Nesting Success, Nest Site Characteristics, and Survival of Wild Turkey Hens in South Carolina

William F. Moore,[1] *Department of Forest Resources, 261 Lehotsky Hall, Clemson University, Clemson, SC 29634*

John C. Kilgo, *USDS Forest Service, Southern Research Station, P.O. Box 700, New Ellenton, SC 29809*

William D. Carlisle,[2] *Department of Forest Resources, 261 Lehotsky Hall, Clemson University, Clemson, SC 29634*

David C. Guynn, Jr., *Department of Forest Resources, 261 Lehotsky Hall, Clemson University, Clemson, SC 29634*

James R. Davis, *Department of Forest Resources, 261 Lehotsky Hall, Clemson University, Clemson, SC 29634*

Abstract: We captured 60 wild turkey (*Meleagris gallopavo*) hens from 1998–2001 on the U.S. Department of Energy's Savannah River Site (SRS) in South Carolina to assess nesting success, identify characteristics of successful and unsuccessful nests, and determine survival rates and mortality factors of hens. Hen nesting success varied greatly among years, ranging from 0–80% and was strongly correlated (r = 0.998) with the number of poults per hen observed during brood surveys. Woody stem densities ($F_{30} = 5.1$; $P = 0.03$) and nest concealment ($F_{30} = 4.69$; $P = 0.04$) both were greater at successful than at unsuccessful nest sites. The mean annual survival rate for hens on SRS was 0.74 ± (0.02), and bobcats (*Lynx rufus*) were the primary predator of marked hens. The dynamics of the long-established, unhunted population at SRS were apparently similar to those of recently established or hunted populations elsewhere.

Key words: wild turkey, *Melagris gallopavo*, hen, nesting success, hen success, nest sites, survival, cause-specific mortality, South Carolina

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 64:24–29

Populations of wild turkeys (*Meleagris gallopavo*) in most eastern states are currently higher than they have been since before European colonization (Tapley et al. 2005, McGhee and Berkson 2007). However, some populations in the Southeast are experiencing declines (Palmer et al. 1993, Miller et al. 1998, Thogmartin and Johnson 1999). Nesting success is the factor that usually has the greatest influence on population growth in wild turkeys (Vangilder 1992, Roberts and Porter 1996). Managing areas to increase the availability of quality nesting habitat could help increase population productivity (Hillestead and Speake 1970).

Wild turkey hens have been documented to nest in a wide range of dissimilar habitat types, including fields, rights-of-way, pine plantations, mature pines, and bottomland hardwoods (Everett et al. 1985, Lazarus and Porter 1985, Sisson et al. 1990, Porter 1992). Several shared microhabitat characteristics, such as dense shrub and herbaceous cover, have been reported for turkey nest sites (Seiss et al. 1990, Still and Baumann 1990, Badyaev 1995). Concealment of nests by vegetation is critical for ground-nesting birds because nest predation is the primary cause of nest failure in most birds (Keppie and Herzog 1978, Bowman and Harris 1980, Badyaev 1995). Hen survival rates are also critically linked to reproductive success. In areas with fall either-sex turkey harvests, a high hen harvest can significantly impact reproduction in the successive breeding season (Vangilder 1992). Low hen survival resulting from any mortality factor can reduce population growth or cause population declines (Alpizar-Jara et al. 2001).

Most research on hen productivity and survival has occurred either in newly-established populations or populations subjected to hunting pressure (Kurzejeski et al. 1987, Vangilder and Kurzejeski 1995). Our objectives were to assess nesting success, identify characteristics of successful and unsuccessful nest sites, and determine the survival rate and primary mortality factors of hens in a long-established population that had never been subjected to harvest mortality.

Study Area

We conducted our study on the U.S. Department of Energy's Savannah River Site (SRS), an approximately 80,000-ha National Environmental Research Park in the upper coastal plain of South Carolina. The SRS was closed to the public in 1951, at which time the USDA Forest Service (USFS) was authorized to reforest abandoned farm fields and to manage undeveloped areas. During our study, approximately 85% of SRS was forested. Uplands were dominated by longleaf (*Pinus palustris*), loblolly (*P. taeda*), and slash pine (P. *elliottii*) stands, mostly planted after 1950. Bottomland hardwood forests (*Quercus michauxii*, *Quercus pagoda*, *Fraxinus*

1. Current address: Abraham Baldwin Agricultural College, School of Ag and Natural Resources, 2802 Moore Hwy, ABAC 8, Tifton, GA 31794
2. Current address: South Carolina Department of Natural Resources, 305 Black Oak Rd, Bonneau, SC 29431

pennsylvanicus) occupied the floodplains. Additional habitats included upland hardwood forests (*Quercus falcata*, *Carya glabra*, *Quercus stellata*), mixed pine-hardwood forests, isolated wetlands, and early successional vegetation in rights-of-way and around industrial areas (Imm and McLeod 2005).

On most of the SRS, prescribed burning was planned on a 3- to 5-year rotation for fuels reduction and to enhance habitat for the endangered red-cockaded woodpecker (*Picoides borealis*) and other wildlife. The majority of prescribed burning occurred during the dormant season (approximately 6000–8000 ha/yr), but approximately 1000 ha per year were burned during the growing season, mainly for understory control in red-cockaded woodpecker recovery areas.

The SRS was closed to turkey hunting in 1951. Prior to restocking in the early 1970s, wild turkeys were essentially absent from SRS, with only occasional sightings in more remote areas (Moore et al. 2005). In 1973 and 1974, the South Carolina Department of Natural Resources (SCDNR) released turkeys onto SRS, and beginning in 1977 trapped turkeys for use in reestablishing populations in other parts of the state. By the late 1990s, the SRS wild turkey population was well-established, relatively large, and stable to increasing.

Methods

We captured wild turkeys during January–March of 1998–2001 using 9×18-m rocket nets (Bailey et al. 1980). We fitted each turkey with a numbered aluminum leg band and a "backpack" harness containing an 80-g radio transmitter equipped with a mortality signal (Telonics, Mesa, Arizona). Capture and handling techniques were approved by the Clemson University Research Committee (Animal Use Protocol # 01-003).

We evaluated survival, nesting success, and nest-site selection during 1998–2000. During 2001, we assessed only nesting success. We monitored turkeys ≥3 times per week using triangulation with a handheld Yagi antenna and portable receiver (Telonics, Mesa, Arizona). When mortality was suspected, we located birds and attempted to determine the cause of death based on evidence at the mortality site, such as hair, tracks, bite marks, and cache characteristics. We excluded from analyses birds not surviving 14 days post-instrumentation because of potential capture injury or stress. We calculated mean annual survival rates for 1998–2000 using the Kaplan-Meier procedure to allow for staggered entry of newly marked animals (Kaplan and Meier 1958, Pollock et al. 1989).

From April–July 1998–2001, we monitored hens every two days to determine the onset of nesting. We presumed hens that remained stationary for seven days were nesting (Vander Haegen et al. 1988). To minimize disturbance to incubating hens, we visited nests only once, after the onset of incubation, to determine clutch size. We checked them again just after hatching to determine apparent nest success. This monitoring schedule did not permit us to calculate daily nest survival.

We measured vegetative characteristics encompassing nest sites during July in circular plots using the nest as the plot center. To determine overstory basal area, we used a 25-m radius circular plot to measure woody stems with a diameter at breast height (dbh) ≥10.2 cm. We used a 5-m radius circular plot to measure % ground cover via ocular estimation and to measure stem density (n / m^2) for all woody stems with dbh ≤10.2 cm. We used a modified (0.4 m^2) density board (Nudds 1977) to measure nest concealment (%) by vegetation. We placed the board on the nest bowl and viewed it from four cardinal directions at ground level from a distance of 10 m. We plotted nest site coordinates into ARCVIEW GIS (Environmental Systems Research Institute 2000), and obtained habitat type using the USFS Continuous Inventory of Stand Conditions database. We also used ARCVIEW to ascertain proximity of nests to roads and of random points in stands containing nests to roads. We compared mean distances between nests and roads and between random points and roads using a two-tailed t-test. We compared vegetative characteristics between successful and unsuccessful nests using a one-way analysis of variance (ANOVA). We analyzed data for homogeneity of variance and normal distribution using the Shapiro-Wilk test. We accepted significance at the $P \leq 0.05$ level.

As an additional measure of reproductive success, we obtained brood survey data from SCDNR. Surveys were conducted on SRS from 1 July–24 August each year. Participating field-going personnel at SRS reported all turkeys observed, by age, sex, and location, during the course of normal duties. SCDNR compiled data and attempted to eliminate repeat observations at the same location. We calculated the Pearson correlation coefficient for the relationship between the number of poults per hen from brood surveys and nesting success of radio-monitored hens.

Results

During January–March of 1998, 1999, 2000, and 2001, we captured 15, 7, 15, and 23 hens, respectively. One hen in 2000 was excluded from analyses because her death was thought to be capture-related. The mean annual survival rate for hens on SRS during 1998–2000 was 0.74 ± 0.02; Figure 1), with 14 hens dying during that period. Bobcat (*Lynx rufus*) predation was the primary cause of mortality, accounting for 64% of deaths, followed by coyote (*Canis latrans*) predation (14%), vehicle collisions (14%), and 1 unknown predator mortality (7%). The majority (83%) of hen predation occurred during May–July; 3 hens died during incubation,

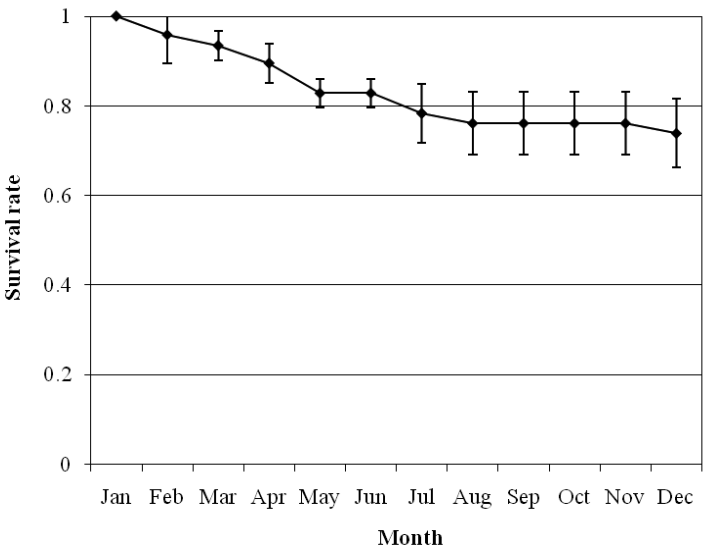

Figure 1. Mean annual survival rate of monitored wild turkey hens on the Savannah River Site (SRS), South Carolina, 1998–2000.

4 died while caring for poults, and 3 died after their nests had failed.

Annual nesting success of monitored hens varied greatly (Table 1) so we did not calculate an overall nest survival rate. In 1998, 77% (10) of monitored hens that attempted to nest hatched nests successfully on their first attempt. First nests of two other hens were depredated, but they were both successful on their second attempt. One hen abandoned her first nest because of unfertilized eggs and did not renest. In 1999, the nest of only 1 of 15 hens survived to incubation, and it was depredated shortly thereafter. The remaining hens either made no attempt to nest or their nests were destroyed during egg-laying, and they did not renest. In 2000, only 1 nest out of an attempted 16 for which incubation was initiated hatched successfully. Predators, including raccoons (*Procyon lotor*), opossums (*Didelphis virginiana*), and rat snakes (*Pantherophis obsoleta*), destroyed 15 nests, including 3 renests, before they could hatch. In 2001, 9 of 23 hens initiated incubation and only 2 nests hatched successfully. Five nests were depredated and 2 were destroyed by prescribed fires. One hen whose nest was destroyed by fire attempted to renest, but that nest was depredated. Median dates for incubation initiation and hatching during 1998–2000 were 4 May and 7 June, respectively.

Hens nested in many different habitat types, including mature pines, mixed pine-hardwoods, upland hardwoods, bottomland hardwoods, rights-of-way, and young (≤15 years) pine plantations. Vegetation surrounding the monitored nests also varied greatly in species composition and stem densities, and there were few similarities among nest sites. Mean distance of nest sites to roads (112.3 m ± 23.2) was less ($t_{30} = 2.01$; $P = 0.02$) than the mean distance of random points to roads (195.8 m ± 27.6). Woody stem densities immediately surrounding the nest ($F_{30} = 5.1$; $P = 0.03$) and nest concealment values ($F_{30} = 4.69$; $P = 0.04$) were greater at successful than unsuccessful nest sites (Table 2).

The number of turkeys observed during SCDNR brood surveys during 1998–2001 ranged from 811–891. The number of poults per hen observed during this period was strongly correlated with nesting success of radio-monitored hens (r = 0.998; Figure 2).

Table 1. Nesting success of monitored hens on the Savannah River Site, South Carolina 1998–2001.

	1998	1999	2000	2001
n hens	15	14	17	23
n hens nesting (%)[a]	13 (87)	1 (7)	13 (76)	9 (39)
n hens successful (%)[b]	12 (80)	0 (0)	1 (6)	2 (9)
n nests	15[c]	1	16[d]	10[e]
n nests successful[f]	12 (80)	0 (0)	1 (6)	2 (20)
Clutch size, 1st attempt (SE)	11.4 (0.9)	8	10.7 (1.1)	10.0[g]
Clutch size, renest (SE)	8.0 (0.0)	N/A	8.3 (1.5)	?[h]

a. *n* hens that initiated incubation / total *n* monitored hens
b. *n* hens that hatched ≥1 egg / total *n* monitored hens
c. Includes 2 renests
d. Includes 3 renests
e. Includes 1 renest
f. *n* nests that hatched ≥1 egg / total *n* nests
g. *n* = 4; clutch size unknown for remainder of nests
h. Unknown

Table 2. Mean (SE) vegetative characteristics at successful and unsuccessful wild turkey nest sites on the Savannah River Site, South Carolina, 1998–2000. Significant differences ($P \leq 0.05$) are denoted by an asterisk.

	Successful (*n* = 13)	Unsuccessful (*n* = 19)	F_{30}	*P*
Basal area (m^2/ha)	3.57 (0.43)	2.93 (0.33)	1.37	0.24
Woody stems (*n* /m^2)	10.67 (1.16)	7.62 (0.86)	5.04	0.03*
Ground cover (%)	19.28 (3.59)	17.67 (2.83)	0.13	0.72
Understory species richness	7.50 (1.03)	7.73 (0.83)	0.09	0.86
Nest concealment (%)	57.14 (4.99)	42.33 (4.65)	4.69	0.04*

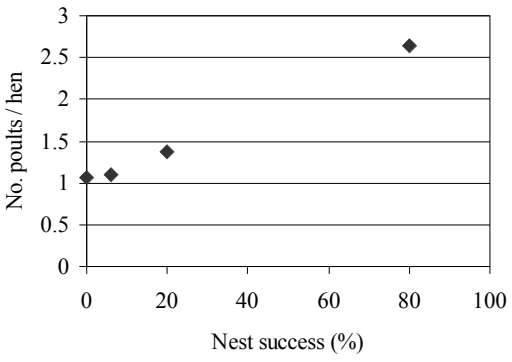

Figure 2. Relationship between the number of poults per wild turkey hen observed during the South Carolina Department of Natural Resources summer brood survey and nesting success of radio-monitored hens at the Savannah River Site, South Carolina, 1998–2001.

Discussion

Annual nesting success of monitored hens varied greatly during the study. Vangilder (1992) reported that such variability is common in wild turkey populations. In 1998, nesting success of monitored hens on SRS was 80%. The next two years it declined to near zero and then increased somewhat in 2001 to 20%. Annual brood surveys conducted by SCDNR documented the presence of poults at SRS during 1999 and 2001, demonstrating that actual nest success in the population was not as low as that in the radio-monitored sample. However, the brood survey strongly corroborated the relative trend indicated by our estimates of nesting success, as the two variables were highly correlated. In 1998, when we estimated 80% nesting success, the number of poults observed on SRS was among the highest on record over a 24-yr span. During the poor nesting-success years of 1999 and 2000, the number of poults observed declined 60%, but increased slightly with better nesting success in 2001. Thus, our estimates of nesting success from radio-monitored hens are more appropriately viewed as an index to actual nest success than as estimates of actual nesting success.

Such drastic fluctuations in nest success may be due to a variety of factors including changes in predator populations, mast production, or climatic conditions (Vander Haegen et al. 1988, Roberts et al. 1995). The status of predator populations on SRS during our study was unknown, with the exception that coyotes were generally increasing (Mayer et al. 2005). Hard mast production during fall 1998 and 1999 may have affected hen condition during the springs of 1999 and 2000 when nesting success was low. Mast production at SRS during 1998 and 1999 represented the two lowest years for the period 1995–2000 (D. J. Levey et al., University of Florida, unpublished data). Finally, climate factors, such as drought and flooding, can influence wild turkey nest success (Beasom and Patte 1980). On SRS, a four-year drought that began in May 1998 may have negatively impacted nesting success during the study. However, a relationship between any of these factors and nesting success is at best speculative.

Hens nested in a wide range of habitat conditions. Overstory conditions and percent ground cover did not differ between successful and unsuccessful nests, but woody stem densities immediately around the nest and concealment values were greater at successful nest sites. Similarly, Badyaev (1995) and Nguyen et al. (2004) reported that successful nests were more concealed than unsuccessful nests. At several monitored nests that were successful in 1998, basal area and stem densities of the overstory and midstory were low, while stem densities immediately at the nest site were high. Even when the hens chose a relatively open stand to nest in, they were still often successful when sufficient vegetative cover was present immediately surrounding the nest.

The hen survival rate was in the range of those reported in other populations (Miller et al. 1998, Ransom et al. 1987, Vander Haegen et al. 1988). Bobcats appear to be the primary predator of both hens and gobblers on SRS (Moore et al. 2005), although coyotes may increase in importance if their densities on the area continue to increase. Hen predation was highest during the spring and summer months while hens were nesting and caring for poults, as previous research has also documented (Swank et al. 1985, Vander Haegen et al. 1988, Everett et al. 1980). Most of the monitored hens nested close to roads or firebreaks, possibly to allow easy travel from the nest site to brood habitats after hatching. Increased sunlight or fire shadows associated with such areas may also have resulted in more dense vegetation. Similarly, Thogmartin (1999) reported that hens in Arkansas nested closer to roads than expected based on random locations. However, because predators often use roads and firebreaks as travel corridors, higher adult and nest predation may occur when hens nest in close proximity to these areas.

Our data indicated that nesting success and survival of hens in the long-established, unhunted population at SRS was similar to that reported from recently established or hunted populations elsewhere. Wild turkey populations are subject to a multitude of influences that vary both spatially and temporally. However, we suggest that the similarity in population parameters between the long-established SRS population and recently established or hunted populations elsewhere lends credence to the general long-term applicability of wild turkey research; i.e., there is apparently little unique in the dynamics of a population that has been established for >25 years.

Managers occasionally express concern that growing-season prescribed fire may be detrimental to turkey nesting. In addition to burning nests, such fires may reduce understory woody stem densities, which, based on our findings, could increase nest predation by decreasing nest concealment (Olson and Platt 1995, Sparks et al. 1999). Only 2 of 42 (5%) nests we monitored were directly destroyed by fire, but only a minor portion (approximately 1%) of the area was burned during the growing season, making the direct effect of fire on turkey reproduction minimal. However, as part of expanded recovery efforts for the red-cockaded woodpecker, the acreage subjected to growing-season burning at SRS may increase. Since hens nest in a wide range of vegetation types and growing-season burning is typically conducted only in mature pine stands, even with an expanded growing-season burn regime, the chances of a nest being destroyed by fire may remain low. Additionally, some hens whose nests are burned will attempt to renest and may thus still be successful. Finally, growing season burns may restore pine understories to grassy conditions that favor successful nesting. Whether large-scale growing season fire would result in net

positive or negative impacts remains unclear and warrants further investigation.

Acknowledgments

This project was funded by the U. S. Department of Energy—Savannah River Operations Office through the USDS Forest Service Savannah River and the USDA Forest Service Southern Research Station under Interagency Agreement DE-AI09-76SR00056, the National Wild Turkey Federation, and Clemson University. We thank J. Blake and M. Caudell for assistance with logistics; M. Caudell for providing SCDNR brood survey data; A. Marshall, J. Hart, and R. Moore for assistance with trapping and telemetry; and M. Caudell, D. Lanham, and B. Wigley for reviewing the manuscript.

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