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Habitat Selection of the Southern Flying Squirrel in the Virginia Piedmont

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ABSTRACT

Southern Flying Squirrels (*Glaucomys volans*) were trapped from June-October 2013 at three mature forest sites dominated by hardwood trees in southwestern Virginia to determine variability in capture rates among sites and to relate them to different habitat variables. Nineteen squirrels were captured in similar numbers at two sites, with no captures at the third site. The density of cavity trees was the most important variable related to capture success, along with the relative proportion of conifer tree basal area, the amount of downed coarse woody debris, and the density of hard mast-producing tree species. Capture success was negatively related to percent slope. This study indicates that Southern Flying Squirrels select habitat based on several variables and may not be a generalist species of mature forests.

Key words: *Glaucomys volans*, habitat selection, small mammals, Southern Flying Squirrel, Virginia.

INTRODUCTION

Southern Flying Squirrels (*Glaucomys volans*) occur throughout deciduous forests of Virginia. Earlier studies of this species described it as an opportunistic generalist (Madden, 1974; Muul, 1974). The Southern Flying Squirrel also occurs in residential areas surrounded by large trees (Linzey, 1998) and frequently takes advantage of bird feeders close to human residences (T. S. Fredericksen, pers. obs.). Habitat features shown to be important for this species include mature deciduous trees, cavity trees, proximity to water, mast-producing trees, higher shrub layer stem density, and a relatively sparse midstory (Sonenshine et al., 1979; Sonenshine & Levy, 1981; Bendel & Gates, 1987; Fridell & Litvaitis, 1991; Merritt et al., 2001). While many forest stands have these conditions in southern Virginia and the species is considered common throughout the state (Linzey, 1998), we have observed that Southern Flying Squirrel populations are highly variable in different forest stands. For example, one forest stand on the campus of Ferrum College has a large population of this species with frequent captures over a series of years. The stand is dominated by Chestnut Oak (*Quercus montana*), Red Maple (*Acer rubrum*), and White Pine (*Pinus strobus*) and is located near a small pond. Trapping in other similar stands in forests at Ferrum College yielded only a few or no captures (T. S. Fredericksen, unpub. data). In a three-year study by Shively et al. (2006) that included nine mature forest stands in Franklin, Patrick, and Henry counties, the Southern Flying Squirrel was only captured in one stand. There also appears to be a seasonal effect of capture success related to the activity of flying squirrels near the ground. In past years, we observed a particularly high number of captures in this stand during the fall when oak (*Quercus* spp.) and hickory (*Carya* spp.) nuts were on the ground, perhaps because squirrels were more actively foraging on the ground where traps were located. Other studies have shown more activity of squirrels in forests during periods of hard mast availability (Taulman & Smith, 2004).

The objectives of this study were to compare the relative abundance of Southern Flying Squirrels at mature forest sites with different habitats within sites and relate the number of new captures to an array of habitat variables hypothesized to be important for this species.

METHODS

The study was conducted at two sites on the campus of Ferrum College in Franklin County (Chapman Pond and Moonshine Creek), Virginia and another site on private property approximately one mile from the

College (Rambling Rose). All trapping sites contained mature (>70-year-old) mixed pine-hardwood forests with the canopy dominated by oaks (*Quercus* spp.), Red Maple, Tuliptree (*Liriodendron tulipifera*), and White Pine, and each had been subjected to light selective logging approximately 30 years earlier. The Chapman Pond site was situated on a low ridge with relatively flat topography. The Moonshine Creek site was on a moderate (2-10%) slope with an east-facing aspect, and the Rambling Rose site had variable aspects and slopes (0-10%).

At each site, we established six trapping locations that differed in topographic variables, such as slope and aspect and the amount of ground cover, shrub cover, midstory tree cover, hard mast tree density, and the amount of coarse woody debris on the forest floor. Some of the variability in vegetation cover and coarse woody debris was due to experimental forestry treatments that were conducted at each site within the previous 1-3 years.

We trapped each of the 18 locations three times from late June to early October for three consecutive nights. During each sampling period, we trapped at each location within one of the three sites in consecutive weeks. Sixty Sherman live traps were located within each site, with 10 traps at each trapping location. Total trapping effort per site was therefore 90 trap-nights (3 trapping periods x 3 nights x 10 traps).

Traps were placed in pairs, with the pairs located approximately 5 m from the center of the trapping site in a circular arrangement. One trap in each pair was placed on a wooden shelf attached by nails to a tree approximately 2 m above the ground and the other trap was placed on the ground. Similar to Risch & Brady (1996), we found from previous experience that placing traps on the boles of trees, as well as on the ground, increases trapping success. Above-ground traps were secured to the shelf using duct tape. Traps were baited with peanut butter, oats, and sunflower seeds.

Captured animals were ear-tagged, weighed, and immediately released. An attempt was made to follow the squirrels back to their cavity tree. If a cavity tree was located, the species, diameter-at-breast-height (DBH), and total height (estimated with a clinometer), as well as the distance to trapping location, were recorded.

At all trapping locations, we conducted a habitat analysis using the 5 trapping points as sampling sites. At each sampling point, we collected habitat data listed in Table 1. Data for each point were averaged over the five sampling points for each trapping location.

We compared trapping type (ground vs. platform) and trapping sites (Chapman Pond, Moonshine Creek, and Rambling Rose) for individual squirrel captures (excluding recaptures) using a chi-square test. In addition, we created models to examine the effect of quantitative habitat variables at each trapping location on individual captures using backwards stepwise multiple regression with $p < 0.15$ as a criterion for entry into the model. Models were ranked using Akaike's Information Criterion (AIC), as well as the final model from stepwise regression. Analyses were carried out using Systat 12 (Systat Inc., San Jose, CA).

RESULTS

Nineteen flying squirrels were captured during the study period, with eight recaptures recorded, for a total of 27 captures. Captured individuals included six males and ten females, plus three others that escaped before their sex could be determined. Significantly more captures occurred in traps on tree platforms than those placed on the ground ($X^2 = 11.84$, $p = 0.001$). Only two captures (7.4%) occurred in ground traps. Captures also significantly varied among sites ($X^2 = 7.58$, $p = 0.023$). Ten squirrels were captured at the Rambling Rose site and nine at the Chapman Pond site, but none at the Moonshine Creek site.

We followed seven squirrels from their trapping location to a tree cavity. Cavity trees included four Chestnut Oaks, one Scarlet Oak (*Quercus coccinea*), and two White Pine snags. Four of the seven trees were snags. Mean tree diameter at breast height was 19 cm (range 12-40) and mean tree height was 14 m (range 2-

Table 1. Habitat variables and sampling methods employed for comparison with captures of Southern Flying Squirrels in Franklin County, Virginia.

Variable	**Method**
Tree basal area (overall and by species)	10-factor prism count
Cavity tree density	# of trees in a 20 x 20 m plot
Snag density	# of trees in a 20 x 20 m plot
Percent overstory tree cover (≥ 10 m tall)	Canopy densitometer
Percent midstory tree cover (>2 m, but < 10 m tall)	Canopy densitometer
Percent shrub cover (0.5 – 2 m tall)	Ocular estimate 3 x 3 m plot
Percent herbaceous cover (< 0.5 m tall)	Ocular estimate 3 x 3 m plot
Downed coarse woody debris volume (> 10 cm wide)	Length and width of all logs within 10 x 10 m plot
Distance to water by water type (stream, pond)	Ground measurement or calculation from aerial photo

23). Cavities ranged from approximately 10-30 m from the trapping location. We were unable to determine if the cavities were those normally used by the squirrels or just ones opportunistically used for escape.

The model with the lowest AIC (82.6), corrected for small sample size, included a positive relationship with the number of cavity trees ($t = 3.52$, $p = 0.004$), conifer basal area ($t = 2.31$, $p = 0.04$), coarse woody debris ($t = 1.91$, $p = 0.081$), and mast tree basal area ($t = 1.65$, $p = 0.13$). It also included a negative relationship with percent slope ($t = -2.83$, $p = 0.015$). The location with the highest capture success had very little shrub cover (7%) or midstory cover (15%), but the site with the second highest capture success had both high shrub cover (62%) and midstory cover (58%), with a particularly high density of Mountain Laurel (*Kalmia latifolia*). Both sites with the highest captures were dominated by hard mast trees, particularly Chestnut Oak, Scarlet Oak, and White Oak.

DISCUSSION

Despite reportedly being common in mature forests throughout Virginia (Linzey 1998), we observed high variability in capture rates for Southern Flying Squirrels in our study area. We captured squirrels at only two of three study sites, and at one site (Chapman Pond), eight of nine squirrels were captured at the same trapping location. It is unclear why squirrels were not captured at the Moonshine Creek site because it appeared to be similar to the other two sites and apparently contained suitable habitat. Past studies conducted on the Ferrum College campus (T. S. Fredericksen, unpub. data) have had highly sporadic trapping success among sites and Shively et al. (2006) captured Southern Flying Squirrels at only one of nine mature forest sites in a three-county area over a three-year period. Taulman & Smith (2004) concluded, however, that Southern Flying Squirrels are fairly selective in their habitat use and are not forest generalists.

Habitat variables within mature forests have been shown to be related to the density of Southern Flying Squirrels. One important habitat requirement is the availability of cavities. Flying Squirrels will sometimes construct leaf nests, but prefer hollow stumps or tree cavities (Linzey, 1998). We found that the density of cavity trees was the most important habitat variable related to the number of flying squirrel captures in our study. Older forests may perhaps be preferred habitat for flying squirrels because they are more likely to have decay that results in more cavities (Holloway & Malcolm, 2007). We found that squirrels used cavities in both oak and pine trees. Tree height or condition apparently did not affect cavity use because squirrels used cavities in short (2 m) stumps of dead trees, as well as cavities on the boles of live trees.

Another habitat variable that was significant in this study was conifer basal area, with more squirrels tending to be captured in stands with a higher conifer component. White Pine was the dominant conifer species on the study sites, although Virginia Pine (*Pinus virginiana*) was also common. It should be noted, however, that all stands in this study were dominated by hardwoods. A study in Arkansas also noted that the Southern Flying Squirrel preferred mature pine-hardwood forests, rather than pure hardwood forests or pine plantations (Taulman, 1999; Taulman & Smith, 2004). Pine seeds are an additional food source for flying squirrels (Linzey, 1998) and Taulman (1999) found that pines were used more frequently for outside nests than hardwood trees.

Downed coarse woody debris was another habitat variable that was related to capture rates. Our study had a wide range of coarse woody debris volumes because several sites included areas with timber stand improvement where poorly-formed trees were either felled and left on-site or felled and removed for firewood. Coarse woody debris may increase flying squirrel habitat quality for several reasons. First, it may be important cover that reduces predation risk during ground foraging, particularly in the late summer and fall when squirrels begin to store food for the winter. Second, coarse woody debris, particularly long logs, provides runways for small mammals, such as the flying squirrel, which facilitates ground travel and reduces noise that may attract predators (Loeb, 1989; McCay, 2000). Finally, coarse woody debris is invaded by insects and fungi which provide additional food sources for flying squirrels.

Another habitat variable identified as important in this study for flying squirrels was the abundance of hard mast-producing trees, such as oaks, hickories (*Carya* spp.) and American Beech (*Fagus grandifolia*). Most of the hard mast trees in the study area were oaks and the two sites with the highest captures had high densities of oaks. These species are particularly important food sources during the late summer and fall (Fridell & Litvaitis, 1991). In forests of central Ontario, Holloway & Malcolm (2007) found a close association between radio-locations of Southern Flying Squirrels and mast and decaying trees, probably because these factors provide both food and nesting sites. Interestingly, we found a negative relationship between squirrel captures and percent slope. This relationship may be an artifact related to the higher abundance of oaks and hickories on the flatter upland sites of the study area where there was high trapping success. Sonenshine et al. (1979) found no relationship between

Southern Flying Squirrel density and slope percentage.

Some other habitat variables that have been identified as important for the Southern Flying Squirrel that were not related to capture success in our study include shrub cover and midstory cover. Similar to coarse woody debris, understory shrub cover may provide cover for flying squirrels when foraging on the ground (Sonenshine & Levy, 1981; Bendel & Gates, 1987). Also, because gliding is a primary means of travel, an open midstory is thought to be important for the Southern Flying Squirrel (Bendel & Gates, 1987). Proximity to water (streams, pond) did not vary greatly in this study, but is another variable thought to be important for Southern Flying Squirrels (Sonenshine et al., 1979). The availability of cavity trees and other variables identified in this study may have offset the importance of these habitat variables.

In summary, Southern Flying Squirrel capture rates varied significantly between mature forest sites in this study and this species seems to be much more selective with respect to habitat conditions than previously believed. Habitat selection may depend on a mixture of habitat variables, but the availability of cavity trees appears to be the most important of these.

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LITERATURE CITED

Bendel, P. R., & J. E. Gates. 1987. Home range and microhabitat partitioning of the southern flying squirrel (*Glaucomys volans*). Journal of Mammalogy 68: 243-255.

Fridell, R. A., & J. A. Litvaitis. 1991. Influence of resource distribution and abundance on home-range characteristics of southern flying squirrels. Canadian Journal of Zoology 69: 2589-2593.

Holloway, G. L., & J. R. Malcolm. 2007. Northern and southern flying squirrel use of space within home ranges in central Ontario. Forest Ecology and Management 242: 747-755.

Linzey, D. W. 1998. The Mammals of Virginia. McDonald & Woodward Publishing Company, Blacksburg, VA. 459 pp.

Loeb, S. C. 1999. Response of small mammals to coarse woody debris in a southeastern pine forest. Journal of Mammalogy 80: 460-471.

Madden, J. F. 1974. Female territoriality in a Suffolk County, Long Island, population of *Glaucomys volans*. Journal of Mammalogy 55: 647-652.

McCay, T. S. 2000. Use of woody debris by cotton mice in a southeastern pine forest. Journal of Mammalogy 81: 527-535.

Merritt, J. F, D. A. Zegars, & L. R. Rose. 2001. Seasonal thermogenesis of southern flying squirrels (*Glaucomys volans*). Journal of Mammalogy 82: 51-64.

Muul, I. 1974. Geographic variation in the nesting habits of *Glaucomys volans*. Journal of Mammalogy 55: 840-844.

Risch, T. S., & M. J. Brady. 1996. Trap height and capture success of arboreal small mammals: Evidence from southern flying squirrels (*Glaucomys volans*). American Midland Naturalist 136: 346-351.

Shively, H. S., J. D. Fiore, & T. S. Fredericksen. 2006. The effects of timber harvesting on the abundance and diversity of small mammals on non-industrial private forestlands in southcentral Virginia. Banisteria 27: 31-36.

Sonenshine, D. E., D. M. Lauer, T. C. Walker, & B. L. Elisberg. 1979. The ecology of *Glaucomys volans* (Linnaeus, 1758) in Virginia. Acta Theriologica 24: 363-377.

Sonenshine, D. E., & G. F. Levy. 1981. Vegetative associations affecting *Glaucomys volans* in central Virginia. Acta Theriologica 26: 359-371.

Taulman, J. F. 1999. Selection of nest trees by southern flying squirrels (Sciuridae: *Glaucomys volans*) in Arkansas. Journal of Zoology 248: 369-377.

Taulman J. F., & K. G. Smith. 2004. Home range and habitat selection of southern flying squirrels in fragmented forests. Mammalian Biology 69: 11-27.