Nesting Activity and Nest Site Characteristics of a Translocated Eastern Wild Turkey Population in East Texas

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Abstract: Sustainability of eastern wild turkey (*Meleagris gallopavo silvestris*, hereafter turkey) populations following translocation is dependent on reproductive success. Extensive efforts to restore turkeys to east Texas using translocation have yielded mixed results, leading to low-density, fragmented populations. Dynamics of a translocated turkey population are dependent on the outcome of nesting activity and nest success which can be influenced by vegetative characteristics selected by females when nesting. Because translocated turkeys transition from natal to new habitats, understanding patterns of nesting activity and vegetative characteristics selected by nesting females are important to continued restoration of turkey populations. We translocated 78 female and 23 male turkeys from Iowa, Missouri, and West Virginia to southern Angelina National Forest near Zavalla, Texas, during 2016–2017. In 2017, we recaptured eight previously-translocated females and captured three resident females. We used GPS telemetry to monitor nesting behavior of translocated turkeys (first nesting season after translocation) and resident turkeys (second nesting season after translocation or resident turkeys) and evaluated vegetative characteristics at nest sites. Initial nesting rates of translocated females varied from 74% to 82%, whereas renesting rates ranged from 21% to 74% between years; both rates were 100% for resident turkeys. Only two of 31 initial nests (7%) were successful across years, whereas no renests were successful. We documented only one brood surviving 28 days after hatching. Translocated turkeys selected nest sites with more woody cover and greater vegetation height than did resident turkeys, whose nests had more vine cover and lower vegetation height. We 1.) identify potential ways for improving adult survival and reproductive success of translocated birds and 2.) recommend that managers carefully consider source populations prior to translocation attempts.

Key words: eastern wild turkey, *Meleagris gallopavo*, nesting chronology, nest site selection, reproduction, Texas, translocation

Journal of the Southeastern Association of Fish and Wildlife Agencies 7:164–171

Translocations are used to reintroduce species to historic ranges and have been an important tool for species conservation (IUCN 1987, Lyles and May 1987, Fischer and Lindenmayer 2000). Translocation success hinges on a species' ability to adapt to potentially new habitat conditions and on the ability of individuals to reach stability in behaviors so fitness can be maximized (Armstrong and McLean 1995, Pople et al. 2001). Successful translocations require reproductive success either during the year of translocation or in subsequent years (De Leo et al. 2004, Baxter et al. 2010). For translocated birds, species capable of nesting successfully in a variety of vegetative conditions are more likely to be successful relative to more specialized species (Sol et al. 2002).

Eastern wild turkey (*Meleagris gallopavo silvestris*; hereafter, turkey) populations have been restored throughout the historic geographic range using translocations of wild caught birds. Restoration of turkey populations is considered one of the great success stories in North American wildlife conservation (Mosby 1975, Kennamer and Kennamer 1990, Shands 1992). However, restorations have not been uniformly successful, with one notable example occurring in east Texas (Newman 1945, Campo et al. 1984). Despite the release of >7,000 turkeys since the 1970s (Seidel et al. 2013), turkey density in east Texas remains low, driven by poor reproduction following translocation (Lopez et al. 2000, Conway et al. 2010, Isabelle et al. 2016). Early translocation attempts in east Texas used block stocking (<20 birds released per site), but simulation models indicated potential benefit of using a super stocking approach (>70 birds released per site, Lopez et al. 2000).

Reproductive success is the primary driver of population dynamics for turkeys (Vangilder and Kurzejeski 1995, Pollentier et al. 2014, Byrne et al. 2015). Nest success can be influenced by a variety of environmental factors, such as temperature, precipitation, and vegetative characteristics, each of which may influence nest predation risk (Bowman and Harris 1980). Turkeys exhibit considerable plasticity in nest selection, using a diversity of cover types throughout the species' range (Thogmartin 1999, Nguyen et al. 2004, Martin et al. 2012, Fuller et al. 2013, Conley et al. 2016).

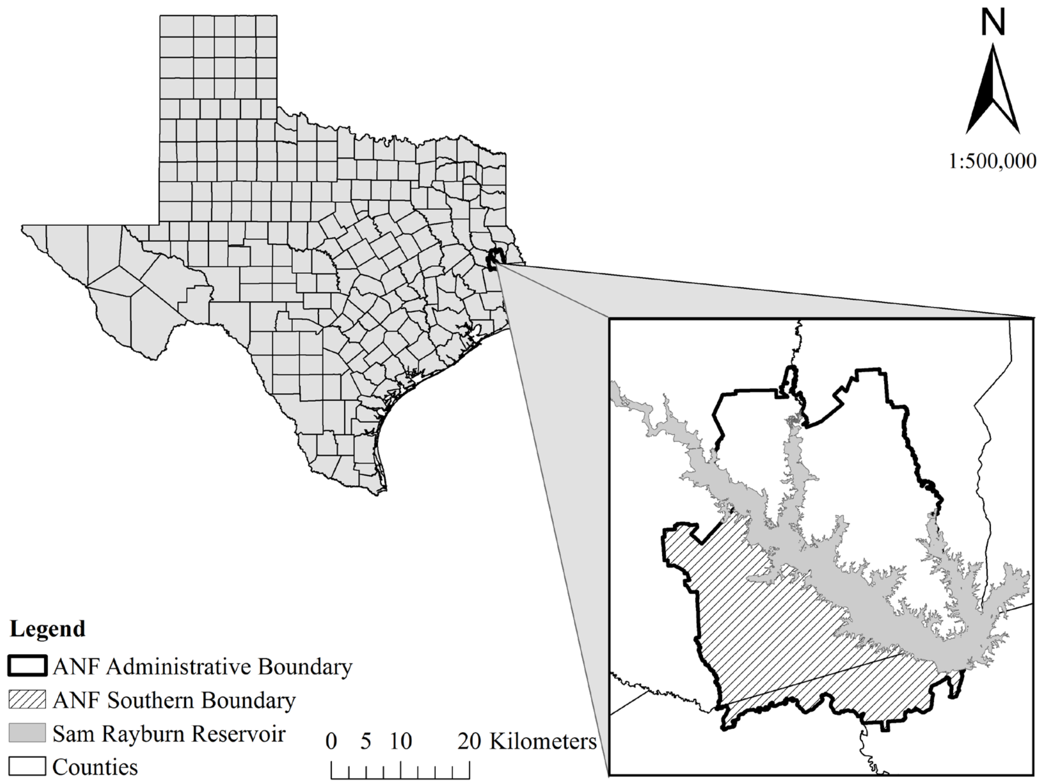

Figure 1. Location of Angelina National Forest, Texas, with boundary indicated by solid black line. Sam Rayburn Reservoir (gray filled) divided ANF into northern and southern (black-crossed lines) sections. We conducted research during 2016–2017 in and around the southern section at the intersection of Angelina and Jasper counties (black lines).

Moreover, across the range, predation is the primary cause of nest loss (Miller and Leopold 1992, Palmer et al. 1993, Miller et al. 1998, Badyaev 1995, Thogmartin 1999, Nguyen et al. 2004, Fuller et al. 2013), with numerous studies noting extensive loss to predation of nests and nesting females (Vangilder et al. 1987, Badyaev 1995, Miller et al. 1998, Isabelle et al. 2016).

Turkeys nest in a wide range of vegetative conditions, and although characteristics at nest sites have potential to influence reproductive success (Badyaev et al. 1996, Fuller et al. 2013), translocated turkeys must select nest sites with no prior experience as to characteristics that could most influence nest success in the new habitat. Isabelle et al. (2016) noted that translocated turkeys in east Texas used a diversity of habitat types for nesting and found no relationship between vegetation at nests and nest success. However, nest site selection by translocated turkeys may change after the initial year of release. Our understanding of this process is poor, despite the recognition that translocated individuals may alter resource selection temporally following release and such responses have potential to influence reproductive fitness (Letty et al. 2007, Dickens et al. 2009). A hindering factor is that previous studies investigating reproductive behavior of translocated turkeys in east Texas relied upon VHF transmitters to determine nesting behavior and nest success (Campo et al. 1984, Lopez et al. 1998, Isabelle et al. 2016). The advent of GPS transmitters for turkeys has allowed researchers to more appropriately describe various behaviors of turkeys, including nesting and movement ecology (Guthrie et al. 2011). Notably, contemporary research on both resident and translocated turkeys using GPS telemetry has demonstrated improved inferences relative to estimating various demographic parameters with VHF telemetry (Collier and Chamberlain 2011, Cohen et al. 2015, Yeldell et al. 2017, Wood et al. 2018a).

To increase our understanding of translocated wild turkey reproductive ecology, our objectives were to examine and characterize nesting activity and success of GPS-marked turkeys translocated to east Texas during 2016–2017. We also sought to compare nest success between translocated and resident turkeys, while evaluating vegetative characteristics at nest sites of translocated and resident turkeys. Our purpose for comparing nest success and vegetative characteristics at nest sites of translocated and resident wild turkeys was to provide managers with pertinent information of the temporal changes in nest site selection and reproductive productivity during and after the initial year of translocation.

Study Area

We conducted our research in and around the southern portion of Angelina National Forest (hereafter ANF, Figure 1) located in the Pineywoods ecoregion of east Texas. The southern shoreline of Sam Rayburn reservoir served as the northern boundary of ANF, whereas the Neches River formed the southern boundary. The western boundary of ANF was Shawnee Creek and Farm to Market State Road (hereafter; FM) 69, and the eastern portion was bounded by the Angelina River and FM 255. The ANF was approximately 18,751 ha and was comprised mostly of mature longleaf pine (*Pinus palustris*) with hardwood drainages near streamside management zones and other riparian areas. Understory ground cover was characterized by dense yaupon (*Ilex vomitoria)* and American beautyberry (*Callicarpa americana*) with a midstory dominated by sweetgum (*Liquidambar styraciflua*), shortleaf pine (*P. echinata*), loblolly pine (*P. taeda*) and longleaf pine. Hardwood riparian areas were found throughout the pine-dominated system and consisted of post oak (*Quercus stellata*), various oaks (Quercus *spp.*), elm (*Ulmus spp*.), maple (*Acer spp*.), hickory (*Carya spp.*), magnolia (*Magnolia spp*.), and American beech (*Fagus grandifolia*). Upland pine stands on ANF were managed by large-scale prescribed fires (≥600 ha) conducted by aerial ignition with a fire-return interval of 1–3 years. However, prescribed fire, timber harvests, and other forest management practices (e.g., thinning) on ANF were limited during our study because of weather restrictions and availability of aerial support. We released turkeys at a single release site on the southern portion of our study area.

Methods

We released 78 females and 23 males from Iowa, Missouri, and West Virginia in ANF during 2016–2017. We also captured three female turkeys on ANF using rocket nets in February 2017. Prior to release, we classified each turkey as adult or subadult based on barring of ninth and tenth primary feathers (Pelham and Dickson 1992) and fitted individuals with butt-end aluminum leg bands (National Band and Tag Company, Newport, Kentucky). We also affixed backpack-style GPS transmitters equipped with VHF weighing approximately 88-g (Lotek-Biotrack LTD: Wareham, Dorset, UK). We programmed transmitters to record hourly locations from 0800 to 1700 hours post-release to 1 March. Beginning 1 March, transmitters recorded hourly locations from 0700 to 1800 hours, and a roost location at 2330 hours (Cohen et al. 2018). All capture and handling procedures were approved by the University of Georgia Institutional Animal Care and Use Committee (Approval number A2015 07-009-Y1-A0).

We monitored turkeys daily using VHF. We also remotely-downloaded GPS data ≥1 time/week post-release to end of February. When mortality events were detected, we recovered transmitters and assessed causes of mortality. Beginning 1 March, we began remotely-downloading GPS data ≥2 times per week. Using GPS locations, we determined when a female was incubating a nest when locations became clustered around a single point (Yeldell et al. 2017, Wood et al. 2018b). Once females were located away from the nest site for >1 day, we examined nests to determine the outcome (failure or success). We determined the nest to be successful if evidence of ≥1 hatched egg was found at the nest site, and visually confirming presence of a brood by relocating brooding females using VHF telemetry within 24 hours after they left the nest site (Wood et al. 2018b). If nests were successful, we monitored brooding females for 28 days post-hatch because poults are considered juveniles after 28 days (Hurst 1992). We classified nests as failed if we found eggshell fragments in and around the nest bowl and there was clear evidence of a predation event on either the nest or the incubating female (Yeldell et al. 2017, Wood et al. 2018b).

We assessed nesting rates and nest success following methods outlined in Melton et al. (2011). We defined initial nesting rate as the percentage of available females that initiated incubation of ≥1 nest. Likewise, we defined second, third, and fourth nesting rates as the percentage of available females that initiated incubation of second, third, and fourth nests following loss of an earlier nest. We defined nest success rate for each nesting attempt as the percentage of nests producing ≥1 hatched egg (Yeldell et al. 2017). Nesting behavior of female turkeys is known to cycle annually (Vangilder et al. 1987, Roberts et al. 1995, Roberts and Porter 1996); hence we considered translocated females who survived into their second nesting season to be residents whereas females nesting in the year of translocation were considered translocated.

We examined vegetative characteristics in a 15-m radius circular plot (Streich et al. 2015, Little et al. 2016, Yeldell et al. 2017) at the nest site and in each cardinal direction in order to compare nest sites between translocated and resident female turkeys. We estimated percent ground cover for eight cover types (woody, grass, forbs, vine, fern, moss, debris) or lack thereof (bare), maximum vegetation height (cm), mean vegetation height (cm), visual obstruction (cm), canopy cover (%), understory cover (%), and basal area (m^2 per ha). We estimated percent ground cover using a modified 1-m^2 Daubenmire frame (Daubenmire 1959) centered over the nest site and in each cardinal direction 15 m from the nest. We measured maximum and mean vegetation height and visual obstruction by placing a 2-m Robel pole (Robel et al. 1970) at the nest site and viewed it from 15 m in each cardinal direction approximately 1 m above ground to simulate the height of a turkey (Pelham and Dickson 1992, Yeldell et al. 2017). We determined visual obstruction as the lowest point on the Robel pole obscured by vegetation viewed from 1 m above the ground. We measured understory cover 1 m above ground and canopy cover at breast height of the observer at the nest site and in each cardinal direction 15 m from the nest site using a convex densiometer (Lemmon 1956). We calculated mean percent understory cover and canopy

Table 1. Nesting rate and success by year (2016 vs. 2017) and age (adult vs. subadult) of female wild turkeys affixed with µGPS telemetry transmitters and monitored in Angelina National Forest, Texas. In 2016, all female wild turkeys were translocated to Angelina National Forest. In 2017, 18 additional female wild turkeys were translocated along with recapture of 10 female wild turkeys translocated in 2016 and 3 female wild turkeys of unknown origin in Angelina National Forest.

	1st Nest attempt			2nd Nest attempt			3rd Nest attempt			4th Nest attempt		
Year	Available (*n*)	Rate (%)	Success (%)	Available (*n*)	Rate (%)	Success (%)	Available (*n*)	Rate (%)	Success (%)	Available (*n*)	Rate (%)	Success (%)
2016												
Adult	21	71	7	13	23	0	3	33	0	–	–	–
Subadult	14	79	9	6	17	0	1	0	0	–	–	–
Overall	35	74	8	19	21	0	4	25	0	–	–	–
2017												
Adult	20	85	0	14	71	0	8	25	0	2	50	0
Subadult	2	50	0	1	0	0	–	–	–	–	–	–
Overall	22	82	0	15	67	0	8	25	0	2	50	0

Table 2. Nesting rate and success of translocated and resident female wild turkeys by class and age (adult vs. subadult) affixed with µGPS telemetry transmitters in Angelina National Forest, Texas, during 2017. Female wild turkeys translocated in 2016 and recaptured in 2017 (*n* = 10) were pooled with female wild turkeys of unknown origin (*n* = 3) captured in Angelina National Forest in 2017 and defined as resident female wild turkeys.

	1st Nest attempt			2nd Nest attempt			3rd Nest attempt			4th Nest attempt		
Class	Available (*n*)	Rate (%)	Success (%)	Available (*n*)	Rate (%)	Success (%)	Available (*n*)	Rate (%)	Success (%)	Available (*n*)	Rate (%)	Success (%)
Translocated												
Adult	10	70	0	6	33	0	2	0	0	–	–	–
Subadult	2	50	0	1	0	0	–	–	0	–	–	–
Overall	12	67	0	7	29	0	2	0	0	–	–	–
Residents												
Adult	10	100	0	8	100	0	6	33	0	2	50	0
Total	22	82	0	15	67	0	8	25	0	2	50	0

cover by taking the mean of readings at the nest site and in each cardinal direction. We recorded basal area using a 10-basal area factor (BAF) prism centered on the nest site and in each cardinal direction 15 m from the nest site.

We calculated mean Julian date for onset of incubation by dividing initiation dates by total number of nests and renests. We described vegetative characteristics of nest sites by two classes of nest types: translocated and residents. We compared each vegetation variable between classes using analysis of variance (ANOVA). We considered vegetative characteristics to differ at $\alpha = 0.05$. We conducted all analyses using software program R (R Core Team 2013).

Results

During 2016, 56 and 4 female turkeys were translocated to ANF from Iowa and West Virginia, respectively. Of the 60 females released on ANF in 2016, 35 (21 adults, 14 subadults) were available to nest; the remaining 25 females were lost to mortalities ($n = 13$) or transmitter failure ($n = 12$; Table 1) prior to nest initiation. We observed an initial nesting rate of 74% comprised of 15 and 11 nests by adult and subadults, respectively (Table 1). Mean incubation start date of initial nests was 5 May, ranging from 13 April to 9 June. Only two initial nests were successful and one brood survived until 28 days after hatch. Renesting rates for second and third nest attempts in 2016 were 21% and 25%, respectively, but no renests were successful (Table 1).

We translocated 18 additional females from Iowa ($n = 7$) and Missouri ($n = 11$) to ANF in 2017 and recaptured eight females originally translocated in 2016, as well as three resident females (from unknown origin) on private lands within ANF. Of these 29 females we radio-tracked in 2017, seven were lost before nesting to mortality ($n = 2$) or transmitter failures ($n = 5$). The remaining 22 females (20 adults, 2 subadults) included 12 translocated females (10 adults, 2 subadults) and 10 (adult) resident females (Tables 1 and 2). Mean date of onset of incubation for initial nests was 23 April, ranging from 31 March to 12 June. Initial nesting rates were 67% and 100% for translocated and resident females, respectively (Table 2). Renesting rates were 29% for translocated females and 100% for resident females (Table 2). Three resident females

Table 3. Vegetative characteristics for each nest site by class (translocated = 41 nest attempts, residents = 21 nest attempts) representing percent ground cover for eight ground cover types, maximum vegetation height (cm), mean vegetation height (cm), visual obstruction (cm), understory cover (%), canopy cover (%), and basal area (m^2 per ha) for translocated ($n = 34$) and resident ($n = 10$) female wild turkeys in Angelina National Forest, Texas during 2017. Data is mean ± 1 SE.

	Vegetation by class ($\bar{x} \pm 1$ SE)	
Vegetation characteristics	**Translocated ($n = 41$)**	**Residents ($n = 21$)**
Woody (%)	27.44 ± 2.13	14.88 ± 2.77
Grass (%)	19.84 ± 2.81	28.88 ± 5.95
Forbs (%)	4.90 ± 1.01	6.44 ± 1.15
Vine (%)	3.54 ± 0.77	9.31 ± 3.24
Fern (%)	3.17 ± 1.11	0.31 ± 2.53
Moss (%)	0.24 ± 0.13	0
Debris (%)	34.92 ± 3.40	30.44 ± 5.63
Bare (%)	3.51 ± 1.09	9.75 ± 3.32
Maximum vegetation height (cm)	168.70 ± 5.46	152.34 ± 9.19
Mean vegetation height (cm)	118.77 ± 6.24	91.00 ± 7.86
Visual obstruction (cm)	98.40 ± 7.02	96.44 ± 11.09
Understory cover (%)	68.50 ± 3.71	72.61 ± 6.17
Canopy cover (%)	78.13 ± 22.89	68.61 ± 6.26
Basal area (m^2 per ha)	54.41 ± 54.44	44.44 ± 6.38

attempted a third nest, and one resident female attempted a fourth nest. No nests were successful in 2017. Overall, causes of nest failure during 2016–2017 included mortality of the incubating female ($n = 9$), prescribed fire ($n = 2$), flooding ($n = 2$), and nest predation ($n = 47$).

We sampled vegetation characteristics at 41 and 21 nest sites of translocated and resident female wild turkeys, respectively (Table 3). Translocated females selected nest sites with a greater percentage of woody ground cover ($\bar{x} = 27.44\%$, SE ± 2.13%, $F = 6.63$, df = 1, 60; $P = 0.01$), whereas resident females tended to select nests with greater percentage of vine cover ($\bar{x} = 9.31\%$, SE ± 3.24%, $F = 4.99$, df = 1, 60; $P = 0.03$). Maximum vegetation height ($F = 3.01$, df = 1, 60; $P = 0.09$) was similar between translocated and resident females (translocated; $\bar{x} = 168.70$ cm, SE ± 5.46 cm, resident; $\bar{x} = 152.34$ cm, SE ± 9.19 cm) but mean vegetation height was greater at nests of translocated females ($\bar{x} = 118.77$ cm, SE ± 6.24 cm, $F = 6.78$, df = 1, 60; $P = 0.01$) than nests of resident females ($\bar{x} = 91.00$ cm, SE ± 7.86 cm). No other vegetative characteristics differed between nests of translocated and resident females.

Discussion

Translocated turkeys experienced substantive mortality following release and prior to nesting. Translocated animals are confronted with the necessity to adjust to new landscapes that often differ in predator abundance relative to natal habitats (Chivers et al. 2014, Ferrari et al. 2015, Kenison and Williams 2018). Although quantifying predator abundance was beyond the scope of our work, richness of predator species in east Texas was likely higher than at all natal sites, given known latitudinal gradients in predator richness and abundance (Gaston 2000, Willig et al. 2003). For turkeys and other ground nesting birds, excessive mortalities immediately after translocation can compromise translocation success through reductions in fitness potential (Kelly 2001, Whiting et al. 2005, Martin et al. 2017). Therefore, translocation success may ultimately hinge on the ability of surviving individuals to reproduce successfully soon after translocation events (De Leo et al. 2004, Letty et al. 2007, Baxter et al. 2010). We observed greater initial nesting rates than those previously reported for translocated turkeys in east Texas (Lopez et al. 1998, Isabelle et al. 2016) and note that these rates were comparable to or slightly less than initial nesting rates in established populations (Yeldell et al. 2017 [87%], Wood et al. 2018 [96%], Chamberlain et al. 2018 [~70%]). Conversely, we observed renesting rates markedly lower than what has been reported in contemporary literature (but see Chamberlain et al. 2018). Regardless, we offer that the use of GPS telemetry allowed a more accurate assessment of nesting activity than reported previously for translocated wild turkeys via improved abilities to monitor reproductive behaviors and movements associated with nesting (Collier and Chamberlain 2011, Yeldell et al. 2017).

We observed nest success rates well below those necessary to ensure sustainable populations (Vangilder et al. 1987, Wood et al. 2018b). Furthermore, average nest success for translocated and resident females was lower than that reported for any translocated or resident turkey population in the southeastern United States (Thogmartin and Johnson 1999, Miller et al. 1995, Yeldell et al. 2017), including previously reported estimates for translocated turkeys in east Texas (Campo et al. 1984, Isabelle et al. 2016). Previous authors have suggested silvicultural or other management practices to improve landscape conditions for translocated wild turkeys in east Texas under the assumption that such improvements would translate into improved reproductive fitness (e.g., Isabelle et al. 2016). However, as noted earlier, we informally observed silvicultural practices (prescribed fires, timber stand improvements) were uncommon on ANF during our study and most birds we monitored did not inhabit portions of the landscape where such practices did occur. Therefore, drawing potential links between our findings and stand-level habitat conditions or silvicultural practices was beyond the scope of our study. We hypothesize that greater nest success rates reported in previous studies in east Texas compared to our findings may be attributed to the composition of natal habitats where birds were captured for translocation.

Previous studies involved translocations of turkeys from generally similar forested habitats (e.g., Louisiana and Mississippi, Campo et al. 1984; South Carolina and Tennessee, Isabelle et al. 2016). Conversely, translocated turkeys in our study primarily originated from open, agricultural landscapes and fragmented hardwood forests of the upper Midwest, which may have influenced their ability to identify nest sites offering reduced predation risk.

Translocation presents a unique opportunity to study nest site selection because translocated individuals do not have predisposed knowledge of the landscape prior to release. Although we noted subtle differences in vegetative characteristics between nest sites of resident and translocated females, these characteristics collectively were consistent with those observed at nest sites throughout pine-dominated forests of the southeastern United States (Moore et al. 2010, Streich et al. 2015, Yeldell et al. 2017, Wood et al. 2018b). The consistency of vegetative characteristics at nest sites is not surprising when considering nest selection of birds is evolutionarily linked (Joyce 1993, Verlando and Márquez 2002) and thus requires an innate understanding of selecting nest sites capable of mitigating thermoregulation and protecting the attending female from predatory risks (Collias 1964, Heenan 2013, Mainwaring et al. 2014).

We note that nest success was poor for both translocated and resident females, irrespective of vegetation characteristics at nests. It is plausible that predator communities in portions of east Texas are rich and diverse and thus hamper translocation attempts, regardless of numbers of individuals released during specific translocations. Future research should attempt to quantify predation risks to adults and nests prior to translocation attempts.

Management Implications

The success of a translocation depends on the ability of translocated individuals to quickly adapt to new habitat conditions, thereby maximizing individual fitness and positively influencing fecundity. Given the markedly low nest success of both translocated and resident turkeys at our study site, we recommend managers identify potential ways of improving reproductive success, along with survival of adults immediately after release. Likewise, managers in east Texas should consider translocating turkeys from natal landscapes comparable to those encountered after translocation, in hopes of improving reproductive fitness.

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