Sampling Small Mammals in Southeastern Forests: The Importance of Trapping in Trees

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Because estimates of small mammal species richness and diversity are strongly influenced by sampling methodology, 2 or more trap types are often used in studies of small mammal communities. However, in most cases, all traps are placed at ground level. In contrast, we used Sherman live traps placed at 1.5 m in trees in addition to Sherman live traps and Mosby box traps placed on the ground to sample small mammals in pine stands in the Upper Coastal Plain of South Carolina. To determine the importance of placing traps in trees, we compared estimates of small mammal (primarily rodent) species richness and diversity based on data from all traps (ground and tree) with estimates based on data from ground traps only. Estimates of species richness based on data from ground traps only did not differ from estimates based on data from all traps. However, 4 other diversity indices (Simpson Index, Shannon-Wiener Index, Shannon Evenness Index, and Brillouin Index) based on data from both tree and ground traps were significantly greater than indices based on data from ground traps only. The increase in the diversity estimates when data from all traps were used was primarily due to the large number of southern flying squirrels ***(Gluucomys volans)*** captured in tree traps. When data from ground traps only were considered, the community was highly dominated by cotton mice ***(Peromyscus gossypinus),*** but, when data from all traps were considered, cotton mice and southern flying squirrels were co-dominant (567 and 580 individuals, respectively). Our data suggest that studies of forest small mammal communities which do not include tree traps are biased because one of the most common and potentially important species, the southern flying squirrel, is highly under-represented. We recommend that future studies of forest mammal communities, particularly those designed to test the effects of forest management practices on small mammal communities, include arboreal traps.

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Small mammals play an important role in the community dynamics and energy flow of forest ecosystems (Hamilton and Cook 1940). Therefore, effective management and monitoring of forests requires an understanding of the composition, structure, and function of small mammal communities. The need to understand small mammal communities and how they change with time, management activities, and natural disturbance will increase as greater emphasis is placed on managing forests for multiple purposes (Hunter 1990).

Previous studies of southern Coastal Plain and Piedmont mature forests indicated that cotton mice, golden mice *(Ochrotomys nuttalli),* and southern short-tailed shrews *(Blarina carolinensis)* were the most abundant small mammals (Shadowen 1963, Stephenson et al. 1963, Hatchell 1964, Smith et al. 1974, McComb and Noble 1980, Wolfe and Lohoefener 1983, Hamilton et al 1987, Whiting and Fleet 1987, Tappe et al. 1993, Mitchell et al. 1995, Masters et al. 1998, Loeb 1999). However, characterization of small mammal communities is strongly influenced by the sampling methods employed (Kirkland and Sheppard 1994). For example, pitfall traps with drift fences were more effective than snap traps in capturing shrews while snap traps were more effective in capturing rodents (Williams and Braun 1983, Bury and Corn 1987). Further, a combination of mouse and rat snap traps increased the estimates of species richness and diversity compared to mouse traps alone (Perry et al. 1996).

To overcome the biases associated with the used of a particular trap type, 2 or more types are often used to sample small mammal communities. In most cases, all traps are placed at ground level. However, many terrestrial small mammals such as cotton mice and golden mice are quite arboreal (Layne 1970, Packer and Layne 199 1). Gentry et al. (1968) found that golden mice were more likely to be captured in traps placed in trees than on the ground. Further, although southern flying squirrels are sometimes caught in ground traps, their capture rates are low and consequently they are not considered to be important components of the small mammal community (Taylor and Lowman 1996). Two recent studies suggested that traps should be placed >4.5 m above ground (Risch and Brady 1996) or in the canopy (Taylor and Lowman 1996) to adequately sample flying squirrels. However, Engel et al. (1992) found that height above ground did not affect trappability of southern flying squirrels.

In 1997, a large-scale cooperative study was initiated on the Savannah River Site in the Upper Coastal Plain of South Carolina to test the importance of coarse woody debris (CWD) for small mammals, birds, herpetofauna and insects. To test the effects of CWD loadings on rodent diversity, population dynamics, and habitat selection we placed traps on both the ground and in the trees. The objective of this paper is to illustrate the effect of placing traps in trees on estimates of rodent community composition and structure, particularly species richness and diversity.

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Methods

The study was conducted on the Department of Energy's Savannah River Site, Aiken and Bamwell counties, South Carolina. The approximately 78,000-ha site is a National Environmental Research Park located in the Upper Coastal Plain physiographic region. Soils are generally sandy, well-drained, and infertile in the uplands and on ridges, but are of higher fertility in the stream terraces and floodplains (Batson et al. 1985, Workman and McLeod 1990). Plant community types include old fields, sandhills, scrub-oak, upland hardwoods, upland pine, bottomland hardwoods, and swamp forests.

This study was conducted in managed upland loblolly pine *(Pinus taeda)* stands that were planted between 1950 and 1953. Although loblolly pine was the dominant overstory tree species, oaks (*Quercus* spp.), hickories *(Carya* spp.), sweetgum *(Liquidumbar styraciflua),* and wax myrtle *(Myricu cerifera)* were scattered throughout all plots in the midstory and overstory. The understory was relatively sparse and included poison oak *(Rhus toxicodendron),* dog-fennel *(Euputorium* spp.), and lespedeza *(Lespedezu* spp.). Most stands had been burned within 3-4 years and thinned within l-6 years of the initiation of the study.

Twelve trapping grids were arranged in 3 blocks of 4 plots each. Each block was located wholly or primarily within 1 forest stand. Plots were 9.3 ha and surrounded by a 61-m buffer. CWD loadings were manipulated in 2 of the plots in each block; however, the effects of those manipulations had little effect on small mammal abundance (S. C. Loeb, unpubl. data) and were ignored for the purposes of this paper. No management, including CWD manipulations, occurred in the buffer areas. In the center of each plot, an 8 *X* 8 trapping grid with 20-m spacing between each trap station was established. At each station, we placed 1 Sherman live trap (7.5 *X* 9.0 *X* 25.5 cm) on the ground and 1 Sherman live trap on the nearest (≤ 5 m) tree trunk to the station marker. Tree traps were placed in wooden sleeves attached to the tree at approximately 1.5 m above ground. Mosby-type wooden box traps (19 cm X 19 cm X 61 cm; Day et al. 1981) were placed on the ground at odd-numbered stations on lines 1, 3, 5, and 7 and even-numbered stations on lines 2, 4, 6, and 8. Sherman traps in the trees were baited with peanut butter. Because of high populations of red-imported fire ants *(Solenopsis invictu)* and other ants in the grids, we baited Sherman traps on the ground with sunflower seeds. It was our hope that sunflower seeds would last longer than peanut butter and not attract as many ants to the traps. Box traps were primarily intended to sample gray squirrels *(Sciurus carolinensis)* and fox squirrels (S. *niger)* and, thus, were baited with corn.

Trapping sessions were conducted every other month from March 1997 through January 1999. Each trap session was 9 consecutive nights and conducted during the new to quarter moon phases. Based on our previous experience trapping southern flying squirrels during winter, we did not open tree traps when temperatures were expected to fall below 35 °F to minimize chance for mortality. It was only necessary to close tree traps during the January trapping sessions (7 nights during each trap session). We checked traps each morning, individually identified all newly-caught mammals with a unique Monel No. 1 ear-tag in each ear, and recorded plot number, trap station number, trap type, trap location (ground or tree), species, ear-tag numbers, and capture history. Based on tom ear pinnae, 5 1 flying squirrels likely lost their original tags. We re-tagged these animals and recorded them as "re-captures." We included data from these animals in analyses that considered number of captures regardless of individual but did not include data from these animals when we considered the number of captures/individual. Procedures used in this study were approved by the Clemson University Animal Research Committee (Protocol No. 96-056).

We used t-tests adjusted for unequal variances to compare the number of captures/individual between cotton mice and flying squirrels. We calculated species richness, Simpson's Index of Diversity, the Shannon-Wiener Index of Diversity, the Shannon-Wiener Evenness Index, and the Brillouin Index of Diversity using programs DIVERS (Krebs 1989) for each grid based on data from only ground traps and based on data from all traps. We used a Signed Rank Test to test for differences in species richness estimates between trapping procedures and paired t-tests to test for differences in the diversity indices. Means $\pm$ 1 SE are presented and a significance level of $P< 0.05$ was used for all tests.

Results

We captured 1,362 mammals 4,593 times during 40,957 box trap nights, 82,247 Sherman ground trap nights, and 71,343 Sherman tree trap nights. Southern flying squirrels and cotton mice were the most abundant species in the sample (Table 1). Although the number of flying squirrels and cotton mice captured was almost equal, the average number of captures per individual was significantly greater ($t=8.18$, df=

Table 1. Number of individuals and total number of captures of small mammals on the Savannah River Site, South Carolina, from March 1997 through January 1999 in ground traps only and in all traps (ground and tree).

	Ground traps		All traps	
Species	**Animals**	**captures**	**Animals**	**Captures**
Southern flying squirrel *(Glaucomys volans)*	12	12	580	1,696
Cotton mouse *(Peromyscus gossypinus)*	521	1,893	567	2,461
Golden mouse *(Ochrotomys nuttalli)*	46	93	64	169
Fox squirrel *(Sciurus niger)*	31	45	31	45
Eastern cottontail *(Sylvilagus floridanus)*	27	63	27	63
Southern short-tailed shrew *(Blarina camlinensis)*	25	26	25	26
Old-field mouse *(Pemmyscuspolitwtus)*	20	38	20	41
Cotton rat *(Sigmodon hispidus)*	19	59	19	59
Harvest mouse *(Reithrodontomys humulis)*	16	20	16	20
Long-tailed shrew *(Sorex longimstis)*	3	3	3	3
Opossum *(Didelphis virginiana)*	4	4	4	4
Gray squirrel *(Sciurus camlinensis)*	2	2	2	2
Raccoon *(Procyon lotor)*	2	2	2	2
Long-tailed weasel *(Mustela frenata)*	2	2	2	2
Total	730	2,262	1,362	4,593

Table 2. Number of small mammals captured in box traps, Sherman live traps placed on the ground, and Sherman live traps placed in trees from March 1997 through January 1999 on the Savannah River Site, South Carolina.

Species	Ground traps: Box	Ground traps: Sherman	Tree traps: Sherman	Other[a]
Southern flying squirrel *(Glaucomys volans)*	2	10	1,684	0
Cotton mouse *(Peromyscus gossypinus)*	1	1,900	552	8
Golden mouse *(Ochrotomys nuttalli)*	0	94	14	0
Fox squirrel *(Sciurus niger)*	45	0	0	0
Eastern cottontail *(Sylvilagus floridanus)*	60	3	0	0
Southern short-tailed shrew *(Blarina carolinensis)*	0	26	0	0
Old-field mouse *(Peromyscus polinotus)*	0	38	2	1
Cotton rat *(Sigmodon hispidus)*	27	32	0	0
Harvest mouse *(Reithrodontomys humulis)*	0	20	0	0
Long-tailed shrew *(Sorex longirostis)*	0	3	0	0
Opossum *(Didelphis virginiana)*	4	0	0	0
Gray squirrel *(Sciurus carolinensis)*	2	0	0	0
Raccoon *(Procyon lotor)*	2	0	0	0
Long-tailed weasel *(Mustela frenata)*	1	1	0	0
Total	144	2,127	2,312	9

a. Captured in pitfall traps used in other studies or found dead next to trap.

983, P=0.0001) for cotton mice (4.32 ± 0.16, range= 1-28) than for flying squirrels (2.72 ± 0.11, range 1-17). Golden mice, fox squirrels, eastern cottontails *(Sylvilagus floridanus),* southern short-tailed shrews, old-field *mice (P. polionotus),* cotton rats *(Sigmodon hispidus),* and harvest mice *(Reithrodontomys humulis)* were also relatively common although they were far less abundant than cotton mice and flying squirrels.

Only 2.1% (12) of flying squirrels were captured in traps placed on the ground and 99.3% of all flying squirrel captures were in tree traps (Table 2). The majority (77.2%) of cotton mouse captures were in Sherman ground traps (Table 2). Although 9 1.9% of cotton mice were captured at least once in Sherman ground traps, 8.1% (46) of cotton mice were captured only in tree traps. Slightly more than half (55.0%) of

Table 3. Diversity indices of small mammals on 12 trapping grids based on data from Sherman live traps and box traps set on the ground and based on data from Sherman live traps and box traps on the ground and Sherman traps set at 1.5 m in the trees on the Savannah River Site, South Carolina. Means ± 1 SE are presented (N = 12). P represents the probability that the 2 estimates differ due to chance.

Diversity index	Ground traps	All traps	P
Species richness	7.25 ± 0.71	7.58 ± 0.62	0.1250
Simpson Index	0.46 ± 0.05	0.61" 0.02	0.0004
Shannon-Wiener Index	1.49 ± 0.17	1.72 ± 0.11	0.0128
Shannon Evenness Index	0.53 ± 0.04	0.60 ± 0.03	0.0171
Brillouin Index	1.30 ± 0.16	1.60 ± 0.34	0.0008

the golden mouse captures were in Sherman ground traps and 7 1.9% of all individuals were captured at least once in a ground trap. However, 28.1% (18) of the golden mice were captured exclusively in tree traps.

Estimates of species richness based on ground traps only did not differ significantly from estimates based on all traps (Table 3). However, all other diversity estimates were significantly greater when based on data from all traps than when based on data from ground traps only (Table 3).

Discussion

Sherman live traps or snap traps of various sizes are commonly used to sample mammal communities of eastern forests (e.g., Whiting and Fleet 1987, DeGraaf et al. 1991, Tappe et al. 1993). Auxiliary sampling with pitfall traps or large box traps may also be conducted (e.g. Wolfe and Lohoefener 1983, Daniel and Fleet 1999, Loeb 1999). However, traps have traditionally been placed solely on the ground. Our study shows that the addition of tree traps to the conventional ground trap sampling design results in very different estimates of the rodent community structure. Without tree traps, we would have concluded that cotton mice were the most abundant rodent in mature upland loblolly pine stands on the Savannah River Site because, like other studies (Whiting and Fleet 1987, Engel et al. 1992, Tappe et al. 1993), we captured very few southern flying squirrels in ground traps. However, flying squirrels were readily captured in traps placed at approximately 1.5 m in the trees resulting in almost equal numbers of southern flying squirrels and cotton mice.

The large difference in capture rates of flying squirrels in tree and ground traps was probably not related to a preference by southern flying squirrels for the peanut butter baits in tree traps over sunflower seed baits in ground traps. Daniel and Fleet (1999) placed Sherman live traps baited with a peanut butter-oat mixture on the ground in mature bottomland hardwood, sideslope hardwood, mixed pine-hardwood, and upland pine forests in eastern Texas and captured only 3 flying squirrels compared to 381 *Peromyscus* spp. and 204 *O. nuttalli*. Further, traps placed at 1.0-3.1 m in trees were 34 times more effective than ground traps in capturing southern flying squirrels in Wisconsin even though peanut butter was used as bait in all traps (Engel et al. 1992) and traps baited with peanut butter, oatmeal, and bacon and placed at 1-2 m in a mature hardwood forest in Massachusetts were 5 times more effective in capturing southern flying squirrels than traps placed on the ground (Taylor and Lowman 1996). Thus, the differences in capture of southern flying squirrels in tree and ground traps was most likely due to their vertical placement and not bait type.

Although addition of tree traps to the sampling design did not change our estimates of species composition, the use of tree traps greatly changed our estimates of the structure of the small mammal community. The diversity indices we used incorporated both the number of species and the number of individuals per species (Krebs 1989). Thus, the increases in diversity estimates when tree trap data were included represent an increase in the equitability of the community across species. When data from only the ground traps were used, the community appeared to be strongly dominated by 1 species, the cotton mouse. In contrast, when data from the tree traps *were* included, the community was dominated by 2 species, the cotton mouse and the southern flying squirrel, and, thus, exhibited far greater equitability. Increased equitability in the data may have also been due to the increase in the number of golden mice resulting from tree trapping. Golden mice are relatively arboreal (Packer and Layne 1991) and the addition of tree traps resulted in a 37% increase in golden mouse individuals captured. It should also be noted that although the number of captures in box traps was low, the use of box traps contributed greatly to our knowledge of the small mammal community. All of the fox squirrels, gray squirrels, opossums, and raccoons were captured in box traps and almost 50% of the cotton rat captures were in box traps. Pitfall trapping was conducted by other investigators (T. McCay and J. Laerm) and the addition of those data will provide an even more complete picture of the structures and composition of the small mammal community.

Failure to more thoroughly sample the small mammal community through the use of a variety of trap types set in a variety of positions not only leads to an underestimation of diversity, but may also lead to a poor understanding of the structure and function of small mammal communities and the forest ecosystems they inhabit. Our data clearly demonstrate that southern flying squirrels are far more abundant and may play far more prominent roles in the functioning of forested ecosystems than has been recognized in the past. For example, the major dietary items of southern flying squirrels throughout the year were acorns and other hard mast (Harlow and Doyle 1990). Considering their abundance, size, and ability to move across the landscape, southern flying squirrels are probably major consumers, as well as dispersers, of oak seeds. Further, if there is interspecific competition for mast, it is likely that southern flying squirrels play an important role in those interactions, particularly during years of low mast production (Wolff 1996). However, studies that have examined the relationship between mast, small mammals, and forest ecosystem function have ignored southern flying squirrels (e.g., McCracken 1996, Ostfeld et al. 1996, Wolff 1996). Further, because cavities are the primary nest sites of southern flying squirrels throughout most of their range (Muul 1974), flying squirrels likely play an important role in the interactions among cavity nesters. For example, Carmichael and Guynn (1983) found that southern flying squirrels were the dominant user of cavities in the Upper Piedmont Region of South Carolina and several cavities that were initially occupied by downy ***(Picoides pubescens)*** and pileated woodpeckers ***(Dryocopus pileatus)*** were later occupied by flying squirrels. In some areas, southern flying squirrels significantly reduced the reproductive success of the endangered red-cockaded woodpecker, l? ***borealis*** (Laves and Loeb 1999), and numerous incidental interactions between southern flying squirrels and a variety of cavity nesting birds have been reported in both natural cavities (Stabb et al. 1989, Ridley et al. 1997) and nest boxes (Goertz et al 1975). In addition, flying squirrels were important prey for many vertebrates including owls, rat snakes (***Elaphe*** spp.), and many of the mammalian predators such as bobcats ***(Lynx rufus),*** foxes ***(Urocyon cinereoargenteus*** and ***Vulpes vulpes),*** raccoons ***(Procyon lotor),*** weasels ***(Mustela*** spp.), and domestic cats (Dolan and Carter 1977).

Risch and Brady (1996) recommended that traps for southern flying squirrels be placed 4.5–5.0 m above ground and Taylor and Lowman (1996) suggested that adequate sampling for southern flying squirrels required that traps be placed in the canopy. However, our trap success (number of captures per 100 trap nights) for flying squirrels in tree traps was 2.4% which was greater than Risch and Brady's trap success at either 4.5–5.0 m (1.7%) or 8.0-8.5 m (1.6%). Further, traps set at 4.5 m require ≥ 1 ladder section and a climbing belt and traps set in the canopy require either considerable climbing equipment or a pulley system. Even if setting traps at >4.5 m is superior for in-depth studies of flying squirrel behavior and vertical stratification of arboreal mammals, the increased time and equipment necessary to set, check, and maintain traps at these heights precludes large scale sampling. Little additional time and no additional equipment (other than traps) are needed to set and maintain the traps set at 1.5 m in trees. Because placing traps in trees has the potential to greatly increase our understanding of forest ecosystem structure and function at relatively low cost, we recommend that future studies of forest mammal communities include arboreal traps.

Literature Cited

Batson, W. T., J. S. Angerman, and J. T. Jones. 1985. Flora of the Savannah River Plant: an inventory of the vascular plants on the Savannah River Plant, South Carolina. U.S. Dep. Energy, Savannah River Plant, SRO-NERP-15. 64pp.

Bury, R. B. and P. S. Corn. 1987. Evaluation of pitfall trapping northwestern forests: trap arrays with drift fences. J. Wildl. Manage. 51:112–1 19.

Carmichael, D. B., Jr., and D. C. Guynn, Jr. 1983. Snag density and utilization by wildlife in the upper piedmont of South Carolina. Pages 107-l 10 in J. W. Davis, G. A. Goodwin, and R. A. Ockenfels, eds. Snag habitat management: Proceedings of the symposium. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep., RM-99, Flagstaff, Ariz.

Daniel, R. S. and R. R. Fleet. 1999. Bird and small mammal communities of four similar-age forest types of the Caddo Lake area in east Texas. Texas J. Sci. 51:65–80.

Day, G. I., S. D. Schemnitz, and R. D. Taber. 1981. Capturing and marking wild animals. Pages 61-98 *in* S. D. Schemnitz, ed. Wildlife techniques manual. The Wildl. Soc., Washington, D. C.

DeGraaf, R. M., D. P. Snyder, and B. J. Hill. 1991. Small mammal habitat associations in poletimber and sawtimber stands of four forest cover types. For. Ecol. Manage. 46:227–242.

Dolan, P. G. and D. C. Carter. 1977. *Glaucomys volans.* Mammal. Species 78:1–6.

Engel, T. C., M. J. Lemke, and N. F. Payne. 1992. Live capture methods of sympatric species of flying squirrel. Trans. Wisc. Acad. Sci. Arts and Letters. 80:149–152.

Gentry, J. B., F. B. Golley, and M. H. Smith. 1968. An evaluation of the proposed international biological program census method for estimating small mammal populations. Acta Theriologica 13:313–327.

Goertz, J. W., R. M. Dawson, and E. E. Mowbray. 1975. Response to nest boxes and reproduction by *Glaucomys volans* in northern Louisiana. J. Mammal. 56:933–939.

Hamilton, R. B., S. W. Ellsworth, and J. C. Smith. 1987. Mammalian use of habitat in the loblolly-shortleaf pine type of Louisiana. Pages 81-91 *in* H. A. Pearson, F. E. Smeins, and R. E. Thill, eds. Ecological, physical, and socioeconomic relationships within southern National Forests. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep., SO-68, New Orleans, La.

Hamilton, W. J., Jr. and D. B. Cook. 1940. Small mammals and the forest. J. For. 38:468–473.

Harlow, R. F. and A. T. Doyle. 1990. Food habits of southern flying squirrels *(Glaucomys volans)* collected from red-cockaded woodpecker *(Picoides borealis)* colonies in South Carolina. Am. Midl. Nat. 124:187–191.

Hatchell, G. E. 1964. Small-mammal species and populations in the loblolly-shortleaf pine forest type of Louisiana. U.S. Dep. Agric., For. Serv. Res. Pap., SO-l 1. 12pp.

Hunter, M. L., Jr. 1990. Wildlife, forests, and forestry: principles of managing forests for biological diversity. Prentice Hall, Englewood Cliffs, N.J. 370pp.

Kirkland, G. L., Jr. and P. K. Sheppard. 1994. Proposed standard protocol for sampling small mammal communities. Pages 277-283 *in* J. F. Merritt, G. L. Kirkland, Jr., and R. K. Rose, eds. Advances in the biology of shrews. Carn. Mus. Nat. Hist. Spec. Publ. No. 18.

Krebs, C. J. 1989. Ecological methodology. Harper and Row, New York. 654pp.

Laves, K. S. and S. C. Loeb. 1999. Effects of southern flying squirrels *Glaucomys volans* on red-cockaded woodpecker *Picoides borealis* reproductive success. Anim. Conserv. 2:295–303.

Layne, J. N. 1970. Climbing behavior of *Peromyscus floridanus* and *Peromyscus gossypinus* J. Mammal. 51:580–591.

Loeb, S. C. 1999. Small mammal responses to coarse woody debris in a southeastern pine forest. J. Mammal. 80:460–471.

Masters, R. E., R. L. Lochmiller, S. T. McMurray, and G. A. Bukenhofer. 1998. Small mammal response to pine-grassland restoration for red-cockaded woodpeckers. Wildl. Soc. Bull. 26:148–158.

McComb, W. C. and R. E. Noble. 1980. Small mammal and bird use of some unmanaged and managed forest stands in the mid-south. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 34:482–491.

McCracken, K. E. 1996. Seed predation by small mammals on three species of trees in an oak-pine forest ecosystem. Ph.D. Diss, Univ. Maine, Orono. 104pp.

Mitchell, M. S., K. S. Karriker, E. J. Jones, and R. A. Lancia. 1995. Small mammal communities associated with pine plantation management of pocosins. J. Wildl. Manage. 59:875–881.

Muul, I. 1974. Geographic variation in nesting habits of *Glaucomys volans.* J. Mammal. 55:840–844.

Ostfeld, R. S., C. G. Jones, and J. 0. Wolff. 1996. Of mice and mast: ecological connections in eastern deciduous forests. Bioscience 46:323–330.

Packer, W. C. and J. N. Layne. 1991. Foraging site preferences and relative arboreality of small rodents in Florida. Am. Midl. Nat. 125:187–194.

Perry, R. W., P. A. Tappe, D. G. Peitz, R. E. Thill, M. A. Melcoirs, and T. B. Wigley. 1996. A comparison of snap traps for evaluating small mammal populations. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 50:280–286.

Ridley, T. R., G. L. Chapman, and S. C. Loeb. 1997. Southern flying squirrel displaces a red-cockaded woodpecker from its cavity. Chat 61:112–1 15.

Risch, T. S. and M. J. Brady. 1996. Trap height and capture success of arboreal small mammals: evidence from southern flying squirrels *(Glaucomys volans).* Am. Midl. Nat. 136:346–351.

Shadowen, H. E. 1963. A live-trap study of small mammals in Louisiana. J. Mammal. 44: 103-108.

Smith, M. H., J. B. Gentry, and J. Pinder. 1974. Annual fluctuations in a small mammal population in an eastern hardwood forest. J. Mammal. 55:23 l-234.

Stabb, M. A., M. E. Gartshore, and P. L. Aird. 1989. Interactions of southern flying squirrels *(Glaucomys volans)* and cavity-nesting birds. Can. Field-Nat. 103:401-403.

Stephenson, G. K., P. D. Goodrum, and R. L. Packard. 1963. Small rodents as consumers of pine seed in east Texas uplands. J. For. 61:523-526.

Tappe, P. A., R. E. Thill, J. J. Krystofik, and G. A. Heidt. 1993. Small mammal communities of mature pine-hardwood stands in the Ouachita Mountains. Pages 74-81 in J. B. Baker, ed. Ecosystem management research in the Ouachita Mountains: pretreatment conditions and preliminary findings. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. SO-1 12, New Orleans, La.

Taylor, P. H. and M. D. Lowman. 1996. Vertical stratification of the small mammal community in a northern hardwood forest. Selbyana 17:15-21.

Whiting, R. M. and R. R. Fleet. 1987. Bird and small mammal communities of loblolly-shortleaf pine stands in east Texas. Pages 49-66 *in* H. A. Pearson, F. E. Smeins and R. E. Thill, eds. Ecological, physical, and socioeconomic relationships within southern National Forests. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep., SO-68, New Orleans, La.

Williams, D. F. and S. Braun. 1983. Comparison of pitfall and conventional traps for sampling small mammal populations. J. Wildl. Manage. 47:841-845.

Wolfe, J. L. and R. Lohoefener. 1983. The small mammal fauna of a longleaf-slash pine forest in southern Mississippi. J. Miss. Acad. Sci. 28:37-47.

Wolff, J. 0. 1996. Population fluctuations of mast-eating rodents are correlated with production of acorns. J. Mammal. 77:850-856.

Workman, S. W. and K. W. McLeod. 1990. Vegetation of the Savannah River Site: major community types. U.S. Dep. Energy, Savannah River Site, SRO-NERP-19. 137pp.