Use of Nest Boxes by Squirrels in the South Carolina Piedmont

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Abstract: Nest box use by gray squirrels (*Sciurus carolinensis*) and southern flying squirrels (*Glaucomys volans*) was studied in 2 isolated hardwood stands in the South Carolina Piedmont from December 1980 through December 1983. Over a 3-year period, an average of 94% of 100 boxes were used by squirrels. The number of squirrels occupying boxes increased ($P < 0.001$) over the 3-year period. Parturition dates and litter sizes were determined for 104 litters containing 283 squirrels. Two peaks of parturition occurred: 47% of the litters were born during January to March, and 46% were born during August to October. Differences in nest box use by squirrels between study areas, box use by other species, and effects of nest boxes on estimated squirrel densities are discussed.

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In South Carolina over 600,000 man-days are expended annually to harvest over 1 million gray squirrels (Webb 1982). Recent silvicultural trends show intensive pine management and increased use of southern hardwoods by the timber industry. The potential exists for reduced availability of natural tree cavities because of the removal of cull trees and a reduced rotation length for hardwoods. The importance of tree cavities to gray squirrels as nurseries and escape cover has been described by Burger (1969), Nixon et al. (1978), and Williamson (1983).

The study was initiated in 1980 to determine the use of nest boxes by tree squirrels in the Piedmont Region of South Carolina. The objectives were to: (1) determine the acceptance and use of nest boxes by gray squirrels and southern flying squirrels in 2 upland hardwood stands of similar age, but of different management histories, (2) determine peak dates of gray squirrel parturition and nursing, and (3) define landscape variables that potentially affect use of nest boxes by gray squirrels.

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Methods

The 2 study areas (3.5 km apart) were located within the Tyger Ranger District of the Sumter National Forest in Union County, South Carolina. Both study areas were isolated by adjacent pine stands of various ages.

Study Area 1 was 22 ha with an overstory primarily composed of white oak (*Quercus alba*), southern red oak (*Q. falcata*), and hickories (*Carya* spp.), with scattered yellow poplar (*Liriodendron tulipifera*). The mean age of overstory trees was 62 years as determined by the U.S. Forest Service stand inventory. Midstory species included flowering dogwood (*Cornus florida*), yellow poplar, and sweetgum (*Liquidambar styraciflua*). Understory vegetation included thick yellow poplar reproduction (2,900 stems/ha), flowering dogwood, sweetgum, red maple (*Acer rubrum*), sumac, (*Rhus* sp.), and blackberry (*Rubus* sp.). During 1975 the stand was thinned and fertilized. Windthrow, lightning strikes, and mortality resulted in a stand that was essentially a hardwood shelterwood with a basal area of 12.8 m^2/ha. Almost no natural tree cavities were observed in the stand.

Study Area 2 was more characteristic of Piedmont upland hardwood stands—highgraded and allowed to develop through natural regeneration without additional timber management such as thinning. Natural tree cavities were abundant throughout the stand. This 37-ha stand had an overstory of white oak, red oak, and hickory with an average age of 56 years and a basal area of 17.2 m^2/ha. The midstory was composed of flowering dogwood, red maple, sweetgum, and red cedar (*Juniperus virginiana*). Understory vegetation was basically absent due to a closed canopy.

Nest boxes were constructed of 2.5-cm thick baldcypress (*Taxodium distichum*) and were 53 × 25 × 25 cm with a circular 7.6 cm diameter side entrance. Bottoms were 9.5-mm mesh hardware cloth. Material cost for each box was approximately $6.50.

During July 1980, 50 boxes were erected at a density of 1 box per 0.2 ha on each study area. Boxes were equally spaced along east-west transects which extended the width of the stand. Transects were spaced approximately 61 m apart along a north-south line until enough transects were established to accommodate 50 boxes. Boxes were attached to trees using 7.6 cm galvanized nails at a height of 5.5 m. Boxes were erected on the tree (regardless of species) nearest the measured location points along the transect and included 9 species of hardwoods and 2 species of pine.

Nest boxes were examined monthly for use by squirrels. The first box check was made during December 1980. The presence of new nest material, evidence of feeding, or cache behavior was recorded as squirrel use. The number of squirrels present when boxes were checked were identified by species. When gray squirrel

litters were found in the boxes, the number of young was recorded and age estimated up to 6 weeks using the characteristics described by Uhlig (1955) and Sharp (1958). Gray squirrels between 6 weeks of age and adults (≥ 1 year) were designated as juveniles. Parturition dates were calculated by backdating from estimated age of each litter and recorded by month of birth. Flying squirrels were aged as young or adults.

Statistical analysis of box use considered 4 response variables: (1) the number of adults per box, (2) the litter size, (3) the number of juveniles per box, and (4) the number of young per box (where young is the sum of litter size and the number of juveniles per box). Analysis of variance was used to test for differences among years, between areas, and among months, as well as second and third order interactions of these effects. A log transformation was used to stabilize variances (Snedecor and Cochran 1980).

Results and Discussion

Gray Squirrel Use and Occupancy

There were 3,700 box inspections. Nest boxes were readily accepted on both study areas with 61 of 100 available boxes used at the initial inspection. Thirty-one of the boxes were occupied by 42 gray squirrels when inspected. This use is considerably higher than the 17% box occupancy reported by Fowler and Dimmick (1983) for gray squirrels during winter in a Tennessee woodland habitat. Percent use by gray squirrels continued to increase during the 3-year study (Fig. 1).

The number of adult gray squirrels occupying boxes increased significantly ($P < 0.001$) over the 3-year study period (Table 1). A mean of 18 squirrels per 100 boxes per month was recorded for combined areas in 1981. The mean for 1983 was 29 per 100 boxes per month. During the final inspection in December 1983, 193

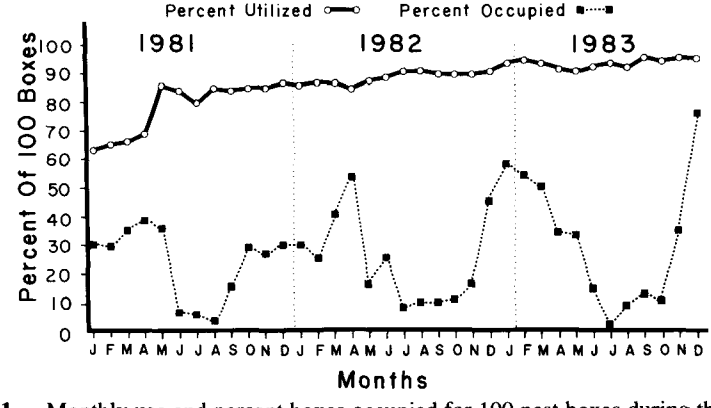

Figure 1. Monthly use and percent boxes occupied for 100 nest boxes during the period January 1981 through December 1983.

Table 1. Use of 100 artificial nest boxes on 2 study areas in the South Carolina Piedmont, January 1981 through December 1983.

Year	Number boxes used per month[a]			Number boxes occupied/month			Gray squirrels per month	
	$\bar{X}$	Range		$\bar{X}$	Range		$\bar{X}$	Range
				Area 1				
1981	40.4	44	35	12.3	24	1	19.7	0–39
1982	44.3	46	42	14.8	36	4	21.2	2–70
1983	46.7	49	45	18.2	41	1	31.0	1–123
				Area 2				
1981	38.0	44	26	11.7	19	3	17.5	4–27
1982	44.4	46	42	10.0	21	3	13.6	2–35
1983	47.4	48	43	15.2	36	2	23.9	2–70

[a]Includes feeding sign, nests, caches, and actual presence.

gray squirrels were counted in 71 boxes. For all years combined, boxes were used more during January to March; however, the month of greatest occupancy was different ($P < 0.001$) among years for both areas (Fig. 1).

Parturition Dates and Litter Sizes

There were 2 peaks of parturition (Table 2). Of the 104 litters recorded, 49 (47%) were born in January to March and 48 (46%) were born in August to October. The other 7 litters (7%) were distributed throughout the remaining months of the year. Births were recorded in every month except June and November. Similar results have been reported throughout the United States, and indicated that latitude apparently has little effect on gray squirrel breeding seasons (Brown and Yeager 1945, Allison 1953, Uhlig 1956, Smith 1967, Kirkpatrick et al. 1976).

The mean litter size found during the 3-year study was 2.7 young and did not differ among years ($P > 0.22$). However, differences in litter size between breeding periods were significant ($P < 0.001$). Larger litters ($\bar{x} = 3.0$) were recorded during August to October than in January to March ($\bar{x} = 2.4$). Kirkpatrick et al. (1976) also reported larger litters during summer-fall than during winter-spring in the Virginia Piedmont and Coastal Plain.

Differences Between Study Areas

For the 3 years combined, the number of adult gray squirrels, the number of juveniles, and the number of young (litter size plus the number of juveniles) recorded per box per month was greater ($P < 0.02$) for Area 1 than Area 2 (Fig. 2). The number of young per litter did not differ ($P > 0.089$) between areas; however, more litters were found on Area 1 than on Area 2. Heavy thinning and fertilization in Area 1 had resulted in a hardwood stand composed primarily of high quality trees with straight trunks and few natural cavities. In contrast to Area 1, Area 2 was more characteristic of unmanaged upland hardwood stands containing a number of lower merchantable quality hardwoods characterized by abundant branching with few

Table 2. Reproductive data obtained for gray squirrels by examination of 100 nest boxes in the South Carolina Piedmont, January 1981 through December 1983.

Year	Winter/spring peak							Summer/fall peak					Total all months
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1981[a]													
N litters	1	8	2	0	1	0	1	13	1	6	0	2	35
$\bar{X}$ litter size	2.0	2.4	2.5	—	2.0	—	3.0	3.8	2.0	3.2	—	4.0	3.1
1982[a]													
N litters	8	10	5	2	0	0	3	7	2	0	0	0	37
$\bar{X}$ litter size	2.8	2.8	2.4	2.5	—	—	2.7	2.7	3.5	—	—	—	2.7
1983[a]													
N litters	1	13	1	0	0	0	0	13	3	1	0	0	32
$\bar{X}$ litter size	3.0	1.9	2.0	—	—	—	—	2.5	2.0	4.0	—	—	2.2
All years													
N litters	10	31	8	2	1	0	4	33	6	7	0	2	104
Mean litter size	2.7	2.3	2.4	2.5	2.0	—	2.8	3.1	2.5	3.3	—	4.0	2.7

[a]Represents only squirrels known to have been born in boxes (104 litters containing 283 squirrels).

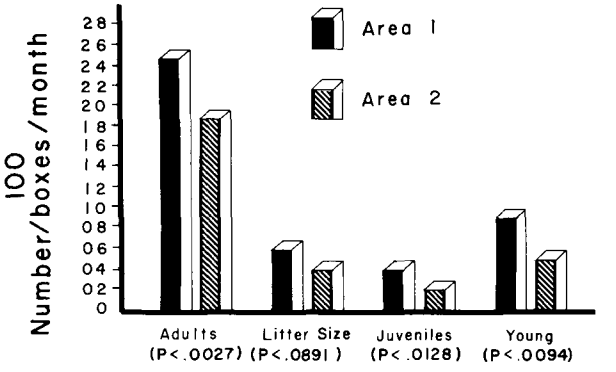

Figure 2. Number of adult gray squirrels, number of litters, numbers of juveniles, and number of young (litter size plus the number of juveniles) recorded per box per month on 2 study areas in Union County, South Carolina from January 1980 through December 1983.

"clear" trunks. Visual inspection of individual trees along box transects indicated numerous potential den holes on Area 2 but few visible on Area 1. The higher use of boxes on Area 1 may be attributed to a scarcity of natural cavities, a preference for artificial nest boxes, or both. Although hard mast production was not quantified on the study areas, visual examination indicated more abundant mast on Area 1. Higher mast availability may account for increased productivity in the presence of adequate nesting sites. Because only about one half of the available naturally occurring tree cavities may be suitable for squirrel use (Allen 1952), the more abundant potential den cavities observed on Area 2 may not represent significantly more available den sites for gray squirrels on that area.

Use of Natural Cavities and Litter Movement

Production in natural cavities or leaf nests was indicated by the presence of young squirrels of a specific age in a nest box which were not present in the box or immediately adjacent boxes during the prior monthly check. For example, if a box contained 3 young gray squirrels approximately 6 weeks of age, the previous month's data were examined to determine if 2-week old squirrels were present in the box in question or any adjacent box. If a record of young squirrels was reported that corresponded to the age at first capture, then the new litter was assumed to be the litter previously reported. Otherwise, new litters were assumed to have been moved to the nest box after birth in a natural cavity or leaf nest. All squirrels less than 4 weeks of age were assumed born in the box in which they were first observed. Based on the above criteria, 25 litters containing 59 young were moved from cavities or leaf nests to nest boxes on Area 1. On Area 2, only 9 litters containing 24 young were moved to nest boxes from cavities or leaf nests. A movement of young from one box to another was recorded on 11 occasions. In Ohio, Nixon et al. (1968) reported a litter movement of 45 m for a 25-day-old litter of gray squirrels. In the current study all known movement occurred after young were at least 3 weeks old, and most (72%) occurred after 5 weeks of age. Movement of young squirrels to a

new box occurred only among adjacent boxes (61 m apart). According to Cordes and Barkalow (1972), some individual gray squirrels tend to remain within the same area close to their mother for their lifetime; some young squirrels remain with their mother for 6 months or longer. In the same North Carolina study, an affinity for postpartum nest sites was demonstrated by 9 females who produced litters in the same nest boxes in which they were born (Cordes and Barkalow 1972).

Variables Affecting Nest Box Use

Use of a box by gray squirrels was affected by the location of a box within the stand. Boxes placed within the hardwood stand proper were used first and more often than boxes located on the edge of the study area adjacent to pine stands or adjacent to regeneration areas. As use increased, boxes located in marginal squirrel habitat were used. During the first year of the study, litters were found in only 3 of 39 boxes located within 60 m of the stand edge. By 1983, 11 boxes near stand edges contained litters. The majority of reproduction, however, was located well within the 2 hardwood stands. Boxes located in marginal habitat areas (stand edges) appeared to be used most often for resting and shelter and were frequently used by juvenile squirrels by the second year of the study.

Flying Squirrels

Use of boxes by flying squirrels decreased throughout the study on Area 1 but remained stable on Area 2 (Table 3). Flying squirrels occupied boxes on 92 occasions and occurred 66% of the time in groups of 3 or more. Only on 8 occasions (9%) were single flying squirrels recorded. It was rare to find very young flying squirrels (without pelage development). Because flying squirrels appearing less than 3 weeks of age were found only on 3 occasions, most flying squirrel litters were apparently moved to boxes sometime after birth. The maximum number of flying squirrels simultaneously occupying a single box was 13. The largest aggregation reported by Sawyer and Rose (1985) in nest boxes in Virginia was 11.

Table 3. Flying squirrel use of nest boxes, use by other species, and unused boxes on 2 South Carolina Piedmont study areas, January 1981 through December 1983.

Year	*N* flying squirrels per month		Boxes used by other species[a] per month	Empty boxes per month
	Average	Range		
		Area 1		
1981	11.0	0–41	3.3	6.2
1982	12.0	0–25	1.3	4.2
1983	9.7	0–31	0.6	2.7
		Area 2		
1981	2.7	0– 7	1.7	10.0
1982	4.6	0–12	0.6	5.0
1983	3.5	0–15	0.6	2.1

[a]Included bees, screech owls, tufted titmice, and opossums.

Use by Other Species

The mean number of boxes used by vertebrate and invertebrate species other than squirrels decreased throughout the study (Table 3). The maximum number of boxes used by other species for both areas combined was 9. This occurred in July 1981, which was also the month of lowest squirrel use. The major user of boxes, other than squirrels, were honeybees (*Apis mellifera*). Once occupied, use by bees generally continued until they were physically removed from the box. Other species using boxes included: screech owls (*Otis asio*), tufted titmice (*Parus bicolor*), and opossum (*Didelphis virginianus*). Use of nest boxes by these similar species was also reported by Hesselschwerdt (1942) on intensively farmed areas in Illinois.

Population Response to Nest Boxes

Barkalow and Soots (1965) concluded that nest boxes increased the number of gray squirrels on their North Carolina study area. Burger (1969) reported heavy use and significant population increases of gray squirrels as a result of improved survival of both young and adults after placement of rubber-tire squirrel dens at Remington Farms, Maryland. For our study, the number of squirrels actually observed in the boxes during each box check did not represent a total squirrel density because additional squirrels were usually observed outside the boxes. During December 1981, 39 squirrels occupied boxes on Area 1 and 27 squirrels occupied boxes on Area 2. By December 1983, the number of squirrels occupying boxes had increased to 123 and 70 on Areas 1 and 2, respectively.

Considering the number of young produced in the boxes, high squirrel densities could result even with moderate survival rates. Excluding the number of young possibly moved from 1 box to another between subsequent box checks, there were 104 litters containing 283 squirrels produced in nest boxes on the 2 study areas combined during the 3-year study. Including litters believed to have been born in leaf nests or natural cavities and then moved to the boxes, the total known reproduction during the study was 138 litters containing 366 squirrels.

Conclusion

Intensive timber management may remove the mature and residual trees that provide most of the dens needed by tree squirrels (Sanderson et al. 1975). However, our data show if adequate food is available, nest boxes may increase the value of hardwood stands for gray squirrels by replacing den sites removed by thinning operations.

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