Survival and Reproduction of Wild Turkey Broodstock Relocated to the Pineywoods of East Texas

James R. George,[1] *Arthur Temple College of Forestry, Stephen F. Austin State University, P.O. Box 6109 SFA, Nacogdoches, TX 75962*

R. Montague Whiting, Jr., *Arthur Temple College of Forestry, Stephen F. Austin State University, P.O. Box 6109 SFA, Nacogdoches, TX 75962*

John D. Burk, *Texas Parks and Wildlife Department, P.O. Box 4655 SFA, Nacogdoches, TX 75962*

Abstract: We assessed survival and reproduction of Georgia and Iowa eastern wild turkeys *(Meleagris gallopavo silvestris)* relocated to the Pineywoods of Texas. Using approximately equal numbers from each state, 12 females and 3 males were radio tagged and released at each of 4 sites in February 1994. In February 1995, 8 resident females were captured, radio tagged, and released on a disjunct study area intensively managed for wildlife. Radio tracking of the turkeys began immediately after release and continued until 30 June 1996. We found no differences in annual, first-year after release, spring-summer nesting season, or study-period survival among Georgia, Iowa, or resident females ($P > 0.05$). For each group, nests were initiated later ($P \leq 0.05$) in the spring following capture than during subsequent springs. Georgia males survived better than Iowa males ($P \leq 0.05$), which were all dead or missing 16 months post-release. Reproductive success was minimal, with 4 females producing 7 nests (11 fledged poults) during 3 springs. Nest predation was high (86.9%) and nesting rate low (67.6%). Our results suggest overall reproductive success, not broodstock source, was the primary limiting factor. However, due to male mortality, southeastern broodstock should be used when available and numbers of birds released at each site should be increased to 15 females and 5 males. Block stocking, which allows dispersal among release sites, should continue.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 54:374–382

Historically, wild turkey populations nationwide began to decline before 1900 and probably reached their lowest levels in the 1930s (Mosby 1975). In 1942, the wild turkey population in east Texas was estimated at 45 to 125 birds (Newman

1. Present address: 6 Howard Street, Collinswood, South Australia 5081.

1945). Since that time, there have been numerous failed efforts to restore wild turkeys to east Texas (Boyd and Oglesby 1975); most of these efforts used pen-reared birds or non-indigenous subspecies.

In the early 1980s small-scale restorations using the eastern subspecies were successful (Hopkins 1981, Campo 1983). These successes encouraged Texas Parks and Wildlife Department (TPWD) to initiate a large-scale restoration program using the eastern subspecies in 1987. The program used the block-stocking technique whereby 12 females and 3 males were released in each unit of appropriate habitat within a county; all sites in a county were stocked simultaneously (Burk 1993). Due to the extensive area involved and the lack of resident birds, biologists had to use eastern wild turkeys from a variety of southern and midwestern states.

Northern bobwhite *(Colinus virginianus)* captured in south Texas and relocated to east Texas did not survive or reproduce as well as birds captured in disjunct areas of east Texas and released on the study site. The south Texas birds encountered plant and animal communities radically different from those of their origin and these negatively impacted survival and reproduction (Parsons 1994, Liu 1995). If a similar response is present in eastern wild turkeys, intrasubspecific variation may be a detriment to stocking success. Therefore, we attempted to determine if eastern wild turkey broodstock from midwestern, southeastern, and indigenous sources exhibited differential survival and reproduction.

Partial funding of this project was provided by TPWD using Turkey Stamp revenue, the Federal Aid in Wildlife Restoration Grant W-126-R, the Arthur Temple College of Forestry at Stephen F. Austin State University, and the National Wild Turkey Federation. Additional assistance and access was provided by Champion International Corporation, International Paper Company, Louisiana Pacific Corporation, and Temple-Inland Forest Products Corporation.

Methods

Our study was conducted in the Pineywoods Ecological Region of Texas (hereafter Pineywoods; Gould 1962). In Texas, the Pineywoods is bounded on the south and west by the Gulf Prairies and Marshes and Post Oak Savannah Regions, and on the east and north by Arkansas, Louisiana, and Oklahoma. Landform is gently rolling to flat with acidic to highly acidic, sandy and sandy loam soils. Loblolly *(Pinus taeda),* longleaf *(P. palustris)*, and shortleaf *(P. echinata)* pines, oaks (*Quercus* spp.), American beech *(Fagus grandifolia)*, magnolias (*Magnolia* spp.), elms (*Ulmus* spp.), hickories (*Carya* spp.), maples (*Acer* spp.), and sweetgum *(Liquidamber stryaciflua)* are common midstory and overstory tree species (Simpson 1988).

Of the 9 release sites in Tyler County, Texas, 4 were selected for study. The county receives approximately 125 cm of annual rainfall, and elevations range 33–135 m above sea level. Major industries in Tyler County involve forest products. Other agricultural businesses include cattle, hogs, horses, hay, blackberries, and Christmas trees (Kingston 1992).

Using approximately equal numbers of Iowa- and Georgia-trapped turkeys, 12 females and 3 males were released at each site in February 1994. Prior to release, all birds were sexed, aged (juvenile or adult), and fitted with a leg band and backpack style radio transmitter. Mortalities which occurred within 2 weeks of release were considered stress-related and the birds were replaced immediately; turkeys that died after that period were not replaced.

The Boggy Slough Hunting and Fishing Club (hereafter Boggy Slough) in the Pineywoods of Houston and Trinity counties was added to the project to evaluate survival and reproduction of resident and relocated turkeys on an area intensively managed for wildlife. Boggy Slough is owned by Temple-Inland Forest Products Corporation and was originally stocked with eastern subspecies birds in 1984 and 1991 (G. Spencer, TPWD, unpubl. data). In February 1995, 8 adult females were captured, aged, radio tagged, and released at the point of capture. In February 1996, 15 radio-tagged Iowa females were also released on Boggy Slough.

All turkeys were monitored at least twice weekly during the majority of the year using a truck-mounted 7-element Yagi antenna system and a Model R2000 programmable-scanning receiver (Advanced Telemetry Systems, Bethel, Minn.). All females were monitored at least 3 times weekly during the 140-day spring-summer nesting seasons (14 March-1 Aug) in 1994, 1995, and 1996. Monitoring began immediately after release and continued until 30 June 1996.

Survival

When telemetry data indicated that a mortality had occurred, a hand-held antenna was used to locate the transmitter and carcass, if present. Cause of death was determined by condition of the carcass and/or transmitter or through necropsy when possible. Cause of death was categorized as: 1) mammalian predation—carcass fresh but scattered, transmitter scarred and bent; 2) avian predation—carcass fresh and largely intact, head removed, transmitter unmarked; 3) unknown predation—carcass old and scattered, no predator sign; 4) disease—carcass completely intact, no sign of injury or obvious trauma, or; 5) other—poaching, road kill, etc.

We used the Kaplan-Meier product-limit method (Kaplan and Meier 1958) for estimating survival rates of each broodstock. We examined annual survival rates of each sex for the first 2 years after release and for the entire 28-month study period. Survival rates of females during the first year after capture and during each spring-summer nesting season also were examined. We used LIFETEST procedures (SAS 1982) to compute survival probabilities. Log-rank chi-square tests were applied to computed survival probabilities to determine differences among broodstock sources. Also, we used a chi-square test of independence to compare causes of mortality of Georgia and Iowa turkeys.

Reproduction

Three consecutive telemetry fixes of a female at the same location during spring was assumed to indicate a nesting attempt. After a female had been incubating for about 2 weeks, the nest site was marked (J. D. Burk, TPWD, unpubl. guidelines). When she left the area, we searched for the nest and if it was found, gathered information on its fate, clutch size, identity of the nest predator, etc. Date of initiation of incubation was determined by back-dating 28 days from date of hatch. If the nest was successful, poult counts were conducted 2 and 4 weeks post-hatch (Vangilder et al. 1987). In instances of nest predation, we assumed the date of the female's first radio location at the site was the date of incubation initiation. The nest predator was classified as mammalian if eggs were crushed and scattered and/or the nest bowl was disturbed. If the nest bowl was intact and there were no egg fragments, snake predation was assumed.

A 1-way ANOVA with Tukey's multiple range test was used to compare mean nest initiation dates among years. Due to low reproductive rates, we were unable to statistically compare reproduction parameters among broodstocks or years. However, nest success (the proportion of nests within which ≥ 1 egg hatched) and hen success (the proportion of females which fledged ≥ 1 poult; Vangilder 1992) were computed.

Results

The first-year population included 23 juvenile turkeys. To ensure that age class did not impact our results, first-year survival rates of adult and juvenile Georgia and Iowa birds were compared. Excluding turkeys which died (1) or disappeared (4) early in the study, there were no differences between age classes for either Georgia ($N = 27$, $\chi^2=0.020$, $P=0.901$, 1 df) or Iowa ($N=28$, $\chi^2=0.961$, $P=0.328$, 1 df) broodstock during the first year after release. Therefore, adults and juveniles were pooled for calculating broodstock survival probabilities.

During the first year of study (1 Mar 1994–28 Feb 1995), annual survival probabilities ($\pm$ standard errors) of females from Georgia and Iowa were 0.685 ± 0.100 and 0.696 ± 0.096, respectively ($N=47$, $\chi^2=0.002$, $P=0.959$, 1 df). During the second year (1 Mar 1995–29 Feb 1996), annual survival probabilities for Georgia, Iowa, and Texas (i.e., resident) females were 0.857 ± 0.094, 0.688 ± 0.116, and 0.625 ± 0.171, respectively ($N=38$, $\chi^2=1.762$, $P=0.414$, 2 df). For the 28-month study period, survival probabilities of Georgia and Iowa females were 0.533 ± 0.110 and 0.391 ± 0.102, respectively ($N=47$, $\chi^2=0.671$, $P=0.415$, 1 df). Survival probabilities of the 3 groups of females during the first year after being captured, radio tagged, and released were similar ($N=55$, $\chi^2=0.200$, $P=0.904$, 2 df). Likewise, there were no differences in the spring-summer nesting season survival of Georgia and Iowa females in 1994 ($N=45$, $\chi^2=0.219$, $P=0.640$, 1 df), Georgia, Iowa, and Texas females ($N=37$, $\chi^2=1.669$, $P=0.434$, 2 df) in 1995, or Georgia, Iowa, Texas, and supplemental Iowa females ($N=44$, $\chi^2=0.463$, $P=0.927$, 3 df) in 1996.

One Georgia and 4 Iowa males were depredated during the first year, and an Iowa male disappeared. As a result, first-year survival probabilities of Georgia (0.833 ± 0.152) and Iowa (0.200 ± 0.127) males were different ($N=12$, $\chi^2=7.879$, $P=0.005$, 1 df). Survival of Georgia males did not change during the second year, but the remaining Iowa male was predated, thus survival was zero ($N=6$, $\chi^2=8.807$, $P=0.003$, 1 df). Due to these differences, overall survival of Georgia broodstock (0.595 ± 0.096) during the 28-month study was higher than that of Iowa broodstock (0.322 ± 0.088; $N=59$, $\chi^2=4.134$, $P=0.042$, 1 df).

Table 1. Suspected causes of mortality of 36 radio-tagged eastern wild turkeys in the Pineywoods of east Texas, March 1994 through July 1996.

	Predation					
Broodstock source	Mammal	Avian	Unknown	Disease	Other[a]	Total
Georgia	2	1	4	2	3	12
Iowa	11	2	2	2	2	19
Texas	2	0	1	0	1	4
Supplemental Iowa	0	0	1	0	0	1
Total	15	3	8	4	6	36

a. Includes road kill, poaching, and unknown causes of mortality.

Mammalian predation was the most common form of identifiable mortality (Table 1). Of 36 confirmed deaths, mammalian predators killed 15 turkeys, 11 of which were Iowa birds. The remaining mortalities were attributed to avian (3) and unknown predators (8), disease (4), and other (6). Mammalian predators were responsible for 57.9%, 16.7%, and 50.0% of Iowa, Georgia, and Texas mortalities, respectively. Mammals killed more Iowa than Georgia birds (N=31, χ^2=5.130, P =0.023, 4 df). Numbers of Texas (4) and supplementally stocked Iowa (1) females depredated were too small to examine statistically.

During the 3-year study, evidence of 84 wild turkey nests was recorded, 32

Table 2. Numbers of Georgia, Iowa, Texas, and supplementally stocked Iowa female eastern wild turkeys alive at the beginning of the nesting season and numbers of nests produced by those birds in the Pineywoods of east Texas during springs of 1994, 1995, and 1996. Hen success and nest success (Vangilder 1992) also are shown.

	N		Success	
Bird origin	Females	Nests	Hen	Nest
1994				
Georgia	23	12	0 (0.0)[a]	0 (0.0)
Iowa	22	15	1 (4.5)	1 (6.6)
1995				
Georgia	14	10	2 (14.3)	2 (20.0)
Iowa	15	10	1 (6.7)	1 (10.0)
Texas	8	7	0 (0.0)	0 (0.0)
1996				
Georgia	11	9	1 (9.1)	1 (11.1)
Iowa	11	10	2 (18.2)	2 (20.0)
Texas	5	2	0 (0.0)	0 (0.0)
Supplemental	15	9	0 (0.0)	0 (0.0)
Total	124	84	7 (5.6)	7 (8.3)

a. Percentages are shown in parentheses.

confirmed and 52 assumed. For 71 of these nests, a date of initiation of incubation could be estimated. No difference was detected in the mean date of initiation for confirmed and assumed nests (F=0.360, P=0.552, 1,69 df), therefore, these data were pooled for further analysis.

Mean dates of initiation of incubation for all nesting attempts in 1994, 1995, and 1996 were 21 May, 6 May, and 26 April, respectively. The start of nesting season was delayed in 1994, with the first nest initiated on 20 April and only 25% of initiations occurring by 14 May. In 1995 and 1996, some nests were initiated during the first week of April and 50% of all initiation attempts had been made by the fourth week. Mean nest initiation dates differed among years (F=7.323, P=0.001, 2,68 df); dates for 1994 and 1996 were dissimilar, but the 1995 date was similar to the 1994 and 1996 dates. Each broodstock showed similar trends. For each, nest initiation was significantly later during the spring following capture than during 1 or more subsequent years (George 1997).

During the 3 springs, only 4 females had reproductive success (Table 2). These birds hatched 7 clutches and fledged 11 poults. Due to dense ground vegetation and nest disturbance post-hatch, we were able to locate only 32 nests. We documented 22 eggs in 3 successful nests; 4 successful nests were disturbed before counts could be made. Unsuccessful nests were attributed to mammals (10), snakes (11), unknown predators (2), and abandonment (2).

Discussion

Some authors (Porter 1978, Vander Haegen et al. 1988) have reported differences in survival rates of juvenile and adult turkeys. However, others have failed to detect such differences (Kurzejeski et al. 1987, Vangilder and Kurzejeski 1995). Although there was a large proportion of immature birds (23 of 60) in our first-year population, we also failed to detect such differences. Therefore, survival of immature birds did not hamper the restocking efforts.

Kurzejeski et al. (1987) reported Kaplan-Meier annual survival probabilities of 0.435 for wild turkey females in northern Missouri, while Vangilder (1992) recounted Hurst's (1988) findings of 0.540–0.620 for females in Mississippi. In east Texas, Campo (1983) reported annual survival values of 81% and 86%. Use of percentages to estimate survival in radio-telemetry studies may be biased (Vangilder 1992) and makes comparison with Kaplan-Meier estimates difficult. However, our estimates ranged from 69%-86%, which are similar to those of Campo (1983). Since our survival rates are higher than those reported in midwestern and southeastern populations, it is unlikely that normal adult mortality adversely affected stocking success.

Our spring-summer nesting season survival estimates, which ranged 0.625–0.909 (George 1997), are comparable to those of Kurzejeski et al. (1987), who reported a spring survival estimate of 0.767 ± 0.055 and a summer estimate of 0.869 ± 0.050 for wild turkey females in northern Missouri, and Vangilder (1992), who recounted Hurst's (1988) findings of 0.80 spring and 0.90 summer survival of females in Mississippi. Therefore, it seems unlikely that mortality of females during the spring and summer hampered restoration efforts in the Pineywoods.

Survival of males is of concern, however. While some of our comparisons may not be appropriate for Log-rank chi-square tests because end-point populations were less than 20 individuals (Pollock et al. 1989), male eastern wild turkeys from Iowa did not survive as well as males from Georgia. Similarly, Lopez (1996) reported 29% annual survival for midwestern males in the Post Oak Savannah Region of east Texas, with 2 of 4 study sites losing all males within the first year.

Low survival of midwestern males was due to mammalian predation, especially bobcat (*Lynx rufus*). The bobcat is a common predator of wild turkeys in the Southeast (Miller and Leopold 1992). However, Iowa is outside the geographic range of the bobcat (Burt and Grossenheider 1980), thus turkeys from there may be encountering that predator for the first time when they are relocated to Texas. Lopez (1996) found that mammalian predators accounted for 63% of mortality in his study. He suggested that dense understory, especially yaupon (*Ilex vomitoria*), may increase susceptibility of turkeys to ambush predators such as bobcats.

Swank et al. (1985) indicated that in east Texas it was reasonable to expect a good hatch once every 3 years. If a release site was stocked entirely with midwestern males, the potential to miss this narrow reproductive window becomes important. However, TPWD's current practice of block stocking (Burk 1993) allows dispersal among adjacent release sites. Three Georgia males in our study did move to other release sites. Likewise, 2 study sites had no radio-tagged males by the 1996 nesting season, yet females on those sites did nest. Presumably these females were bred by unmarked males released at other sites. The distance between the release sites in Tyler and surrounding counties averaged 15 km.

The capture, relocation, and release process was no doubt stressful to turkeys in this study. In 1994, 8 relocated birds died of stress-related problems and were replaced; 8 other deaths after the replacement period may have been stress related (George 1997). Since the birds in our study were monitored, replacement was easily accomplished. However, monitoring was not conducted on other release sites and effects of stress-related mortality are unknown. It is noteworthy that nest initiation was later in the first spring after capture than during subsequent springs. Even Texas females, which were captured and released in less than 2 hours, nested later the first year than the second.

Our nest success rates (Table 2) were much lower than those reported elsewhere, which ranged 25.0%-62.0% (Vangilder 1992, Lopez 1996). Likewise, our hen success rates were lower than the 15.4%-82.8% reported by Vangilder (1992). However, Lopez (1996) reported zero hen success in the Post Oak Savannah of Texas. In both that study and ours, poult production failed to replace losses to the adult population. There are a variety of possible reasons for the lack of reproductive success.

We were unable to examine differences in nest success or hen success among broodstocks. However, it is unlikely that reproductive success was a function of broodstock source. Rather, the problem was the overall lack of reproductive success. Our data suggest that nest predation was a major factor impacting reproductive success of wild turkeys relocated to the Pineywoods. Several studies (Glidden and Austin 1975, Speake 1980, Vangilder et al. 1987) show nest predation between 44.5% and 65.0%; our rate was 86.9% (73 of 84). Also, whereas nesting attempt rates of 87.5%-100.0% are normal for eastern wild turkey females (Vangilder 1992), the rate for our study averaged only 67.7% over 3 years. In our study, most nest predation (71.2%, 52 of 73) occurred prior to or during the early stages of incubation. This suggests that we likely failed to detect some nesting attempts, thus our estimates of both nesting attempt and nest predation rates may be low.

Management Implications

Our research indicates that southeastern wild turkey broodstock should be used in the east Texas restoration whenever it is available. Differences in male survival between broodstock sources were significant. Although differences in female survival were not significant, they may be of ecological importance. The higher survival of southeastern females may result in more females available to breed when a good breeding season does occur. Due primarily to male mortality, Lopez (1996) recommended that the stocking rate be increased to 15 females and 5 males. We agree with these recommendations, especially if midwestern males are used. Also, the current practice of block stocking should continue. This allows for dispersal among release sites and reduces the impact of high mortality of either sex at a specific release site.

Our results suggests high nest predation is the factor limiting successful restocking of wild turkeys in the Pineywoods of east Texas. Whether predator densities are high, appropriate nesting habitat is unavailable, or newly introduced turkeys are more susceptible to nest predation than are birds in stable populations remains unclear. In our study, birds at Boggy Slough showed nest predation rates similar to those in Tyler County, yet sightings of unmarked turkeys in the area indicate that the population is stable. This suggests that stable populations may be tolerant of high nest predator densities whereas recently introduced turkeys may be unable to overcome such pressure.

The TPWD has begun supplementally stocking selected sites in east Texas in an attempt to boost populations where restocking has been unsuccessful. Presumably, supplementally stocked turkeys will encounter birds from the initial stocking and interact with the experienced birds. This may increase survival and reproductive success of the supplementally stocked turkeys. However, the extent and impacts of such associations on survival and reproduction are unknown. The next research step in the restoration program could be to determine if supplementally stocked turkeys are associating with the originally stocked birds, and if so, whether survival and reproduction improve.

Literature Cited

Boyd, C. E. and R. D. Oglesby. 1975. Status of wild turkey restoration in east Texas. Proc. Natl. Wild Turkey Symp. 3:14–21.

Burk, J. D. 1993. Eastern turkey management plan (1993–2002). Wildl. Div., Texas Parks and Wildl. Dep., Austin. 51pp.

Burt, G. H. and R. P. Grossenheider. 1980. A field guide to the mammals of North America north of Mexico. Third ed. Houghton Mifflin Co., Boston, Mass. 289pp.

Campo, J. J. 1983. Brood habitat use, reproduction, and movement of recently stocked eastern wild turkeys in east Texas. Ph.D. Diss., Texas A&M Univ., College Station. 145pp.

George, J. R. 1997. Comparsions of eastern wild turkey broodstock relocated into the Pineywoods Ecological Region of Texas. M.S. Thesis, Stephen F. Austin State Univ., Nacogdoches, Texas. 90pp.

Glidden, J. W. and D. E. Austin. 1975. Natality and mortality of wild turkey poults in southwestern New York. Proc. Natl. Wild Turkey Symp. 3:48–54.

Gould, F. W. 1962. Texas plants—a checklist and ecological summary. Texas Agric. Exp. Sta., College Station. 112pp.

Hopkins, C. R. 1981. Dispersal, reproduction, mortality, and habitat utilization of restocked eastern turkeys in east Texas. Ph.D. Diss., Texas A&M Univ., College Station. 117pp.

Hurst, G. A. 1988. Population estimates for the wild turkey on Tallahala Wildlife Management Area. Miss. Dep. Conserv. Compl. Rep. P-R Proj. W-48, Study 21, Jackson. 46pp.

Kaplan, E. L. and P. Meier. 1958. Nonparametric estimation from incomplete observations. J. Am. Stat. Assoc. 53:457–481.

Kingston, M. 1992. Texas almanac and state industrial guide. The Dallas Morning News, Dallas, Texas. 607pp.

Kurzejeski, E. W., L. D. Vangilder, and J. B. Lewis. 1987. Survival of wild turkey hens in north Missouri. J. Wildl. Manage. 51:188–193.

Liu, X. 1995. Survival, movements, and habitat selection of relocated and resident northern bobwhite in east Texas. D. F. Diss., Stephen F. Austin State Univ., Nacogdoches, Texas. 132pp.

Lopez, R. R. 1996. Population dynamics of eastern wild turkeys relocated into the Post Oak Savannah of Texas. M.S. Thesis, Texas A&M Univ., College Station. 54pp.

Miller, J. E. and B. D. Leopold. 1992. Population influences: predators. Pages 119–128 *in* J. G. Dickson, ed. The wild turkey: biology and management. Stackpole Books, Harrisburg, Pa.

Mosby, H. S. 1975. The status of the wild turkey in 1974. Proc. Natl. Wild Turkey Symp. 3:22–26.

Newman, C. C. 1945. Turkey restocking efforts in east Texas. J. Wildl. Manage. 9:279–289.

Parsons, D. S. 1994. Nesting, brood habitat, and utilization of planted food plots by northern bobwhite in east Texas. M.S. Thesis, Stephen F. Austin State Univ., Nacogdoches, Texas. 115pp.

Pollock, K. H., S. R. Winterstein, C. M. Bunck, and P. D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. J. Wildl. Manage. 53:7–15.

Porter, W. F. 1978. The ecology and behavior of the wild turkey *(Meleagris gallopavo)* in southeastern Minnesota. Ph.D. Diss., Univ. Minnesota, St. Paul. 122pp.

SAS Institute, Inc. 1982. SAS user's guide: statistics. Cary, N.C. 584pp.

Simpson, B. J. 1988. A field guide to Texas trees. Gulf Publ. Co., Houston, Texas. 372pp.

Speake, D. W. 1980. Predation on wild turkeys in Alabama. Proc. Natl. Wild Turkey Symp. 4:86–101.

Swank, W. G., D. J. Martin, J. J. Campo, and C. R. Hopkins. 1985. Mortality and survival of wild trapped eastern wild turkeys in Texas. Proc. Natl. Wild Turkey Symp. 5:113–120.

Vander Haegen, W. M., W. E. Dodge, and M. W. Sayre. 1988. Factors affecting productivity in a northern wild turkey population. J. Wildl. Manage. 52:127–133.

Vangilder, L. D. 1992. Population dynamics. Pages 144–164 *in* J. G. Dickson, ed. The wild turkey: biology and management. Stackpole Books, Harrisburg, Pa.

——— and E. W. Kurzejeski. 1995. Population ecology of the eastern wild turkey in northern Missouri. Wildl. Monogr. 130. 50pp.

———, ———, V. L. Kimmel-Truitt, and J. B. Lewis. 1987. Reproductive parameters of wild turkey hens in north Missouri. J. Wildl. Manage. 51:535–540.