

**NESTING ECOLOGY OF RIO GRANDE WILD TURKEYS IN THE EDWARDS
PLATEAU OF TEXAS**

A Thesis

by

JUSTIN ZACHARY DREIBELBIS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2008

Major Subject: Wildlife and Fisheries Sciences

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Approved by:

Chair of Committee,	Markus J. Peterson
Committee Members,	Nova J. Silvy
	Bret A. Collier
	Humberto Perotto
Head of Department,	Thomas E. Lacher, Jr.

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ABSTRACT

Nesting Ecology of Rio Grande Wild Turkeys in the Edwards Plateau of Texas.

(August 2008)

Justin Zachary Dreibelbis, B.S., Texas A&M University

Chair of Advisory Committee: Dr. Markus J. Peterson

Rio Grande wild turkey (*Meleagris gallopavo intermedia*) numbers in the southeastern region of the Edwards Plateau (EP) have shown a significant decline since the 1970s; however, the remainder of the EP had stable populations during this period. Since 2001, research has been conducted in the southeastern EP evaluating factors which could be responsible for the decline of Rio Grande turkeys in this region of Texas.

I used digital cameras to evaluate the effect of nest predation on the reproductive success of Rio Grande wild turkeys in the region. Nest predation was the leading cause of nest loss in my study and I documented frequent predation events involving ≥ 1 predator species. While studying nest predation, I examined the effects of my methods, and those commonly used by others, on nest success. Nests with cameras failed at the same frequency as those without cameras but at a faster rate. Predation rates observed for artificial nests underestimated predation rates of real nests. Additionally, I photographed known turkey nest predators at 27% of random points with no eggs, suggesting that nest predation could be a random process depending on the nest predator's unique search image.

I also examined the spatial structure of the habitat surrounding nest locations of turkeys on my study sites to evaluate the effect of disturbance on nest-site selection. Out of 59 nests located on the Kerr Wildlife Management Area from 2005 through 2007, only 5 were in areas that had not been burned in the 9 years prior. Turkeys in my study consistently chose areas characteristic of the fire maintained, oak–juniper savanna historically found in the region.

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CHAPTER I

INTRODUCTION

Rio Grande wild turkey (*Meleagris gallopavo intermedia*) numbers prior to European settlement are estimated at as many as 1.8–2 million birds (Beasom and Wilson 1992) and a major stronghold for this population was in the Edwards Plateau of Texas (Walker 1954, Collier et al. 2007a). Rio Grande wild turkeys have significantly expanded their range since this time and a good part of this expansion is due to translocations from Texas (Beasom and Wilson 1992). Since the late 1970s, turkey abundance in the southeastern section of this region has declined while populations on the remainder of the Edwards Plateau have remained stable (Collier et al. 2007a, Fig. 1.1). In January of 2001, Texas Parks and Wildlife Department (TPWD) and Texas A&M University (TAMU) initiated a research program to examine factors that could be responsible for differences in population dynamics between regions. Previous work evaluated predator abundance, vegetation characteristics during nesting, spatial distribution of hens, nest survival, and survival of juveniles and adults (Willsey 2004, Randel et al. 2005, Schaap 2005, Collier et al. 2007a, Melton 2007).

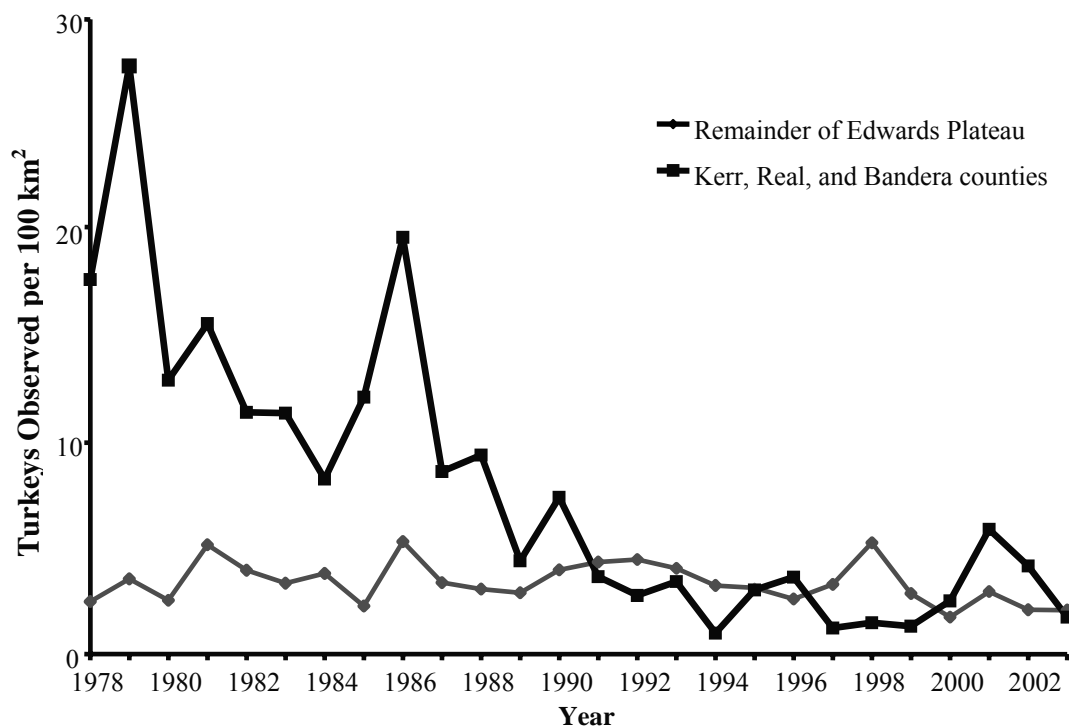


Figure 1.1. Number of Rio Grande wild turkeys observed per 100 km² by Texas Parks and Wildlife Department biologist during summer production surveys for Bandera, Kerr, and Real counties, and the remainder of the Edwards Plateau (excluding 12 counties averaging <1 turkey observed per 100 km²), Texas, USA 1975–2003 (Collier et al. 2007a).

My objectives were to: 1) determine predators that are responsible for turkey nest predation events in the Edwards Plateau and quantify multiple predator and partial predation events, 2) determine the effect of cameras on the reproductive success of turkey nests and evaluate the reliability of artificial nests at estimating turkey nest predation, and 3) determine the effect of disturbance on spatial structure of nest sites selected by turkeys in the Edwards Plateau.

STUDY AREA

My research was conducted in regions with both stable and declining Rio Grande wild turkey abundance in the southeastern Edwards Plateau (Fig. 1.2). Study sites were chosen within both regions based on known locations of turkey populations and extensive landowner participation due to research previously conducted at these sites. Stable site A (SA) included the Kerr Wildlife Management Area (KWMA) in western Kerr County and an associated privately owned property adjacent to the KWMA. The KWMA was used primarily for public education, habitat management seminars, and hunting. The neighboring property was a 4,843 ha wildlife management oriented cattle ranch used for livestock production and hunting. Stable site B (SB), located in southern Real County, northwest of Leakey, Texas, was a privately owned game ranch used primarily for hunting. Declining site A (DA) was located in northwestern Bandera County, west of Medina, Texas. It was also a privately owned ranch primarily used for hunting and livestock production. Declining site B (DB) was located in northern Medina County, south of Bandera, Texas and was a privately owned cattle and sheep ranch. The owners leased the hunting rights on the property. Limited numbers of turkey hunts were

conducted on all sites except DA, and a rotational livestock grazing program was in place on all properties except SB.

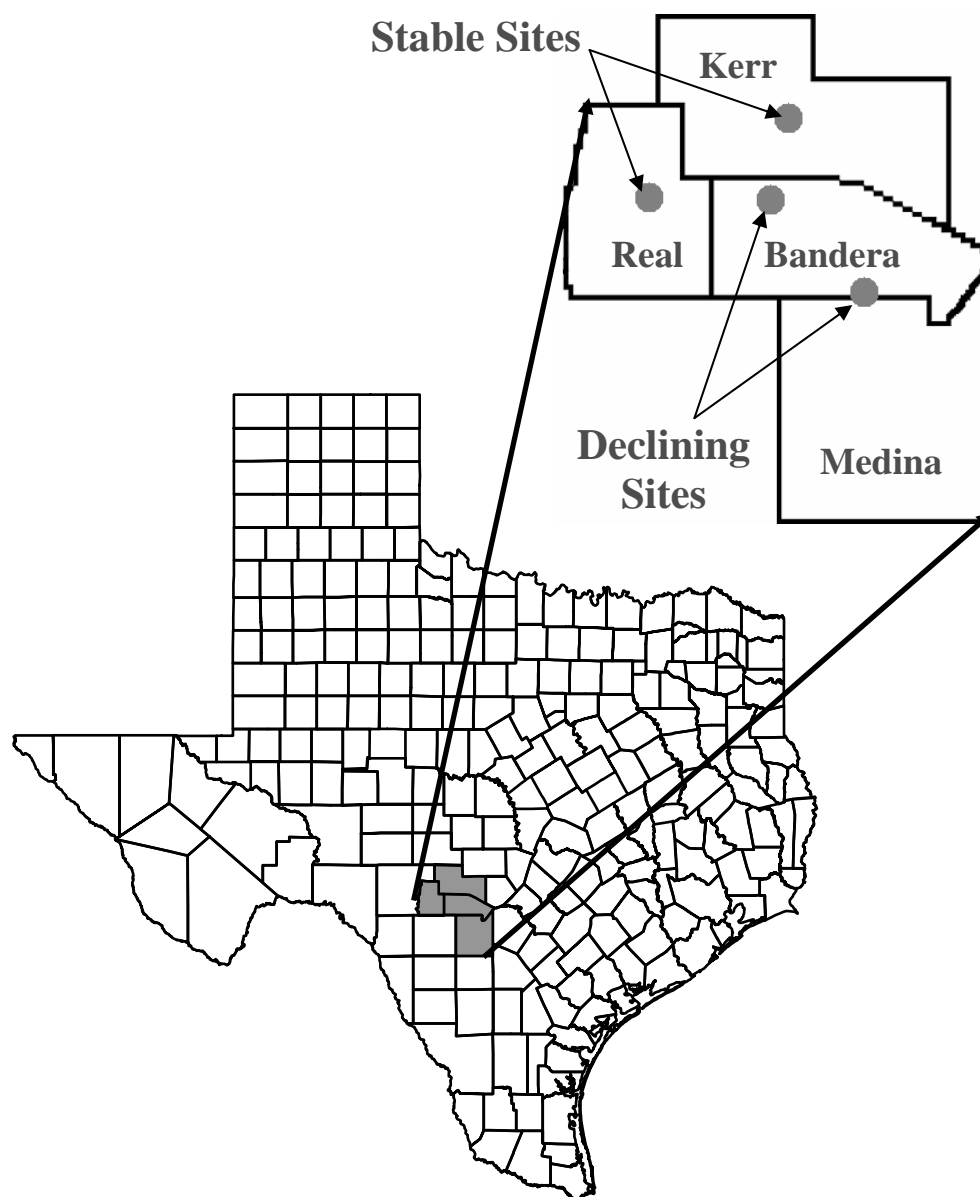


Figure 1.2. Location of study sites for Rio Grande wild turkey project in Edwards Plateau, Texas, 2005–2007 (Melton et al. 2007).

CHAPTER II
PREDATION OF RIO GRANDE WILD TURKEY NESTS ON THE EDWARDS
PLATEAU, TEXAS*

Natality is one of the primary biological processes influencing dynamics of wildlife populations (Everett et al. 1980). Understanding which factors cause changes in individual and group natality is important for managing bird populations. Methods to estimate and understand components of nest survival have received recent attention, particularly for species of ground nesting birds (Dinsmore et al. 2002, Shaffer 2004, Grant et al. 2005). A variety of factors can influence nest survival, but for ground nesting birds, nest predation appears most influential (Ricklefs 1969, Farnsworth and Simons 2000, Rollins and Carroll 2001, Stephens et al. 2005). Given the vulnerability of ground nesting species, predation will affect nest survival and population productivity (Baker 1978, Rollins and Carroll 2001).

Accurate identification of nest predators for ground nesting birds is important in understanding effects of predation on population parameters (Lariviere 1999, Rader et al. 2007). Nest predation studies often rely on physical evidence at the nest, such as tracks, hair, and eggshell fragments to identify predators (Major 1991, Lariviere 1999).

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Use of physical evidence can be highly subjective (Trevor et al. 1991, Lariviere 1999) and may fail to account for multiple-predator and partial-predation events (Leimgruber et al. 1994). Predation events may be difficult to identify if eggshells are removed by the incubating hen following partial nest predation (Lariviere and Walton 1998), or if predation is by reptilian or avian species, as snakes consume whole eggs in the nest (Staller 2001) and avian species often remove eggs from the nest before consumption (Montevecchi 1976).

Abundance of Rio Grande wild turkeys (*Meleagris gallopavo intermedia*) on the southeastern Edwards Plateau, Texas has declined since the late 1970s (Randel et al. 2005, Collier et al. 2007a). Recent work has focused on evaluating factors contributing to this decline (Collier et al. 2007b), including variation in reproductive potential and nest survival (Melton 2007). Predation is the primary cause of nest failure in the region (Cook 1972, Melton 2007), and nest loss can adversely influence wild turkey populations (Davis 1959, Baker 1978). Our objectives were to: (1) identify predators of Rio Grande wild turkey nests and (2) examine the frequency of total nest loss, partial predation events, and multiple-predator predation events.

METHODS

We trapped wild turkey hens during January–March, 2006 and 2007. We attached radio transmitters (69.0–95.0 g; Advanced Telemetry Systems, Isanti, MN, USA) to 39 and 22 hens in 2006 and 2007. We located individual hens 3 times weekly (White and Garrott 1990) during the breeding season until behaviors indicated a hen had initiated a nest (Ransom et al. 1987). We located nests within 1 day after we suspected

hens had begun incubation. Once located, we ascertained initiation date, clutch size, and approximate age for each nest. We estimated nest age and initiation date by backdating from the day we found the nest to the day we first located the hen in the nest area. We defined the active nesting period as 39 days; the sum of the average number of eggs in a clutch (11) and a 28-day incubation period (Bailey and Rinnell 1967, Melton 2007). We floated eggs to estimate age of nests found during incubation (Westerskov 1950), and monitored nests 3 times weekly from a distance of ≥ 100 m to prevent further disturbance to the hen. We assumed the nest was active if hen locations remained constant. One week before estimated hatch date, we visited nests daily to ensure accurate identification of hatch date.

We used motion-activated trail cameras (Game Spy 100 and Outfitter Cam, Moultrie Feeders, Alabaster, AL, USA) at a sample of nests. Each camera was equipped with 16 MB of internal memory (we added a 256 MB memory card to each camera in 2007), a 10.2 mm lens, and a 9.14 m flash. We learned through a pilot study in 2005 that cameras set within 5 m of a nest require flash reduction, otherwise night photographs were over-exposed. To reduce flash, we covered 100% of the flash surface with one to 3 layers of masking tape, dependent upon nest distance (most often one layer/m from the nest under 5 m). We attached the camera, based on vegetation surrounding the nest area, to a tree near the nest or to a post. We programmed cameras to take 2 pictures ~ 5 sec apart, followed by a 5 or 10 minute delay. After the delay period, the next event in the nest area would trigger the camera. We checked cameras after initial setup, only when the bird was located out of the nesting area for more than 1

day. Nests receiving camera surveillance were chosen randomly across study sites depending on camera availability and nest initiation timing.

RESULTS

We placed cameras at 21 of 47 active turkey nests in 2006, with 12 (57%) nests depredated and 8 (38%) nests abandoned. These rates are comparable to 69% depredation and 15% abandonment for those nests in our study without cameras. Three of 12 depredated nests with cameras involved more than 1 predator, 4 involved a single predator, and 5 had no photographs of the nest predator (Table 2.1). We placed cameras at 31 of 71 active nests in 2007. Twenty of 31 (65%) nests with cameras were depredated and 6 of 31 (19%) were abandoned. Four of the depredated nests involved more than one predator, 7 involved a single predator, and 9 had no predator photographs. We observed 68% (27/40) predation and 18% (7/40) abandonment at nests without cameras in 2007. Nests survived on average 12.5 and 13.0 days with and without cameras in 2006, and 18.4 and 18.7 days with and without cameras in 2007.

Table 2.1. Nest predators documented via remotely-triggered cameras at active Rio Grande Wild Turkey nests in the Edwards Plateau, Texas, 2006–2007 (n = number of nests with photographed predation events).

	2006	2007
Species	($n = 7$ nests)	($n = 11$ nests)
Nine-banded armadillo (<i>Dasypus novemcinctus</i>)	0	1
Bobcat (<i>Lynx rufus</i>)	0	1
Feral hog (<i>Sus scrofa</i>)	2	1
Gray fox (<i>Urocyon cinereoargenteus</i>)	4	2
Common raccoon (<i>Procyon lotor</i>)	2	7
Common Raven (<i>Corvus corax</i>)	0	3
Striped skunk (<i>Mephitis mephitis</i>)	2	0
Texas rat snake (<i>Elaphe obsoleta lindheimeri</i>)	1	0
Total multiple predator events	3	4

We were able to examine timing of predation events in greater detail on approximately half the nests with cameras. For example, a multiple predator event occurred at a nest of a yearling hen found incubating her first nest containing 11 eggs on 17 May 2006. We flushed the hen, estimated nest age at 6 days of incubation, and placed a camera at the nest. We recorded a remarkable series of predation events on 19 May at this nest. At 1818 hrs, a common raccoon (scientific names of predator species are in Table 1) was recorded leaving the nest area and subsequent photographs showed a raccoon consuming an egg ~ 2 m from the nest. Later that evening (2212 hrs), 2 photographs (<10 sec apart) were taken of a raccoon predating the nest. Shortly thereafter (2242 hrs), a gray fox visited the nest. Less than 1 hr later (2328 hrs), a striped skunk depredated the nest followed by a gray fox that visited the nest at 2344 hrs. We documented additional predator visits on subsequent days. Raccoons were observed at the nest on 20 May at both 0111 and 0705 hrs as well as on 22 May at 0005 hrs. We photographed feral hogs at the nest on 22 May at 0534 hrs and 2315 hrs, removing the remaining shell fragments from earlier predation events. The last recorded nest visitor was a raccoon on 24 May at 0409 hrs. The hen remained in the general vicinity of the nest until 24 May when we examined the nest site at 1126 hrs, finding no eggshell remains and little disturbance to the leaf litter. Given there was no evidence (egg shells, tracks, scat, hair, etc.) at the nest site when researchers arrived, we initially believed a reptilian or avian predator was responsible.

We also documented an instance of partial nest predation. We located the nest on 17 April 2006, during incubation by an adult hen of her first nest of the season, which

contained 16 eggs. We monitored the nest for 28 days, which was successful, and located the hen with 8 poults on 14 May. When we returned to the nest area to collect eggshells, we found remnants of only 9 hatched eggs. Upon checking the photographs, we found the nest had been partially depredated by a Texas rat snake 11 days earlier. On 3 May at 2118 hrs, we photographed the snake in the nest. The hen hatched the remaining 9 eggs on 13 May 2006. There was no physical evidence at the nest, and we initially believed the nest was predated by either a reptilian or avian predator.

DISCUSSION

Our observations indicate that nest predation was the proximate factor affecting overall nest survival of Rio Grande wild turkeys during our study, although our sample of nests was fairly small. Additionally, our results suggest that nest predation events involving multiple predators were common. There is a diverse predator community on the Edwards Plateau (Davis and Schmidly 1994) and key predators can change from year to year. The method of depredation used and the evidence left at the nest site after depredation events (e.g., eggshell fragments) may overlap among species. Gray fox were documented in 2006 at 57% of the predation events but were photographed at only 2 (18%) predation events in 2007 (both of which involved multiple predators). Three of 11 (27%) camera nests in 2007 identified common ravens removing eggs; however, no ravens were photographed in 2006. Nests depredated by ravens were similar to those depredated by snakes as they contained no shell fragments and had little disturbance around the nest.

Staller (2001) correctly identified 61% of predators at northern bobwhite (*Colinus virginianus*) nests using physical evidence at the nest site as compared to data from miniature video cameras; however, diversity of predators on his study area was small. Only 12% of predation events from Staller (2001) involved multiple predators compared to Leimgruber et al. (1994) who observed multiple predator visits (2–5 species) in 43% of predation events, a rate similar to ours. Hernandez et al. (1997a) attempted to construct a dichotomous key for identification of ground-nest predators in west Texas but were not successful because of insufficient physical evidence and overlap of nest predation habits among species. Incubating blue-winged teal (*Anas discors*) and mallard (*A. platyrhynchos*) hens are known to remove damaged eggs and shell fragments from the nest area following partial predation events by striped skunks (Lariviere and Walton 1998).

The relationship between ground nesting birds and nest predators is complicated and we caution researchers to understand the limitations of using physical evidence to predict nest predator species. Our results provide insight into nest predator communities and confirm that multiple predator events are frequent (39% of the predation events recorded with cameras in our study) in the wild. Multiple predation events can greatly alter physical evidence left at the depredated nest site; thus, it is crucial that researchers test and apply any method which is used to assess nest predator communities before mitigation strategies are developed.

CHAPTER III

EFFECT OF CAMERAS AND HUMAN ACTIVITY ON THE SUCCESS OF RIO GRANDE WILD TURKEY NESTS ON THE EDWARDS PLATEAU OF TEXAS

Nest survival (proportion of nests hatching ≥ 1 young) underlies recruitment for many bird species (Martin 1987, Miller and Leopold 1992, Dinsmore et al. 2002) and is therefore of considerable importance to landowners and wildlife managers. Nest predation is the leading cause of nest loss for avian species (Rickleffs 1969) and rates of nest predation are usually high for ground nesting species (Ransom et al. 1987, Trevor et al. 1991, Rollins and Carroll 2001). In order to estimate predation rates of nests without disturbing active nests, researchers have used artificial nests with mixed results (George 1987, Major and Kendal 1996). Conflicting research has indicated that artificial nests provide an accurate surrogate for estimating predation of real nests (Gottfried and Thompson 1978, Major 1990, Hernandez et al. 2001) or that use of artificial nests provide biased nest success estimates (Butler and Rotella 1998, Wilson et al. 1998, King et al. 1999). In most cases, artificial nests overestimate predation rates for real nests (Major and Kendal 1996). Increased predation rates on artificial nests are often attributed to human scent associated with researchers checking nests (Whelan et al. 1994) and lack of parental protection (King et al. 1999). Often, artificial nests attract a community of predators that would normally not locate nests (Willebrand and Marcstrom 1988), although predators such as snakes typically do not find artificial nests due to lack of heat and the scent of a hen tending to her eggs (Wilson et al. 1998).

A wide variety of studies have used automatically triggered cameras to identify nest predators (Leimgruber et al. 1994, Picman and Schriml 1994, Hernandez et al. 1997*a,b*). Presence of cameras at the nest may bias results (Hernandez et al. 1997*b*); however, few studies have addressed this bias using real nests. In a study using live and artificial nests, Herranz et al. (2002) found predators avoided nests monitored with non-camouflaged cameras, but predated nests with camouflaged cameras at the same intensity as those without cameras. Both Pharris and Goetz (1980) and Leimgruber et al. (1994) observed no difference in nest predation between artificial nests with and without cameras. Presence of cameras requires human visitation to nests; however, few studies have explicitly evaluated the affects of human observers on nest survival and those which have addressed this topic have yielded conflicting results (Gottfried and Thompson 1978, Major 1990, Ortega et al. 1997).

Ground nesting species, such as wild turkeys (*Meleagris gallopavo* spp.), are particularly impacted by nest predation given the host of potential predators and vulnerability of their nests. Predation is the primary cause of nest failure for turkeys across their range (Cook 1972, Speake 1980, Vangilder et al. 1987), and nest loss can influence population growth (Davis 1959, Baker 1978, Roberts and Porter 1996). Therefore, techniques to estimate nest predation rates are necessary for sound management decisions. Because nest predation impacts population trajectories of wild turkeys, and because of the conflicting results regarding camera effects, artificial nest reliability, and observer affects on nest survival, I evaluated the effect of cameras and

human activity on Rio Grande wild turkey (*M. g. intermedia*) nests and artificial turkey nests on the Edwards Plateau of Texas.

STUDY AREA

I conducted research on the Edwards Plateau region of Texas from January through July of 2007 on 2 of our study sites in Kerr and Bandera counties. Each site was characteristic of Edwards Plateau topography—rolling divides with limestone bedrock and outcrops with rocky soils (Gould 1975). This region previously was a fire-evolved grassland savanna interspersed with live oaks (*Quercus virginiana*) and mesquite (*Prosopis glandulosa*), with Ashe juniper (*Juniperus ashei*) along sheltered outcroppings (Taylor and Smeins 1994). Fire suppression and grazing concomitant with settlement gradually converted the area to brushland and open woodland consisting primarily of live oak mottes and Ashe juniper thickets. The sites included a corporately owned cattle ranch (8,858 ha) along the Medina River and the Kerr Wildlife Management Area (KWMA; Texas Parks and Wildlife Department; 2,627 ha) near Hunt, Texas. Both sites were managed for native and exotic hunting; rotational livestock grazing occurred on both sites.

METHODS

Data Collection

I trapped wild turkeys on 2 study sites on the Edwards Plateau from January through March 2007. Hens were captured using drop-nets baited with milo. Each captured individual was fitted with a mortality-sensitive, backpack style radiotransmitter (69.0–95.0 g; Advanced Telemetry Systems, Isanti, MN). Using radio-telemetry, we

located hens ≥ 3 times weekly during the breeding season until behavioral shifts suggested incubation of a nest had begun. Upon locating nests, hens were usually flushed once from the nest so we could collect data on each nest (e.g., clutch size, nest location). Because wild turkeys lay approximately 1 egg per day, I estimated the date of nest initiation by subtracting the number of eggs in the nest from the approximate date when incubation began (Badyaev 1995). During nest location throughout the season, every other nest was allocated to a treatment (monitored by a motion sensor digital trail camera; Moultrie Outfitter Cam, Moultrie Feeders, Alabaster, Alabama, USA) and the next to a control (left without a camera) group. After each treatment nest was equipped with a camera, I placed 3 additional cameras in the same pasture at 3 randomly generated points. To prevent radio-tracking activities from attracting predators to experimental nest sites, I established a 150 m buffer around each treatment turkey nest to ensure independence (e.g., activities at one nest site would not influence fate of other nest sites). I constructed artificial nests in habitat we subjectively (based on our monitoring of 162 live nests between 2005 and 2007) classified as nesting substrate within 5 m of the random point. At each nest site, an artificial nest was constructed using 4 unwashed chicken eggs. The first artificial nest site was treated exactly as the treatment turkey nest and was not revisited until hatch, predation, or abandonment of the treatment turkey nest. The second artificial nest site was equipped with a camera on an artificial nest (constructed as above); however, I approached this nest and handled the eggs each time the study site was visited (once every 2 days). The final camera was placed overlooking a random point with no eggs. This camera was not revisited until

hatch, predation, or abandonment of the treatment turkey nest. I approached and constructed artificial nests wearing leather boots and without gloves, making no attempt to disguise human scent. Upon a treatment nest hatch or failure, all cameras within that experimental group were collected and events up to that point were determined.

Data Analysis

I estimated daily nest survival for nests of each experimental group using the nest survival approach (Dinsmore et al. 2002) in program MARK (White and Burnham 1999). I used an information theoretic approach to model selection and assessed model strength based on AIC_c and Akaike weights (w_i ; Burnham and Anderson 2002). When I found evidence of model selection uncertainty ($w_i < 0.8$; Mong and Sandercock 2007), I used multimodel inference and provide model-averaged estimates of survival (Burnham and Anderson 2002). I developed a set of candidate models specific to describing differences in nest loss for each experimental group in our camera study (Table 3.1). I only considered daily nest survival models with constant survival as I was dealing with a relatively small sample of experimental nests, thus limiting the complexity of the models I could evaluate. My models were based on a priori hypotheses I had regarding nest loss, differences between handled and unhandled nests, differences between live and dummy nests, as well as models which accounted for the amount of time a hen spent on the nest before the nest was included in the study (e.g., had a camera put into place).

Table 3.1 Candidate models^a used to examine the difference in daily nest survival between each nest type during the 2007 nesting season (T1 = turkey nest without camera, T2 = turkey nest with camera, A1 = artificial nest not handled, A2 = artificial nest handled regularly, R = camera overlooking random point without eggs).

Model	No. of parameters	Deviance	ΔAIC_c	w_i
DSR $T1=A1 \neq T2=A2 \neq R$	3	352.62	0.00	0.521
DSR $T1=T2=A1=A2 \neq R$	2	356.40	1.77	0.215
DSR $T1 \neq T2 \neq A1 \neq A2 \neq R$	5	352.07	3.51	0.090
DSR $T1=T2 \neq A1=A2 \neq R$	3	356.30	3.68	0.083
DSR $T2 \neq A2 \neq T1=A1=R$	3	357.15	4.53	0.054
DSR $T2 \neq A1 \neq T1=A2=R$	3	360.27	7.65	0.011
DSR $T1 \neq T2 \neq A1=A2=R$	3	360.27	7.65	0.011
DSR Days on nest	2	364.38	9.74	<0.01
DSR $T1=T2=A1=A2=R$	1	366.46	9.81	<0.01
DSR $A1=A2 \neq T1=T2=R$	2	365.89	11.25	<0.01
DSR $T1 \neq T2=A1=A2=R$	2	366.31	11.67	<0.01
DSR $T1 \neq A2 \neq T2=A1=R$	3	365.13	12.51	<0.01
DSR $A1 \neq A2 \neq T1=T2=R$	3	365.13	12.51	<0.01
DSR $T1 \neq A1 \neq T2=A2=R$	3	366.20	13.58	<0.01

^aMinimum $-2\ln L = 352.6185$

RESULTS

I found 86% of turkey nests with cameras failed, compared to 85% of turkey nests without cameras. After removing abandoned nests (with camera = 5; without camera = 3) from the data, nest failure due to predation was the same (14/17). Artificial nests handled regularly failed more frequently than artificial nests that were not handled (68 and 50%, respectively). In addition, 27% of cameras set up on random points with no eggs captured events (e.g., predator photographs), which I considered an analogue to nest failure. The most common nest predators photographed in my study were common ravens (*Corvus corax*), raccoons (*Procyon lotor*), and feral hogs (*Sus scrofa*) in that order, and each predator species had a different preference for particular nest types (Table 3.2).

Model averaged estimates based on the best approximating model ($DSR_{T1=A1 \neq T2=A2 \neq R}$; Table 1) for daily nest survival partitioned my nests into 3 groups; control (no camera) and artificial nests that were unhandled (0.9066; unconditional SE=0.0205); treatment and artificial nest that were handled (0.8659; unconditional SE=0.0285), and a non-baited random point with a camera (0.9629; unconditional SE=0.0188).

DISCUSSION

Based on my descriptive results, artificial nests were less likely to fail than live nests, regardless of whether a camera was used. My results contrast with those in most published studies, which find artificial nests failing at higher rates than live nests (Major and Kendal 1996). My estimates of daily survival, however, indicated little support for the model equivalent to the descriptive results ($DSR_{A1=A2 \neq T1=T2 = R}$; Table 1).

Table 3.2. Predators photographed at different nest types during camera study (n = number of nests where predator species were identified from photographs).

Predator	Turkey nest with camera ($n = 7$ nests)	Artificial not handled ($n = 6$ nests)	Artificial handled ($n = 6$ nests)	Camera no eggs ($n = 6$ nests)
Collared peccary (<i>Pecari tajacu</i>)	0	0	0	2
Common raven (<i>Corvus corax</i>)	3	2	4	0
Coyote (<i>Canis latrans</i>)	0	0	0	2
Feral hog (<i>Sus scrofa</i>)	1	0	1	3
Gray fox (<i>Urocyon cinereoargenteus</i>)	1	0	0	1
Nine-banded armadillo (<i>Dasypus novemcinctus</i>)	1	0	0	0
Porcupine (<i>Erethizontidae Erethizon</i>)	0	0	1	0
Raccoon (<i>Procyon lotor</i>)	3	0	2	0
Western scrub jay (<i>Aphelocoma californica</i>)	0	1	1	0
Western spotted skunk (<i>Spilogale gracilis</i>)	0	1	0	0

Rather, my model selection results indicated that unhandled artificial nests were lost at the same rate as control nests (turkey nests without cameras), whereas handled artificial and treatment nests (turkey nests with cameras) were lost at an equal rate but at a higher rate than unhandled and control nests. An equal percentage of control and treatment nests failed via predation; however, loss rate differed between these 2 groups as treatment nests exhibited lower survival probability over a 28 day incubation period (0.0177) than did control nests (0.064).

Protocols for data collection at control and treatment nests differed only in the use of cameras, so my results indicate that cameras negatively impacted nest survival of Rio Grande wild turkey hens. My results contrast with those of Pharris and Goetz (1980) and Leimgruber et al. (1994) who found cameras had no effect on nest success as well as Herranz et al. (2002) who found that cameras that were not camouflaged repelled predators. In addition, 27% of cameras I set up at random points photographed known nest-predator species. As expected, estimates of daily survival were much higher for randomly located, non-baited camera locations; however, the frequency of predator activity at these locations supports the contention that cameras, or at least the action of setting up cameras, can draw nest predators to camera locations (Hernandez et al. 1997b). Whether predators photographed at random camera locations were just passing by, investigating the camera, following my scent, or following trails in the vegetation made by researchers is unknown. Regardless, event frequency at these random points implies that predation of nests within this system is to some degree a random process tied to the specific search image of the predator (Wilson and Cooper 1998).

Attracting predator species that would not typically predate an active nest is a concern for those conducting studies using artificial nests (Major and Kendal 1996). Avian species are often reported as unnatural nest predators in artificial nesting studies (Willebrand and Marcstrom 1988); therefore, I expected more predation from avian species on our artificial nests. Instead, treatment nests and handled artificial nests were predated actively by raccoons (Table 3.2), the most frequent nest predator in the region (Schwertner et al. 2004), while unhandled artificial nests and random camera points were unvisited by raccoons. Thus, raccoons might follow trails or movement (hen or human) into nesting areas (Picman and Schriml 1994).

Given the importance of sound nesting studies to the management of avian populations, it is imperative that researchers and managers understand the reliability and consequence of methods such as artificial nests and camera use. If these approaches do not reliably predict predation, or if they show a detrimental effect on natural populations, then their use should be limited to stable or increasing populations while attempts are made to fine tune their application.

CHAPTER IV

EFFECTS OF DISTURBANCE ON NEST SITE SELECTION OF RIO GRANDE WILD TURKEYS ON THE EDWARDS PLATEAU

Avian species most likely select habitat for 3 primary reasons: food availability, safety (reduced risk of predation), and availability of nest sites (Brawn et al. 2001). However, at a larger scale birds may consider size, shape, distribution, configuration, and connectedness of different patch types when making a selection (Wiens et al. 1993). Understanding why individuals select certain habitat types and at which scale decisions are made is required if managers are to successfully manipulate habitat to benefit the species.

Quality nesting habitat is important to ground-nesting avian species due to the vulnerability of their nests (Rollins and Carroll 2001), as areas with limited nesting habitat characteristically have higher nest predation (Badyaev 1995). Since nest predation is the leading cause of avian nest loss (Ricklefs 1969, Martin 1987), limited nesting habitat could account for low recruitment. Different disturbance regimes (e.g., controlled fire, mechanical clearing, herbicide application, and livestock grazing) are often used to manage avian habitat. While disturbance can be detrimental to a system, managed disturbance also can maintain a system in an earlier successional stage (Smeins 1980, Porter 1992) which can benefit many wildlife species. Fire, for example, removes litter, returns nutrients to the soil, promotes new growth of herbaceous vegetation, and increases forage quality and palatability (Holbrook 1961, Porter 1992). Other forms of disturbance such as mechanical clearing can be used to remove woody vegetation in

order to reestablish grassland habitat and promote vegetative diversity (Lezberg et al. 2006).

Nest site selection by wild turkeys (*Meleagris gallopavo* spp.) has been widely studied, typically at a microhabitat level (Schmutz et al. 1989, Chamberlain and Leopold 1998, Lehman et al. 2002, Randel et al. 2005). Obstruction of vision created by dense vegetation is one factor identified regularly in determination of nest site location for both eastern (*M. g. silvestris*) and Rio Grande subspecies (*M. g. intermedia*; Lazarus and Porter 1985, Schmutz et al. 1989, Porter 1992, Randel et al. 2005). Nest-site characteristics of both subspecies in the same area showed no differences between vegetative characteristics selected for nesting sites (Lehman et al. 2002). Common habitat management recommendations from studies of eastern wild turkeys are to intersperse freshly burned areas for brooding with dense, unburned undergrowth for nesting (Stoddard 1963, Hurst 1978, Hurst 1981). Nest habitat studies often report birds nesting in areas close to other habitat requirements (e.g., brooding habitat, water; Cook 1973, Hon et al. 1978, Hurst 1978, Ransom et al. 1987, Beasom and Wilson 1992, Healy 1992). Hence, spatial structure of the area surrounding nests could be as important as vegetative structure at the nest location. While various disturbance regimes are commonly recommended for Rio Grande turkey habitat management (Cathey et al. 2007), little work has been done on the effect of management practices on nest site selection.

The Edwards Plateau of Texas was historically a fire maintained oak–juniper savanna (Smeins 1980), and according to a model developed by Fuhlendorf et al. (1996),

cool season fire at a return interval of less than 25 years will maintain an area in the western part of this region as a grassland for 150 years. Recent land ownership fragmentation, along with urbanization and livestock overgrazing, altered the fire regime resulting in juniper encroachment (Fuhlendorf et al. 1996, Wills 2005).

Historically, the Edwards Plateau was the stronghold for Rio Grande wild turkeys (Walker 1954), although certain areas of the region have experienced recent declines in turkey abundance (Schaap et al. 2005, Collier et al. 2007a, Randel et al. 2007). I evaluated the effect of disturbance on the spatial structure of nest sites selected by Rio Grande wild turkeys in the Edwards Plateau of Texas. My objectives were to: 1) evaluate nest site selection in disturbed (burned and unburned) areas on an intensively managed wildlife management area, 2) quantify the spatial structure of burned areas, and 3) compare spatial structure of burned areas to nesting habitat selected at additional research locations on the Edwards Plateau.

STUDY AREA

I conducted research on the Edwards Plateau of Texas from January through July 2005–2007 on 4 sites in Kerr, Real, Bandera and Medina counties. All of my study sites were rangelands with flat to rolling divides, shallow soils, and limestone bedrock (Gould 1975). The first site was the Kerr Wildlife Management Area (KWMA) in western Kerr County and a privately owned property adjacent to the KWMA. The KWMA was used primarily for public education, habitat management seminars, and hunting. Cool season prescribed fire was used on certain areas of the property on a 5 year rotation to maintain savanna and open woodland habitat for wildlife and livestock (Wills 2005). The

neighboring property was a 4,843 ha wildlife management-oriented cattle ranch used for livestock production and hunting. The second site, located in southern Real County, northwest of Leakey, Texas, was a privately owned game ranch used primarily for hunting. Site 3 was located in northwestern Bandera County, west of Medina, Texas. It also was a privately owned ranch primarily used for hunting and livestock production. Site 4 was located in northern Medina County, south of Bandera, Texas, and was a privately owned cattle and sheep ranch. The owners leased the hunting rights on the property. A livestock grazing program was in place on all properties except site 2 and some mechanical clearing was used on all sites.

METHODS

I trapped wild turkeys on 4 study sites on the Edwards Plateau from January–March, 2005–2007. Hens were captured using drop-nets and walk-in traps baited with milo. Each captured individual was fitted with a mortality-sensitive, backpack style radiotransmitter (69.0–95.0 g; Advanced Telemetry Systems, Isanti, MN). Using radio-telemetry, I triangulated hens ≥ 3 times weekly during the breeding season until behavioral shifts suggested nest incubation had begun. I located nests within 1 day after we suspected hens were incubating to determine nest location (UTM), initiation date, clutch size, and approximate nest age.

I used burn data from the KWMA (unpublished) to create a geographic information system (GIS) database using nest locations, historical maps of burned areas (KMWA), and 2004 digital aerial photography from Texas Natural Resource Information Service (TNRIS). Nest locations on the KWMA were categorized into

burned and non-burned areas to evaluate frequencies of hen use, with use being defined as nesting. I used ERDAS 9.1 (Leica Geosystems, Atlanta, Georgia, USA) to classify vegetation from historical aerial photos into 3 separate classes: juniper (*Juniperus* spp.), oak (*Quercus* spp.), and non-woody cover. An accuracy assessment of the image classification was conducted by generating 200 points and comparing classified images with visual interpretation of the original image (Congalton 1991). Overall accuracy was 86% at the KWMA. Files were imported into ArcGis 9.2 (Environmental Systems Research Institute, Redlands, California, USA). Because vegetation within 40 m of the nest site has been shown to be similar to that of the nest site (Lazarus and Porter 1985), I chose to evaluate the spatial structure surrounding the nest sites at a slightly larger scale (100 m). I clipped 59 nest-location buffers from the KWMA in a grid and analyzed them using FRAGSTATS 3.3 (McGarigal et al. 2002). Metrics that describe the spatial pattern and structure (patch density – number of patches/100 ha, mean patch area – average patch area, edge density – m/ha of edge habitat, and percent of landscape – percent of area consisting of class) were used to evaluate habitat structure surrounding nest locations.

After evaluating the relationship of fire to nest locations on the KWMA, I compared the spatial structure of nest locations from the KWMA to the habitat structure of nest areas from my remaining 3 study sites where fire was not regularly used. Spatial structure of nest locations from the other 3 sites was analyzed in the same manner as that of the KWMA except there were no burn data available for these sites.

RESULTS

I trapped 142 hens on 4 study sites January–March, 2005–2007. Because of hen mortality, land access issues, and radio failure I was able to actively track 93 hens during my 3-year study, locating 162 nests on the 4 study sites.

Turkey hens on the KWMA consistently nested in burned areas. Out of 59 nests, only 5 were located in areas that were not burned during the 9 previous years (19 of 20 nests in 2005, 19 of 22 in 2006, 16 of 17 in 2007). Three of the 5 nests from unburned areas were located $\leq 100\text{m}$ from a burned area. I found no difference in the number of successful nests from burned (11 of 54; 20.3%) and unburned (1 of 5; 20%) areas.

Burned areas on the KWMA were characteristic of savanna habitat with large grassland areas interspersed with small woody patches (Fig. 4.1). Non-woody species made up the greatest percentage of the landscape in burned areas. Burned areas also were characterized by high edge density of both woody and non-woody species (Fig. 4.2). Rio Grande wild turkey hens inhabiting all my study sites where fire was not used as a management tool chose nesting habitat with the same spatial structure as that of the burned areas on the KWMA (Fig. 4.3).

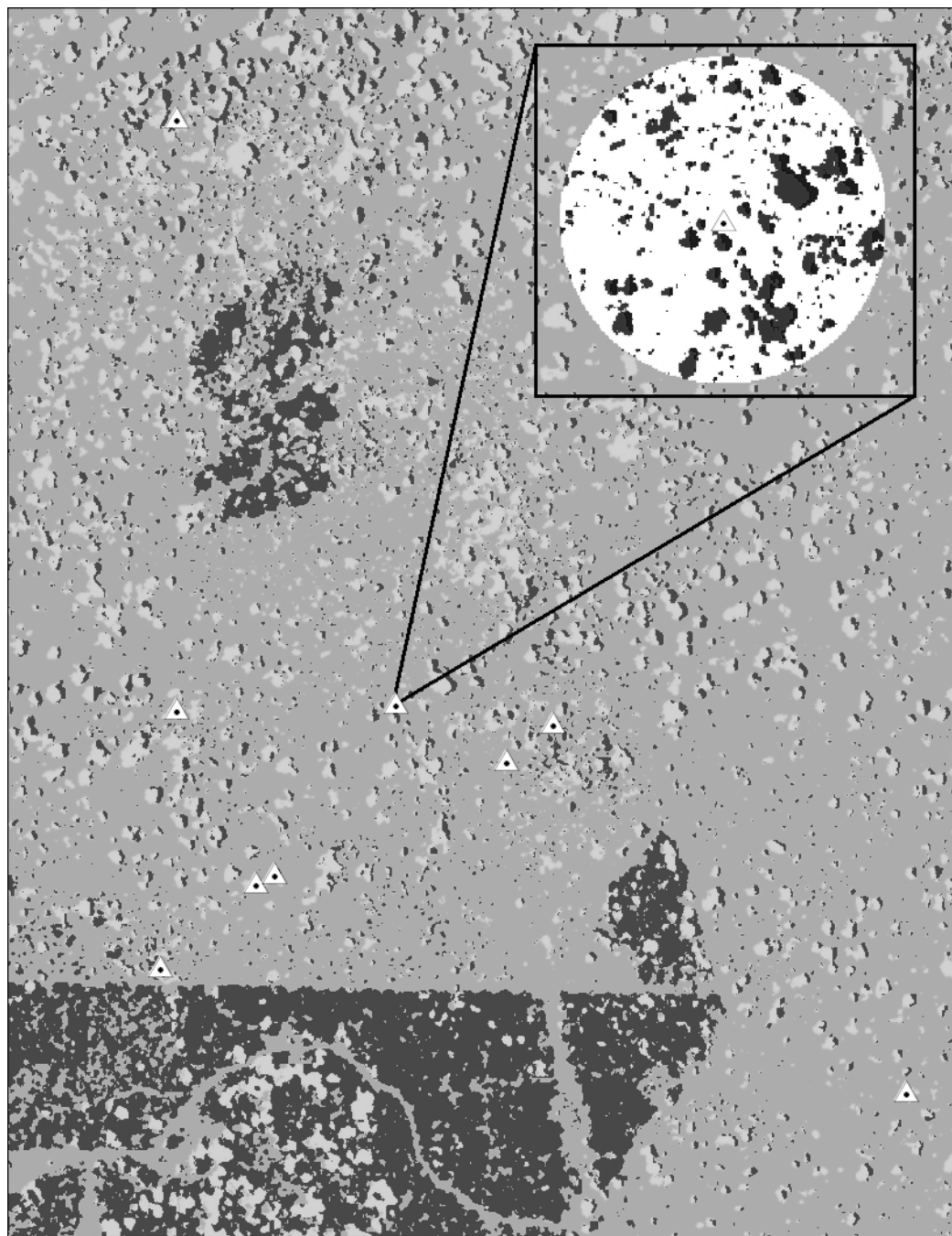


Figure 4.1. Sample of 9 Rio Grande wild turkey nest locations in 100.46 ha of savanna habitat found on the Kerr Wildlife Management Area, Texas. Inset shows the spatial structure of habitat surrounding a single nest.

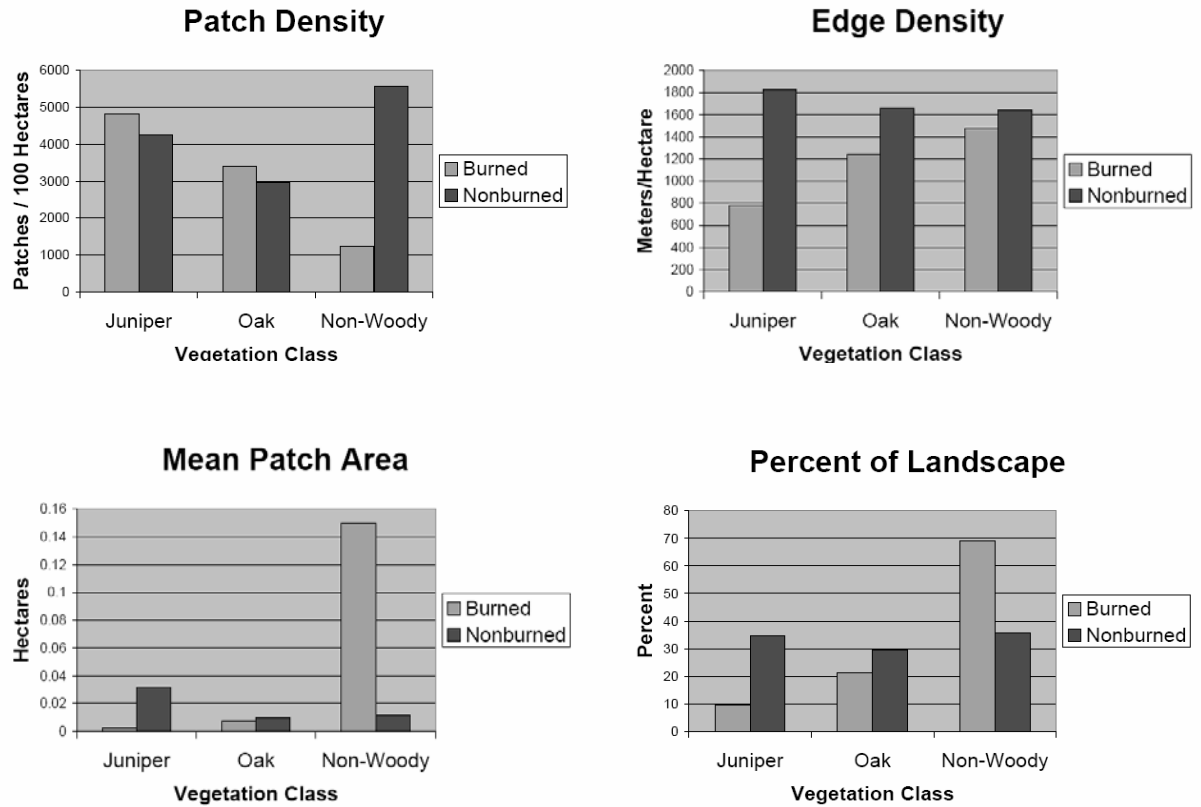


Figure 4.2. Spatial structure of Rio Grande wild turkey nest sites in burned and unburned areas on the Kerr Wildlife Management Area, Texas, 2005–2007.

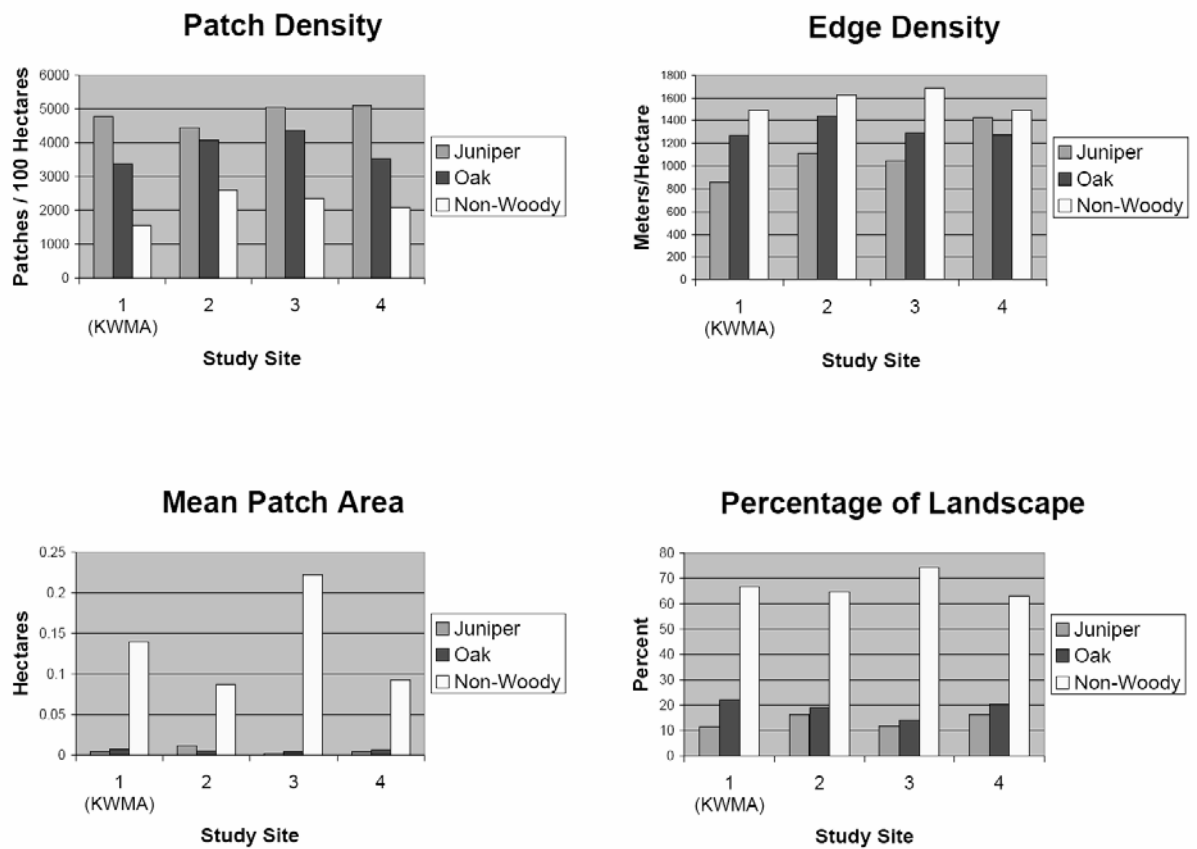


Figure 4.3. Spatial structure of all Rio Grande wild turkey nest sites for the Kerr Wildlife Management Area (KWMA) and 3 additional study areas in the Edwards Plateau of Texas, 2005–2007.

DISCUSSION

Frequent cool season fire is an important management practice on the KWMA, providing wildlife with habitat structure much like that historically found in the region (Smeins 1980). While my other study locations were not regularly disturbed by controlled fire, Rio Grande wild turkey hens at these sites chose nest locations essentially identical to those used at the KWMA, demonstrating that Rio Grande hens in the southern Edwards Plateau preferentially select nesting habitats. Selected nest locations occurred in areas with large numbers of small, irregular shaped, oak-juniper motts surrounded by large patches of grassland. I suggest hens select these areas to obtain sufficient nesting cover, but also so they can move freely during foraging and detect predators at a distance (Holbrook 1961).

Areas with large amounts of edge habitat have been shown to be a favored nesting location for turkeys (Thogmartin 1999). Turkeys in my study exhibited similar results; they consistently nested in areas with high edge density of woody and non woody vegetation. Vegetation structure at wild turkey nests has been well documented, and studies generally point to screening cover provided by dense herbaceous vegetation as important nest site selection criterion (Schmutz et al. 1989, Porter 1992, Randel et al. 2005). Because of the consistency with which turkeys in my study selected a specific spatial structure for nest locations, my results suggest that the spatial structure of the area surrounding the nest is likely an important factor for Rio Grande hens in the nest site selection process. Recent work has quantified spatial structure around eastern wild turkey nests (Lazarus and Porter 1985, Thogmartin 1999), but to my knowledge, my

study is the first to do so for the Rio Grande subspecies. Research by Lazarus and Porter (1985) examined spatial structure of areas surrounding nest sites of eastern wild turkeys in Minnesota at 3 different scales (0.003 ha, 0.5 ha, and 65 ha), and found that the structure of the 0.5 ha surrounding the nest was similar to that of the immediate nest area. Thogmartin (1999) evaluated the spatial structure of nest areas for eastern turkeys in Arkansas at a broad scale (900 ha), finding patch size, slope, aspect, cover type, and cover type interspersions to all be important nest-site selection criteria. I chose to use a 100 m buffer (3.14 ha) around each nest site in order to sample a sufficiently large area, including habitat outside of the 0.5 ha area that is likely to be similar to habitat at the nest site, but much smaller than the 65 ha used by Lazarus and Porter (1985) that would probably not be fully utilized by an incubating hen spending ≤ 1 hour off the nest per day (Healy 1992).

Because lack of suitable nesting habitat is believed to limit wild turkey populations (Thogmartin 1999), it is crucial that managers understand habitat selection by nesting Rio Grande hens. Turkeys on my study sites consistently selected nesting habitat with a specific spatial structure, suggesting that birds on the Edwards Plateau may select nesting habitat on a more general scale before concentrating on the microhabitat factors that are often evaluated. Since disturbance can affect all aspects of avian habitat from the microhabitat to the regional scale (Brawn et al. 2001), my results indicate that regular disturbance can be useful in molding habitat to cater toward a particular avian species (Baker and Lacki 1997, Klaus et al. 2005).

CHAPTER V

CONCLUSION

In an attempt to explain the declining Rio Grande wild turkey (*Meleagris gallopavo intermedia*) numbers in the southern Edwards Plateau, several factors have been investigated over the last 7 years. This research project evolved toward investigating reproductive ecology, and my particular focus was nesting ecology. The objectives of my study were to: 1) determine predators that are responsible for turkey nest predation events in the southeastern Edwards Plateau and quantify multiple predator and partial predation events, 2) determine the effect of cameras on the reproductive success of turkey nests and evaluate the reliability of artificial nests at estimating live nest predation rates, and 3) determine the effect of disturbance on spatial structure of nest sites selected by turkeys in the Edwards Plateau.

Nest predation was the leading cause of nest loss and predator communities in the region appeared to change between 2006 and 2007. The most frequent nest predator species in 2006 was the gray fox (*Urocyon cinereoargenteus*) followed closely by raccoons (*Procyon lotor*) and striped skunks (*Mephitis mephitis*; Table 2.1). In 2007, the most frequent nest predators were raccoons followed by Common ravens (*Corvus corax*; ravens were not photographed predating any nests in 2006). Additionally, 39% of predation events in my study included ≥ 1 predator species. This is significant because most nesting studies have used physical evidence left at nest sites to determine the nest predator responsible for the event. Having ≥ 1 predator predate the nest can greatly alter the appearance of the physical evidence left following the event. I also documented a

partial predation event by a Texas rat snake (*Elaphe obsoleta lindheimeri*) where the snake ate 7 of the 16 eggs in the clutch; the hen then resumed incubation and hatched the remaining eggs. Studies based on nest evidence would simply have concluded that the clutch size was 7, not 16, and that a predation event had not occurred. Based on my findings, I suggest that managers be aware of the potential bias involved with using physical evidence left at nest sites to determine nest predators due to the fact that the method makes it difficult to account for events such as multiple species and partial predation events. It is imperative that researchers test and apply any method before mitigation strategies are developed.

Because artificial nests have been widely used in studies of avian nesting ecology and cameras are becoming a popular way to monitor them, I evaluated the effect of cameras on real and artificial Rio Grande wild turkey nests. I also evaluated the accuracy of artificial nests at determining predation rates of real nests. My descriptive results suggested that cameras had no effect on the success of live nests and that artificial nests underestimated live nest predation rates. Additionally, I photographed known nest predator species at 27% of random points with no eggs. Model averaged estimates for daily survival of nests in my experiment separated nests into 3 groups; control (no camera) and artificial nests that were unhandled (DSR = 0.9066; SE=0.0205); treatment and artificial nest that were handled (DSR = 0.8659; SE=0.0285) and a random point with a camera (DSR = 0.9629; SE=0.0188). Contrary to my descriptive results, daily survival rates suggest that cameras and human activity associated with nest surveillance could increase the rate at which nests fail. My results also demonstrate that nest

predation could be a random occurrence depending on nest predators' unique search image. Given the importance of sound nesting studies to the management of avian populations, it is imperative that researchers and managers understand the reliability and consequence of methods such as artificial nests and camera use. If these approaches do not reliably predict predation, or if they show a detrimental effect on natural populations, then their use should be limited to stable or increasing populations while attempts are made to fine tune their application.

I evaluated the effect of disturbance on nest site selection of Rio Grande wild turkeys. Turkey hens on the Kerr Wildlife Management Area (KWMA) consistently chose burned areas to nest in. Out of 59 nests on the KWMA, 2005–2007, only 5 nests were located in areas that had not burned in the 9 years prior (19 of 20 nests in 2005, 19 of 22 in 2006, 16 of 17 in 2007). These burned areas on the KWMA were large grassland patches interspersed with many small, irregular shaped, woody patches. Birds across all of my study sites chose nesting habitat with the same spatial structure as that of the burned areas on the KWMA. Because hens in my study chose nesting habitat in burned areas, and those areas that resembled the historic oak–juniper savanna, I recommend landowners use a rotational controlled burning regime, or some other form of disturbance, to achieve the specific spatial structure for nesting habitat preferred by the Rio Grande wild turkey hens in our study.

With the current urbanization and land ownership fragmentation occurring in the Edwards Plateau, it is important for small landowners to understand the importance of sound habitat management, and that it will most likely have to be done through the work

of cooperatives. Working together, small landowners can provide wildlife with large patches of well managed habitat. Since available nesting habitat is believed to limit some turkey populations (Thogmartin 1999), these cooperatives could be one way to provide Rio Grande wild turkeys with more useable nesting habitat, consequently lowering predation and increasing recruitment.

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VITA

Justin Zachary Dreibelbis

Address: 210 Nagle Hall 2258 TAMU, College Station, TX, 77843-2258

Email Address: dribbs15@tamu.edu

Education:

B.S. Texas A&M University, Agricultural Development, College Station,
Texas. 2003.

M.S. Texas A&M University, Department of Wildlife and Fisheries Sciences,
College Station, Texas. 2008.