

The Effect of Small Rodents on Northern Red Oak Acorns in North-central West Virginia

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Abstract: The effects of small mammals on surface-sown northern red oak (*Quercus rubra*) acorns was assessed in highly productive Appalachian hardwood stands. Study plots were established in October 1990 on excellent (average site index of 89 feet for red oak) and good (average site index of 72 feet) sites. Each plot included: 1) a rodent-proof enclosure, 2) an enclosure accessible only to small rodents, and 3) a non-enclosed open quadrat. By comparing the survival of acorns on the rodent-accessible quadrats with that on the open quadrats, it was determined that small rodents have a highly significant effect on the acorn crop. Of the 360 acorns placed in the open, only 10 survived until June. Only seventeen of 360 survived on the partially enclosed quadrats. It was determined through snap-trapping that white-footed and deer mice (*Peromyscus* spp.) were primarily responsible for removal of the acorns from the partially enclosed quadrats. In addition, it was determined through the use of regression analysis that small rodent damage to the acorn crop was greatest in stands that included small snags and large non-red oaks in the upper canopy.

INTRODUCTION

Throughout the Appalachian hardwood region, the regeneration of valuable species such as northern red oak (*Quercus rubra*) is often unsuccessful. This is particularly true on the more productive sites where yellow-poplar (*Liriodendron tulipifera*) and black cherry (*Prunus serotina*) often dominate after harvest cuts (Sander and Clark 1971). These faster-growing, more shade intolerant species tend to outcompete slow-growing oak seedlings and, in the absence of advance oak regeneration, may all but preclude oak from newly established stands.

Many factors are involved in the establishment of advance oak regeneration. Among these, the destruction of acorn crops by insects and animals has historically been of interest to both forest and wildlife managers. Much of the early work of investigators such as Korstian (1927), Wood (1938), Downs and McQuilken (1944), Gysel (1957), and Tryon and Carvell (1962) indicates that animals and insects often cause significant or total loss of acorn crops. More recently, several researchers have found that small rodents, rather than larger game species such as deer, squirrels, and turkey, may cause the greatest amount of animal damage to acorn crops (Shaw 1968, Marquis et al. 1976, Delong and Yahner 1991). The destruction of the entire crop by animals and insects can be expected in years of low to moderate acorn production. Therefore, it has been suggested that most oak seedlings are established when acorns are overlooked in years of bumper crops (Olson and Boyce 1971).

Healy (1988) notes a relative lack of evidence to support the contention that acorn predation by animals is a serious factor in the regeneration of Appalachian hardwoods. Additionally, little information is available to assist forest managers in identifying stands in which animals may be a serious impediment to the establishment of oak. This paper describes the results of the first year

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of a 2-year study conducted in northern West Virginia to determine the site-specific effects of small mammals on northern red oak acorn crops. In addition, it suggests silvicultural practices that may lessen the impacts of small mammals on highly productive Appalachian hardwood sites.

METHODS

This study was conducted on the West Virginia University Forest located in north-central West Virginia along the westernmost range of the Allegheny Mountains. Two study sites were selected. The first site was located in the Lick Run watershed of the Forest where cove hardwood stands were selected on a northeast-facing slope. This study area was characterized by very high site indices for northern red oak (81 to 97 ft.), an abundance of mature yellow-poplar and northern red oak, and a moderate ground cover of herbaceous and woody vegetation. The second site was located in the Glade Run watershed of the Forest. The stands selected in this area were located on a drier northwest-facing slope and were characterized by lower site indices for northern red oak (68 to 73 ft.), an absence of yellow-poplar, a significant component of mature black cherry, and sparse ground cover. These study areas will henceforth be referred to as the Lick Run and Glade Run sites.

Square plots of 0.5 acre were established on each site. Due to constraints imposed by a concurrent study, six plots were located on the Lick Run site and four were located on the Glade Run site. On each plot, four mature (> 12 inches dbh) dominant or co-dominant northern red oaks were selected. A cluster of three 1-foot square quadrats was randomly located within the area under the crown of each of these 40 trees. One of the quadrats in each cluster was fully enclosed with 0.5-inch mesh hardware cloth to exclude all potential mammalian and avian predators. These exclosures were constructed with mesh bottoms to prevent predators from entering from below. The second quadrat in each cluster was enclosed on the top and sides, but not below, with 0.5-inch mesh hardware cloth. In addition, a 2-inch by 2-inch square opening was cut at ground level on each side of the exclosure. These quadrats were accessible to small rodents such as mice and chipmunks but were not accessible to other predators including squirrels. The last quadrat in each cluster was marked with stakes and left open to allow access to all potential acorn predators. The tops of all of the exclosures were hinged so that they could be opened for observation as the study progressed.

Northern red oak acorns were collected off the study area in September of 1990. The acorns were tested for viability using the float method (Schopmeyer 1974). Apparently sound, undamaged acorns were placed on each quadrat in a square grid pattern. Nine acorns per quadrat was determined to be a reasonable approximation of that naturally occurring on a 1-foot square area as suggested by Gysel (1956). The acorns were pressed slightly into the humus to prevent them from rolling but were not buried.

The quadrats were checked biweekly to monthly from late fall until germination in the spring. Each acorn was recorded as damaged by insects, damaged by animals, removed, or germinated. In addition, litter depth was monitored and adjusted within the exclosures to approximate that on the open quadrat.

A complete tally by 1-inch class of all trees 2 inches dbh and above was taken on each 0.5-acre plot. In addition, the distance was measured from the center of each cluster to the nearest: seedling (< 3 feet tall), small shrub/sapling (3 to 10 feet tall), large shrub/sapling (> 10 feet tall but less than 4 inches dbh), small pole (4 to 8 inches dbh), large pole (8 to 12 inches dbh), mature tree of any species (> 12 inches dbh), mature soft-mast producing tree, mature hard-mast producing tree, small snag (< 10 inches dbh), large snag (at least 10 inches dbh), open water or seep, fallen or cut log, tops or branches, and rocks. Most of the study area was at one time mined for iron ore resulting in pit and mound soil disturbance. Since these soil mounds were used extensively by mice for

nesting, the distance to the nearest mound was recorded. Ocular estimates of percent woody debris and percent rock cover within a 100-foot diameter circle originating at the cluster center were also made.

Snap-trapping of small mammals was conducted on five consecutive nights in early December 1990 to determine relative densities and species composition of animals on the plots. Four parallel trap lines, each 150 feet in length, were established on each plot. Each trap line consisted of six trap stations placed at 25-foot intervals. Each trap station included three snap-traps placed approximately equidistant from the center of a 3-foot diameter circle. Eastern chipmunk and southern flying squirrel populations were sampled by including a rat trap in every third trap station.

RESULTS

Acorn Survival

Very few of the acorns that were accessible to small mammals survived to germinate in the spring. Of the 360 placed on the open quadrats, only 10 remained in early June. Seventeen of the 360 acorns on the partially enclosed quadrats survived.

Chi-square analysis was performed on the fate of the acorns on the open and partially enclosed quadrats. Overall, there was no significant difference between acorn removal on open and partially enclosed quadrats (Chi-square = 1.886, $p > 0.05$). As can be seen in Figure 1, where total number of surviving acorns is plotted against number of days, acorn removal rate is nearly identical on the two types of quadrats.

Chi-square analyses were performed by plot by combining the results from the four clusters of quadrats on each plot. For only one plot, located in the Glade Run watershed, were the results significant at the 0.05 level. On this plot, eight of the 36 acorns on the partially enclosed quadrats survived, whereas only 1 survived on the open quadrats (Chi-square = 6.22, $p < 0.05$).

With such complete removal of acorns from the quadrats, it is difficult to identify stand variables that may be influencing survival. Therefore, a new dependent variable, acorn survival days, was used in the multiple regression analysis of stand variables. Acorn survival days, the mean number of days the acorns survived on each quadrat, is a good indication of the intensity of acorn predation on the plots.

The basal area of non-red oak dominant and co-dominants per acre and the minimum distance to a snag less than 10 inches dbh were found to be significantly correlated at the 0.01 level with acorn survival days. The non-red oaks included primarily white oak and chestnut oak, although one plot contained scarlet oak and another included a small number of black oaks. After natural log transformation of acorn survival days and the independent variables, linear regression was used to develop the following model:

$$\ln(\text{ASD}) = 3.301 - 0.603 \cdot \ln(\text{BPA}) + 0.555 \cdot \ln(\text{SNAGD})$$

where ASD = mean acorn survival days, BPA = basal area of non-red oak dominant and co-dominant trees per acre, SNAGD = minimum distance to a snag less than 10 inches dbh, and $r^2 = 0.74$. The relationship between acorn survival days and each of the independent variables is shown in Figure 2.

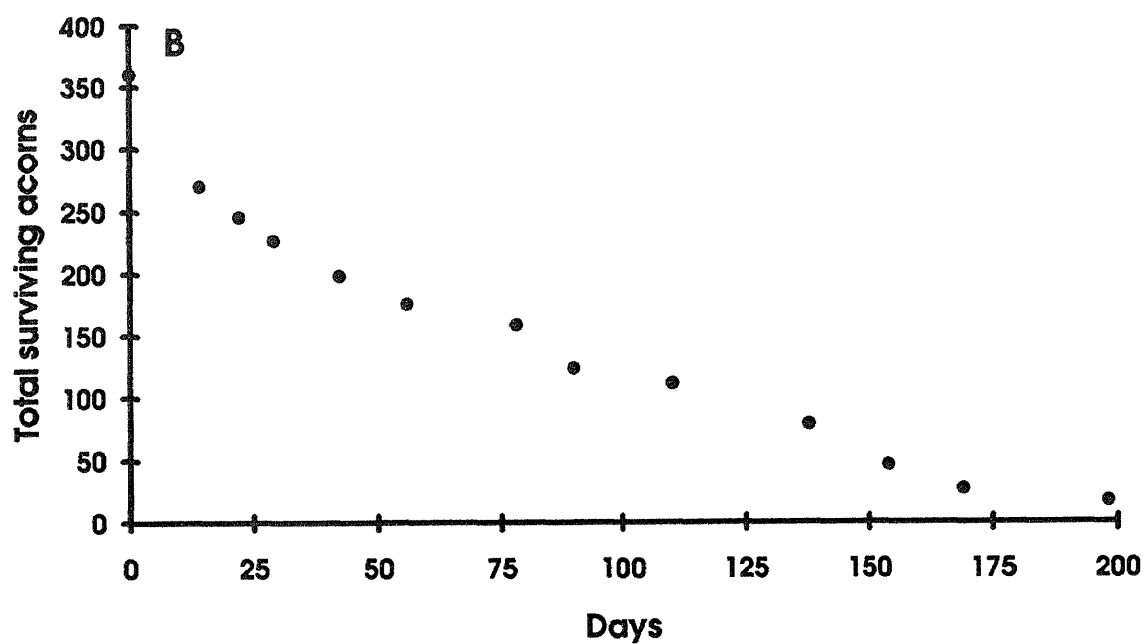
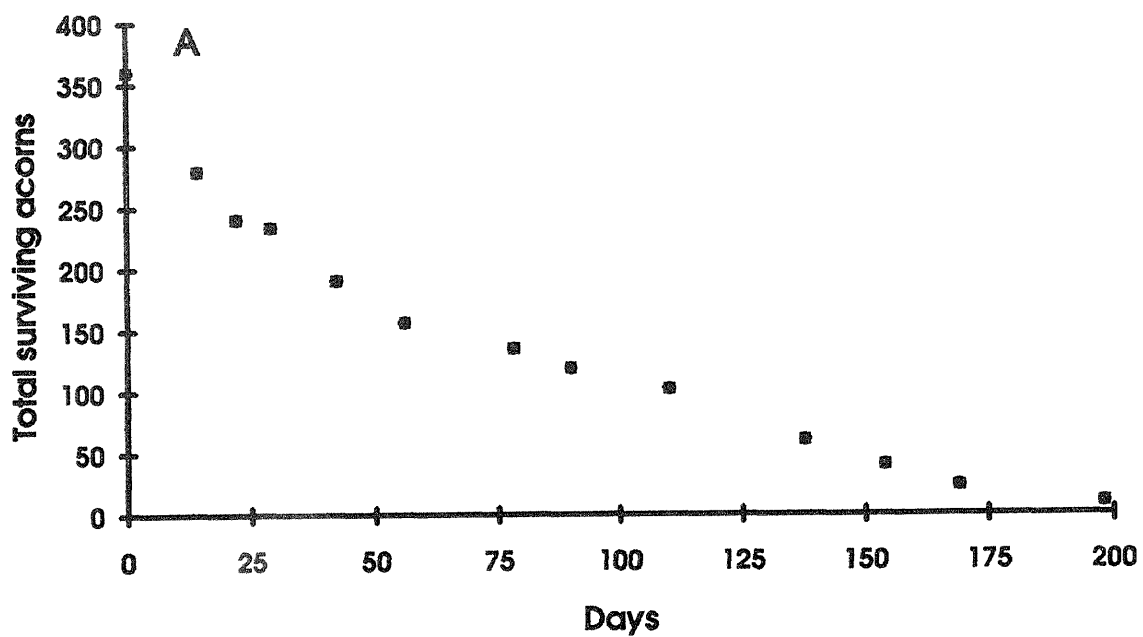


Figure 1.—Captures of small rodents in the Lick Run and Glade Run watersheds.

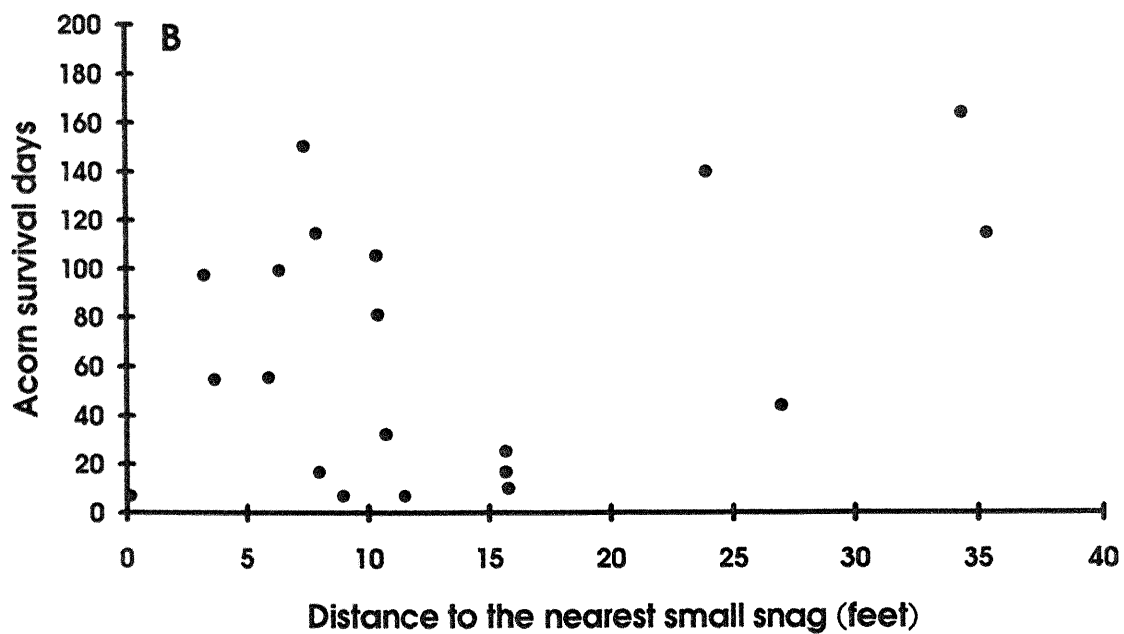
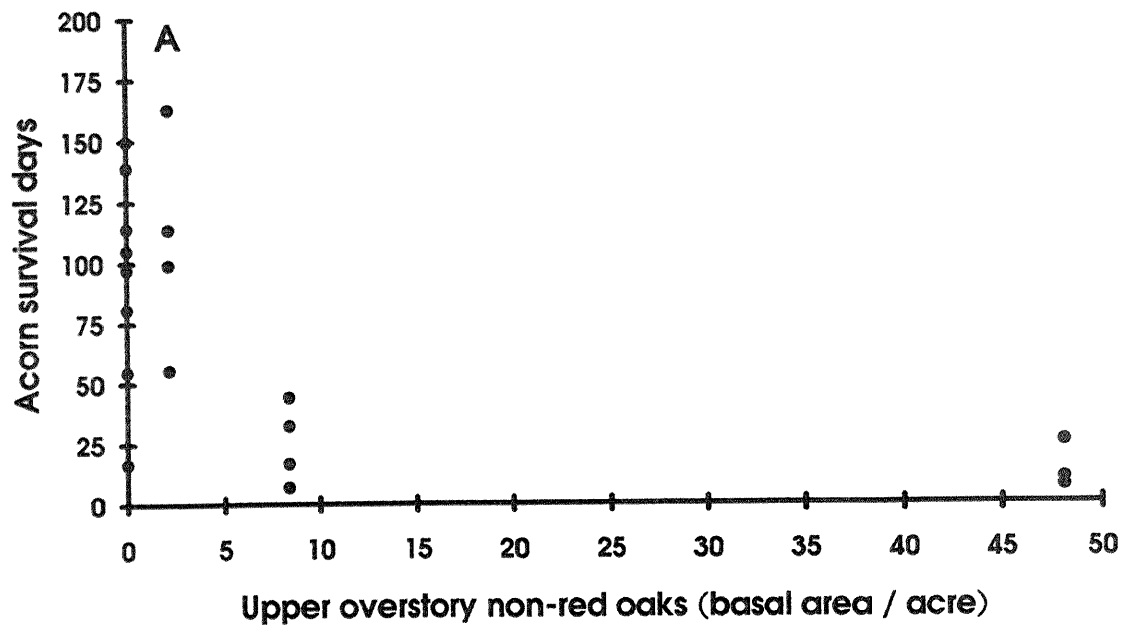


Figure 2.—Total surviving acorns over time on: A) open quadrats and, B) partially enclosed quadrats.

Small Mammal Trapping

The results of the small mammal trapping are presented in Table 1. White-footed and deer mice (*Peromyscus* spp.) and red-backed voles (*Clethrionomys gapperi*) were present throughout the study area and were well-represented in the sample. Southern flying squirrels (*Glaucomys volans*) were trapped on only a single plot in the Lick Run watershed. A few masked shrews (*Sorex cinereus*) were also trapped on the Lick Run plots. In addition, eastern chipmunks (*Tamias striatus*) were seen on the plots earlier in the fall but did not appear in the sample. This may have been due to the late date of the trapping (early December) and limited foraging activity of chipmunks during the 5-day trapping period. Short-tailed shrews (*Blarina brevicauda*) were also absent from the sample even though they were successfully trapped on the study area the following year.

Table 1.—Captures of small rodents in the Lick Run and Glade Run watersheds

	Captures/100 trap nights	
	Lick Run	Glade Run
Mice and voles:		
<i>Peromyscus</i> spp.	15.05	5.79
<i>Clethrionomys gapperi</i>	11.57	10.42
Squirrels and chipmunks:		
<i>Glaucomys volans</i>	10.42	0.00
<i>Tamias striatus</i>	0.00	0.00
Shrews:		
<i>Sorex cinereus</i>	2.31	0.00
<i>Blarina brevicauda</i>	0.00	0.00

Pearson correlations indicate that, at the 0.05 level, *Peromyscus*, southern flying squirrel, and masked shrew captures per 100 trap nights were all negatively correlated with acorn survival days ($r = -0.69$ for *Peromyscus*, $r = -0.53$ for southern flying squirrel, and $r = -0.77$ for masked shrews). The relationship between acorn survival days and *Peromyscus* captures is shown in Figure 3. Red-backed vole captures per 100 trap nights were not found to be significantly correlated with acorn survival days ($r = 0.17$). In addition, capture of masked shrews per 100 trap nights was found to be highly positively correlated with capture of *Peromyscus* and southern flying squirrel ($r = 0.91$ for *Peromyscus* and $r = 0.61$ for southern flying squirrel).

Pearson correlation between captures of *Peromyscus* and basal area of non-red oaks in the upper canopy indicates that captures increase as basal area increases ($r = 0.60$, $p = 0.01$). However, captures of *Peromyscus* was not found to be significantly correlated with minimum distance to a snag ($r = -0.14$, $p > 0.05$).

Due to the limited capture of southern flying squirrels, numbers of this species could not be related to the two stand variables. However, the plot on which flying squirrels were found included many large residual white oaks.

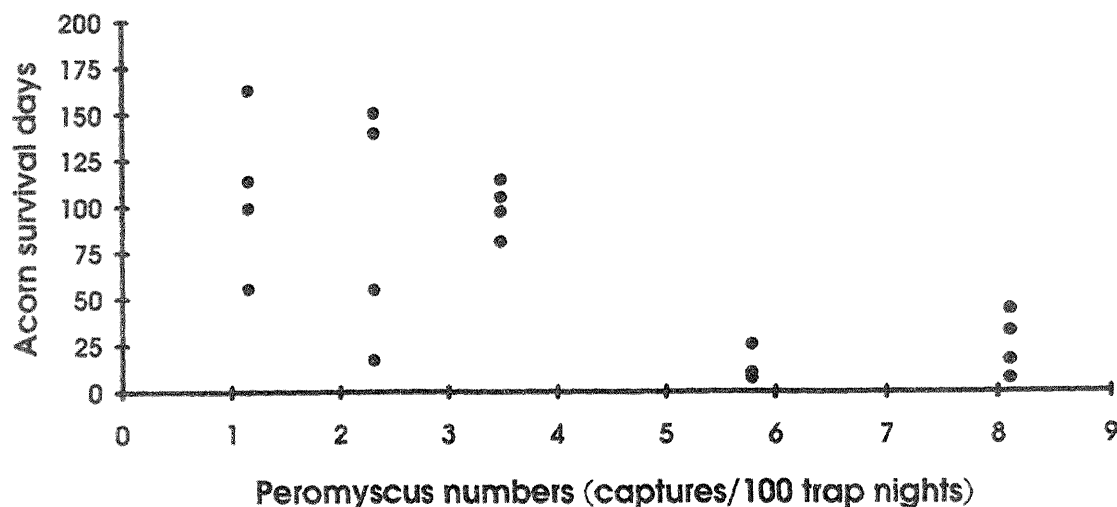


Figure 3.—Acorn survival days versus *Peromyscus* captures per 100 trap nights.

DISCUSSION

The results of the chi-square analysis on total acorn removal indicate that small mammals have a serious impact on red oak acorn survival in this study area. Acorns were removed quickly and almost completely from the partially enclosed quadrats. In addition, acorns were removed from the open quadrats at approximately the same rate, indicating that small rodents, and not the larger game species, were primarily responsible for acorn predation on open ground.

It is presumed that most of the removed acorns are consumed, destroyed, or cached in multiple-nut larders where they have very little chance of germinating successfully. Smith (1962) found in laboratory feeding trials that even though northern red oak acorns are not highly preferred by *Peromyscus*, they will be consumed in combination with other foods. It was also noted in these trials that *Peromyscus* will often destroy red oak acorns by gnawing or peeling the shell, rendering them non-viable or predisposing them to invasion by insects and pathogens. Even when red oak acorns do survive initial contact with small rodents, they are often cached in trees and under rocks and woody debris where germination is not probable (Sork, 1984).

Of the two small mammal species that were well-represented in the trapping sample, only *Peromyscus* can be considered a major consumer of acorns. The diet of the red-backed vole cannot be expected to regularly include acorns (Martin et al., 1951). Therefore, on this study area it can be assumed that *Peromyscus* were primarily responsible for the removal of acorns from the partially enclosed plots. The negative correlation between captures of *Peromyscus* and acorn survival days further implicates this species.

The results of the multiple regression on acorn survival days indicate that mouse damage to the acorn crop can be expected to be higher in stands that include small snags and large non-red oaks in the upper canopy. Small snags are often used by mice as food caching sites and also for hiding and nesting cover. The lack of a correlation between *Peromyscus* numbers and minimum distance

to a snag indicates that small rodents may not necessarily be more numerous in areas where snags are present. However, they may be more active. It is probable that acorns are collected initially from areas close to caching sites such as snags. Later in the season as acorns become more scarce, small rodents could be expected to forage further away from the caching site and to be more willing to transport acorns over longer distances. This could explain the finding that acorns survived longer with increasing distance from a snag.

The plots that suffered the most intense acorn predation included large residual white oaks in the upper canopy. These plots, which contained from 8 to 48 square feet of basal area of white oak in very few large diameter trees, were located in the Lick Run watershed and were characterized by very high site indices for northern red oak. It was on these plots that *Peromyscus* captures were the highest. In contrast, the plots on which acorns survived the longest were located in the Glade Run watershed. These plots contained neither white oaks nor other non-red oaks in the upper canopy. They were characterized by lower site indices for northern red oak, and the lowest relative densities of *Peromyscus*.

The presence of dominant and co-dominant white and other oaks on the Lick Run plots may increase the suitability of these sites for *Peromyscus* by providing a more palatable and nutritious food supply than that provided by northern red oak acorns alone. Smith (1962) found that when given a choice among white, chestnut, and northern red oak acorns, *Peromyscus* will virtually reject the red oak while showing very high preference for white oak and moderate preference for chestnut oak. However, it may be reasonable to expect that mice will utilize northern red oak acorns as the supply of white oak acorns in the area is depleted.

CONCLUSIONS

The lack of successful northern red oak regeneration on good sites in the Appalachian hardwood region continues to be of concern to forest managers. The results of this study indicate that white-footed and deer mice are major consumers of acorns on very productive sites. Unlike squirrels, which are generally thought to aid regeneration through the dispersal and burial of acorns, mice can usually be considered detrimental. Their activity may severely impact oak regeneration through almost complete destruction of acorn crops in some years especially in stands with a very high site index and a mixture of oak species. Alteration of small rodent habitat through the removal of low-quality white and other non-red oaks from the overstory and the elimination of snags from the stand may reduce mouse numbers and aid in the regeneration of northern red oak on some highly productive sites.

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