found no significant differences in relative abundance of white-footed mice *(Peromyscus leucopus)*, southeastern shrews *(Sorex longirostris)* pygmy shrews *(Sorex hoyi)* or southern short-tailed shrews *(Blarina carolinensis)* among unburned shelterwood stands and those treated with winter, spring, or summer burns. Based on our results, prescribed burning in these shelterwood stands is not adversely impacting small mammals.

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The eastern deciduous forest covers much of the eastern United States and provides important habitat for a wide range of wildlife species as well as substantial economic benefits. Oaks (*Quercus* spp.) are a major component of this system and are critical for numerous wildlife species. However, regeneration of oaks on better sites ($SI_{50}$>60) in the eastern United States has been problematic for the past several decades (Clark 1993). Numerous hypotheses have been advanced to explain this dearth of oak stocking in younger stands, including deer and insect herbivory, competition, and fire suppression (Lorimer 1993). Recent research has indicated that oaks can respond well to prescribed burns, whereas other woody competitors are less tolerant to fire (Keyser et al 1996, Brose and Van Lear 1998, Brose et al. 1999). As a result, oaks can increase their competitive position in the presence of prescribed fire.

A silvicultural approach that seems particularly promising to regenerate oak involves partial canopy removal through a shelterwood harvest followed several years later by prescribed fire (Van Lear et al. 2000). If this system gains wide acceptance and becomes relatively common, it will be necessary to understand the impacts of this silvicultural techniques on non-target organisms, such as non-game wildlife. Burning effects on a number of game species have been studied in the Coastal Plain (see Brennan et al. 1998), but similar work on many non-game species generally is lacking. This information gap may present problems for land managers when implementing shelterwood-burn practices where concerns for wildlife are high, or management guidelines require environmental assessments.

Implications of the shelterwood-burn technique on small mammals may be particularly critical because many species are considered important predators of oak seeds (Lorimer 1993, McShea and Schwede 1993, Ostfeld et al. 1996, McShea 2000). For example, if fire increases small mammal populations, there conceivably could be a negative impact on oak seedling recruitment through increased seed predation. Alternatively, if prescribed fire has negative impacts on small mammals, effects could cascade across trophic levels to species such as medium-sized mammalian predators and avian predators that depend on small mammals as a prey base. Therefore, we examined the effects of prescribed fire on small mammal communities in shelterwood-harvested upland oak stands in the Piedmont of Virginia. Field protocols were consistent with American Society of Mammalogists guidelines except that it was necessary to use formalin in the pitfalls to preserve specimens for Ferrum College teaching collections. All work was conducted under a Virginia Department of Game and Inland fisheries (VDGIF) blanket collection permit. We acknowledge the following for their contributions to this project: L. Sausville, J. Trollinger, D. Harris, wildlife students from Ferrum College, and D. Schwab. We also acknowledge the VDGIF for their support of this research.

## Methods

We conducted research at the Horsepen Wildlife Management Area located in Buckingham County, Virginia, in the Piedmont physiographic province (37°30' N, 78°33' W). The area was dominated by mixed stands of scarlet oak *(Q. coccinea)*, white oak *(Q. alba)*, northern red oak *(Q. rubra)*, and black oak *(Q. veluntina)*. Other important associates were yellow-poplar *(Liriodendron tulipifera)*, red maple *(Acer rubrum)*, black gum *Nyssa sylvatica)*, and American beech *(Fagus grandifolia)*.Climate was warm continental with an annual growing season of 190 days and 104 cm of evenly distributed annual precipitation. The topography was rolling with elevations from 125–200 m. The VDGIF manages the 1,700-ha property.

As part of a larger study designed to assess impacts of seasonal prescribed fire effects on oak regeneration (Brose and Van Lear 1998), 4 burning treatments were completed in 1995: winter (Feb), spring (Apr), summer (Aug), and a control. Each burn treatment was replicated 3 times in a randomized complete block design. Treatment units were 2–5 ha in size. First-stage shelterwood harvests had been completed 3–5 years earlier, leaving approximately 11 $m^2$ of BA/ha comprised of better form oaks and a few scattered yellow-poplars.

Small mammal surveys were initiated with pre-treatment trapping in January 1995 and followed in January 1996 and 1997 with post-treatment trapping. We trapped 5 consecutive nights each year using snap-traps arrayed in 6x6 grids (10-m spacing) centered in each treatment unit (Jones et al. 1996). Two Victor® snap-trap mouse traps baited with peanut butter were placed at each of the 36 stations, or 72 traps/grid (864 total). Sampling for shrews was conducted from May through October 1996. This involved using the same snap-trap protocol in May and September that had been employed in January. In addition, pitfalls were run for a total of 53 nights during June, July, and October. We placed 20 946-$cm^3$ pitfalls near cover objects along transects centered in each treatment area (240 total, Ford et al. 1994). We did not conduct pre-treatment sampling for shrews with either snap-traps or pitfalls. All collections were completed by or under the direct supervision of VDGIF personnel.

Snap-trap data for white-footed mice were analyzed using a repeated measure analysis of variance (ANOVA) (Neter et al. 1996, SAS 1993). Pitfall data and snap-trapping results for summer 1996 were combined for all shrews. Because only 1 year of data was available for shrews, we analyzed the data using a 1-way ANOVA with blocking. We used a Duncan's Multiple Range Test to test for differences in treatment means (Neter et al. 1996, SAS 1993). White-footed mice data were evaluated and found to be normal and were analyzed without transformation. Shrew data were not normal and were rank-ordered and analyzed as a non-parametric ANOVA.

## Results

Snap-trapping during the 3 January sampling periods generated 12,960 trap-nights resulting in 372 total captures (2.87 captures/100 trap-nights). Trapping for shrews in 1996 yielded 8,640 trap-nights with 21 shrews captured (0.16/100 trap-nights). Pitfall sampling resulted in 12,720 pit-nights with 99 captures or 0.79 captures/100 pit-nights. The combined snap-trap and pitfall effort produced a total capture of 124 shrews. The most abundant species was the white-footed mouse *(Peromyscus leucopus)*, followed by golden mice *(Ochrotomys nuttalli)* and pine

**Table 1**. Summary of small mammal captures using snap-trapping and pitfalls at Horsepen Wildlife Management Area, Buckingham County, Virginia, during 1995–1997. Results are for all 4 burn categories: spring, summer, winter, and control.

| Species | Captures | % Captures |
|---|---|---|
| January 1995–1997 snap-trapping: | | |
| Southern flying squirrel | 1 | 0.27 |
| Southern short-tailed shrew | 4 | 1.08 |
| Pine vole | 9 | 2.42 |
| Golden mouse | 17 | 4.57 |
| White-footed mouse | 341 | 91.67 |
| Summer 1996 sampling: | | |
| Pygmy shrews | 11 | 9.17 |
| Southeastern shrew | 38 | 31.67 |
| Southern short-tailed shrew | 71 | 59.17 |

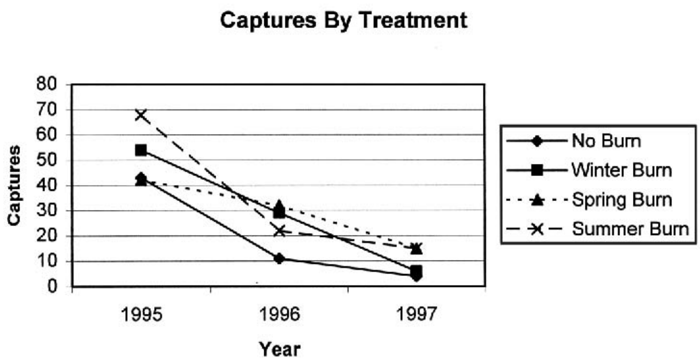


**Figure 1.** Results of snap-trap effort repeated measures analysis for 4 burn treatments (winter, spring, summer, and control), at Horsepen Wildlife Management Area, Buckingham County, Virginia, 1995–1997.

voles *(Microtus pinetorum)*, both of which were considerably less abundant (Table 1). Two other species accounted for <1% each. For shrews, the community was more equitably distributed among 3 species: southern short-tailed shrew *(Blarina carolinensis)*, southeastern shrew *(Sorex longirostris)*, and pygmy shrew *(S. hoyi)* (Table 1). Because white-footed mice dominated the rodent sample, further analysis was confined to this species. Due to limited sample sizes, all 3 species of shrews were combined for analysis.

Season of burn had no effect on capture rates for white-footed mice ($F_3$=0.54, *P*=0.67), although capture rates differed among years, declining over time ($F_2$=9.77, *P*=0.0002) (Fig. 1). Similarly, we detected no difference among fire treatments for shrew capture rates ($F_{11}$=1.82, *P*=0.243).

## Discussion

Undisturbed oak-dominated hardwood forests in the region are likely to change markedly due to the suppression of fire and be replaced by forests dominated by beech, poplar, and maple (Kellison 1993). The burn-shelterwood technique shows promise for maintaining a substantial oak component in eastern hardwood forests in the face of decades of limited regeneration success. Given the rate of development and loss of forested habitats in many parts of the Southeast, the importance of maintaining as many hectares of quality, ecologically healthy hardwood forests as possible undoubtedly will increase. Our results suggest that no adverse effects from this technique are likely with respect to small mammal assemblages in the Piedmont.

Most spring and summer burns were particularly intense and consumed virtually all fine fuels (Brose and Van Lear 1998), reducing leaf litter to minimal depths and shifting ground-layer vegetative communities from primarily woody to those dominated by herbaceous vegetation. Despite this, neither white-footed mice nor shrews were impacted by any burn regardless of season. This finding is consistent with results of a study of an intense community restoration fire in the Southern Appalachians (Ford et al. 1999). In that study, no differences in small mammal captures were detected between burned and unburned areas leading the authors to conclude that the amount of functional refugia was adequate to protect animals during and after fire. The large amount of slash still on site in our study (Brose and Van Lear 1998) as the result of the initial shelterwood harvest may have mitigated the loss of any cover provided by leaf litter and small woody debris consumed by the fires.

Research on large-scale conversion of closed-canopy forests to pine-grassland communities in the Ouachita Mountains demonstrated that small mammal communities show little response to fire (Master et al. 1998). In that study, fire followed overstory reductions in a process that loosely paralleled the shelterwood-burn technique and it affected habitat in very similar ways. An increase in abundance, richness, and diversity of small mammals in treated stands was associated with both cutting and burning treatments, although harvest effects may have been greater than fire effects. White-footed mice dominated their sample as well with 68% of 611 captures (Masters et al. 1998).

Kirkland et al. (1996) reported a decrease in white-footed mice and several species of shrews following a dormant-season burn on an oak-dominated site in Pennsylvania. Fire impact was transitory, and differences disappeared 8 months following the burn. This study lacked both pre-treatment sampling and replication, and the apparent differences could have been present prior to burning or have been an artifact of the site. Because we compared populations only in January, it is possible that changes reported by Kirkland et al. (1996) during the spring months were present in Virginia as well. If so, we may have failed to detect them because our methodologies did not involve sampling at that time of year.

Masters et al. (1998) and Pagels et al. (1998) concluded that the generalist adaptation of the white-footed mouse explained its ability to prosper in disturbed habitats. Master et al. (1998) also speculated that the golden mouse, the second most abundant animal in the snap-trap samples in our study, would likely benefit from fire managed landscapes since historically they may have been dependent on such systems in that region. We believe that the apparent year effect observed in our data is most reasonably explained by the substantial removals that resulted from our sampling method. Cyclical variation may account for a part of this, however (Ostfeld 1996, Kesner and Linzey 1997); to what extent cannot be assessed from our data.

The benefits that can be realized from a stand-level and ecosystem-level perspective to eastern hardwood forests from maintaining or restoring a substantial oak component are substantial. That the application of fairly intense growing season fires had no measurable impact on the small mammal community suggests that this may be a viable technique for achieving those goals. Given the serious concerns about the loss of fire as an ecosystem component and its effects of biota in the South and East (Brennan et al. 1998, Delcourt and Delcourt 1998, Frost 1998) this tool may have additional merit for maintaining healthy and diverse ecosystems. Research is currently being pursued to assess impacts of the shelterwood-burn technique to other components of these systems including herpetofauna and avifauna.

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