Western North American Naturalist 66(3), © 2006, pp. 298–309

SURVIVAL AND REPRODUCTION OF TRANSLOCATED EASTERN WILD TURKEYS IN A SPARSELY WOODED LANDSCAPE IN NORTHEASTERN SOUTH DAKOTA

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ABSTRACT.—We studied the survival and reproduction of a newly introduced population of Eastern Wild Turkeys (*Meleagris gallopavo silvestris*) during 1999 and 2000 to determine the adaptability of this subspecies to a minimally wooded (<10%) region located north of their recorded historic distribution in South Dakota. During 1999 and 2000, the South Dakota Department of Game, Fish and Parks (SDGFP) released 111 female and 25 male turkeys from Iowa and Kentucky onto a study area in northeastern South Dakota. We used radio telemetry to monitor survival and reproduction of the females for 2 years after their initial release. Annual survival for 71 females averaged 67%. Seasonal survival was lowest in fall and highest in winter. Mortality agents included avian and mammalian predators, haying equipment, automobiles, and unknown causes. Nesting rate for the 2 years averaged 93%, and renesting rate of turkeys with failed 1st-nest attempts averaged 45%. Nest success for all nests was 50%, and 62% of females attempting to nest each year were successful in at least 1 attempt. Predation was the primary cause of nest failure during both years. Overall, 72% of brooding females successfully raised ≥1 poult to 4 weeks post-hatch while individual poult survival to 4 weeks post-hatch averaged 36%. Despite <10% woodland cover, Eastern Wild Turkeys appeared to thrive in a glacial escarpment topography north of their historic range in the northern plains.

Key words: Eastern Wild Turkeys, Meleagris gallopavo silvestris, *survival, reproduction, poult survival, introduction, northeastern South Dakota.*

Aided by the use of wild-trapped birds, Eastern Wild Turkeys (*Meleagris gallopavo silvestris*) have now been successfully reestablished in many landscapes initially believed to be unsuitable for turkeys (Little 1980, Hecklau et al. 1982, Clark 1985, Miller et al. 1985). Additionally, introductions have expanded the occupied range north of the regular historic distribution (Wisconsin: Dreis et al. 1973; Michigan: Ignatoski 1973; South Dakota: Lehman et al. 2001, Leif 2001; Ontario, Canada: Nguyen et al. 2003). Despite severe winter conditions in these areas, introduced populations of Eastern Wild Turkeys have thrived and displayed remarkable adaptability (Little 1980, Vander Haegen et al. 1989, Paisley et al. 1996b).

In South Dakota, Eastern Wild Turkeys historically inhabited riparian woodlands and oak forests associated with the Missouri and James Rivers in the south central and southeastern portions of the state (Schorger 1966). The northern boundary of their range likely oscillated in relation to winter severity (Schorger 1942), because historically there were few, if any, cultivated crops available to offset severe winter conditions or mast failures. Healy (1992b) stated that the historical distribution of Eastern Wild Turkeys, in general, was limited by persistent deep snow to the north and by a lack of roosting trees to the west.

As future introductions are considered, questions arise as to what the minimum limits are for woodland habitat and how far north populations of Eastern Wild Turkeys can expand. For agricultural regions of eastern South Dakota, Leif (2001) determined that introductions of Eastern Wild Turkeys should be successful along river drainages interspersed with at least 15% woodland cover. Our objective was to determine if survival and reproduction were adequate to sustain Eastern Wild Turkeys in an area of sparse deciduous woodlands and mixed agriculture lying north of the recent historical range in South Dakota.

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STUDY AREA

Our study took place in Grant County in northeastern South Dakota (45°5′N, 96°47′W). The county as a whole is 65% cropland, 25% native grassland, and only about 1% woodland (Miller 1979, Leatherberry et al. 2000). However, our 34,500-ha study site comprised approximately 43% pasture and idle grassland, 36% cropland, 11% grass hayland and alfalfa (*Medicago sativa*), and 9% woodland (Shields 2001). Major crops grown in the area included corn (*Zea mays*), spring wheat (*Triticum aestivum*), oats (*Avena sativa*), alfalfa, and soybeans (*Glycine max*).

Our study site was located where the rocky highlands of the Prairie Coteau, a glacial plateau, transition into the Minnesota–Red River Lowlands (Johnson et al. 1995). Small patches and narrow corridors of mature deciduous woodland are found in the "breaks" and draws along the eastern edge of the Prairie Coteau and along the long, narrow tributaries of the Whetstone and Yellow Bank rivers that extend eastward from the coteau into the lowlands. Common tree species include bur oak (*Quercus macrocarpa*), green ash (*Fraxinus pennsylvanica*), American basswood (*Tilia americana*), box elder (*Acer negundo*), and sugar maple (*A. saccharum;* Knupp-Moore and Flake 1994). Native tallgrass prairie vegetation occurs in the highlands and "breaks" of the Prairie Coteau (Johnson and Larson 1999) and is used mainly as pasture. Pastures also feature numerous patches of western snowberry (*Symphoricarpos occidentalis*). Introduced smooth bromegrass (*Bromus inermus*) and Kentucky bluegrass (*Poa pratensis*) occur throughout the study area, but mainly in association with the cultivated areas along and to the east of the Prairie Coteau.

Grant County lies about 200 km beyond the northwestern extent of historic Eastern Wild Turkey range (Schorger 1966). Winters can be severe with cold temperatures and deep snow, especially along the Prairie Coteau. For the period 1971–2000, winter (December–February) temperature and total seasonal snowfall, as measured in Summit, South Dakota, approximately 28 km (17.7 mi) northwest of the study's center, averaged –10.3°C (13.5°F) and 122.6 cm (48.3 in), respectively (Todey 2004). The mean winter minimum temperature and mean winter maximum snow depth (mean of monthly maximums) for the same period were, respectively, –15.6°C (3.9°F) and 28.8 cm (11.4 in). Summer (June–August) temperatures averaged 19.4°C (67.0°F) over the same 30-year period. Annual precipitation for 30 years averaged 58.8 cm (23.1 in) with 75% of this total falling between April and September. Winter temperature and total snowfall during our study (1998–1999 and 1999–2000) averaged –6.9°C (19.6°F) and 91.4 cm (36.0 in), respectively, with mean minimum temperature and mean maximum snow depths of –12.4°C (9.7°F) and 9.7 cm (3.8 in). Annual precipitation (1999–2000) averaged 56.6 cm (22.3 in; Todey 2004).

METHODS

We assisted SDGFP personnel in releasing 111 Eastern Wild Turkey females—38 from Kentucky and 73 from Iowa—and 25 males from Iowa on the study area in January 1999 and 2000. Three males and between 15 and 18 females were released at each of 5 locations in 1999. In 2000 we made additional releases at specific sites to replace birds that died during the course of the 1st year. Additionally, in March 2000 we rocket-netted 9 female offspring from the 1999 turkey release and added them to our study sample. All birds were aged (adult or subadult), weighed (g), and leg-banded. Age criteria were based on appearance of the primary wing feathers and greater upper secondary wing coverts (Williams 1961, Pelham and Dickson 1992).

We selected 52 adult (48 IA, 4 KY) and 22 subadult (19 IA, 3 KY) transplanted female turkeys and 9 F_1-generation subadult females for radio instrumentation. To reduce the number of mortalities associated with the capture and transplanting process, we did not place radio transmitters on birds that appeared sick, unusually weak, or visibly wounded ($n < 4$). Losses of small patches of contour feathers, typically on the breast, legs, or neck, were not considered a serious risk to survival. We fitted each bird with a necklace-style, mortality-sensing transmitter (Advanced Telemetry Systems, Isanti, MN) that weighed ≤55 g (approximately 1% of female body weight at time of release). The transmitters operated at a frequency of 151 MHz and had a life expectancy of 400–800 days. We primarily used truck-mounted, null-peak directional antenna systems and scanning receivers to monitor instrumented turkeys.

Survival Estimation

We monitored survival ≥3 days each week from January through August and weekly or biweekly from September through December. Newly released turkeys were not entered into survival analysis until 10 days following release (Wilson and Norman 1996). The 10-day adjustment period was selected based on the results of this study's 1st-year release during which mortality events occurred more frequently during the first 10 days (10 mortalities) and abruptly declined in frequency thereafter. We censored data on turkeys that left the study area, or for which transmitters failed, on the day following the last normal radio contact. Transmitters featured a mortality switch that changed the broadcasted signal after 4 hours of inactivity. We investigated mortality signals using handheld Yagi antennas and scanning receivers. At mortality sites we examined turkey remains, predator tracks, and appearance of the surrounding area to identify the specific cause of death. Hemorrhaging of wounds indicated that turkeys were alive when injuries occurred (David H. Zeman, DVM, Animal Disease Research and Diagnostic Laboratory, South Dakota State University, personal communication). When no specific cause could be determined, we recorded an unknown cause of mortality. Incubation behavior occasionally activated the mortality signal; so, to avoid disturbing incubating females, we delayed investigation of mortality signals for females thought to be nesting until a typical 26- to 28-day incubation period had transpired or the location of the signal had moved from its original position.

We estimated annual and seasonal survival rates using the modified Kaplan-Meier method of Pollock et al. (1989). We compared annual survival distributions between ages using the log-rank test (Pollock et al. 1989). For comparison of seasonal survival, we designated 4 seasons: winter, 1 January (or date of release)–15 March; spring, 16 March–15 June; summer, 16 June–31 August; and fall, 1 September–31 December. Because seasonal intervals were not of the same duration, we converted seasonal survival estimates to daily survival rates. Differences in daily survival estimates were tested using a 2-way analysis of variance (ANOVA) with age and season–year as main effects and the interaction term as an estimate of variance; this procedure was similar to the method used by Vangilder and Kurzejeski (1995).

Nesting

We determined onset of nesting by individual turkeys by using localized spring movements of females as an indication of nest initiation (Williams et al. 1975, Rumble and Hodorff 1993, Lehman et al. 2005). We assumed that incubation had begun when a constant transmitter signal was received from the same location for 2 consecutive radio-locations separated by ≥24 hours. We located nest sites by approaching incubating females on foot using a handheld Yagi antenna and flagging ≥4 points around the nest at distances of 7–20 m, depending on cover height and density (Still and Baumann 1990). We used caution not to disturb the females, but nests that were likely abandoned as a result of investigator disturbance were censored from nest success analyses.

Once an incubating female moved from the nest, we revisited the site to determine nest fate. We classified each nest as successful if ≥1 egg hatched, or unsuccessful if only unhatched eggs remained or sign of disturbance was evident. At depredated nests, we examined the surrounding area, including the appearance of eggshell fragments and hair samples, to identify, when possible, the depredating species (Sargeant et al. 1998). In many cases we were unable to determine the nest predator.

Because much of our data was counts and because sample sizes were small (particularly for juveniles), we used nonparametric tests for analyses of nesting data. We tested within-year differences in initial nesting chronology between age groups by comparing incubation initiation dates with a Wilcoxon rank-sum (Mann-Whitney) test. We analyzed rates of nesting and nesting success for differences between years and ages with log-linear models. Nesting rate was defined as the proportion of available females initiating ≥1 nest attempt. Females that left the study area or died before 15 June of each year were not considered available. However, we assumed females that exhibited typical nesting behavior (localized movements) followed by a sudden increase of movement had had nests destroyed before the nests were marked; we considered them as having made an attempt (Rumble and Hodorff 1993, Lehman et al. 2005). We defined renesting rate as the proportion of females unsuccessful in their 1st nesting attempt that initiated another nest; nest success as the proportion of all identified nests that produced ≥1 poult; and hen success as the proportion of nesting females that hatched ≥1 poult. Differences between specific causes of nest losses were tested using log-linear models.

Brood and Poult Survival

At 2 and 4 weeks post-hatch, we deliberately flushed brooding females and counted the number of poults to determine survival of broods and poults (Hubbard et al. 1999b). We did not include amalgamated broods in survival analyses when members of individual broods could not be discriminated by size differences. We calculated survival estimates for the periods extending 0–2 weeks (first 2 weeks), 2–4 weeks (second 2 weeks), and 0–4 weeks (1 month) from the date of hatching. We estimated brood survival as the proportion of broods with ≥1 poult present at the beginning of a given sampling period that had ≥1 poult still surviving at the end of the sampling period. We estimated individual poult survival using the Kaplan-Meier method modified for brood-mate dependence (Flint et al. 1995). Initial brood size was defined as the number of successfully hatched eggs. Brood and poult endpoint survival estimates by year and age of brooding female were compared with program CONTRAST (Hines and Sauer 1989) using a general chi-square statistic according to the methods of Sauer and Williams (1989). If the overall test of endpoint estimates was significant, we then conducted multiple comparisons to determine which estimates differed, and a Bonferroni correction was applied to the *a priori* α-level (0.10) to adjust for the number of comparisons.

Unless otherwise noted, all statistical analyses were completed using SAS/STAT software (SAS Institute Inc. 1996) with an *a priori* significance level of α set at 0.10. Variation around means is presented as $\pm 1\ s_{\bar{x}}$, unless noted otherwise.

RESULTS

We present the results with minimal reference to year effects because of the virtual certainty that testing for year effects with survival and nesting variables will produce significant *P*-values given enough years of data (Johnson 1999). However, we present data for individual years, pooled data, and values for $s_{\bar{x}}$ in the tables and, where important, have tested for between-year differences prior to pooling for hypothesis testing.

Survival and Cause-specific Mortality

Seventy-one females (43 in 1999, 28 in 2000) survived the adjustment period following release and were entered into survival analyses. We found no difference in survival distributions between adults and subadults in 1999 ($\chi^2 = 0.21$, df = 1, $P = 0.648$) or 2000 ($\chi^2 = 0.11$, df = 1, $P = 0.740$; Fig. 1). Annual survival for adult and subadult females varied from 64.2% to 75.0% and averaged 67.6% ± 2.3% (Table 1). Daily survival rates were similar between age groups ($F_{1, 6} = 0.09$, $P = 0.775$) and seasons ($F_{7, 6} = 0.61$, $P = 0.735$) across the 2-year study period (Table 2).

Over the 2 years, we recorded 31 mortalities: 13 in 1999 and 18 in 2000. We were able to determine the cause for 55% ($n = 17$) of all known mortalities, which included deaths due to predators ($n = 12$), haying machinery ($n = 4$), and automobiles ($n = 1$). Predators observed on the study area included coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*), Great Horned Owls (*Bubo virginianus*), Bald Eagles (*Haliaeetus leucocephalus*), and domestic dogs (*Canis familiaris*).

Nesting

We collected reproductive data on 65 radio-instrumented females; however, we monitored some females in both 1999 and 2000. Thus, cumulative sample sizes were 41 in 1999 and 50 in 2000. Onset of incubation for 1st nests ranged from 1 May to 7 June in 1999 and 24 April to 6 June in 2000. Within years, ages did not differ in median date of 1st-nest incubation initiation (Wilcoxon 2-sample test: *S*-values ≤ 216, *P*-values ≥ 0.545).

The proportion of females initiating 1st nests did not differ by age group ($\chi^2 = 0.31$, df = 1, $P = 0.575$) or between years ($\chi^2 = 0.01$, df = 1, $P = 0.913$; Table 3). Although the rate of initial nesting was high for both age groups during both years of the study, we observed some variation between ages and years for renesting, nest success, and hen success (Tables 3, 4).

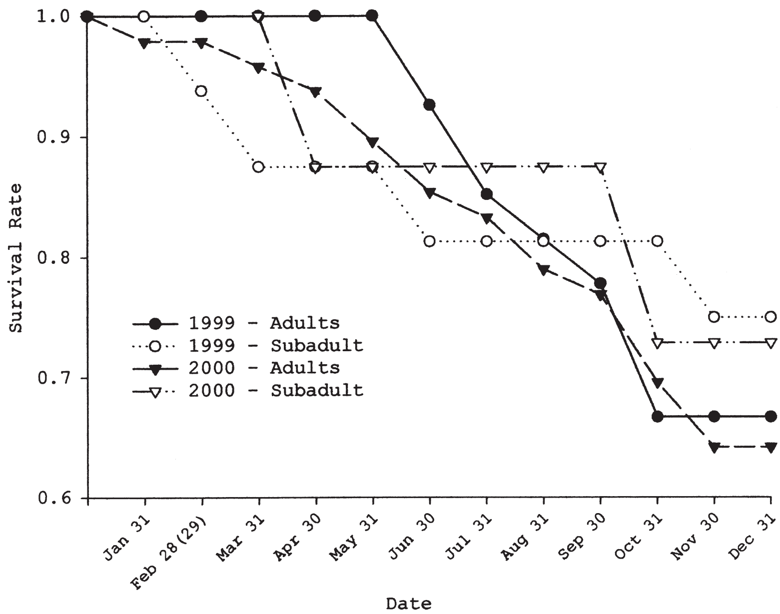

Fig. 1. Annual survival distributions for adult and subadult female Eastern Wild Turkeys in Grant County, South Dakota, 1999–2000. Period starts on 1 January in both years.

Nest success of 1st nests for adults varied little between years (Table 4), but subadult females had extreme annual variation with an unusual 100% (6 of 6 nests) success in 2000 and 23% (3 of 13 nests) success in 1999. Nesting success was greater (χ^2 = 2.78, df = 1, P = 0.096) for adult than subadult females in 1999; we note, however, that the estimates for pooled years were similar.

Rates of renesting (2nd attempts) for adult females with failed 1st nests were high in both 1999 and 2000, ranging from 0.46 to 0.64 (Table 3). All 6 nesting juveniles in 2000 were successful in hatching their initial clutches so there was no opportunity for renesting, but in 1999 a smaller proportion of subadult females attempted to renest than did adult females (0.22 versus 0.46, χ^2 = 3.17, df = 1, P = 0.075; Table 4). Renest success rates in adults were excellent (0.57–0.73), and we found no difference in renest success between ages in 1999 (χ^2 = 0.03, df = 1, P = 0.858).

For ages and years combined, 46% ± 3% of 1st-nest attempts (n = 85) and 64% ± 9% of 2nd-nest attempts (n = 20) were successful. Success did not differ by attempt (χ^2 = 2.30, df = 1, P = 0.129). For both years combined, nest success was 50% ± 5% (n = 106). Substantially more unsuccessful nests (n = 45) were lost due to predation (73%) than from other known (18%) and unknown (9%) causes (χ^2 = 39.19, df = 3, P < 0.001). Species implicated in nest depredations included coyote, red fox, raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), American badger (*Taxidea taxus*), and American Crow (*Corvus brachyrhynchos*). Other known sources of nest loss included abandonment (n = 4), destruction by haying equipment (n = 3), and trampling by livestock (n = 1).

Brood and Poult Survival

Our estimates of brood and poult survival were obtained from a total of 380 poults from 41 broods. We found no differences in survival of poults by year and age of the brooding female for the periods extending 0–2, 2–4, and 0–4 weeks post-hatch (χ^2-values ≤ 3.30, df = 3, P-values ≥ 0.348; Table 5). Combined survival of poults during the second 2-week period was significantly higher than during the first 2-week period (χ^2 = 24.58, df = 1, P < 0.001). The pooled average for survival of poults to 4 weeks was 0.36 ± 0.05.

We did not compare estimates of brood survival (i.e., survival of at least 1 poult) by age of brooding females since there were so few subadult brooding females (Table 6); but for adults,

TABLE 1. Sample sizes and estimates of annual survival for Eastern Wild Turkey females in Grant County, South Dakota, 1999–2000.

Year Age class	No. at risk (beginning)	No. at risk (ending)	No. censored	Survival rate[a]	90% CI
1999					
Subadult	16	12	0	0.750	0.572–0.928
Adult	27	17	1	0.667	0.484–0.850
Combined	43	29	1	0.698	0.581–0.815
2000					
Subadult	9	5	2	0.729	0.450–1.000
Adult	48	17	15	0.642	0.489–0.795
Combined	57	22	17	0.653	0.518–0.788
Total	100	51	18		
Mean[b]				0.676	0.624–0.728

[a]Annual survival rate was calculated beginning 1 January through 31 December.
[b]Average of the combined survival rates from 1999 and 2000

brood survival from 0–2 weeks was significantly lower ($\chi^2 = 8.15$, df = 1, $P = 0.004$) in 2000 than in 1999. We detected no difference in mean survival of broods between the 0–2-week, 2–4-week, and 0–4-week survival periods ($\chi^2 = 3.02$, df = 2, $P = 0.221$). The pooled average for survival of broods to 4 weeks was 0.72 ± 0.15.

DISCUSSION

Survival and Cause-specific Mortality

During late summer and fall 2000, 16 female turkeys were censored from survival analyses because of lost radio signals, presumably due to battery expiration. Censoring data for turkeys of unknown fate may lead to an overestimate of survival if lost signals are the result of transmitter failure at the time of death due to poaching or a high-impact collision. However, we noted a similar pattern of radio signal decline prior to the lost signal in all cases, increasing our confidence that each of these was correctly classified as a radio failure and not a mortality event.

Although some authors (Roberts et al. 1995, Paisley et al. 1996a, Leif 2001) have reported censoring turkeys that slipped out of transmitters, we were not able to confirm that this occurred on our study. On 6 occasions, upon investigation of a mortality signal, only a fully intact transmitter was recovered with no other evidence of mortality. In these situations, we recorded an unknown cause of mortality as opposed to censoring the individuals. The result of this action would be an overestimated mortality rate if any turkeys had actually slipped out of the transmitter. However, overestimating mortality provides a worst-case scenario and is preferable to erroneously overestimating survival.

Annual survival of female Wild Turkeys in Grant County (69.7%) is among the highest reported for the eastern subspecies (Vangilder 1992). Survival in our study was higher than survival of females from established populations subject to either-sex fall hunting in southwestern Wisconsin (52.7%; Wright et al. 1996), south central New York (49.8%; Roberts et al. 1995), and northern Missouri (44.5%–69.3%; Vangilder and Kurzejeski 1995), and for a newly established, unhunted population in Minnesota (48.6%; Porter 1978). Comparable annual survival rates were reported for females from an established population in south central Iowa with either-sex fall hunting (67.6% and 71.3% for adults and subadults, respectively; Hubbard et al. 1999a) and an expanding, unhunted population in northeastern South Dakota (72.1%; Lehman et al. 2001). Annual survival in our study was lower than the 77.7% reported for a newly introduced, unhunted population from the James River area of South Dakota (Leif 2001).

We observed the highest survival (96.6%) in our study during winter months. Other studies of northern populations of Eastern Wild Turkeys indicate that winter mortality can exceed 50% during severe winters (Austin and DeGraff 1975, Wunz and Hayden 1975, Porter et al. 1980). Winter losses may, however, be ameliorated to ≤10% by availability of agricultural

TABLE 2. Seasonal and daily survival rate estimates for Eastern Wild Turkey females in Grant County, South Dakota, 1999–2000.

Year / Age class	Winter[a] n^b	Winter[a] $\hat{S}_{(t)}$	Winter[a] s	Winter[a] Daily[c]	Spring[a] n	Spring[a] $\hat{S}_{(t)}$	Spring[a] s	Spring[a] Daily	Summer[a] n	Summer[a] $\hat{S}_{(t)}$	Summer[a] s	Summer[a] Daily	Fall[a] n	Fall[a] $\hat{S}_{(t)}$	Fall[a] s	Fall[a] Daily
1999																
Subadult	16	0.88	0.08	0.9974	14	1.00	0.00	1.0000	14	0.93	0.07	0.9990	13	0.92	0.07	0.9993
Adult	27	1.00	0.00	1.0000	27	0.93	0.05	0.9992	25	0.88	0.06	0.9983	22	0.82	0.09	0.9984
Combined	43	0.95	0.03	0.9991	41	0.95	0.03	0.9995	39	0.90	0.05	0.9986	35	0.86	0.06	0.9987
2000																
Subadult	NA	NA	NA	NA	9	0.88	0.12	0.9985	7	1.00	0.00	1.0000	6	0.83	0.15	0.9985
Adult	48	0.98	0.02	0.9997	47	0.87	0.05	0.9985	41	0.93	0.04	0.9990	37	0.81	0.09	0.9983
Combined	48	0.98	0.02	0.9997	56	0.87	0.04	0.9985	48	0.94	0.04	0.9991	43	0.82	0.08	0.9983
Mean[d]	91	0.97	0.02	0.9994	97	0.91	0.06	0.9990	87	0.92	0.03	0.9989	78	0.84	0.03	0.9985

[a]Winter, release date or 1 January–15 March; spring, 16 March–15 June; summer, 16 June–31 August; fall, 1 September–31 December.
[b]Number of females at risk at beginning of given period
[c]Daily rate = 1 + [ln($\hat{S}_{(t)i}$)/d_i], where $\hat{S}_{(t)i}$ = survival rate of given season, and d_i = number of days in given season.
[d]Average of the combined survival rate from 1999 and 2000

food sources (Porter et al. 1980, Vander Haegen et al. 1988, Hubbard et al. 1999a) and by mild winters (Miller 1990). Milder winters with little snow cover and abundant agricultural foods probably enhanced survival of turkeys during the winter periods of our study. During a severe winter in Roberts and Marshall Counties, directly northwest of Grant County, access to farmstead grains resulted in higher winter survival among Eastern Wild Turkey females remaining near farmsteads (S = 1.0) compared to those without emergency food sources and troubled by deep snow (S = 0.64; Lehman 1998).

Although seasonal survival did not differ statistically during any season of this study, numerically the fall period had the lowest survival. Results of other studies of the eastern subspecies indicate that highest mortality rates typically occur during severe winters (Austin and DeGraff 1975, Wunz and Hayden 1975, Porter et al. 1980) or the periods associated with reproduction (Vander Haegen et al. 1988, Vangilder and Kurzejeski 1995, Wright et al. 1996, Lehman et al. 2001). Causes of mortality were only evident in 33.3% (4 of 12) of the deaths recorded during the fall. However, all of the known-cause fall mortalities were due to predation. Further, since no carcasses or other turkey sign were recovered for 6 of the 8 unknown fall mortalities, we believe weather and disease are improbable causes of these deaths. Although the possibility of poaching cannot be eliminated, we do not suspect that this occurred either, because the transmitters and attachments were recovered intact and were not buried.

Reproduction and Brood Survival

Overall, Eastern Wild Turkey females in our study had excellent reproduction. As noted, mild winters during the 2 years of the study and the availability of agricultural food sources likely resulted in females entering spring in good physical condition (Porter et al. 1983, Roberts et al. 1995) and promoted the high nesting rate we observed (93%). Nevertheless, such nesting rates are not uncommon for Eastern Wild Turkeys (Vangilder 1992). The renesting rate (45%) was similar to rates from established populations in southwestern Wisconsin (55%; Paisley et al. 1998), northern Missouri (41%; Vangilder and Kurzejeski 1995),

TABLE 3. Nesting and renesting rates of female Eastern Wild Turkeys in Grant County, South Dakota, 1999–2000.

Age class Year	Nesting rate[a]			Renesting rate[b]		
	n[c]	Proportion	$s_{\bar{x}}$	n[d]	Proportion	$s_{\bar{x}}$
SUBADULT						
1999	14	0.929	0.069	9	0.222	0.139
2000	7	0.857	0.132	—	—	—
Pooled	21	0.905	0.064	9	0.222	0.139
ADULT						
1999	27	0.926	0.050	11	0.636	0.145
2000	43	0.953	0.032	24	0.458	0.102
Pooled	70	0.943	0.028	35	0.514	0.084
COMBINED						
1999	41	0.927	0.041	20	0.450	0.111
2000	50	0.940	0.034	24	0.458	0.102
Mean	91	0.934	0.007	44	0.454	0.004

[a]Proportion of available females that attempted to nest
[b]Proportion of females unsuccessful on their 1st attempt that attempted to renest
[c]Number of females available to nest
[d]Number of females unsuccessful on their 1st attempt available to renest

and Massachusetts (50%; Vander Haegen et al. 1988). It was lower than the renesting rates reported for expanding populations in southeastern Minnesota (65%; Porter et al. 1983) and South Dakota (59%; Lehman et al. 2001) but higher than reported for an expanding population in southeastern South Dakota (26%; Leif 2001).

Nest success for renest attempts is often equal to or greater than that of initial attempts in eastern turkeys (Porter et al. 1983, Vangilder 1992, Roberts et al. 1995, Paisley et al. 1998). We observed that renest success was not statistically better than initial nest success during our study. Altogether, nest success in our study (50% overall) was higher than nest success of Eastern Wild Turkey populations in New York (38%; Roberts et al 1995), Massachusetts (45%; Vander Haegen 1988), and southeastern South Dakota (41%; Leif 2001) and much higher than populations in Iowa (33%; Jackson et al. 1995), Wisconsin (1st nests, 14%; 2nd nests, 21%; Paisley et al. 1998), and northern Missouri (<35%; Vangilder and Kurzejeski 1995). Nest success was lower in our study than reported for other expanding populations in northeastern South Dakota (70%; Lehman et al. 2001) and southeastern Minnesota (63%; Porter et al. 1983).

Initiation of nesting can vary greatly by year depending on spring phenology (i.e., green up; Vangilder and Kurzejeski 1995). However, the range for initiation of incubation of 1st nests in our study (24 April–7 June) was similar to the ranges reported in other studies of Eastern Wild Turkeys. Adjusting for an approximate 12-day laying period to estimate onset of incubation (Healy 1992a), 1st-nest incubation initiation dates for other northern turkey populations ranged between 21 April and 17 June (Little and Varland 1981, Vander Haegen et al. 1988, Paisley et al. 1998, Lehman et al. 2001).

The majority of nest failures (33 of 45 failed nests) in this study were a result of nest predation, which is commonly the most significant cause of nest loss (Vander Haegen et al. 1988, Lehman 1998, Miller et al. 1998, Paisley et al. 1998). For unsuccessful turkey nests, Vangilder and Kurzejeski (1995) reported that 64% of known nest failures were due to predation and 36% from abandonment. In our study, only 9% of unsuccessful Wild Turkey nests were cases of abandonment.

Brood and poult survival to 4 weeks posthatch was comparable to survival rates reported from other studies of Eastern Wild Turkeys. Brood survival in our study (72%) was slightly below that of other South Dakota Eastern Wild Turkey populations (88%, Lehman 1998; 75%, Leif 2001). Four-week poult survival in our study (36%) was within the range of values reported by Vangilder (1992) for Eastern Wild Turkeys (24%–47%); but studies of other northern populations report 40%–51% poult survival—higher than we found (Porter et al. 1983, Roberts et al. 1995, Vangilder and Kurzejeski 1995, Paisley et al. 1998, Hubbard et al. 1999b, Lehman et al. 2001). Like previous studies (Vangilder and Kurzejeski 1995, Hubbard et al. 1999b, Lehman et al. 2001), the majority of

TABLE 4. Nest success and hen success of female Eastern Wild Turkeys in Grant County, South Dakota, 1999–2000.

Age class	Nest success[a]									Hen success[b]		
	First attempts			Second attempts			All attempts					
Year	n	Rate	$s_{\bar{x}}$	n	Rate	$s_{\bar{x}}$	n	Rate	$s_{\bar{x}}$	n	Rate	$s_{\bar{x}}$
SUBADULT												
1999	13	0.231	0.117	2	0.500	0.354	15	0.267	0.114	13	0.308	0.128
2000	6	1.000	0.000	NA	NA	NA	6	1.000	0.000	6	1.000	0.000
Pooled	19	0.474	0.115	2	0.500	0.354	21	0.476	0.109	19	0.526	0.115
ADULT												
1999	25	0.520	0.100	7	0.571	0.187	32	0.531	0.088	25	0.680	0.093
2000	41	0.415	0.077	11	0.727	0.134	53	0.491	0.069	41	0.634	0.075
Pooled	66	0.455	0.061	18	0.667	0.111	85	0.506	0.054	66	0.652	0.059
COMBINED												
1999	38	0.421	0.080	9	0.556	0.166	47	0.447	0.073	38	0.553	0.081
2000	47	0.489	0.073	11	0.727	0.134	59	0.542	0.065	47	0.681	0.068
Mean	85	0.455	0.034	20	0.642	0.086	106	0.495	0.048	85	0.617	0.064

[a]Proportion of nests from which ≥1 poult hatched
[b]Proportion of available hens that hatched ≥1 poult

poult mortality in our study occurred during the first 2 weeks post-hatch (see Table 5).

CONCLUSIONS

Leif (2001) stated that successful establishment of Eastern Wild Turkeys should be possible in river drainages of eastern South Dakota offering ≥15% woodland habitat (based on home range composition). The estimates of survival and reproduction from our study indicate that successful establishment of Eastern Wild Turkeys can occur in mixed agricultural areas with <10% woodland habitat available within aggregated turkey home ranges.

The high rate of winter survival we observed was probably enhanced by milder winters than are typical for this area. Even so, winters during our study still were characterized by long periods of subfreezing temperatures and substantial snow accumulations. Throughout the winter months, we often observed flocks foraging in croplands that offered agricultural foods close to woody cover. Use of feedlots and grain stores was minimal during these 2 relatively mild winters. Juxtaposition of roost sites to open, wind-swept fields free of accumulated snow appeared to provide food sources when snow accumulations in the breaks and river drainages covered many natural food sources. We believe that even during severe winters, such crop fields will offer winter flocks ample foraging opportunities. No-till and minimum tillage practices can add considerably to the availability of winter food sources, as do established wildlife food plots and unharvested crop fields.

As populations reach carrying capacity, other factors such as predation can become more important in determining reproductive success (Vander Haegen et al. 1988). Although losses of nests and poults were not limiting during the study, predation may become more severe as the turkey population reaches carrying capacity and as predators adapt to this new food source.

ACKNOWLEDGMENTS

This study was funded by the South Dakota Department of Game, Fish and Parks primarily through the Federal Aid to Wildlife Restoration Fund (Project W-75-R-38, No. 7595); the National Wild Turkey Federation (national and state chapters); the South Dakota Agricultural

TABLE 5. First 2-week, second 2-week, and 1-month survival rates for Eastern Wild Turkey poults in Grant County, South Dakota, 1999–2000.

Year	Age class (brooding female)	No. of females (poults)	0–2 week		2–4 week		0–4 week	
			$\hat{S}_{(t)}$	$s_{\bar{x}}$	$\hat{S}_{(t)}$	$s_{\bar{x}}$	$\hat{S}_{(t)}$	$s_{\bar{x}}$
1999	Subadults	4 (34)	0.589	0.225	0.900	0.098	0.529	0.260
	Adults	11 (108)	0.417	0.113	0.911	0.046	0.380	0.107
	Combined	15 (142)	0.458	0.101	0.908	0.041	0.416	0.101
2000	Subadults	3 (31)	0.484	0.182	0.933	0.089	0.452	0.212
	Adults	23 (207)	0.348	0.081	0.833	0.024	0.290	0.067
	Combined	26 (238)	0.366	0.073	0.851	0.028	0.311	0.064
Mean[a]		41 (380)	0.412	0.046	0.880	0.029	0.364	0.053

[a]Average of the combined survival rate from 1999 and 2000

TABLE 6. First 2-week, second 2-week, and 1-month survival rates for Eastern Wild Turkey broods in Grant County, South Dakota, 1999–2000.

Year	Age class (brooding female)	No. of broods	0–2 week		2–4 week		0–4 week	
			$\hat{S}_{(t)}$	$s_{\bar{x}}$	$\hat{S}_{(t)}$	$s_{\bar{x}}$	$\hat{S}_{(t)}$	$s_{\bar{x}}$
1999	Subadults	4	1.000	0.000	0.750	0.217	0.750	0.217
	Adults	11	0.909	0.087	1.000	0.000	0.909	0.087
	Combined	15	0.933	0.064	0.929	0.069	0.867	0.088
2000	Subadults	3	1.000	0.000	1.000	0.000	1.000	0.000
	Adults	23	0.522	0.104	1.000	0.000	0.522	0.104
	Combined	26	0.577	0.097	1.000	0.000	0.577	0.097
Mean[a]		41	0.756	0.178	0.965	0.036	0.722	0.145

[a]Average of the combined survival rate from 1999 and 2000

Experiment Station (McIntire-Stennis Funding), and South Dakota State University. We express appreciation to the many landowners of Grant County who generously allowed us unlimited access to their property. We also recognize B. Reishus and D. Thompson for their field assistance; T. Wittig (deceased) and J. Jenks for statistical guidance; and K. Higgins, L. Perrin, and 2 anonymous reviewers for critical review of this manuscript.

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Received 2 February 2005
Accepted 6 April 2006