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Volume 7, Number 4
February 15, 2008

PURPOSE

The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 350 projects at a cost of $29 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf***.

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An Assessment of Fox Squirrel Habitat on Golf Courses Along the South Carolina Coast

Kristin Meehan and Patrick G. R. Jodice

SUMMARY

Fox squirrels are declining throughout the southeastern U.S. but appear to occur regularly on golf courses in this same region. Researchers at Clemson University and the South Carolina Cooperative Fish and Wildlife Research Unit conducted surveys on golf courses along the entire South Carolina coast to determine which landscape-level characteristics best predicted fox squirrel presence on a golf course. The data indicate:

- Fox squirrels were present on 68 of 98 courses surveys, but abundance appeared low on most courses. There was a strong correlation in the determination of fox squirrel presence or absence between on-the-ground surveys and phone interviews with golf course personnel.
- The best predictor of fox squirrel presence on a course was the presence of a fox squirrel population on the nearest neighbor course regardless of distance. For golf courses with fox squirrels, the mean distance to the nearest neighbor course with fox squirrels also present was ca. 2.0 km while for golf courses without fox squirrels the mean distance to the nearest neighbor course was ca. 2.5 km.
- Results suggest that fox squirrel populations in this region may be stabilized by multi-patch population dynamics, and, as such, landscape-level variables need to be considered when assessing the potential conservation value of golf courses for fox squirrels. Connectivity among courses or habitat patches may be important given the strength of the "nearest neighbor effect".

Research efforts to improve our understanding of wildlife use of golf courses have increased significantly in number, geographical scope, and complexity during the past decade. The need for golf courses to provide habitat for native fauna has become especially important in developed areas where golf courses now represent some of the largest tracts of remaining open space (1, 17, 18). Unfortunately, much of the research that has examined wildlife management issues on golf courses has occurred at what might best be described as a "within-course scale". In other words, habitat features within a course are often examined and identified with respect to the productivity or population status of a specific species or group of species.

Golf courses might be better developed or managed for wildlife, however, if species requirements also were considered at the landscape scale. In this approach golf courses may be viewed as habitat patches and approaches and theories of landscape ecology applied. For example, one might examine the positioning and isolation of multiple courses in an area with respect to wildlife needs, with consideration also given to adjacent undeveloped lands.

A landscape approach to examining wildlife habitat on courses might also consider the need for habitat corridors to link habitat patches (e.g. courses). This landscape-scale view may be especially important for species that require habitat patches that are larger than those offered by most single courses or for which single courses may not be large enough to support a viable population of individuals.

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USGA Turfgrass and Environmental Research Online 7(4):1-8.
TGIF Record Number: 132983

Previous research in the southeastern U.S. demonstrated that fox squirrels (*Sciurus niger*) occur on golf courses but that their abundance varies considerably among courses within a region (3, 8). Golfers that play on courses inhabited by fox squirrels quickly learn the difference between these and gray squirrels (*Sciurus carolinensis*). Fox squirrels are quite a bit larger, much more colorful, and spend a considerable amount of time foraging along the ground.

It appears that the use of golf courses by southeastern fox squirrels is due in large part to similarities in habitat structure between this species' preferred native habitat (mature pinelands with open-understory and mast producing hardwoods) and that provided by many of the golf courses in the southeastern U.S., and to abundant food resources that often occur on courses (3, 11). It is unclear, however, how landscape-level habitat factors associated with golf courses affect fox squirrel occurrence and abundance.

We sought to examine the relationship between fox squirrel presence on golf courses along the coast of South Carolina and various landscape-scale variables. Our objectives were to (1) survey courses along the entire coast to determine whether or not fox squirrels were present and (2) determine which landscape-scale features best predicted fox squirrel presence on golf courses.

Methodology

Study Species

Southeastern fox squirrels are declining throughout much of their range due in large part to the loss of native longleaf pine (*Pinus palustris*) habitat (6, 12, 16). In South Carolina the fox squirrel is currently listed as a species of special concern. Primary natural foods for fox squirrels include pine seeds, hardwood mast, palm fruits, and fungi. In golf course habitats, diets appear to expand to take advantage of the many exotic plantings that occur. For example, in southwestern Florida fox squirrels frequently consumed fruits from exotic palms, figs, nectar from flowering exotic plants, and bird seed from back-yard feeders (8).

Another important aspect of fox squirrel ecology that is particularly relevant to golf course populations is their home range size. Although the extent of home ranges varies across the region, data indicate that individual fox squirrels often maintain home ranges > 35 ha (3, 7, 9, 15). Fox squirrels also show high rates of dispersal (10), another important consideration for golf course populations. Unfortunately, this species also appears to be prone to road mortality even in areas with low traffic volumes (11). Their large home ranges, need for dispersal, and apparent inability to successfully navigate road crossings all are important aspects of their ecology in urban settings.

Study Sites

We surveyed 98 golf courses along the South Carolina coast for fox squirrels (Figure 1). We requested permission to survey on each course and attempted to obtain a relatively even distribution of courses along the coast. There were, however, some sections of the coast with few courses, such as the mid-coast area which is comprised largely of public lands (e.g. national forest and national wildlife refuge lands). We also did not

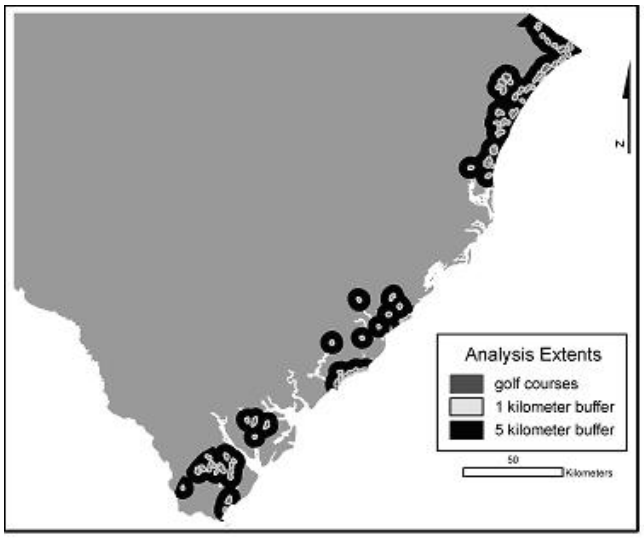
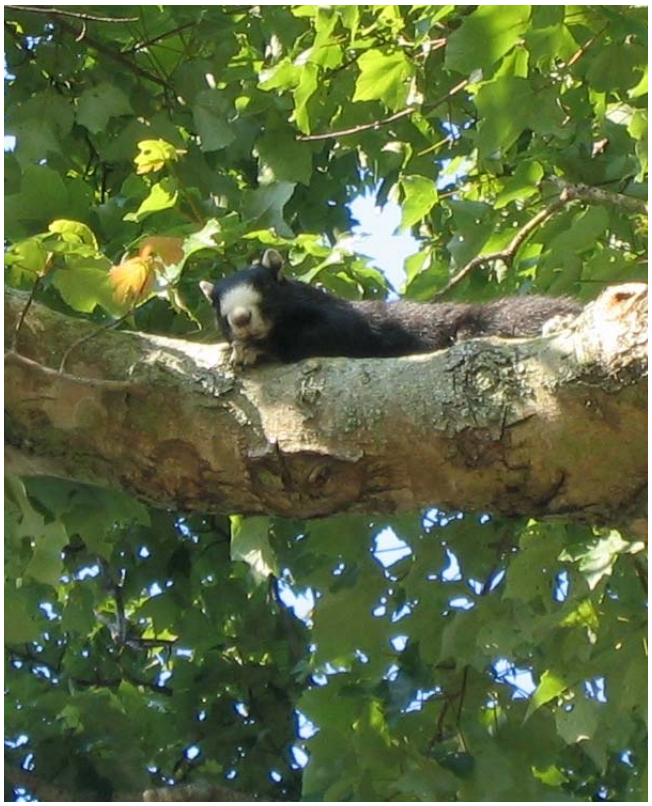


Figure 1. Location of golf courses surveyed for fox squirrels along the South Carolina coast. Study courses were not located along the central portion of the coast because that area is relatively undeveloped with large parcels of land in public ownership. The 'Analysis Extents' show the course along with 1 km and 5 km buffers (14)



Although fox squirrels spend ample time foraging and traveling along the ground, they also spend a considerable amount of time foraging and loafing in trees.

survey for fox squirrels on any sea islands even though fox squirrels do occur there. We opted to skip these areas because fox squirrels were not native to these islands and hence their presence there was strongly influenced by human activity (e.g. release dates and frequency of releases) and not necessarily habitat features. Courses were counted as one entity for data analysis when they adjoined each other, shared the same owner, and were managed as one unit.

Fox squirrel surveys

We used two techniques to measure fox squirrel presence on golf courses. First, we conducted phone interviews with staff at 98 golf courses. Typically the contact was either a course superintendent or golf professional as they were generally the most familiar with landscaping and ecological issues on the course. Along with questions about course design and characteristics, we also asked whether or not fox squirrels had been observed on the course during the past year and what their relative abundance was (e.g., observed once a month, observed infrequently, observed every day). Because the southeastern fox squirrel differs substantially from the eastern gray squirrel in size, coloration, and behavior, and because we included questions in our interviews that focused on coloration and behavior, we were confident that respondents were correctly reporting presence of fox squirrels.

Following the phone interviews we also conducted on-site surveys for fox squirrels at 51 of the 98 study courses to determine the accuracy of the phone interviews. We conducted surveys from golf carts driven along cart paths and counted the number of squirrels (both gray and fox) observed. Surveys were conducted twice on each course, once between May and June 2005, and once between November 2005 and February 2006 (we report the higher of the two counts hereafter). Surveys were conducted primarily during morning hours when fox squirrels are actively foraging and traveling along the ground (8).

Remote Sensing/GIS

Our analysis approach required extensive use of remotely sensed data and GIS tools. Identification of study courses was done using 1999 aerial photos, street addresses from the United States Golf Association member listings, GPS data collected during field visits, or geocoding of street addresses. Land cover, tree canopy closure, and paved surface cover were extracted from the 2001 National Land Cover Database (http://www.mrlc.gov/mrlc2k_nlcd.asp (last accessed 12/12/2006)), the most current landcover data available for the study area. The NLCD has been used in and recommended for analysis of wildlife habitat data at the landscape scale (2).

A roads layer was created from 2000 Census Tiger/Line data which was converted to a raster dataset based on the average width of each road type in the data set. We analyzed landscape data at three different scales: the course itself, the course with a 1-km buffer, and the course with a 5-km buffer (Figure 1). We used program

Fragstats 3.3 (13) to calculate landscape, patch, and class scale metrics for all datasets.

Data Analysis

Although fox squirrels spend ample time foraging and traveling along the ground, they also spend a considerable amount of time foraging and loafing in trees. This, along with the fact that they are not as noisy as gray squirrels, makes it quite difficult to conduct visual surveys that would result in reliable density estimates. Therefore, so as not to place more confidence in our survey data than was reasonable, we opted to simply classify each course as either having fox squirrels (presence) or not having fox squirrels (absence) for our primary analysis. One advantage of this decision was that it allowed us to include information gathered from the many courses that we did not have time to survey in person. Nonetheless, we do present the count data from those courses we surveyed in person as a coarse estimate of abundance.

We used logistic regression models to determine which habitat, landscape, and course variables best predicted the presence or absence of fox squirrels on a course. Logistic regression models are appropriate when the dependent variable is categorical, as in the case of measuring presence or absence. We considered a wide range of independent variables including, but not limited to, the proximity of fox squirrel populations to each other, the extent of development on or surrounding the course, road density, the vegetation structure of the course, course age, course location, and course size (14).

Results

Course Attributes and Fox Squirrel Surveys

The courses in our study area were moderately forested, with 44.0 ± 1.7 % of the total course land area having greater than 20% canopy cover (these values refer primarily to the fairways and interior roughs). Most of the courses we sur-

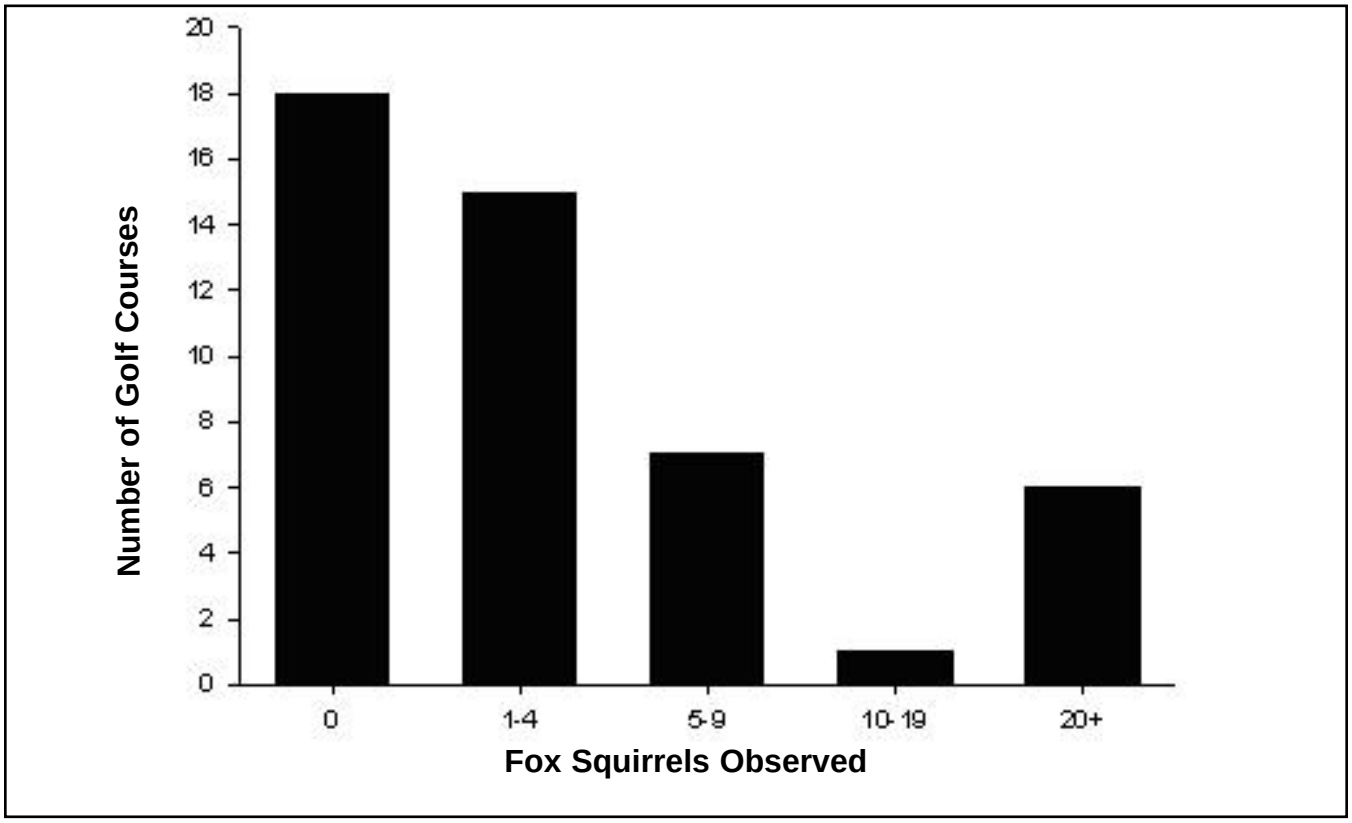


Figure 2. Number of fox squirrels observed during population surveys of 51 coastal South Carolina golf courses during 2005 or 2006

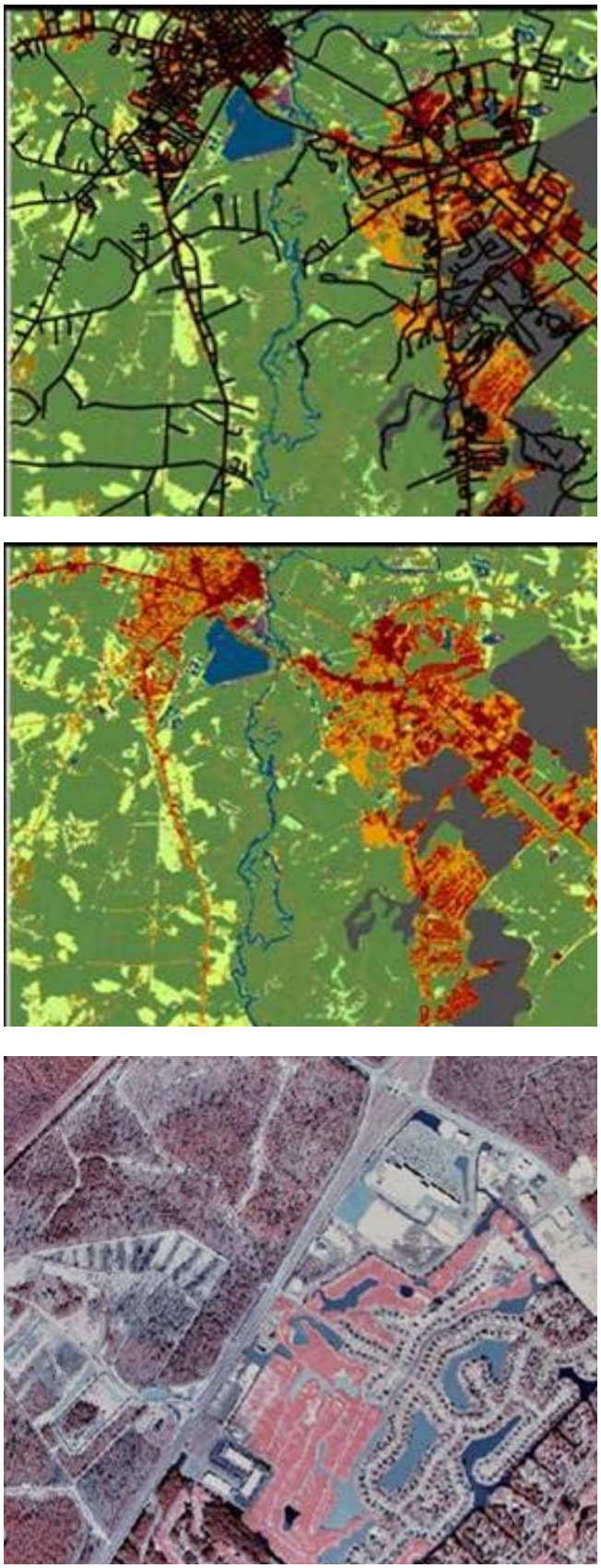


Figure 3. A landscape-scale view of golf courses in an urban habitat setting along the South Carolina coast. The gray polygons are golf courses and the black lines are roads. Development increases with intensity of orange.

veyed had been in existence for quite some time, with a mean age of 24 ± 1.5 years. The area covered by a course varied considerably from 25 to 400 ha (62 to 990 acres). The mean distance from a course to the next nearest course was 1.4 ± 0.2 km (0.9 ± 0.1 miles), while the mean distance to the nearest course with fox squirrels was 2.5 ± 0.4 km (1.6 ± 0.2 miles)(14).

Fox squirrels were present on 68 of 98 courses surveyed along the South Carolina coast. On the courses where onsite surveys were conducted (n = 51) and where fox squirrels were present (n = 33), the mean count was 15.3 ± 4.2 and the maximum count was 59 (Fig. 2). Gray squirrels were present on 79 courses, and only 5 courses were neither fox nor gray squirrels observed. On courses where we conducted both phone interviews and on-site surveys, there was a 91.7% agreement in classification of presence or absence. Interestingly, the three courses with conflicting results each categorized fox squirrels as very rare with < 1 observation estimated per month.

Landscape and Fox Squirrels

Fox squirrel presence on golf courses was best predicted by the presence or absence of fox squirrels on the nearest neighbor course (14). The probability that fox squirrels would be present on a course if they also were present on the nearest neighbor course was 87%. The probability that fox squirrels would be present on a course if they were not present on the nearest neighbor course was only 31%. For golf courses with fox squirrels, the mean distance to the nearest neighbor course with fox squirrels also present was 1.9 + 0.5 km while for golf courses without fox squirrels the mean distance to the nearest neighbor course was significantly greater at 2.5 + 0.4 km (1.6 ± 0.2 miles) (14).

Discussion

Fox squirrel presence on coastal South Carolina golf courses was best predicted by the presence of fox squirrels on the nearest-neighbor

course. We also found that the distance between two neighboring courses when each had fox squirrels was less compared to the distance between two neighboring courses where only one had fox squirrels. We did not find that variables that accounted for the amount of forested land adjacent to the golf course had any effect on fox squirrel presence. There was strong agreement between our phone interviews with golf course personnel and our onsite surveys with respect to fox squirrel presence or absence.

The strength of the nearest-neighbor variable for predicting fox squirrel presence suggests that fox squirrels need to be able to move among courses. Courses may be functioning like separate habitat patches and movement between these patches may be critical for maintaining populations. Fox squirrels can have large home ranges and they often exhibit high rates of dispersal in both natural and urban patches (3, 4, 8, 10). In contrast, most of our study courses, which averaged ca. 125 ha (309 acres) in area, were small relative to the reported home range size for fox squirrels in similar landscapes. A study conducted on fox squirrels on golf courses in southwest Florida observed substantial movement among courses by radio-tagged individuals and, as in our study, found that landscape-scale factors were more important in determining population size on a course compared to course-scale factors (4).

Our fox squirrel surveys also indicated that many of the courses we surveyed did not contain a sufficient number of fox squirrels to maintain a self-contained, viable population. For example, although we observed fox squirrels on 33 of the 51 courses we surveyed in person, we typically observed only 10 - 15 on each course, and we observed > 10 fox squirrels on only 8 courses. We did notice, however, that courses that tended to have a greater abundance of fox squirrels also tended to be large or part of a multi-course patch. Similar results have been observed in studies of fox squirrel ecology on golf courses in southwest Florida where fox squirrel abundance was greater in areas that had a course complex as opposed to isolated courses (3, 8).

Conclusion

Our data strongly suggest that landscape-level variables need to be considered when assessing the potential conservation value of golf courses for fox squirrels in South Carolina. The importance of the 'nearest-neighbor effect' that we observed was similar to results from other studies of fox squirrels that found that presence in fragmented habitats (e.g. woodlots or golf courses) was related to landscape-level variables like the isolation of the habitat patch (3, 5). This does not mean, however, that habitat variables on the course are not important. For example, two previous studies of fox squirrels in the southeastern U.S. also suggested that local habitat features, or within-course variables, likely affected the density of fox squirrels on courses (8, 11).

We suggest that these apparently conflicting results may rather be factors operating at different spatial scales. Local habitat features such as

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food availability, degree of openness of the understory, and canopy cover may play an important role in determining population abundance. In contrast, the ability of individuals to move among courses may have a strong effect on presence versus absence.

While it is still not clear how abundant fox squirrels are on golf courses in South Carolina or what the viability of their populations are across the coast, it does seem clear that golf courses in coastal South Carolina have a greater opportunity to support or retain fox squirrel populations when the land area surrounding or nearby the course also supports fox squirrels. In areas of South Carolina with larger courses and a lower level of development, those interested in conservation of fox squirrels could consider maintaining large contiguous patches of habitat through development and clustering development of new golf courses.

In areas comprised of smaller, more isolated courses where fox squirrels occur at lower densities, it may be difficult to sustain populations. Although fox squirrels are long-lived so populations may continue to persist on a course for some time, our data and those from other studies (3) suggest that opportunities for fox squirrels to move among isolated courses may benefit population stability.

Acknowledgements

Funding for this research was provided by the National Fish and Wildlife Foundation Wildlife Links Program through a grant from USGA's Turfgrass and Environmental Research Program. The South Carolina Cooperative Fish and Wildlife Research Unit supplied logistical support. The staff of the Waddell Mariculture Center, Bears Bluff National Fish Hatchery, and the Belle W. Baruch Institute for Marine and Coastal Sciences provided field housing. Thanks go to all the golf courses that participated in the research, and especially those that allowed repeated access to their course for surveys. Jeff Allen, Susan Loeb, and Bo Song provided comments on an earlier version of the manuscript.

Literature Cited

1. Angold, P. G., J. P. Sadler, M. O. Hill, A. Pullin, S. Rushton, K. Austin, E. Small E, B. Wood, R. Wadsworth, R. Sanderson R, and K. Thompson. 2006. Biodiversity in urban habitat patches. *Science of the Total Environment* 360:196-204.

2. Cunningham, M. A. 2006. Accuracy assessment of digitized and classified landcover data for wildlife habitat. *Landscape and Urban Planning* 78:217-228.

3. Ditgen, R. 1999. Population estimates, habitat requirements, and landscape design and management for urban populations of the endemic big cypress fox squirrel (*Sciurus niger avicennia*). Ph.D. Dissertation, University of Florida, Gainesville, FL.

4. Ditgen, R., J. D. Shepherd, and S. R. Humphrey. 2007. Big Cypress fox squirrel (*Sciurus niger avicennia)* diet, activity, and habitat use on a golf course in southwest Florida. *American Midland Naturalist* 158:403-414.

5. Deuser R. D., J. L. Dooley, and G. J. Taylor. 1988. Habitat structure, forest composition, and landscape dimensions as components of habitat suitability for the Delmarva fox squirrel. Pages 414-421. *In* R. C. Szaro, K. E. Severson, and D. R. Patton (eds.) Management of Amphibians, Reptiles, and Small Mammals in North America. U.S. Forest Service General Technical Report RM-166 Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

6. Harrigal, D. 1993. Fox squirrel (*Sciurus niger*) distribution and habitat presence in South Carolina. *In* N. D. Moncrief, J. W. Edwards J.W., and P. A. Tappe (eds.). Proceedings of the Second Symposium on Southeastern Fox Squirrels (*Sciurus niger*). Virginia Museum of Natural History, Martinsville, VA.

7. Jodice, P.G.R. 1993. Movement patterns of translocated Big Cypress fox squirrels (*Sciurus*

niger avicennia). *Florida Scientist* 56:1-6.

8. Jodice, P. G. R., and S. R. Humphrey. 1992. Activity and diet of an urban-population of big cypress fox squirrels. *Journal of Wildlife Management* 56:685-692.

9. Kantola A. T., and S. R. Humphrey. 1990. Habitat use by Sherman's fox squirrel (*Sciurus niger shermani*) in Florida. *Journal of Mammalogy* 71:411-419.

10. Koprowski, J. L. 1996. Natal philopatry, communal nesting, and kinship in fox squirrels and gray squirrels. *Journal of Mammalogy* 77:1006-1016.

11. Lee, J. C. 1999. Ecology of the southern fox squirrel on Spring Island, South Carolina. M.S. Thesis, University of Georgia, Athens, GA.

12. Loeb S. C., and N. D. Moncrief. 1993. The biology of fox squirrels (*Sciurus niger*) in the southeast: A review. *In* N. D. Moncrief, J. W. Edwards, P. A. Tappe (eds.). Proceedings of the second symposium on southeastern fox squirrels (*Sciurus niger*). Virginia Museum of Natural History, Martinsville, VA.

13. McGarigal, K., S. A. Cushman, M. C. Neel, and E. Ene. 2002. Fragstats: Spatial pattern analysis program for categorical maps. University of Massachusets, Amherst, MA.

14. Meehan, K., and P. G. R. Jodice. . Landscape scale correlates of fox squirrel (*Sciurus niger*) presence on golf courses in coastal South Carolina, USA: the nearest neighbor effect. *Landscape and Urban Planning* (Submitted November 2007)

15. Perkins M.W., and L. M. Conner. 2004. Habitat use of fox squirrels in southwestern Georgia. *Journal of Wildlife Management* 68:509-513.

16. Weigl P. D., M. A. Steele, L. J. Sherman, J. C. Ha, and T. L. Sharpe. 1989. The ecology of the fox squirrel (*Sciurus niger*) in north carolina: Implications for survival in the southeast. Tall Timbers Research Station, Tallahassee, FL.

17. Yasuda M., and F. Koike. 2006. Do golf courses provide a refuge for flora and fauna in Japanese urban landscapes? *Landscape and Urban Planning* 75:58-68.

18. Zipperer W. C., J. Wu, R. V. Pouyat, and S. T. A. Pickett. 2000. The application of ecological principles to urban and urbanizing landscapes. *Ecological Applications* 10:685-688.