RIO GRANDE WILD TURKEY NESTING ECOLOGY IN KANSAS AND THE ROLLING PLAINS OF TEXAS

by

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CHAPTER

INTRODUCTION

The following work represents partial fulfillment of the requirements for the degree of Master of Science in Wildlife Sciences in the Graduate College at Texas Tech University. This research project studied habitat use and breeding area fidelity in Rio Grande wild turkeys (*Meleagris gallopavo intermedia*) in Kansas and the Panhandle of Texas. Chapter II documents nesting habitat at 4 study areas and assesses the differences among the study areas. This chapter also assesses what structural components and vegetation types may provide quality habitat for wild turkey hens to be more successful. Chapter III documents Rio Grande wild turkeys exhibiting breeding area fidelity to their previous nesting area in successive years at 4 study areas and the potential consequences for exhibiting or not exhibiting breeding area fidelity. Both chapters represent manuscripts that are intended for submission in peer-reviewed journals following completion of this thesis. This work represents my writing, analyzing, and researching abilities. With the guidance of my committee, I designed this study, collected the data, and synthesized the research into two manuscripts. Authorships for the following manuscripts were determined based on contributions as well as a synthesis of the guidelines outlined by the CBE Style Manual Committee (1978), Dickson and Conner (1978), and Fine and Kurdek (1993). Authorship will be as follows:

Chapters

II. Terri L. Barnett, Warren B. Ballard, Mark C. Wallace, John H. Brunjes, Derrick H. Holdstock, Richard S. Phillips, Brad Simpson, and Brian L. Spears.

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CHAPTER II

NEST SITE SELECTION AND NESTING SUCCESS OF RIO GRANDE WILD TURKEYS IN KANSAS AND THE ROLLING PLAINS OF TEXAS

Abstract

Habitat change from primarily rangeland to a combination of rangeland and agriculture has occurred in the Panhandle of Texas and southwestern Kansas through the past several decades. Agencies have expressed concern that some Rio Grande wild turkey (*Meleagris gallopavo intermedia*) populations may be declining. I studied Rio Grande wild turkey nesting habitat at 4 locations; 3 in the Panhandle of Texas and 1 in southwestern Kansas in 2000 and 2001. The Gene Howe Wildlife Management Area (GHWMA) and Salt Fork study areas were chosen to represent stable or increasing populations of wild turkeys, while Cimmaron National Grasslands (CNG) and Matador Wildlife Management Area (MWMA) were chosen to represent possible declining populations. My objectives were to describe nesting and non-nesting habitats among the study areas and to compare characteristics of nesting habitats in relation to nesting success. Females at all study areas selected nest plots with greater shrub cover, higher visual obstruction, and less bare ground cover than adjacent, non-nest plots. Nest site differences were not found to distinguish between possible declining turkey populations and stable populations, except at the CNG study area. Turkey nests at CNG had lower visual obstruction, less shrub density and less dense woody understory vegetation than the other study areas. Nest success was not lower at this study area than the other study

areas. Although I did find that females nesting in grassland vegetation at CNG were not as successful as females that nested in other vegetation types at that study area. This suggests that lack of other vegetation types may be a limiting factor for turkey population growth at that study area. Juvenile turkeys nested in areas with more bare ground than adult turkeys, and turkeys that nested late in the nesting season used areas with more herbaceous cover than turkeys that nested early in the season at all study areas.

Introduction

Habitat selection occurs when an individual chooses an area in which to live from among sites that differ with respect to characteristics affecting growth, survivorship, and reproduction (Green and Stamps 2001). Nesting success is the most important demographic parameter affecting wild turkey (*Meleagris gallopavo*) population size in the northeastern United States (Roberts and Porter 1996), however, nest predation is a large source of mortality for all species of wild turkey females (Cook 1972, Glidden and Austin 1975, Speake 1980, Vangilder et al. 1987, Vander-Haegen et al. 1988). Higher nest predation rates have been reported when turkey nests are located in areas with low cover compared to nests with higher cover, indicating that quality of nesting habitat is particularly important to wild turkeys (Hillestad and Speake 1970, Lazarus and Porter 1985). Nesting habitat that provides good cover from predators or poor visibility by prey to detect predators will affect the likelihood of depredation (Roberts and Porter 1996). Dense vegetation may provide visual, auditory and olfactory obstruction at nest sites, thereby reducing nest detection by predators on smaller spatial scales (Bergerud and

Gratson 1988, Martin 1993). High heterogeneity of nest habitats may also prevent common predators from developing search images, and may further reduce predation (Storaas and Wegge 1987, Martin 1988). However, areas that provide too much cover are not commonly used by nesting female turkeys, possibly due to reduced ability to detect predators (Miller et al. 1996).

Microhabitats of nesting wild turkeys have been well described (Lazarus and Porter 1985, Seiss et al. 1990, Badyaev 1995). Females chose nest plots with greater complexity and variability in habitat structure than was generally available (Day et al. 1991, Badyaev 1995). The most prominent habitat characteristics at nest sites in relation to non-nest sites included greater understory density and increased visual obstruction around nest sites (Williams et al. 1968, Lazarus and Porter 1985, Wertz and Flake 1988, Schmutz et al. 1989, Badyaev 1995).

Larger spatial scales for selecting nest plots are not well described for wild turkeys. Thogmartin (1999) reported turkeys nested in larger patch sizes than the mean patch size for the study area. Bowman and Harris (1980) found foraging efficiency of raccoon (*Procyon lotor*) decreased, search time increased, and fewer clutches of bird eggs were found in enclosures where understory vegetation density was artificially increased. Thus, vegetation density in the nest patch may hinder nest discovery by reducing transmission of olfactory, auditory, or visual cues. Therefore, habitat selection at scales larger than the immediate area around the nest should affect predation risk (Martin and Roper 1988).

Differences in habitat characteristics between declining turkey populations and increasing turkey populations have not been well documented. The objectives of this study were to determine nesting habitat characteristics of stable and declining populations of Rio Grande wild turkeys (*Meleagris gallopavo intermedia*) at four study areas. I hypothesized that nests located in sites with reduced visual obstruction and understory vegetation density would have higher depredation rates than nests in areas with greater amounts of visual obstruction and understory vegetation. I also hypothesized that nest plots would be in higher density vegetation than adjacent sites, although sites adjacent to successful nests would have higher complexity and variability (more potential nest sites) in habitat structure than adjacent to depredated nests. This is because larger contiguous habitat patches should reduce nest detection by predators compared to smaller patches. Other hypotheses I tested included: juvenile turkeys due to less nesting experience, would nest in areas with reduced visual obstruction and understory vegetation density than adult turkeys, and second attempt nests among all females would show higher visual obstruction and understory vegetation density than compared to first nesting attempts. I investigated nesting characteristics and nest selection by (1) comparing habitat characteristics at nest plots and adjacent sites, (2) comparing between successful and depredated nests, adult and juvenile nests, first and renesting attempts, and early and late nests in different vegetative types, (3) comparing habitat characteristics of successful nests to adjacent sites and depredated nests to adjacent sites, along with successful adjacent to depredated adjacent sites, and (4) comparing habitat characteristic differences among and within study areas.

Study Areas

I studied Rio Grande turkey nesting habitats at 4 different areas in 2000 and 2001; 3 areas were located in the Panhandle of Texas and 1 in southwestern Kansas (Figure 2.1).

The Kansas study area was located in the southwestern corner of Kansas, centered on the Cimmaron National Grassland (CNG) in Morton County, and included parts of Stevens County, Kansas, and Baca County, Colorado. This area has had declining populations of wild turkeys since the mid 1980s as evidenced by declining turkey poult-female counts (R. Applegate, Kansas Department of Wildlife and Parks, Emporia, personal communication). The Cimmaron River flowed west to east through the center of the study area. Cattle production was the only land use practice on the grassland, but dry cropland and irrigated cropland did occur on privately owned portions of the study area. Dominant vegetation included western cottonwood (*Populus deltoides*) woodlands in the riparian areas, and sand sagebrush (*Artemisia filifolia*) grasslands in the uplands (Cable et al. 1996). Sand sagebrush grassland covered the largest area.

The most northerly Texas site was centered on the Gene Howe Wildlife Management Area (GHWMA) east of Canadian, Texas in Hemphill County. This study site represented a stable to increasing population of Rio Grande wild turkeys (G. Miller, unpublished data, Texas Parks and Wildlife, Canyon). The Canadian River flowed west to east through the center of the study area. Cattle production was the dominant land use practice as well as dry cropland and irrigated cropland within the study area. Dominant vegetation included sand sagebrush, western soapberry (*Sapindus saponaria*), and hackberry (*Celtis spp.*) grassland in the upland areas, and salt cedar (*Tamarix parviflora*), russian olive (*Elaeagnus angustifolia*), and western cottonwoods in the riparian areas (Hodge 2000). Sand sagebrush grassland covered the largest area.

The Salt Fork study site was centered on private ranches along the Salt Fork of the Red River northeast of Clarendon, Texas in Donley and Collingsworth Counties. This study site represented a stable to increasing population of Rio Grande wild turkeys (G. Miller, unpublished data, Texas Parks and Wildlife, Canyon). The Salt Fork of the Red River flowed west to east through the center of the study area. Cattle production was the dominant land use practice. Dry cropland and irrigated cropland was also found within the study area. Dominant vegetation included honey mesquite (*Prosopis glandulosa*), black locust (*Robinia pseudo-acacia*), shinnery oak (*Quercus havardii*), hackberry species, western soapberry and sand sagebrush grassland in the uplands and western cottonwood in the riparian areas. Mesquite grassland covered the largest area.

The southern most study area was centered at the Matador Wildlife Management Area (MWMA) near Paducah, Texas in Cottle County. Turkeys were believed to be declining since the late 1970s (G. Miller, unpublished data, Texas Parks and Wildlife, Canyon). The Pease River flowed west to east through the center of the study area. Cattle production was the dominant land use or wildlife practice on the study area. Dry cropland and irrigated cropland was found within the study area. Dominant vegetation included honey mesquite, hackberry, sand sagebrush, and redberry juniper (*Juniperus pinchotii*) shrubland in the uplands and western cottonwood in the riparian areas, with mesquite grassland covering the largest area (Hodge 2000).

Methods

I captured Rio Grande turkey females during January and February of 2000 and 2001 using rocket and drop nets (Table 2.1). Captured birds were classified as juveniles (<1 year of age) or adults (>1 year of age) based on characteristics of IX and X primaries and rectrice length (Petrides 1942). Each bird was fitted with a 110g backpack style radio transmitter with an 8-hour mortality signal (ATS, Isanti, MN).

I relocated turkeys with a truck mounted null-peak antenna system and using the triangulation method (White and Garrott 1990). Triangulations were performed for each location, alternating among 4 different time periods (i.e., AM, mid-day, PM, roost). Each bird was located ≥ 3 times per week during the nesting season (i.e., April through early August) either by visual location or triangulation. Intersections of triangulations were calculated using ≥ 3 bearings and computer programs LOCATE II (Nams Truro, Nova Scotia 2001) and LOAS (Ecological Software Solutions Sacramento, Calif.). Error ellipses for each triangulation were obtained with maximum likelihood techniques (White and Garrott 1990). Location information was used to determine onset of incubation. Once a female was in approximately the same area (± 200 m) for ≥ 2 locations, the female was thought to be incubating.

Once a female was thought to be incubating, nest sites were located by tracking the nesting hen to ≥ 20 m from the nest and flagging vegetation 1 to 4 places around the nest depending on thickness of vegetation and location of nest. Flags were tied in a knot and excess flagging was cut off to reduce visual cues for predators. Females were flushed after approximately 2 weeks of incubation to determine clutch size and exact nest location. If nest depredation or abandonment occurred prior to 2 weeks of incubation, areas within marked vegetation were searched until nests were found. Incubation and nest completion dates were estimated from examining telemetry locations and confirmed by floating eggs from each nest after the female was flushed (Westerskov 1950). Nest initiation dates were calculated for all nests by subtracting 1 day for every egg in the nest from the estimated incubation date (Williams et al. 1971). Nests were considered successful if ≥ 1 egg in a clutch hatched.

Habitat Measurements

After nest attempts were complete (i.e., either successful or unsuccessful), vegetation structure and composition was measured. I established a 10 x 20 m plot oriented north to south and centered on each nest and a paired adjacent plot located 50 m in an adjacently chosen cardinal direction from the nest.

All trees (i.e., woody plants > 10 cm diameter breast height [DBH]) rooted within plots were recorded by specie. Height, DBH, and decay class (Maser et al. 1979) for each tree was also recorded. The height of each tree was estimated using a wooden pole 2 m in length with different color bands at every 0.5 m. Overstory canopy cover was measured using an ocular tube (i.e., 2-4 cm in diameter with crosshairs at one end) at 20 points spaced evenly around the perimeter of the plot. The total number of hits (i.e., canopy observed at the crosshairs of the ocular tube) was recorded and used to estimate percent overstory canopy cover.

Understory woody vegetation was measured within a 20 x 2 m belt transect along the plot centerline. A 2 meter pole (Hagan et al. 1996) was held 0.5 m off the ground, and all woody stems (< 10 cm DBH) touched by the pole and rooted within the plot along the 20 m transect were recorded. Each species of stem and height class was recorded and classified into 4 classes: 0.5–1.0 m, 1.1–2.0 m, 2.1–4.0 m, and 4.1–6.0 m.

Hiding cover (nest plot visual obstruction) in nesting areas was assessed by measuring visual obstruction ≤1 m tall in nest plot and adjacent plots with a vertical visual obstruction pole (Robel et al. 1970). The visual obstruction pole was 2.5 cm in diameter and 1 m long, marked with 1 dm long vertical bands. Each band was colored red or white with alternating colors to differentiate among bands. The pole was placed along the 20 m centerline of the plot and was observed from a distance of 4 m and a height of 1 m (Robel et al. 1970). A 1 m sighting pole was attached to the visual obstruction pole by a 4 m string to standardize readings (Robel et al. 1970). Ten visual obstruction readings were made 2 m apart along the 20 m centerline transect in each plot alternating sides of the centerline. Visual obstruction was determined by how many vertical bands were visible at the 1 m height and at a distance of 4 m. This was done by recording the lowest band visible and total number of bands visible. If any part of the band could be observed, it was considered visible.

Ground cover was classified into the following 5 categories: grass, shrub, bare, forb, and litter. Ground cover was estimated using the ocular tube at 10 points along the 4 m string between the visual obstruction and sighting poles. Vegetation observed in the crosshairs of the ocular tube was recorded for that point. This resulted in 100 total points per vegetation plot.

Nest bowl measurements included visual obstruction at the nest bowl and at the center of the adjacent plot (nest bowl visual obstruction). The visual obstruction pole was placed inside the nest bowl and visual obstruction was recorded 4 m from the nest bowl at a height of 1 m in all 4 cardinal directions.

Nests were classified as successful, abandoned or depredated, early or late, first or renest attempt, and juvenile or adult. If 1 egg hatched in a clutch the nest was considered successful. Nests that were abandoned (n = 23) as a possible result of human disturbance were excluded from nest success analyses. Nests were classified as early if nest initiation date occurred prior to the median nest initiation date, 1 May. Nests were late if the initiation date occurred after the median nest initiation date.

Nests were classified into different vegetation types. Vegetation types were determined by the dominant species in the measured nesting area. Vegetation types included grassland, upland shrubs, upland trees, cactus-yucca (*Yucca glauca*) rangeland, riparian trees, riparian shrubs, upland shrubs and trees, upland shrubs and riparian trees, riparian shrubs and upland trees, and riparian shrubs and trees. Distance of the nest to the nearest road was determined with the use of ArcGIS (ESRI 2001) software and digitized road maps of the study areas.

Statistical Analyses

tested differences among study and factors (i.e successful vs. depredated, adult juvenile early late, and first renests affecting nesting success with ANOVA (Zar 999 Because sample sizes were small in 2000, year was used as blocking variable. Normality assumptions tested with Shapiro-Wilk tests and homogeneity of variance was tested with Levene tests (Sokal and Rohlf 1999). When interaction occurred and differences were found between factors, factors were pooled for analyses among study When interactions occurred between study area and factors, factors were pooled within study areas (if differences occurred within study area) and 1-way ANOVA was performed to test for differences among study areas. All abandoned nests, both human-induced and natural, were removed from the analyses when successful versus depredated factors analyzed. Least square means multiple comparisons (Tukey adjusted) were used to test for differences among study areas when the overall ANOVA was significant. Nest success among study areas, along with vegetation types at CNG between successful and depredated nests analyzed with G statistics (Schmutz 989 Zar 1999). When the overall G statistic significant, further G statistics were performed by removing 1 variable at time to determine which variable was significant (Zar 1999). All analyses performed using SAS software (SAS Institute 1999 A significance level of P 0.05 was used for all analyses.

Results

captured 324 Rio Grande turkey females during January and February of 2000 and 2001 (Table 2. From those females, 86 nest fates were known, 159 were first nest attempts and 27 were renest attempts collected vegetation measurements from 168 of those nests, 14: first nest attempts and 27 renest attempts (Tables 2.2, 2.3).

Nest Plots versus Adjacent Plots

Turkeys used nest plots with greater shrub cover (P .001), greater visual obstruction (P 0.0001), and less bare ground cover (P 0.0001 than their adjacent sites at all study (Table 2.6). CNG nests had more overstory canopy cover (P 0001 less shrub cover (P 0.0), and less understory woody vegetation at the 0.5 1.0 m height class than any other study area (P .05). MWMA had higher woody understory cover at the 2.1 .0 and .0 height class than any other study area (P 0.0001). Salt Fork had less grass cover (P 0.0001 greater shrub cover (P 0.0001), greater understory woody vegetation at 0.5 1.0m height class (P 0.0001 and total understory woody vegetation (P 0.01) than any other study area.

Successful versus Depredated Nests

Nest not different among study areas (Table 2.15). Nest depredation not related to distance nests were from roads (P .49) (Table 2.7). Among the study areas, there were no differences between successful and depredated nests among all variables measured at the nest. There were differences among vegetation type at

GHWMA, MWMA and Salt Fork between successful and depredated nests. Grassland vegetation type at CNG had a higher number of depredated nests than riparian or sand sagebrush vegetation type at that site (Tables 2.4, 2.5). I compared visual obstruction among vegetation types at CNG since Rio Grande turkeys nesting in grassland areas at CNG were less successful than Rio Grande turkeys nesting in other vegetation types at that study area. Grassland areas had greater nest bowl visual obstruction and plot visual obstruction than was recorded in riparian areas at CNG ($P < 0.01$) (Table 2.8). Grassland areas had similar visual obstruction around the nest bowl and nest plot as upland sand sagebrush areas ($P > 0.05$) while upland sand sagebrush had similar visual obstruction around the nest bowl and nest plot than riparian areas ($P > 0.05$). Nest bowl visual obstruction was not different between successful and depredated nests, however, nest plot visual obstruction was greater at successful nests than depredated nests ($P < 0.001$)

There were differences between successful and depredated nest plots when analyzed with their adjacent plots. Successful nests were analyzed with successful adjacent plots and depredated plots were analyzed with depredated adjacent plots. In the case of depredated nests and depredated adjacent plots, most of the difference was contributed by increased shrub cover, increased visual obstruction and reduced bare ground at all study areas, along with increased overstory canopy cover at CNG than depredated adjacent plots ($P < 0.05$) (Table 2.9). In the case of successful nests and successful adjacent plots, most of the difference was contributed by increased visual obstruction and reduced bare ground cover than successful adjacent plots ($P < 0.05$).

Successful adjacent plots and depredated adjacent plots were analyzed for indication of larger landscape level habitat differences. The only difference between successful adjacent plots and depredated adjacent plots litter cover with successful adjacent than depredated adjacent plots, meaning successful adjacent nests may be located in areas with greater tree cover (P 0.02) (Table 2.9

Adult versus Juvenile Nests and Early Late Nests

Adult females chose nest plots with less bare ground than nest plots chosen by juvenile hens (P 0.02) (Table 2.10). Other habitat variables did not differ (P 0.05) between adult and ju female turkeys. The only distinguishing habitat characteristic between early and late nests was late nests had forb cover than early nests (P .02) (Table 2.11

First versus Renests

Female turkeys at all study areas renested in areas with greater woody understory density at the 2.1–4.0 height class than first nests (P 0.01) (Table 2.12 Turkeys at individual study areas selected for additional variables. Females at Salt Fork nested in areas with greater visual obstruction with renesting attempts than with first nests (P 0.04) and MWMA females nested in areas with greater visual obstruction with first nesting attempts than with renesting attempts (P 0.02) (Table 2.13). MWMA also renested in vegetation with greater woody understory cover at the 4.1–6.0 m height class ($P < 0.01$).

Discussion

Structural composition of nests among Rio Grande wild turkeys appear to remain similar throughout their geographic range. Turkey nest sites are reported to be characterized by high visual obstruction around and above the nest and to occur in dense herbaceous or woody vegetation (Williams et al. 1968, Lazarus and Porter 1985, Wertz and Flake 1988, Schmutz et al. 1989, Badyaev 1995). Structural composition of nest plots among our study areas was similar to what has been previously reported. Structural characteristics common among all study areas included greater visual obstruction around the nest bowl and throughout the nest plot than the surrounding vegetation (adjacent plot). Shrub cover was also greater throughout the nest plot than the surrounding vegetation and less bare ground cover was observed throughout the nest plot than the surrounding vegetation at all study areas. Although high visual obstruction was a key component in the structural composition of turkey nests, other factors were involved in determining nest success of Rio Grande wild turkey females. Visual obstruction and understory density was greater at nest plots than adjacent plots, however nest plots with greater visual obstruction and understory density were not more successful than nest plots with less visual obstruction and understory density. Visual obstruction and shrub cover was consistently lower at CNG than the other study areas, although nest success was similar at this study area to the others. I also found that visual obstruction at CNG varied depending on the vegetation type the nests were located in. Grassland areas at CNG had greater visual obstruction throughout the nest plot and around the nest bowl than nests in the riparian habitat, while upland sagebrush areas had similar visual obstruction to both grassland and riparian areas. Although visual obstruction was higher in the grassland habitat than riparian areas, nest success was lower in this vegetation type with only 11% (1 of 9) nest success. Nest success was high in the upland sand sagebrush habitat with 75% (3 of 4) successful while nests in the riparian areas were 43% (11 of 24) successful. I did not find nest success differences among other vegetation types at the other 3 study areas. Although sample sizes were small, this data suggests that at CNG, nest sites in areas with too much visual obstruction may be a factor in nest depredation. Miller et al. (1996) reported that areas providing too much cover were not commonly used by nesting female turkeys, possibly due to a reduced ability to detect predators. Turkeys at CNG did not avoid grassland areas, but they may not be adequate vegetation for nest sites. Other factors which I did not measure such as predator abundance in grassland areas, may be contributing to the low nesting success rate in this vegetation type. It has also been suggested that turkey movements in grassland areas may be more easily detected by predators, although low nest success did not occur among the other study areas in this vegetation type (Logan 1973, Speake et al. 1975, Day et al. 1991). We also found that females at CNG study area nested in areas with greater canopy cover than the other study areas. Sand sagebrush grassland areas consisted of 13 nests, whereas riparian areas consisted of 24 nests. Turkeys appeared to prefer nesting in riparian areas over sand sagebrush grassland habitat. This means turkeys preferred to nest in riparian areas over sand sagebrush grassland habitat. This is because sand sagebrush grassland habitat was the most abundant habitat in this study area (J. Brunjes, unpublished data, Texas Tech University, Lubbock). This may indicate that the riparian habitat at this study area may be more adequate nesting habitat and the upland sand sagebrush grassland habitat may be contributing to the population decline in this area.

I did not find structural characteristic differences between successful and depredated nests among the study areas. Successful nests were analyzed with their adjacent plots, along with depredated nests with their adjacent plots to examine larger spatial scale differences. Plots adjacent to successful and depredated nests did not appear to have structural characteristic trends that could distinguish between successful and depredated nests. Patterns at larger spatial scales than what was measured in this study, predator abundance, or other factors not measured may determine an ultimately successful or depredated nest.

A great deal of variability appears to occur among juvenile and adult turkey nest habitat. One study of wild turkeys has reported several vegetation differences between adult and juvenile nests (Badyaev 1995), whereas another study of wild turkeys has reported no differences in habitat variables between adult and juvenile nests (Schmutz 1989). Juvenile wild turkeys are less experienced than adults, therefore, it has been suggested that juvenile females will be less selective and nest in areas with less variability and complexity than adults (Badyaev 1995). The difference found between adult and juvenile nest plots in this study was that juvenile nest plots had more bare ground than adult nest plots; in addition, GHWMA adult turkeys also chose nest plots with greater shrub cover than juvenile nests. This suggests that juveniles, especially at GHWMA may choose slightly less suitable nesting habitat than adults.

Turkeys that nested later in the nesting season chose nest plots with greater forb cover than turkeys that nested earlier (27% vs. 17%). This was mainly confounded by vegetation changes during the nesting season. Woodland sites usually provide denser visual obstruction early in the spring (Porter 1992), but as visual obstruction increased with the growth of herbaceous vegetation during nesting, females nesting later or attempting second or third nests select more open field sites (Day et al. 1991, Porter 1992). Schmutz (1989) found that nesting females used western snowberry (*Symphoricarpos occidentalis*) heavily early in the nesting season when snowberry provided much greater cover than that provided by herbaceous vegetation, but shifted to forbs and grasses as the cover value of these approached that of snowberry.

Management Implications

Rio Grande wild turkeys in general select nesting habitats that provide high visual obstruction surrounding the nest plot and dense understory vegetation. Rio Grande wild turkey females nested in structural composition dependent on the study area. Salt Fork study area nests were located in areas with greater shrub cover than the other study areas. This was due to shinnery oak, sand sagebrush and honey mesquite vegetation being the dominant vegetation at that study area. MWMA study area nests were located in understory cover 2.1–6.0 m in height. This study area consisted largely of honey mesquite vegetation, therefore more nests consisted of dense understory vegetation at this height class than the other study areas. GHWMA study area did not have 1 characteristic that was different from the other study areas, although shrub, forb and grassland percentages were relatively high. This was largely due to the dominant vegetation being sand sagebrush and grassland vegetation in the upland areas of this study area. W found females at CNG nested in areas with greater canopy cover than the other study This means the majority of nests were located in riparian areas at this study Thirty five percent of females nested in upland sand sagebrush and grassland areas and 65% of females nested in riparian areas, although sand sagebrush grassland habitat composed large portion of this study area. This may indicate that habitat could be limiting turkey populations at this study Upland areas at this study area may not be suitable habitat for nests. W did find that CNG nest success was similar to the other study areas, although when vegetation type was separated out at CNG, we found nest success was low in grassland getation. Because upland sand sagebrush grassland covers the largest in this study area, it is important to create more adequate nesting habitat by providing high visual obstruction and dense understory vegetation in this habitat.

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Table 2.1. Rio Grande wild turkey juvenile and adult females captured and fitted with radio transmitters at 1 study area in southwest Kansas and 3 study areas in the Panhandle of Texas in January and February of 2000 and 2001.

	Kansas		Texas						
	CNG[a]		GHWMA		Salt Fork		MWMA		Total
Year	Adult	Juv.	Adult	Juv.	Adult	Juv.	Adult	Juv.	
2000	43	13	39	22	42	14	36	22	
2001	20	7	17	12	6	10	10	11	93
Total	63	20	56	34	48	24	46	33	

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

Table 2.2. Rio Grande wild turkey juvenile and adult female nesting data at 1 study area in southwest Kansas and 3 study areas in the Panhandle of Texas in 2000. Data below includes number of adult and juvenile females alive at the start of the nesting season (10 April), number of known nest fates for first and renesting attempts, number of nests where habitat variables were measured, and average nest initiation dates for each age class.

	Kansas		Texas					
	CNG[a]		GHWMA		Salt Fork		MWMA	
Variables	Adult	Juv.	Adult	Juv.	Adult	Juv.	Adult	Juv.
Alive at the start of nesting	32	11	26	14	33	12	24	16
Known nest fates								
-First nests	12	3	13	6	2	4	16	
-Renests	1	0	4	0	3	0	3	0
Habitat measurement								
-First nests	8	2	11	6	1	4	15	4
-Renests	1	0	4	0	3	0	3	0
Nest initiation	26-Apr	03-May	17-May	21-May	28-Apr	14-Apr	05-May	06-May

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

Table 2.3. Rio Grande wild turkey juvenile and adult female nesting data at 1 study area in southwest Kansas and 3 study areas in the Panhandle of Texas in 2001. Data below includes number of adult and juvenile females alive at the start of the nesting season (6 April), number of known nest fates for first and renesting attempts, number of nests where habitat variables were measured, and average nest initiation dates for each age class.

	Kansas		Texas					
	CNG[a]		GHWMA		Salt Fork		MWMA	
Variables	Adult	Juv.	Adult	Juv.	Adult	Juv.	Adult	Juv.
Alive at the start of nesting	34	5	34	9	26	8	33	9
Known nest fates								
-First nests	24	3	28	3	16	4	18	3
-Renests	5	0	3	0	5	0	3	0
Habitat measurements								
-First nests	23	2	27	3	12	4	17	2
-Renests	5	0	3	0	5	0	3	0
Nest initiation	25-Apr	28-Apr	04-May	23-May	25-Apr	06-May	05-May	19-Apr

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

Table 2.4. Nesting habitat vegetation types of Rio Grande wild turkey successful and depredated nests at the Cimmaron National Grassland study area in southwest Kansas in 2000 and 2001. G = 6.08, P = 0.04.

	Grassland	Sand sagebrush	Riparian trees
Depredated	8	1	13
Successful	1	3	11

Table 2.5. Nesting habitat vegetation types without grassland vegetation of Rio Grande wild turkey successful and depredated nests at the Cimmaron National Grassland study area in southwest Kansas in 2000 and 2001. G = 1.21, P = 0.27.

	Sand sagebrush	Riparian trees
Depredated	1	13
Successful	3	11

Table 2.6. Study area differences and nest and adjacent plot differences of habitat parameters measured at Rio Grande turkey nest and paired adjacent plots at all 4 study areas in Texas and Kansas during 2000 and 2001.

	Study area												Plot					
	GHWMA[a] (n = 104)			CNG (n = 82)			MWMA (n = 88)			Salt Fork (n = 58)			Nest (n = 166)			Adjacent (n = 166)		
Variable	$\bar{X}$	SE	$P<0.05$[b]	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	$P<0.05$[a]	$\bar{X}$	SE	
Canopy, %	12.0	0.4	B	47.8	0.6	A	19.3	0.3	B	13.4	0.4	B	23.9	0.3	A	22.4	0.3	A
Tree no.	0.8	0.3	A	2.3	0.4	BC	3.1	0.5	C	1.2	0.5	AB	2.1	0.3	A	1.7	0.3	A
Grass, %	46.6	0.3	A	55.0	0.3	B	52.9	0.2	B	28.0	0.3	C	46.8	0.2	A	47.5	0.2	A
Shrub, %	14.7	0.2	A	6.1	0.1	B	13.4	0.2	A	29.7	0.3	C	18.3	0.2	A	11.3	0.1	B
Bare, %	6.0	0.1	A	9.8	0.1	A	6.7	0.1	A	6.1	0.1	A	4.0	0.0	A	10.2	0.1	B
Forb, %	24.8	0.2	A	17.9	0.2	A	21.8	0.2	A	19.8	0.2	A	21.8	0.2	A	21.1	0.1	A
Litter, %	7.5	0.1	A	10.9	0.1	B	4.4	0.1	A	16.3	0.2	C	8.5	0.1	A	9.4	0.1	A
Understory cover, no.																		
0.5-1, m	11.5	1.6	AB	3.8	0.9	A	14.6	1.9	B	41.5	6.8	C	18.3	2.5	A	13.1	1.9	A

Table 2.6 cont.

	Study area												Plot					
	GHWMA (n = 104)			CNG (n = 82)			MWMA (n = 88)			Salt Fork (n = 58)			Nest (n = 166)			Adjacent (n = 166)		
Variable	$\bar{X}$	SE	P<0.05	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
1.1-2, m	4.7	1.1	A	1.7	0.9	A	7.1	0.8	A	14.4	7.2	A	7.0	0.9	A	5.5	2.5	A
2.1-4, m	0.4	0.1	A	0.7	0.2	A	2.3	0.4	B	0.3	0.1	A	1.1	0.2	A	0.8	0.1	A
4.1-6, m	0.2	0.1	A	0.3	0.1	A	1.4	0.3	B	0.1	0.0	A	0.5	0.1	A	0.5	0.1	A
Total	16.7	2.3	AB	6.4	1.5	A	25.1	2.6	B	55.6	10.1	C	26.5	2.9	A	19.8	3.4	A
Nest visual obstruction																		
Lowest dm	4.7	0.3	A	3.3	0.2	A	4.5	0.3	A	4.6	0.4	A	5.4	0.2	A	2.5	0.1	B
Total dm	6.2	0.3	A	7.6	0.2	A	6.3	0.3	A	6.1	0.4	A	5.4	0.2	A	8.4	0.1	B

Table 2.6 cont.

	Study area												Plot					
	GHWMA (n = 104)			CNG (n = 82)			MWMA (n = 88)			Salt Fork (n = 58)			Nest (n = 166)			Adjacent (n = 166)		
Variable	$\bar{X}$	SE	P<0.05	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
Plot visual obstruction																		
Lowest dm	3.6	0.2	A	2.7	0.2	B	3.0	0.1	B	3.8	0.3	A	3.9	0.1	A	2.6	0.1	B
Total dm	7.4	0.2	A	8.3	0.2	B	7.9	0.1	B	7.1	0.3	A	7.1	0.1	A	8.4	0.1	B

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

[b] Nest and adjacent means within a variable followed by unlike letters are different by a 3-way ANOVA; least-square means multiple comparison method (Tukey adjusted) was used to test for differences among sites when overall ANOVA was significant.

Table 2.7. Means and standard errors of habitat parameters measured at Rio Grande turkey successful and depredated nest plots at all 4 study areas in Texas and Kansas during 2000 and 2001.

	Study area												Fate					
	GHWMA[a] (n = 44)			CNG (n = 37)			MWMA (n = 34)			Salt Fork (n = 27)			Successful (n = 53)			Depredated (n = 89)		
Variable	$\bar{X}$	SE	$P<0.05$[b]	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	$P<0.05$[a]	$\bar{X}$	SE	
Canopy, %	9.3	0.5	A	67.6	0.9	B	13.8	0.3	A	7.4	0.4	A	24.5	0.6	A	25.6	0.5	A
Tree, no.	0.6	0.3	A	3.4	0.6	B	3.0	0.6	B	1.0	0.4	AB	1.8	0.4	A	2.1	0.4	A
Grass, %	44.5	0.4	A	60.9	0.4	B	50.7	0.4	AB	24.8	0.4	C	44.5	0.4	A	47.6	0.3	A
Shrub, %	16.0	0.3	A	6.5	0.2	A	16.1	0.3	A	38.5	0.5	B	18.8	0.2	A	17.4	0.2	A
Bare, %	3.1	0.1	A	4.2	0.1	A	6.0	0.1	A	2.9	0.1	A	5.0	0.8	A	3.5	0.1	A
Forb, %	28.9	0.4	A	17.3	0.3	A	22.1	0.3	A	16.9	0.3	A	21.3	0.3	A	22.4	0.2	A
Litter, %	7.1	0.1	A	11.0	0.2	B	4.1	0.1	AB	17.0	0.3	C	10.4	0.1	A	8.6	0.1	A
Woody understory cover, no.																		
0.5-1m	13.8	2.8	A	4.2	1.5	A	14.4	2.5	A	44.3	12.2	A	14.6	2.6	A	18.8	4.2	A

Table 2.7 cont.

	Study area											Fate				
	GHWMA (n = 44)			CNG (n = 37)			MWMA (n = 34)			Salt Fork (n = 27)			Successful (n = 53)		Depredated (n = 89)		
Variable	$\bar{X}$	SE	P<0.05	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
1.1-2m	5.1	1.7	A	3.2	2.0	A	9.6	1.5	A	10.0	2.7	A	5.9	1.5	A	7.0	1.3	A
2.1-4m	0.3	0.1	A	0.5	0.2	A	2.1	0.5	B	0.7	0.4	A	0.9	0.3	A	0.8	0.2	A
4.1-6m	0.1	0.1	A	0.1	0.1	A	0.5	0.2	A	0.1	0.1	A	0.2	0.1	A	0.2	0.1	A
Total	19.4	3.9	AB	7.9	2.9	B	26.5	3.2	A	53.6	13.0	A	20.8	3.6	A	26.9	4.6	A
Nest visual obstruction																		
Lowest dm	5.7	0.4	A	4.2	0.3	B	5.3	0.4	AB	6.1	0.4	A	5.3	0.3	A	5.3	0.4	A
Total dm	5.2	0.4	A	6.6	0.3	B	5.5	0.4	AB	4.4	0.4	A	5.5	0.3	A	5.5	0.3	A
Plot visual obstruction																		
Lowest dm	4.1	0.3	A	3.2	0.3	A	3.5	0.2	A	4.7	0.4	A	4.0	0.3	A	3.7	0.2	A
Total dm	6.8	0.3	A	7.8	0.3	A	7.3	0.3	A	6.1	0.4	A	6.9	0.3	A	7.1	0.2	A

Table 2.7 cont.

	Study area											Fate				
	GHWMA (n = 44)			CNG (n = 37)			MWMA (n = 34)			Salt Fork (n = 27)			Successful (n = 53)		Depredated (n = 89)	
Variable	$\bar{X}$	SE	$P<0.05$	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	$P<0.05$[a]	$\bar{X}$	SE	
Dist. to road, m	(n = 33)			(n = 35)			(n = 31)			(n = 25)			(n = 47)			(n = 77)		
	156.0	30.1	B	287.2	35.2	A	225.2	35.0	AB	136.0	22.2	B	221.3	31.4	A	197.1	19.2	A

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

[b] Successful and depredated means within a variable followed by unlike letters are different by a 3-way ANOVA; least-square means multiple comparison method was used to test for differences among sites when overall ANOVA was significant.

Table 2.8. Means and standard errors of successful and depredated nests of Rio Grande turkey females at each habitat vegetation type at the Cimmaron National Grassland study area in southwest Kansas in 2000 and 2001.

	Habitat vegetation type									Fate					
	Grassland (n = 9)			Upland Sand Sagebrush (n = 4)			Riparian (n = 23)			Successful (n = 14)			Depredated (n = 22)		
	$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
Nest visual obstruction															
Lowest dm	6.3	0.8	A	4.6	1.3	AB	3.5	0.2	B	4.4	1.9	A	3.9	1.9	A
Total dm	4.6	0.8	A	6.1	1.3	A	7.3	0.3	A	6.4	1.9	A	6.9	1.9	A
Plot visual obstruction															
Lowest dm	5.3	0.7	A	3.7	1.0	AB	2.5	0.2	B	5.0	1.9	A	2.7	1.5	B
Total dm	5.5	0.8	A	7.2	0.9	AB	8.5	0.2	B	5.9	1.9	A	8.2	1.5	B
Distance to roads, m															
	249.9	63.6	A	117.4	44.3	A	343.2	45.6	A						

[a] Successful and depredated means within a variable followed by unlike letters are different by a 2-way ANOVA; least square means multiple comparison method (Tukey adjusted) was used to test for differences among vegetation types when overall ANOVA was significant.

Table 2.9. Means and standard errors of habitat parameters measured at Rio Grande turkey successful nest plots and paired successful adjacent plots, depredated nest plots and paired depredated adjacent plots, and successful adjacent and depredated adjacent plots at all 4 study areas in Texas and Kansas during 2000 and 2001.

	Successful (n = 52)			Adjacent (n = 53)			Depredated (n = 90)			Adjacent (n = 90)			Successful adjacent (n = 52)			Depredated adjacent (n = 88)		
Variable	$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
Canopy, %	24.5	0.6	A	23.5	0.6	A	25.6	0.5	A	20.2	0.4	A	17.7	0.5	A	23.6	0.5	A
Tree, no.	1.8	0.4	A	1.1	0.5	A	2.1	0.4	A	1.5	0.4	A	1.1	0.5	A	1.5	0.4	A
Grass, %	44.5	0.4	A	46.9	0.4	A	47.5	0.3	A	47.5	0.3	A	46.9	0.4	A	47.5	0.3	A
Shrub, %	18.8	0.3	A	12.4	0.2	A	17.4	0.2	A	10.9	0.1	B	12.3	0.2	A	10.9	0.1	A
Bare, %	5.0	0.1	A	9.6	0.2	B	3.5	0.1	A	10.5	0.2	B	9.6	0.2	A	10.5	0.2	A
Forb, %	21.3	0.3	A	21.2	0.3	A	22.4	0.2	A	21.3	0.2	A	21.2	0.3	A	21.3	0.2	A
Litter, %	10.4	0.1	A	9.7	0.2	A	8.6	0.1	A	9.3	0.1	A	9.7	0.2	A	9.3	0.1	B
Understory cover, no.																		
0.5-1m	14.6	2.6	A	11.4	3.1	A	18.8	4.2	A	14.6	2.7	A	11.4	3.1	A	14.6	2.7	A
1.1-2m	5.9	1.5	A	1.7	0.4	B	7.0	1.3	A	8.4	4.7	A	1.7	0.4	A	8.4	4.7	A

Table 2.9 cont.

Variable	Successful (n = 52)			Adjacent (n = 53)			Depredated (n = 90)			Adjacent (n = 90)			Successful adjacent (n = 52)			Depredated adjacent (n = 88)		
	$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
2.1-4m	0.9	0.3	A	0.9	0.3	A	0.8	0.2	A	0.6	0.2	A	0.9	0.3	A	0.6	0.2	A
4.1-6m	0.2	0.1	A	0.4	0.2	A	0.2	0.1	A	0.4	0.2	A	0.4	0.2	A	0.4	0.2	A
Total	20.8	3.6	A	14.4	3.3	A	26.9	4.6	A	24.0	5.8	A	14.4	3.3	A	24.0	5.8	A
Nest visual obstruction																		
Lowest dm	5.3	0.3	A	2.3	0.2	B	5.3	0.3	A	2.7	0.2	B	2.3	0.2	A	2.7	0.2	A
Total dm	5.5	0.3	A	8.6	0.2	B	5.5	0.3	A	8.3	0.2	B	8.6	0.2	A	8.3	0.2	A
Plot visual obstruction																		
Lowest dm	4.0	0.3	A	2.6	0.1	B	3.7	0.2	A	2.5	0.1	B	2.6	0.1	A	2.5	0.1	A
Total dm	6.9	0.3	A	8.3	0.1	B	7.1	0.2	A	8.4	0.1	B	8.3	0.1	A	8.4	0.1	A

[a] Successful, depredated and adjacent plot means within a variable followed by unlike letters are different by a 3-way ANOVA least square means multiple comparison method (Tukey adjusted) was used to test for differences among sites when overall ANOVA was significant.

Table 2.10. Means and standard errors of habitat parameters measured at Rio Grande turkey adult and juvenile nests at all 4 study areas in Texas and Kansas during 2000 and 2001.

	Study area												Age					
	GHWMA[a] (n = 52)			CNG (n = 41)			MWMA (n = 44)			Salt Fork (n = 29)			Adult (n = 140)			Juvenile (n = 26)		
Variable	$\bar{X}$	SE	P<0.05[b]	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
Canopy, %	11.3	0.5	A	61.0	0.9	B	16.6	0.3	A	6.9	0.4	AB	14.9	0.4	A	20.4	0.7	A
Tree, no.	0.6	0.3	A	3.1	0.6	B	3.6	0.6	B	1.0	0.4	AB	2.0	0.3	A	2.3	0.8	A
Grass, %	43.5	0.4	A	59.8	0.4	A	52.3	0.3	A	25.4	0.4	B	47.4	0.2	A	42.9	0.6	A
Shrub, %	18.5	0.3	A	7.7	0.2	A	15.6	0.2	A	38.4	0.5	B	18.6	0.2	A	18.1	0.4	A
Bare, %	2.8	0.1	A	4.6	0.1	A	5.2	0.1	A	3.1	0.1	A	3.6	0.0	A	5.6	0.1	B
Forb, %	27.5	0.3	A	17.0	0.3	A	21.8	0.3	A	16.6	0.3	A	21.6	0.2	A	20.9	0.4	A
Litter, %	7.1	0.1	A	10.6	0.2	AB	3.9	0.1	A	16.6	0.2	B	8.2	0.1	A	12.0	0.3	A
Understory cover, no.																		
0.5-1m	14.9	2.6	AB	5.0	1.5	A	17.0	2.6	B	45.3	11.4	C	18.5	2.9	A	17.2	3.9	A

Table 2.10 cont.

	Study Area											Age				
	GHWMA (n = 52)			CNG (n = 41)			MWMA (n = 44)			Salt Fork (n = 29)			Adult (n = 140)			Juvenile (n = 26)		
Variable	$\bar{X}$	SE	P<0.05	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
1.1-2m	6.5	1.9	A	3.0	1.8	A	9.8	1.3	A	10.3	2.6	A	7.5	1.1	A	5.2	1.3	A
2.1-4m	0.5	0.3	A	0.5	0.2	A	3.1	0.6	B	0.7	0.4	A	1.2	0.2	A	1.1	0.5	A
4.1-6m	0.1	0.1	A	0.1	0.1	A	1.5	0.4	A	0.1	0.1	A	0.5	0.1	A	0.5	0.3	A
Total	22.0	3.9	A	8.4	2.7	A	31.0	3.4	B	54.9	12.1	B	27.7	3.3	A	22.1	4.9	A
Nest visual obstruction																		
Lowest dm	5.6	1.1	A	3.9	1.1	A	5.0	1.1	A	5.0	1.1	A	6.0	1.0	A	3.3	1.0	A
Total dm	5.0	0.3	A	6.5	0.3	A	5.6	0.3	A	4.3	0.4	A	5.5	0.2	A	4.9	0.4	A

Table 2.10 cont.

	Study area												Age					
	GHWMA (n = 52)			CNG (n = 41)			MWMA (n = 44)			Salt Fork (n = 29)			Adult (n = 140)			Juvenile (n = 26)		
Variable	$\bar{X}$	SE	P<0.05	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
Plot visual obstruction																		
Lowest dm	4.3	0.3	A	3.2	0.3	A	3.4	0.2	A	4.7	0.4	A	3.9	0.2	A	3.7	0.4	A
Total dm	6.6	0.3	A	7.8	0.3	A	7.4	0.2	A	6.1	0.4	A	7.0	0.2	A	7.2	0.4	A

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

[b] Adult and juvenile means within a variable followed by unlike letters are different by a 3-way ANOVA; least-square means multiple comparison method (Tukey adjusted) was used to test for differences among sites when overall ANOVA was significant.

Table 2.11. Means and standard errors of habitat parameters measured at Rio Grande turkey early and late nests at all 4 study areas in Texas and Kansas during 2000 and 2001.

	Study area												Time					
	GHWMA[a] (n = 52)			CNG (n = 40)			MWMA (n = 44)			Salt Fork (n = 26)			Early (n = 88)			Late (n = 74)		
Variable	$\bar{X}$	SE	P<0.05[b]	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
Canopy, %	11.3	0.5	A	60.3	0.9	B	16.6	0.3	A	3.5	0.2	A	27.0	0.5	A	19.5	0.5	A
Tree, no.	0.6	0.3	A	2.9	0.5	B	3.6	0.6	B	0.5	0.2	A	2.4	0.4	A	1.4	0.3	A
Grass, %	43.5	0.4	A	59.7	0.4	B	52.3	0.3	AB	26.0	0.4	A	49.2	0.3	A	44.3	0.3	A
Shrub, %	18.5	0.3	A	7.9	0.2	B	15.6	0.2	AB	38.1	0.5	C	19.7	0.2	A	6.8	0.2	A
Bare, %	2.8	0.1	A	4.8	0.1	A	5.2	0.1	A	3.1	0.1	A	3.8	0.1	A	4.1	0.1	A
Forb, %	27.5	0.3	A	16.6	0.3	A	21.8	0.3	A	16.9	0.3	A	17.2	0.2	A	26.8	0.3	B
Litter, %	7.1	0.1	AB	10.7	0.2	AC	3.9	0.1	B	16.1	0.2	C	9.5	0.1	A	7.5	0.1	A
Understory cover, no.																		
0.5-1m	14.9	2.6	A	5.1	1.6	A	17.0	2.6	A	49.6	12.4	B	16.9	2.2	A	20.7	4.9	A

Table 2.11 cont.

	Study Area												Time					
	GHWMA (n = 52)			CNG (n = 40)			MWMA (n = 44)			Salt Fork (n = 26)			Early (n = 88)			Late (n = 74)		
Variable	$\bar{X}$	SE	P<0.05	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
1.1-2m	7.4	2.0	A	3.0	1.8	A	9.9	1.2	A	10.7	2.8	A	8.4	1.4	A	6.5	1.3	A
2.1-4m	0.5	0.3	A	0.5	0.2	A	3.1	0.6	B	0.3	0.2	A	1.0	0.2	A	1.4	0.4	A
4.1-6m	0.1	0.1	A	0.1	0.1	A	1.5	0.4	B	0.1	0.1	A	0.3	0.1	A	0.7	0.3	A
Total	22.9	4.0	AB	8.6	2.7	A	31.1	3.4	BC	59.2	13.3	C	26.0	3.2	A	29.1	5.3	A
Nest visual obstruction																		
Lowest dm	5.9	0.3	A	4.3	0.3	B	5.2	0.3	AB	6.3	0.4	A	5.3	0.2	A	5.5	0.3	A
Total dm	5.0	0.3	A	6.5	0.3	B	5.6	0.3	AB	4.3	0.4	A	5.5	0.2	A	5.2	0.3	A

Table 2.11 cont.

Variable	Study area												Time					
	GHWMA (n = 52)			CNG (n = 40)			MWMA (n = 44)			Salt Fork (n = 26)			Early (n = 88)			Late (n = 74)		
	$\bar{X}$	SE	P<0.05	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
Plot visual obstruction																		
Lowest dm	4.4	0.3	A	3.2	0.3	B	3.4	0.2	B	4.7	0.4	AB	3.8	0.2	A	4.0	0.2	A
Total dm	6.6	0.3	A	7.7	0.3	B	7.4	0.2	B	6.0	0.4	AB	7.1	0.2	A	6.9	0.2	A

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

[b] Early and late means within a variable followed by unlike letters are different by a 3-way ANOVA; least-square means multiple comparison method (Tukey adjusted) was used to test for differences among sites when overall ANOVA was significant.

Table 2.12. Means and standard errors of habitat parameters measured at Rio Grande turkey first and renesting nest plots at all 4 study areas in Texas and Kansas during 2000 and 2001.

	Study area												Attempt					
	GHWMA[a] (n = 52)			CNG (n = 40)			MWMA (n = 44)			Salt Fork (n = 26)			First (n = 137)			Renests (n = 25)		
Variable	$\bar{X}$	SE	P<0.05[b]	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
Canopy, %	11.3	0.5	A	60.2	0.9	B	16.6	0.3	A	3.5	0.2	A	25.0	0.4	A	15.6	0.8	A
Tree, no.	0.6	0.3	A	2.9	0.5	A	3.6	0.6	A	0.5	0.2	A	2.1	0.3	A	1.2	0.5	A
Grass, %	43.5	0.4	AC	59.7	0.4	B	52.3	0.3	AB	26.0	0.4	C	47.7	0.2	A	42.8	0.5	A
Shrub, %	18.5	0.3	AB	7.9	0.2	A	15.6	0.2	A	38.1	0.5	B	18.5	0.2	A	17.7	0.4	A
Bare, %	2.8	0.1	A	4.8	0.1	A	5.2	0.1	A	3.1	0.1	A	4.1	0.0	A	3.1	0.1	A
Forb, %	27.5	0.3	A	16.6	0.3	A	21.8	0.3	A	16.9	0.3	A	20.4	0.2	A	27.6	0.4	A
Understory cover, no.																		
0.5-1m	16.1	2.8	A	5.1	1.6	B	17.0	2.6	AB	49.6	12.4	C	17.3	1.8	A	28.3	13.3	A

Table 2.12 cont.

	Study Area										Attempt				
	GHWMA (n = 52)			CNG (n = 40)			MWMA (n = 44)			Salt Fork (n = 26)			First (n = 137)			Renests (n = 25)
Variable	$\bar{X}$	SE	P<0.05	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
1.1-2m	6.5	1.9	A	3.0	1.8	A	9.8	1.3	A	10.8	2.9	A	7.1	1.1	A	7.7	2.3	A
2.1-4m	0.5	0.3	A	0.5	0.2	A	3.1	0.6	B	0.4	0.2	A	1.0	0.2	A	2.1	0.9	B
Total	23.3	4.0	A	8.6	2.7	B	31.0	3.4	A	59.7	13.8	C	25.2	2.5	A	39.3	13.7	A
Nest visual obstruction																		
Lowest dm	5.9	0.3	AC	4.3	0.3	B	5.2	0.3	AB	6.3	0.4	C	5.3	0.2	A	5.7	0.6	A
Total dm	5.0	0.3	AC	6.5	0.3	B	5.6	0.3	AB	5.6	0.3	C	5.4	0.2	A	5.1	0.6	A

Table 2.12 cont.

	Study area												Attempt					
	GHWMA (n = 52)			CNG (n = 40)			MWMA (n = 44)			Salt Fork (n = 26)			First (n = 137)			Renests (n = 25)		
Variable	$\bar{X}$	SE	P<0.05	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	
Plot visual obstruction																		
Lowest dm	4.4	0.3	AC	3.2	0.3	AB	3.4	0.2	B	4.7	0.4	C	3.8	0.2	A	4.3	0.4	A
Total dm	6.6	0.3	AC	7.7	0.3	AB	7.4	0.2	B	6.0	0.4	C	7.1	0.2	A	6.6	0.4	A

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

[b] First and renest means within a variable followed by unlike letters are different by a 3-way ANOVA; least-square means multiple comparison method (Tukey adjusted) was used to test for differences among sites when overall ANOVA was significant.

Table 2.13. Means and standard errors of interactions between study areas and first and renesting attempts at all 4 study areas in southwest Kansas and Texas in 2000 and 2001.

		Attempt					
		First			Renests		
Variables	Site	$\bar{X}$	SE	P<0.05[b]	$\bar{X}$	SE	
Litter, %	CNG[a]	10.6	0.2	A	11.2	0.7	B
	GHWMA	7.0	0.1	A	7.6	0.2	A
	Salt Fork	17.1	0.3	A	12.6	0.2	B
	MWMA	4.2	0.1	A	2.2	0.0	A
Understory cover, no.							
4.1 – 6.0 m	CNG	0.1	0.1	A	0.0	0.0	A
	GHWMA	0.1	0.1	A	0.0	0.0	A
	Salt Fork	0.0	0.0	A	0.3	0.3	A
	MWMA	1.0	0.3	A	4.3	2.8	B

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

[b] First and renest means within a variable followed by unlike letters are different by a 3-way ANOVA; least square means multiple comparison method (Tukey adjusted) was used to test for differences among sites when overall ANOVA was significant.

Table 2.14. Study area differences of first nest and renest interactions at Rio Grande turkey nest plots in Texas and Kansas during 2000 and 2001. First nests and renest plot measurements were pooled within a study area when no differences occurred.

		Study area										
		CNG[a]			GHWMA			Salt Fork			MWMA		
Attempt	Variable	$\bar{X}$	SE	P<0.05[b]	$\bar{X}$	SE		$\bar{X}$	SE		$\bar{X}$	SE	
First	Litter, %	10.6	0.2	A	7.1	0.1	AB	17.1	0.3	C	3.9	0.1	B
	Understory cover, no.												
	4.1-6.0, m	1.0	0.3	A	0.1	0.1	A	0.1	0.1	A	1.5	0.4	B
Renests	Litter, %	11.2	0.7	A	7.1	0.1	A	12.6	0.2	A	3.9	0.1	B
	Understory cover, no.												
	4.1-6.0, m	1.0	0.3	A	0.1	0.1	A	0.1	0.1	A	4.3	2.8	B

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

[b] Nest means followed by unlike letters within a variable are different by a 1-way ANOVA; least square means multiple comparison method (Tukey adjusted) was used to test for differences among study areas when overall ANOVA was significant.

Table 2.15. Nesting success of Rio Grande wild turkeys at 1 study area in southwest Kansas and 3 study areas in the Panhandle of Texas. Data below indicates nesting success was not different among the study areas. G = 2.99, P = 0.39.

	Kansas	Texas		
	CNG[a]	GHWMA	MWMA	Salt Fork
Successful	20	19	12	11
Unsuccessful	22	32	29	18
Total	42	51	41	29

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

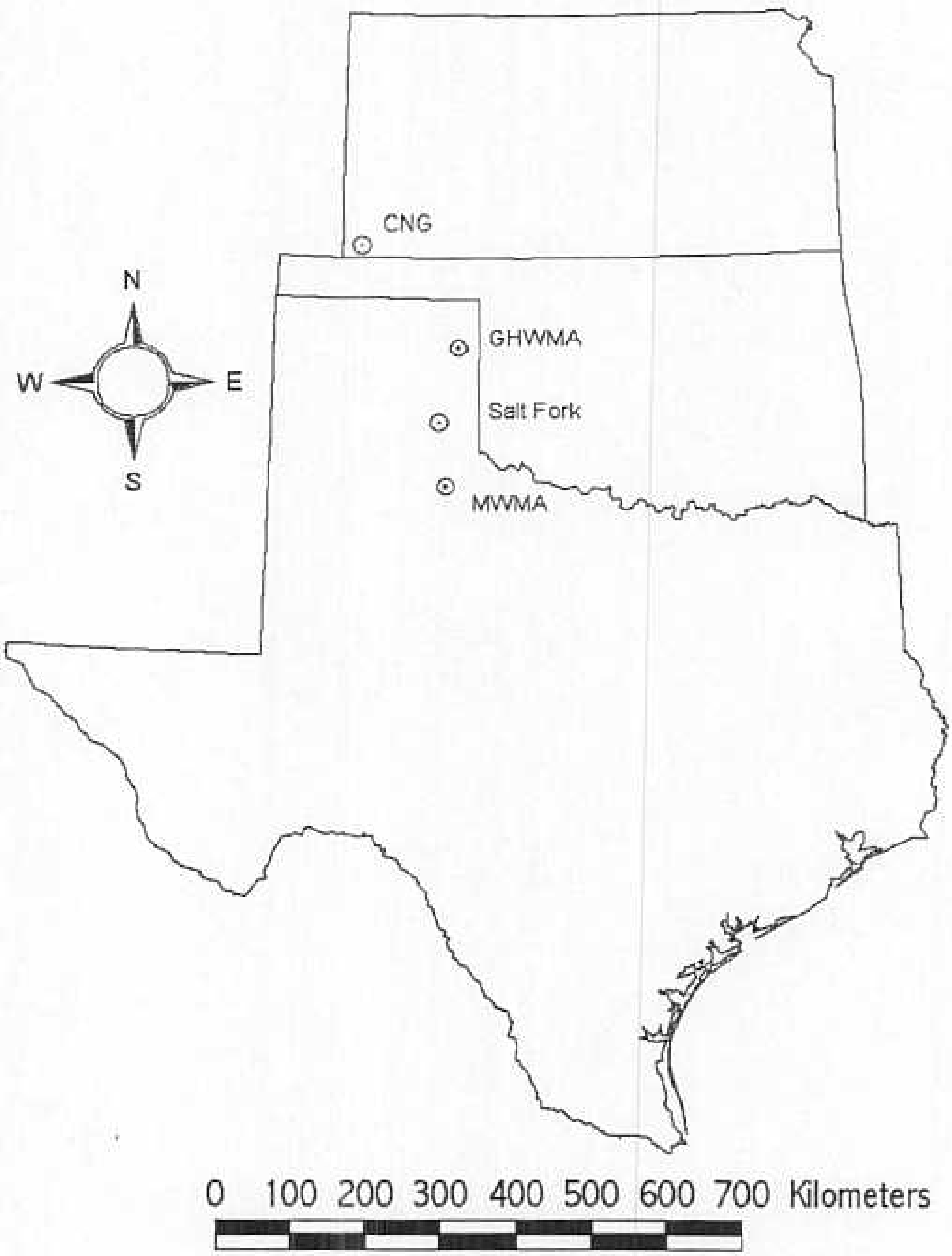

Figure 1.1. Rio Grande Wild Turkey study areas in southwestern Kansas and the Panhandle of Texas [CNG = Cimmaron National Grassland, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.]

CHAPTER III

BREEDING AREA FIDELITY, REPRODUCTIVE PERFORMANCE AND HABITAT SELECTION IN RIO GRANDE WILD TURKEY FEMALES

Abstract

Many species return to breed in the same area in successive years, although it is unknown whether Rio Grande wild turkeys (*Meleagris gallopavo intermedia*) exhibit breeding area fidelity. I examined breeding area fidelity in 43 adult Rio Grande wild turkeys at 4 study areas in Kansas and the Panhandle of Texas during the breeding season of 2000-2002. I examined the hypothesis that females with successful broods would exhibit higher fidelity to their previous breeding area than females that do not produce a successful brood. I found that among all 4 study areas, Rio Grande wild turkeys exhibited overall breeding area fidelity of 74%. Females did not appear to base their return decision on previous year's nesting success. Females that returned to the same area did not exhibit a higher reproductive performance; they were not more successful the following year than females that did not return and their nests did not survive longer before depredation than females that did not return. Spring dispersal distance and home range size was similar between females that returned to the same breeding area and those that relocated to another breeding area. Habitat characteristics were also similar between females that returned and females that did not return to the same area. Because females return to the same area in successive years, it is important to maintain quality nesting habitat in these area to maximize reproductive success.

Introduction

Many species of birds and mammals, both migratory and non-migratory, return to breed in the same area in successive years (Greenwood 1980). Familiarity with local conditions together with traveling costs in terms of energy or time are possible reasons why individuals of many species of birds and mammals return in successive years (Hinde 1956, Baker 1978, Gaines and McClenaghan 1980, Greenwood 1980, Waser and Jones 1983). Foraging and predator avoidance may be more efficient in areas where individuals are familiar with an area and its resources (Greenwood and Harvey 1982). Movement to new areas could result in lower reproductive success and higher mortality than for individuals that remain in the same area.

Juveniles of many species tend to exhibit less site fidelity than adults. Explanations for age-biased fidelity include: (1) older individuals that have remained in the same area for subsequent years have accrued benefits from increased familiarity with an area (Hinde 1956, Greenwood 1980), (2) dominant adults force subordinate juveniles to disperse to other areas (Gauthreaux 1978, Greenwood 1980, Waser and Jones 1983, Waser 1985), and (3) inbreeding avoidance (Howard 1960).

Reproductive success may also play a role in whether a female returns to the same breeding area in successive years. Greenwood and Harvey (1982) hypothesized that females that were successful 1 year would be more likely to return to that same area in successive years than females that were not successful. They also reported a positive correlation between reproductive success and breeding area fidelity. Other studies have also reported individuals switching territories or moving to different areas in subsequent years as a result of low reproductive success (Skeel 1983, Harvey et al. 1984, Shields 1984, Gavin and Bollinger 1988).

Wild turkeys (*Meleagris gallopavo*) in the Arkansas Ozarks exhibited age-biased breeding area fidelity. Females that were >3 years of age exhibited higher fidelity to their previous year's nesting area than females that were 3 years old. Older females (>3 years) returned to their previous breeding area regardless of their previous year's nesting success (Badyaev and Faust 1996). Badyaev (1995) also reported that nest predation strongly affected nest habitat selection; turkeys that attempted to renest within a season, tended to select sites with greater habitat variability and complexity than their first nesting attempt.

In this study, I examined the following hypotheses: (1) female Rio Grande wild turkeys (*M.g. intermedia*) that produced successful broods would have higher breeding area fidelity the following year than females that did not produce successful broods, (2) juvenile females, due to lack of experience (i.e., nesting success and familiarity with resources) would exhibit a lower overall breeding area fidelity than adult females, (3) females that returned to the same area would exhibit smaller home range sizes than females that did not return because of familiarity with the area and resources, and (4) if females that do not produce successful broods nest in different areas the following year, they would select nesting habitat with greater visual concealment from predators the following year.

Study Areas

studied Rio Grande wild turkeys at 4 different sites during 2000-2002. Three of these sites were located in the Panhandle of Texas and one study site in southwestern Kansas.

The Kansas study site was located in the southwestern corner of Kansas and the southeaste corner of Colorado, centered on the Cimmaron National Grassland (CNG) in Morton County and included parts of Stevens County Kansas, and Baca County Colorado The Cimmaron River flows west to east through the center of the study area. Cattle production was the main land practice the grassland, but there limited amounts of dry cropland and irrigated cropland privately owned portions of the study

Dominant vegetation types included western cottonwood (*Populus deltoides*) woodlands in the riparian areas, and sand sagebrush (*Artemisia filifolia* grasslands in the uplands (Cable et al. 996). Sand sagebrush grassland covered the largest area.

The most northerly Texas site was centered the Gene Howe Wildlife Management Area (GHWMA) east of Canadian, T in Hemphill County. The Canadian River flows west to east through the center of the study area. Cattle production was the dominant land use practice There were small amounts of dry cropland and irrigated cropland within the study area. Dominant vegetation types included sand sagebrush, western soapberry (*Sapindus saponaria*), and hackberry *Celtis sp* grassland in the upland areas, and salt cedar (*Tamarix parviflora* russian olive (*Elaeagnus angustifolia* and western cottonwoods in the riparian areas (Hodge 2000 Sand sagebrush grassland covered the largest area.

The Salt Fork study site was centered on private ranches along the Salt Fork of the Red River northeast of Clarendon, Texas in Donley and Collingsworth Counties. The Salt Fork of the Red River flows west to east through the center of the study area. Cattle production was the dominant land use practice. Limited amounts of dry cropland and irrigated cropland was found within the study area. Dominant vegetation types included honey mesquite (*Prosopis glandulosa*), black locust (*Robinia pseudo-acacia*), shinnery oak (*Quercus havardii*), hackberry species, western soapberry and sand sagebrush grassland in the uplands and western cottonwood in the riparian areas. Mesquite grassland covered the largest area.

The southern most study area was centered at the Matador Wildlife Management Area (MWMA) near Paducah, Texas in Cottle County. The Pease River flows west to east through the center of the study area. Cattle production was the dominant land use practice on the study area, limited amounts of dry cropland and irrigated cropland also occurred on the area. Dominant vegetation types included honey mesquite, hackberry, sand sagebrush, and redberry juniper (*Juniperus pinchotii.*) shrubland in the uplands and western cottonwood in riparian areas, with mesquite grassland covering the largest area (Hodge 2000).

Methods

I captured Rio Grande wild turkey hens in January and February during 2000 - 2002 using rocket and drop nets at GHWMA, MWMA and Salt Fork study sites. Turkey hens were captured in January and February of 2000 and 2001 at CNG. classified birds as juveniles 1 year of age and adults year of age based characteristics of IX and X primaries and rectrice length (Petrides 942) Females captured at each study area included 08 at GHWMA (55 adult and 53 juvenile 82 at CNG 62 adult and 20 juvenile 99 at MWMA 66 adult and 33 juvenile and 13 at Salt Fork study site 68 adul and 45 venile fitted each bird ith 10 g backpack style adio transmitter with an 8-hour mortality signal (ATS Isanti, MN) obtained locations of turkeys with the of truck mounted null-peak antenna system (White and Garrott 990). used the triangulation method to obtain locations for determining turkey home ranges. Triangulations were performed for each ocation, alternating among 4 different time periods (i.e., AM, mid-day PM, roost Each bird was located 3 times per week during the nesting season either by visual location or triangulation. Intersections of triangulations we calculated using bearings and computer programs LOCATE II (Nams Truro, Nova Scotia 200 and LOAS (Ecological Software Solutions Sacramento, Calif.). Error ellipses for each triangulation obtained with maximum likelihood techniques (White and Garrott 990 Location information was used to determine the onset of incubation. Once hen was in approximately the same area (i.e., 200 m) for 2 daily locations, hen was thought to be incubating.

Once turkey was thought to be incubating, approached the hen no closer than 20 m from the nest and vegetation was flagged at to 4 places around the nest depending thickness of vegetation and location of nest. Flags tied in knot and flagging was cut off to reduce visual cues for predators. flushed hens after approximately 2 weeks of incubation to determine clutch size and nest location. If depredation or abandonment occurred prior to 2 weeks of incubation, areas throughout marked vegetation were searched until nests were found. Incubation and nest completion dates were estimated from examining telemetry locations and by floating eggs from each nest when the hen was flushed (Westerskov 1950). Nest initiation dates were calculated by subtracting 1 day for every egg laid from the estimated incubation date (Williams et al. 1971). Nests were considered successful if > 1 egg in a clutch hatched.

Breeding area fidelity was determined by comparing breeding period home ranges of each female between the first year (x), representing either 2000 or 2001 and the following year (x + 1), representing either 2001 or 2002. Females were considered to be returned to the same area if their home ranges overlapped. Females were considered to be non-returned if the home ranges did not overlap. Distances between first nests in year x and year x +1 were calculated and also compared as a continuous measure of breeding area fidelity (Badyaev and Faust 1996). Breeding period was defined as post spring dispersal through the start of nest incubation. Spring dispersal was determined by analyzing movement patterns of each hen from their winter range to their spring range. Spring dispersal was calculated as the distance between the arithmetic mean of a female's winter range and her first nest (Badyaev and Faust 1996). Juvenile breeding area fidelity is defined as a first year female's breeding area and her second year breeding area.

Home ranges were calculated with a 95% minimum convex polygon using the software package BIOTAS (Ecological Software Solutions 2000). The average number of locations used to calculate breeding home ranges was 24.4. Nest success was calculated using Mayfield estimation. Data were analyzed with G tests using SAS software (SAS Institute 1996) and T tests using S-PLUS software (S-PLUS Professional 2000) (Sokal and Rohlf 1999, Zar 1999).

Habitat Measurements

After nest attempts were complete (both successful and unsuccessful), I measured vegetation structure and composition at each site. I established a 10 x 20 m plot centered at each nest site and a paired random plot located 50 m from the nest in 1 of the 4 cardinal directions selected at random. A centerline along the long axis of each plot was established in a north-south direction.

I measured all trees (woody plants > 10 cm diameter breast height [DBH]) rooted within the plots. I also recorded height, DBH, and decay class (Maser et al. 1979) for each tree. The height of each tree was estimated using a 2 m pole. Canopy cover was measured using an ocular tube (2-4 cm in diameter with crosshairs at one end) at 20 points spaced evenly around the perimeter of the plot. estimated percent canopy cover by counting the total number of hits (canopy observed at the crosshairs of the ocular tube).

Understory woody vegetation was measured within a 20 x 2 m belt transect along the centerline. A 2 meter pole (Hagan et al. 1996) was held 0.5 m off the ground, and all woody stems (< 10 cm DBH) touched by the pole and rooted within the plot along the 20m transect was recorded. Each species of stem and height class was recorded. I classified woody stem heights into 4 classes: 0.5–1.0 m, 1.1–2.0 m, 2.1–4.0 m, and 4.1–6.0 m.

I measured visual obstruction ≤ 1 m tall throughout the nest and random plot with a vertical visual obstruction pole 2.5 cm in diameter and 1 m long, marked with 1 dm long vertical bands totaling 10 bands. Each band was colored alternately red or white to differentiate among bands. The pole was placed along the 20 m centerline of the plot and was observed from a distance of 4 m and at a height of 1 m (Robel et al. 1970). A 1 m sighting pole was attached to the visual obstruction pole by a 4 m string to standardize readings (Robel et al. 1970). Ten visual obstruction readings were made 2 m apart along the 20 m centerline transect in each plot alternating sides of the centerline. Visual obstruction was determined by how many vertical bands were visible at the 1m height and at a distance of 4 m. This was done by recording the lowest band visible and the total number of bands visible. If any part of the band could be seen, it was considered visible.

In addition to the above measurements, I measured visual obstruction around the nest bowl with the visual obstruction pole. The visual obstruction pole was placed inside the nest bowl and visual obstruction was recorded 4 m from the nest bowl at a height of 1 m in all 4 cardinal directions.

I classified ground cover into 5 categories: grass, shrub, bare, forb, and litter. I estimated ground cover using the ocular tube at 10 points along the 4 m string between the visual obstruction and sighting poles. Vegetation observed in the crosshairs of the ocular tube was recorded for that point. This resulted in 100 total points per vegetation plot.

Nests were classified into different habitat vegetative types. Vegetative types included grassland, upland shrubs, upland trees, riparian trees, riparian shrubs, cactus-yucca (*Yucca glauca*) rangeland, upland shrubs and trees, upland shrubs and riparian trees, riparian shrubs and upland trees, and riparian shrubs and trees.

Results

Overall, 40 of 54 (74%) adult and juvenile females returned to nest within their previous year's breeding range (Table 3.1). Although not statistically significant ($G = 2.59$ $P = 0.11$) juvenile females appeared to have lower return rates (56%) than adult females (82%). Return rates of pooled age classes did not differ ($G = 1.00$, $P = 0.78$) among the 4 study sites (CNG = 80.0%, GHWMA = 83.3%, Salt Fork = 66.6%, MWMA = 82.4%) so study sites were pooled.

Breeding Area Fidelity and Reproductive Performance

There was no difference ($G = 0.56$, $P = 0.46$) in return rates between females that produced successful nests (81%) and those that did not (71%). Also, females that exhibited breeding area fidelity did not experience lower overall nest depredation in year x +1 than females that did not exhibit breeding area fidelity (Table 3.2). Females that did return in year x + 1 had a depredation rate of 66%, while females that did not return had a depredation rate of 38% ($G = 2.01$, $P = 0.16$). Nests of females that returned in year x + 1 did not survive longer before depredation than nests of females that did not return (20.7 vs. 21.8 days, $t = 0.40$, $df = 42$, $P = 0.69$).

Females that did not return had larger clutch sizes in year x + 1 than their previous year ($t = 2.62$, $df = 20$, $P = 0.02$). Females that did return had clutch sizes similar to their previous year (t = 0.74, df = 59, P = 0.46). However, clutch sizes between returned females and not returned females in year x + 1 did not differ (t = 1.81, df = 36, P = 0.08). Female initiation dates did not differ between year x and x + 1 in returned and not returned females and between returned and not returned females in x + 1 (all t's < 2.0, P's > 0.14).

Spring Dispersal, Home Range Size and Nest Distance

Females that returned in year x + 1 traveled an average distance of 5,304 m from their winter range to their first nest (Table 3.3). Females that did not return traveled an average distance of 3,222 m. Travel distances for females that did return were not different than females that did not return (t = 1.02, df = 46, P = 0.31). Females that did return had an average breeding home range size of 1,195.3 km^2, while females that did not return had an average breeding home range size of 884.1 km^2 in year x + 1, but this difference was not significant (t = 1.10, df = 50, P = 0.28). Returned females nested closer to their previous year's nest (969 m) than females that did not return (1,990 m) (t = 3.58, df = 40, P= 0.001) (Table 3.4). Distances between renesting attempts in year x and x + 1 for returned and not returned females were not different (t = 1.36, df = 3, P = 0.26, t = 1.05, df = 11, P = 0.32).

Breeding Area Fidelity in Consecutive Seasons

I determined breeding area fidelity for 11 hens over 3 consecutive years (2000-2001, 2001-2002, 2000-2002). Forty-five percent (n = 5) of females returned in all 3 years, 18% (n = 2) of the females returned in 2 years, 27% (n = 3) of the females returned only 1 year and 9% (n = 1) of the females changed breeding areas all 3 years (Table 3.5). Four of the 11 females were juveniles. Two of the juveniles returned only 1 year, 1 juvenile returned in all 3 years and 1 female did not return in any year. Of the adult females, 57% returned in all 3 years, while only 25% of the juvenile females returned for all 3 years (57% vs. 25%, $G = 1.10$ $P = 0.29$).

Habitat Selection

I measured habitat characteristics between returned and not returned nesting females. Females that returned nested in the same vegetation type as the previous year (43% vs. 57%, $P = 0.67$). Likewise, females that did not return nested in the same vegetation type as the previous year (41% vs. 59%, $P = 0.68$). However, the only structural parameters that differed between nests of females that returned and did not return was canopy cover (Table 3.6). Nests of females that did not return had greater overstory canopy cover than nests of returned females ($P < 0.05$). All other vegetation parameters (percent grass, shrub, bare ground, forb, litter, understory cover, tree numbers, and visual obstruction) were similar between returned and not returned females. Habitat variables between year x and x + 1 in females that did return did not differ nor did habitat variables in females that did not return between year x and x + 1.

Discussion

Rio Grande wild turkey females exhibited relatively high breeding area fidelity (74%). Adult females had a higher fidelity rate (82%) than juveniles (56%). Although not statistically different, these results suggest implications for age-biased breeding area fidelity. Sample sizes were small, and may be the reason for lack of statistical difference. Local familiarity with an area has been suggested as one of the major reasons why species return to the same area in subsequent years (Hinde 1956, Baker 1978, Gaines and McClenaghan 1980, Greenwood 1980, Waser and Jones 1983). Since younger females do not have the local familiarity or experience that adult females have, it has been suggested that adult females will be more faithful to an area than juvenile females. Our data supports this hypothesis, since juvenile females appeared to exhibit less fidelity than adult females. Schiek (1989) found that 69% of willow ptarmigan (*Lagopus lagopus*) females returned to breed in the same territory as the previous year, but did not test fidelity rates of young birds versus older birds. Badyaev (1996) studied wild turkeys in the Arkansas Ozarks and found 69% of turkeys exhibited breeding area fidelity. He also found a greater age-biased breeding area fidelity than this study; females 3 years of age had a much lower probability of returned to their previous nesting area than females >3 years of age (25% vs. 83%), respectively. Although adults are more faithful to an area than juveniles, adults may not return to the same breeding area every year, as indicated by the females that survived all 3 years. Some females returned to the same area, switched breeding areas, and then returned again. Reasons for this are unknown, although hypotheses exist indicating females may attempt to improve their previous habitat search by examining unoccupied habitats of higher quality (Parker 1983, Real 1990).

Reproductive success did not appear to play a role in the decision to return or not return to the same breeding area. Females that returned to the same area to nest did not have higher reproductive success than females that did not return. A turkey's decision to return to the same area to nest in subsequent years may be based on familiarity with the area or other factors I did not measure. Nesting success, clutch size, nest initiation and nest survival did not differ between returned and not returned females. This was not due to differences in nesting habitat between returned and not returned females. Greenwood and Harvey (1980) suggested that foraging and predator avoidance may be more efficient where individuals are familiar with an area. Our results do not indicate that predator avoidance was more efficient in more familiar areas.

Females that exhibited breeding area fidelity did not have larger breeding home ranges nor did they travel farther to breeding areas than females that did not exhibit breeding area fidelity. Since local familiarity, prior nesting experience, and experience with predation enhance nest site selection efficiency, it has been hypothesized that females who return to the same area to nest should have smaller breeding ranges than females that do not return (Real 1990, Pärt 1995). Our results did not support this hypothesis. Returning to the same area was not associated with reduced movements during breeding. Others have suggested that resource sampling can allow more effective nest selection by foraging organisms when patch quality varies in time and space (Heinrich 1979, Parker 1983, Stephens and Krebs 1986, Real 1990). Badyaev et al.

(1996) reported that habitat sampling, as indicated by greater movements prior to nesting, allowed selection of better nesting habitat and resulted in higher nest survival. Our results supported this hypothesis. It has been shown that older females tend to move shorter distances during spring dispersal than younger females (Badyaev et al. 1996). Young individuals are usually forced to disperse in order to acquire a territory, reduce inbreeding, and improve their chances of successful breeding outside of areas already occupied by dominant individuals (Gauthreaux 1978, Greenwood 1980, Waser and Jones 1983, Waser 1985). Therefore, spring dispersal distance has been shown to be a factor of age, not a factor of returning or not returning to a breeding area.

Management Implications

Female wild turkeys exhibit relatively high breeding area fidelity. Wild turkeys appear to exhibit age-biased breeding area fidelity with juveniles exhibiting lower breeding area fidelity than adults. Females did not base their return decision on prior nesting success, nor did returning to the same area increase reproductive performances. Familiarity with the area appeared to be the most important factor in the return decision of Rio Grande wild turkeys. It is, therefore, important to maintain quality nesting habitat in these areas where females return. It is not known, however, whether females will nest in areas with high densities of other nesting females. If females do tend to nest in high densities and return to the same areas in successive years, then it is especially important to manage these areas for quality nesting habitat to maximize reproductive success.

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Table 3.1. Percentage of females and number of adult and juvenile radio equipped females that returned or did not return to their previous breeding area in 2000–2002 at 4 study areas in the Panhandle of Texas and Kansas.

	CNG[a] (n = 5)	GHWMA (n = 16)	Salt Fork (n = 11)	MWMA (n = 22)
Returned, %	80.0	68.8	81.8	72.7
Adult, n	4	10	7	13
Juvenile, n	0	1	2	3
Not Returned, %	20.0	31.2	18.2	27.3
Adult, n	0	4	2	5
Juvenile, n	1	1	0	1

[a] CNG = Cimmaron National Grasslands, Kansas, GHWMA = Gene Howe Wildlife Management Area, Texas, Salt Fork = Salt Fork of the Red River study area, Texas, MWMA = Matador Wildlife Management Area, Texas.

Table 3.2. Reproductive performance of female wild turkeys that returned and did not return to their previous nesting area during 2000–2002 for GHWMA, CNG, MWMA and Salt Fork study areas. Means and standard deviations for both year x and x + 1 for returned and not returned females are listed below.

Variable	Returned ± SD	Not Returned ± SD
Year x		
Nest initiation date	3-May ± 11.8	27-April ± 14.6
Duration of incubation, days	24.9 ± 3.3	23.3 ± 8.1
Clutch size	10.1 ±1.6	10.5 ± 1.7
Nest success, %	33.7	25.8
Year x + 1		
Nest initiation date	28-April ±12.2	20-April ± 17.4
Duration of incubation, days	20.7 ± 4.6	21.8 ± 11.3
Clutch size	10.5 ± 1.5	11.9 ± 2.3
Nest success, %	16.4	31.4

Table 3.3. Spring dispersal distance and prenesting home ranges of returned and non-returned female wild turkeys during 2000–2002 at CNG, GHWMA, MWMA, and Salt Fork study areas. Means and standard deviations are listed for each variable.

Variable	Year x ± SD	Year x + 1 ± SD
Returned		
Spring dispersal dist., m	5,258.9 ± 4,226.6	5,304.7 ± 4,451.4
Prenesting range, km^2	1,717.8 ± 960.1	1,195.3 ± 585.9
Not Returned		
Spring dispersal dist., m	6,554.4 ± 10,251.0	3,222.9 ± 4,604.5
Prenesting range, km^2	1,244.7 ± 1,640.8	884.1 ± 817.9

Table 3.4. Means and standard deviations of distances between first nests and renest sites of returned and non-returned female wild turkeys. Data were collected during 2000-2002 at CNG, GHWMA, Salt Fork, and MWMA study areas.

Variable	Returned ± SD	Non-Returned ± SD	P
Distance between nests, m			
First (x) to first (x + 1)	969.0 ± 404.5 (30)	1,990.3 ± 1,532.9 (11)	0.001
Renest (x) to first (x + 1)	657.0 ± 482.0 (9)	462.9 ± 672.6 (4)	0.32
First (x) to Renest (x + 1)	814.9 ± 1,529.1 (2)	3,675.6 ± 12,794.1 (3)	0.26

Table 3.5. Return rate of 11 females that survived for 3 consecutive years. There were 7 adult females and 4 juvenile females that survived throughout 2000-2002. The numbers listed below are birds from CNG, GHWMA, Salt Fork, and MWMA. G tests were conducted and associated P values are listed below.

Variable	Adult	Juvenile	P
Returned all 3 periods, %	57.1	25.0	0.29
Returned 2 periods, %	28.6	00.0	0.15
Returned 1 period, %	14.3	50.0	0.20
Returned 0 periods, %	00.0	25.0	0.14

Table 3.6. Means and standard errors of habitat structural parameters at nests of returned females and nests of non-returned females. Habitat variables analyzed were measured from nest sites in year 2001 only and include CNG, GHWMA, Salt Fork and MWMA study areas.

	Non-returned (n = 7)			Returned (n = 16)		
Variable	$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	P<0.05
Canopy, %	31.43	1.96	A	3.13	0.20	B
Tree, no.	2.29	1.13	A	1.19	0.55	A
Grass, %	39.55	0.97	A	41.23	0.83	A
Shrub, %	20.96	0.81	A	25.32	0.71	A
Bare, %	6.71	0.23	A	4.50	0.19	A
Forb, %	25.78	1.05	A	20.91	0.61	A
Litter, %	5.13	0.17	A	7.44	0.24	A
Understory cover						
0.5 – 1.0, m	11.66	5.97	A	20.25	6.25	A
1.1 – 2.0, m	13.71	5.76	A	7.06	2.08	A
2.1 – 4.0, m	0.71	0.29	A	1.38	0.69	A
4.1 – 6.0, m	0.00	0.00	A	0.00	0.00	A
Total	26.29	11.73	A	28.69	7.48	A
Nest visual concealment						
Lowest dm	6.75	0.88	A	5.94	0.54	A
Total dm	3.64	0.96	A	4.88	0.54	A

Table 3.6 cont.

	Non-returned (n = 7)			Returned (n = 16)		
Variable	$\bar{X}$	SE	P<0.05[a]	$\bar{X}$	SE	P<0.05
Plot visual concealment						
Lowest dm	4.97	0.79	A	4.35	0.48	A
Total dm	5.77	0.81	A	6.52	0.49	A

[a] Nest means within a variable followed by unlike letters are different by a 1-way ANOVA.

CHAPTER IV

CONCLUSION

Rio Grande wild turkey populations began to decline with European settlement (Kennamer and Brenneman 1992). The decline continued well into the 1900s and probably reached their lowest numbers in the late 1930s (Mosby 1975). With restoration efforts beginning in the 1930s in Texas and 1950s in Kansas, wild turkeys began to repopulate throughout their original range (Beasom and Wilson 1992). With habitat changes and fragmentation occurring today, some populations appear to be declining in parts of the Texas Panhandle and southwestern Kansas (R. Applegate, unpublished data, Department of Wildlife and Parks, Emporia) (G. Miller, unpublished data, Texas Parks and Wildlife, Canyon). We studied Rio Grande wild turkey (*Meleagris gallopavo intermedia*) nesting habitat at four locations; three in the Panhandle of Texas and one in southwestern Kansas in 2000 and 2001. Gene Howe Wildlife Management Area (GHWMA) and Salt Fork study areas represented 2 study areas with stable or increasing populations of wild turkeys, while Cimmaron National Grasslands (CNG) and Matador Wildlife Management Area (MWMA) represented possible declining populations. I investigated nesting characteristics and nest selection by (1) comparing habitat characteristics at nest plots and adjacent sites, (2) comparing between successful and depredated nests, adult and juvenile nests, first and renesting attempts, and early and late nests in different vegetative types, (3) comparing habitat characteristics of successful nests to adjacent sites and depredated nests to adjacent sites, along with successful adjacent to depredated adjacent sites, and (4) comparing habitat characteristic differences among and within study areas. Females at all study areas selected nest plots with greater shrub cover, higher visual obstruction, and less bare ground cover than adjacent, non-nest plots. Turkey nests at CNG had lower visual obstruction, less shrub density and less dense woody understory vegetation than the other study areas, although nest success was not lower at this study area than the others. Females that nested in grassland vegetation at CNG were not as successful as females that nested in other vegetation types. Juvenile turkeys nested in areas with more bare ground than adult turkeys, and turkeys that nested late in the nesting season used areas with more herbaceous cover than turkeys that nested early in the season. Although vegetation types differed among the study areas, structural composition remained similar.

Many species return to breed in the same area in successive years, although it is unknown whether Rio Grande wild turkeys (*Meleagris gallopavo intermedia*) exhibit nest site fidelity (Greenwood 1980). Familiarity with local conditions together with traveling costs in terms of energy or time are some of the reasons why individuals of many species of birds and mammals return in successive years (Hinde 1956, Baker 1978, Gaines and McClenaghan 1980, Greenwood 1980, Waser and Jones 1983). We examined breeding area fidelity in 54 adult Rio Grande wild turkeys at 4 study areas in Kansas and the Panhandle of Texas during the breeding season of 2000-2002. We examined the hypothesis that females with successful broods will exhibit higher fidelity to their previous breeding area than females that do not produce a successful brood. We found that among all 4 study areas, Rio Grande wild turkeys exhibited an overall breeding area fidelity of 74%. Females did not appear to base their return decision on previous year's nesting success. Females that returned to the same area did not exhibit a higher reproductive performance; they were not more successful the following year than females that did not return and their nests did not survive longer before depredation than females that did not return. Spring dispersal distance and home range size was similar between females that returned to the same breeding area and those that relocated to another breeding area. Habitat characteristics were also similar between females that returned and females that did not return to the same area. Because females return to the same area in successive years, it is important to maintain quality nesting habitat in these areas to maximize reproductive success.

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