SURVIVAL AND MAMMALIAN PREDATION OF RIO GRANDE TURKEYS ON THE EDWARDS PLATEAU, TEXAS

A Thesis

by

BEAU JUDSON WILLSEY

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

December 2003

Major Subject: Wildlife and Fisheries Sciences

SURVIVAL AND MAMMALIAN PREDATION OF RIO GRANDE TURKEYS ON THE EDWARDS PLATEAU, TEXAS

A Thesis

by

BEAU JUDSON WILLSEY

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

MASTER OF SCIENCE

Approved as to the style and content by:

Nova J. Silvy (Co-Chair of Committee)	Markus J. Peterson (Co-Chair of Committee)
Xinyuan B. Wu (Member)	Robert D. Brown (Head of Department)

December 2003

Major Subject: Wildlife and Fisheries Sciences

ABSTRACT

Survival and Mammalian Predation of Rio Grande Turkeys on the Edwards Plateau, Texas.
(December 2003)
Beau Judson Willsey, B.S., North Carolina State University
Co-chairs of Advisory Committee: Dr. Nova J. Silvy
Dr. Markus J. Peterson

Trends in Rio Grande wild turkey (*Meleagris gallopavo intermedia*) abundance on the Edwards Plateau (EP), Texas, have been either stable or in decline since the 1970s. Four study areas, 2 each within stable (Stable Area A, SAA; Stable Area B, SAB) and declining regions (Declining Area A, DAA; Declining Area B, DAB), were delineated to examine (1) both annual and seasonal survival, (2) relative mammalian predator mean abundance (RMA), and (3) potential effects of lunar phase on scent-station visitation.

During February 2001–March 2003, 257 turkeys were captured and instrumented with radio transmitters. Survival probabilities were generated using a Kaplan-Meier product limit estimator; a log-rank test tested for differences among sites. Annual survival was statistically different between regions (stable 0.566 ± 0.081; declining 0.737 ± 0.094; $X^2 = 3.68$, $P = 0.055$) in 2002. Seasonal survival differed between regions (stable 0.812 ± 0.103; declining 0.718 ± 0.130; $X^2 = 3.88$, $P = 0.049$) in spring 2003. Annual survival results during 2002 were counterintuitive with turkey trend data.

Scent-station transects were established on non-paved ranch roads within study regions. Scent-station indices revealed higher ($H = 19.653$, $P \leq 0.001$) RMA of opossum (*Didelphis virginiana*) and skunk (eastern spotted [*Spilogale putorius*], striped [*Mephitis mephitis*], or western spotted [*S. gracilis*]) (SAA, $\bar{x} = 0.0148$; SAB, $\bar{x} = 0.0151$; DAA, $\bar{x} = 0.0042$; DAB, $\bar{x} = 0.0065$) on stable areas. Higher RMA of coyotes (*Canis latrans*) on declining areas (SAA, $\bar{x} = 0.0067$; SAB, $\bar{x} = 0.0022$; DAA $\bar{x} = 0.0234$; DAB $\bar{x} = 0.0434$) suggested a possible causative factor of the decline, but abundance indices were not verified by empirical data though.

Lunar phase was not a significant ($T = -0.225$, $P = 0.822$) covariate in scent-station visits by raccoons, opossums (new, $\bar{x} = 0.0111$; full, $\bar{x} = 0.0324$), or unidentified tracks (new, $\bar{x} = 0.0649$; full, $\bar{x} = 0.0375$). Nightly precipitation and wind speed probably influence mammalian use of scent stations more so than lunar illumination.

ACKNOWLEDGEMENTS

This experience has been 5 years in the making; you can never truly thank all the animals and people who have made this a memorable journey. Let me first thank the excellent faculty at N.C. State University who highly recommends their undergraduates to continue on with their education.

To my first couple of graduate student “bosses,” Walter Lane and Jeb Linscombe, never could I have learned what was ahead of me better than to work along side these fine fellows. I left both of them with growing anticipation and apprehension of the years to come.

If you have ever worked for Dr. John Toepfer you will appreciate that no acknowledgement can be complete without thanking him. Dr. Toepfer was instrumental in putting me where I am today; I will never forget my 1.5 years working with him.

Thanks go out to Dr. Nova J. Silvy and Dr. Markus J. Peterson for bringing me in on this turkey project. I’ve enjoyed my time in Texas, but I can only say that since it is almost over. In retrospect my time here will grow fonder. Thank you, too, Dr. Xinyuan B. Wu for taking time to be on my committee.

Many thanks go out to the staff at Kerr Wildlife Management Area, Donnie Frels, Jr., Mark Edinburgh, Fernando Gutierrezz, Jay Carroll, Chad Meadows, Gene Fuchs, Bill Armstrong, and Ebie Gray. Anytime I needed anything, they were either there or at least pointed me in the right direction. To my turkey-trapping partner Ray Aguirre, it was truly a pleasure to know you.

Who could forget my friends and fellow turkey chasers, Dustin Jones, Jody Schaap, C. J. Randel, Dean Marquardt, and John Michael Hairston. I must thank them for many interesting moments, sharing the pain, and making time in those damn trucks tolerable.

I can not thank my family enough. From the get go, leaving home a week and a half from graduation and 2 days after Christmas in 1998, they have been there mentally and spiritually to support me. Unbeknown to them, my family has pulled me through many a depressing time. I owe my family more than I could ever repay; my deepest appreciation goes to them forever.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I
INTRODUCTION

Rio Grande wild turkey (*Meleagris gallopavo intermedia*) numbers are declining on some portions of the Edwards Plateau (EP), Texas, an area once considered the heart of Rio Grande turkey range. Since 1975, turkey abundance on the southern portion of the EP, which traditionally held a higher abundance than the remainder of the region, has been declining while populations elsewhere on the EP have remained relatively stable. To understand this downward trend, hypotheses were formulated and tested to gain insight into the demographic discrepancies recorded between regions of stable and declining populations.

Survival estimates of Rio Grande turkeys on the EP do not exist. However, in other areas of Texas as well as Kansas, adult and juvenile survivorship rates range from 0.324 to 0.762 (Ransom et al. 1987, Glazener et al. 1990, Smith-Blair 1993, Miller et al. 1995). Although coyotes (*Canis latrans*), bobcats (*Felis rufus*), raccoons (*Procyon lotor*), and great-horned owls (*Bufo virginianus*) depredate adult Rio Grande turkeys, Walker (1949, 1951) and Markley (1967) did not consider predation of adults and juveniles (3 –12 months post-hatch) an important limiting factor.

An initial step toward determining causes of declining turkey abundance on the EP was to examine survival and recruitment. My research examined adult and juvenile (3–12 months post-hatch) survival to determine how these demographic variables affected population trends within the EP. I hypothesized there were (1) significant differences in adult and juvenile survival between stable and declining regions, and (2) that observed differences were the result of differing degrees of mammalian predation. These hypotheses will be addressed in Chapters II and III, respectively. A third hypothesis, that lunar phase contributed to mammalian scent-station visitation variance, also was tested and discussed in Chapter IV.

OBJECTIVES

1. To compare survival probabilities between stable and declining turkey populations on the EP.
2. To compare mammalian predator relative mean abundance (RMA) between stable and declining areas on the EP.
3. To determine if lunar phase affected mammalian visitation to scent-station transects.

STUDY REGIONS

Edwards Plateau

The study regions were located on the rolling and irregular topography of west-central Texas “Hill Country,” or the Balcones Canyonlands (Gould 1975). A comprehensive review of vegetation, soil, hydrology, and climate for the area was available (Riskind and Diamond 1988). Additional soil

____

This thesis follows the style and format of the Journal of Wildlife Management.

classification data was available from the National Resource Conservation Service, whom broadly classified the study sites as Low Stony Hill (Range Site Number 081BY337TX), Redland (RSN 081BY340TX), Loamy Bottom (RSN 081BY335TX), or Steep Rocky (RSN 081BY350TX).

The EP was classified predominately as rangeland. Gould (1975) identified the climax vegetation community as tall and mid-size grasses including various species of bluestems (*Andropogon* spp.), gramas (*Bouteloua* spp.), and panicum (*Panicum* spp.). Mid and over-story vegetation included Ashe juniper (*Juniperus ashei*), live oak (*Quercus virginiana fusiformes*), and shinnery oak (*Q. pungens vaseyana*). In addition, important turkey roosting trees found along river bottoms included bald cypress (*Taxodium distichum*), cottonwood (*Populus deltoides*), and pecan (*Carya illnoinensis*) (Glazener 1967, Quinton et al. 1980, Reagan and Morgan 1980).

Much of the private land in the area was used for livestock production (cattle, goat, and sheep) and wild game hunts. In addition to wild turkey, white-tailed deer (*Odocoileus virginianus*), and northern bobwhite (*Colinus virginianus*), abundant exotic game such as Aoudad sheep (*Ammotragus lervia*), feral hog (*Sus scrofa*), black-buck antelope (*Antilope cervicapra*), axis deer (*Axis axis*), fallow deer (*Cervus dama*), and sika deer (*C. nippon*) were found.

Study Regions

The EP is located west of Austin and San Antonio, Texas (Figure 1). On the southern portion of the EP the Texas Parks and Wildlife Department recorded a declining trend of turkey abundance, but not on the remainder of the EP. Surveys were conducted on both private and public land, and biologists, who were in contact with landowners, had an intimate knowledge of where differences in abundance occurred. The first study areas delineated were in Bandera and Kerr counties to represent areas of declining and stable abundance, respectively. Additional sites were located by similar methods, i.e. survey data and cooperation with locale landowners.

Study Areas

Four study areas, 2 each within the stable and declining regions of turkey abundance, were delineated on the EP. Stable areas were located in Kerr and Real Counties, and are hereafter respectively referred to as Stable Area A (SAA) and Stable Area B (SAB). Study areas in the declining region were located on the northwest and southeast corners of Bandera County and are hereafter referred to as Declining Area A (DAA) and Declining Area B (DAB), respectively.

Stable Area A was located along the North Fork of the Guadalupe River, approximately 20.9 km west of Hunt, Texas. It was a 4,843 ha working cattle ranch with exotic and native game species. Stable Area B was located along the Frio River, approximately 9.4 km north of Leakey, Texas. It was primarily an exotic and native game ranch consisting of 984 ha.

Declining Area A, an 8,858 ha working cattle ranch with exotic and native game, was located near the Medina River, approximately 18.8 km northwest of Medina, Texas. Declining Area B, located approximately 17.0 km south of the Medina River and Bandera, Texas, was a 2,910 ha working livestock (cattle and sheep) ranch with exotic and native wildlife.

Varying between 38 and 83 cm, average annual rainfall in the area was sporadic, and has historically resulted in a greater number of drought years (Gould 1975). Given the uneven spatial and temporal distribution of rainfall, precipitation data from 3 National Climatic Data Center (NCDC) weather stations, Camp Verde (Cooperative Station ID 411395), Hunt (Cooperative Station ID 414375), and Leakey (Cooperative Station ID 415113), were obtained. During my study average annual precipitation, January – December, for Camp Verde, Hunt, and Leakey was respectively 8.00 cm, 6.40 cm, and 6.05 cm during 2001 and 13.34 cm, 6.45 cm, and 8.92 cm in 2002, respectively.

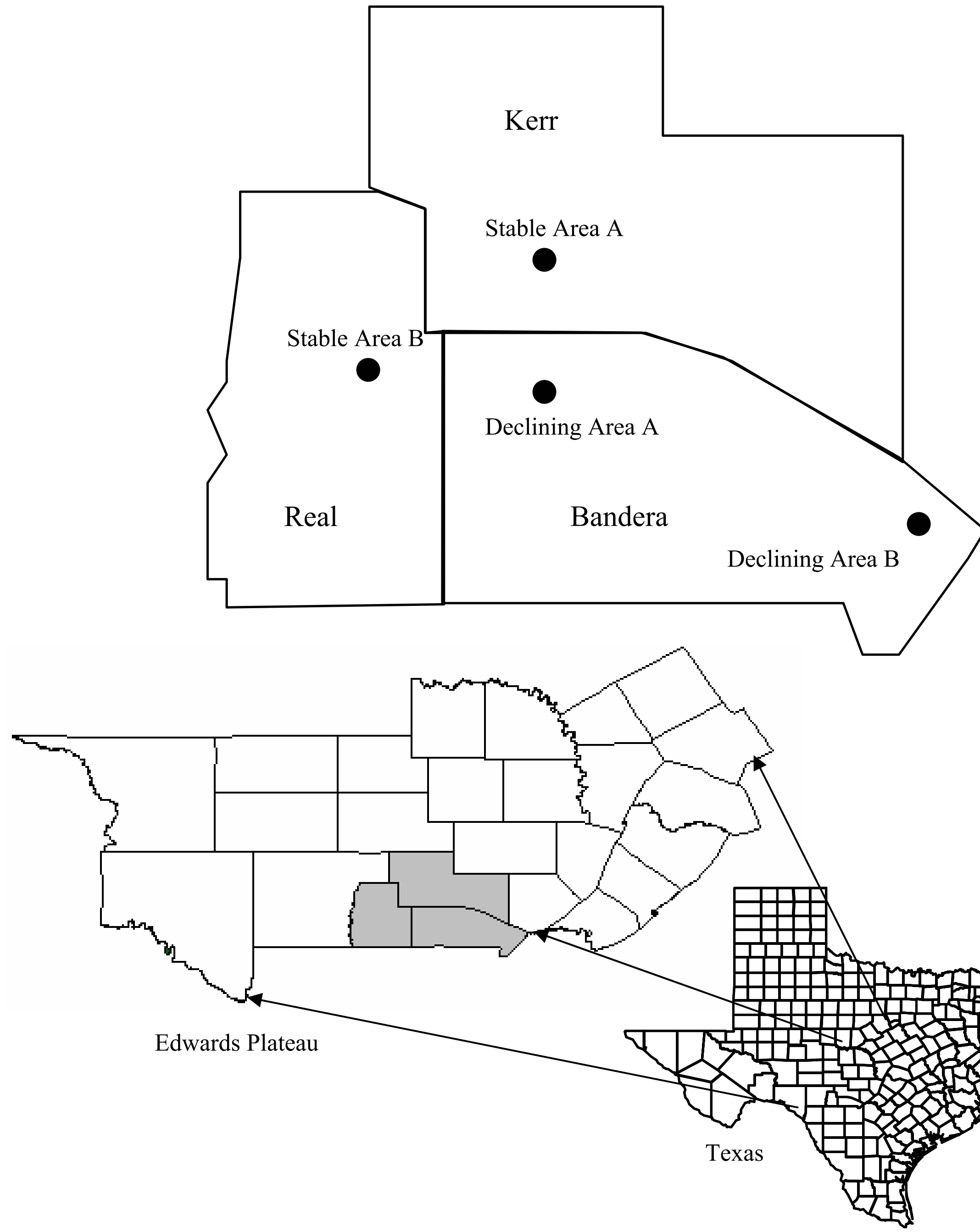

Fig. 1. Study areas within stable and declining regions of Rio Grande turkey abundance, Edwards Plateau, Texas, USA.

CHAPTER II

SURVIVAL OF RIO GRANDE TURKEYS ON THE EDWARDS PLATEAU, TEXAS

Population dynamics are functions of recruitment, death, emigration, and immigration; knowledge of these factors is essential when comparing populations with different trends in abundance. Using radio telemetry, mortality is one of the simplest factors to examine because dead individuals are examined soon after death providing insight into causative reasons for population decline. Therefore, an initial step in assessing trend data is to examine mortality rates and determine the probability of survivorship over time.

Turkey abundance on the EP varies across the region. Historically, the southern portion of the EP held a greater abundance than did the rest of the region. However, since at least the mid 1970s the Texas Parks and Wildlife Department has recorded a decline in turkey abundance on the southern portion, but not for the rest of the region (Chapter I).

Turkey survival estimates within native range exist for certain areas of Texas and south-central Kansas but not on the EP. On the Rob and Bessie Welder Wildlife Refuge Area, Texas, Glazener et al. (1990) reported an annual survival range of 0.324–0.762 from 1961–1972; Ransom et al. (1987) reported an estimated mean annual survival of 0.726 from 2 years of data. Smith-Blair (1993) found annual survivorship in the Texas panhandle to be 52.6 and 54.3 during 1990 and 1991, respectively. Miller et al. (1995) reported mean survival from January–September 1991 and 1992 to be 0.547 in south-central Kansas; estimated mean annual survival during the same time was 0.449 (Miller 1993).

In this chapter, I test the following null hypothesis: there was no difference in survivorship probabilities between regions of stable and declining turkey abundance. The research hypothesis being that survivorship was greater on the stable region.

STUDY AREAS AND METHODS

Study Areas

Study areas were located on the EP, Texas. Both historic (Gould 1975, Riskind and Diamond 1988) and recent data on soils, land use, precipitation, and major faunal and floral species were compiled for the region (Chapter I). Rio Grande wild turkeys were trapped on 4 study areas located within the EP, Texas. Two sites each were located in regions where turkey-trend data from the early 1970s showed either a stable or declining trend (Chapter I). Stable areas (SAA and SAB) were, respectively, located in Kerr and Real counties; declining areas (DAA and DAB) on the northwest and southeast corners of Bandera County (Fig. 1), respectively.

Trapping

Turkeys were trapped only on SAA and DAA during winter 2001; all areas were trapped during winters 2002 and 2003. Winter-turkey flocks were captured using walk-in funnel traps (Davis 1994, Peterson et al. 2003), whereby each turkey was sexed, aged (juvenile or adult; Petrides 1945), and fitted with a numbered Texas Parks and Wildlife Department leg band using standard techniques. An animal use protocol (AUP) was approved by Texas A&M University's Lab Care Committee (AUP #: 2001 – 119).

Captured turkeys were outfitted with a backpack harness of 0.6-cm diameter elastic shock cord and a motion-sensitive radio transmitter broadcasting at 150–152.00 MHz (Advanced Telemetry Solutions, Isanti, Minnesota, USA). Although Nenno and Healy (1979) reported pen-raised turkeys adjusted to wearing backpack style transmitters within 1 week of instrumentation, in this study turkeys dying within 2 weeks of capture were censored from survivorship analysis. Two weeks post-capture was an adjustment period for turkeys being captured, handled, and outfitted with transmitters (Smith-Blair 1993, Miller et al. 1995, Hubbard et al. 1999).

Tracking

Radioed turkeys were located ≥ 3 times per week via triangulation, homing (White and Garrot 1990), or visual sighting. Vehicles mounted with a 4-element Yagi directional antenna were used to locate most turkeys, but other locations were determined by close-range telemetry using a similar, yet smaller, antenna. Many turkeys could not be located as frequently as desired due to land topography, turkey egress from study areas to areas where I could not obtain access, and transmitter malfunctions.

Survivorship rates and probabilities were calculated from mortality events. Turkeys were believed dead once a transmitter emitted a mortality pulse. The transmitter then was located, Universal Transverse Mercator (UTM) coordinates obtained, and the cause of mortality determined when possible.

Data Analysis

Mortality events were stratified by the maximum elapse of time between subsequent locations (Tsai et al. 1999). Turkeys located throughout the month were included in analysis; those that could not be located were censored. Due to the need to censor missing birds as well as add newly trapped birds, I used the staggered-entry modified Kaplan-Meier procedure to calculate survivorship probabilities (Pollock et al. 1989) and 95% confidence intervals (Cox and Oates 1984:51).

The Kaplan-Meier product limit estimator, initially developed for the medical field, has become a popular procedure for determining survival rates of many wildlife species. Pollock et al. (1989) introduced the staggered entry design, which allowed adding or removing (censoring) of individuals from the survey at different periods. Survivorship curves and variance estimates are generated with relative ease making the method widely popular, and therefore permitting comparisons between many wildlife population studies.

I used log-rank tests (Pollock et al. 1989) to test for differences in seasonal and annual survivorship probabilities among study areas and between study regions for radioed turkeys. Data were pooled for age in order to increase precision of estimates.

Annual survival rates were calculated from 1 March 2001–28 February 2002 (2001 estimate) and 1 April 2002–31 March 2003 (2002 estimate). I chose these dates in order to coincide with trapping efforts, which generally began in February and ended in March.

For seasonal analysis, I stratified annual data into 3 seasons, spring (March–July), fall (August–November), and winter (December–February). These seasons (Logan 1973, Baker et al. 1980) coincided with breeding and brood rearing months (spring), the forming of winter flocks and movement back to annual winter roosts (fall), and months when turkeys are in large flocks and staying close to winter roosts (winter).

RESULTS

Turkeys surviving the adjustment period from the trapping and radioing process totaled 257 (189 female, 68 male; Table 1). Annual survival rates (Table 2) during 2001 did not differ ($X^2 = 0.07$, $P = 0.791$) for all turkeys between SAA (0.669 ± 0.104) and DAA (0.724 ± 0.163). Annual survival rates differed in 2002 for all turkeys between SAA (0.533 ± 0.109) and DAA (0.804 ± 0.116) ($X^2 = 6.00$, $P = 0.014$) and between regions (stable, 0.566 ± 0.081; declining, 0.737 ± 0.094) ($X^2 = 3.68$, $P = 0.055$). During 2002, SAA lost 21 turkeys (4 males to hunting; 2 males and 3 females to predation; 3 males and 9 females to unknown causes), whereas DAA lost 6 turkeys, all of which were females (2 to predation; 4 to unknown causes). Turkey mortalities occurred throughout the year with the majority on SAA occurring during the spring (3 each in April and May 2002; 4 in March 2003). Seasonal tests, however, did not detect a difference ($X^2 = 0.27$; $P = 0.603$) between SAA (0.867 ± 0.102) and DAB (0.911 ± 0.099), nor regions ($X^2 = 0.16$; $P = 0.689$) in spring 2002.

During spring 2003 a difference was found between stable areas (SAA, 0.743 ± 0.130; SAB, 0.974 ± 0.069; $X^2 = 6.04$, $P = 0.014$), SAB and DAA (0.622 ± 0.168; $X^2 = 8.32$, $P = 0.004$), and between regions (stable, 0.812 ± 0.103; declining, 0.718 ± 0.130; $X^2 = 3.88$, $P = 0.049$; Table 3). One male turkey died from unknown causes on SAB during spring 2003, compared to 11 (2 each males and females to predation; 2 males and 5 females to unknown causes) and 12 (2 males and 3 females to predation; 1 male and 6 females to unknown causes) turkeys from SAA and DAA, respectively.

Table 1. Rio Grande turkeys surviving ≥ 2 weeks post-capture on study areas in both stable and declining regions, Edwards Plateau, Texas, February 2001–March 2003.

Year	Study area		Adult female	Juvenile female	Total female	Adult male	Juvenile male	Total male
2001	Stable	A	35	3	38	6	7	13
	Declining	A	25	2	27	1	2	3
2002	Stable	A	7	12	19	1	7	8
		B	5	9	14	0	8	8
	Declining	A	11	4	15	3	2	5
		B	6	4	10	0	5	5
2003	Stable	A	16	3	19	5	0	5
		B	14	14	28	2	9	11
	Declining	A	12	1	13	0	0	0
		B	14	2	16	2	8	10

Table 2. Annual Kaplan–Meier survival probabilities and 95% CI of Rio Grande turkeys on study areas in stable and declining regions, Edwards Plateau, Texas.

Year	Study area		Survival rate	95% CI
2001[a]	Stable	A	0.669	0.565 – 0.773
	Declining	A	0.724	0.561 – 0.887
2002[b]	Stable	A*	0.533	0.424 – 0.642
		B	0.623	0.501 – 0.744
	Declining	A*	0.804	0.687 – 0.920
		B	0.577	0.433 – 0.721

* Statistical differences at $\alpha = 0.05$.
[a]2001 (1 March 2001 – 28 February 2002)
[b]2002 (1 April 2002 – 31 March 2003)

Table 3. Seasonal Kaplan–Meier survival probabilities and 95% CI of Rio Grande turkeys on study areas in both stable and declining regions, Edwards Plateau, Texas, spring 2003.

Study area		Sex	*n*	Survivorship	95% CI
Stable	A	M	6	0.495	0.087 – 0.903
		F	26	0.595	0.509 – 0.682
	B	M	9	0.938	0.347 – 1.528
		F	11	0.833	0.404 – 1.263
Pooled stable areas		M	15	0.816	0.468 – 1.159
		F	37	0.817	0.568 – 1.066
Declining	A	M	2	0.400	-0.519 – 1.319
		F	18	0.573	0.427 – 0.718
	B	M	6	0.667	0.400 – 0.933
		F	9	0.667	0.449 – 0.884
Pooled declining areas		M	8	0.571	0.350 – 0.793
		F	27	0.768	0.534 – 1.002

DISCUSSION

Although, annual and seasonal survival rates for male and female Rio Grande turkeys were similar to those reported elsewhere in Texas and Kansas (Ransom et al. 1987, Glazener et al. 1990, Miller 1993, Smith-Blair 1993), a sustained difference between study regions in survival probabilities was not evident. No difference in the annual rate between regions in 2001 and greater survival on the declining region during 2002 falsified my research hypothesis. During 2002, turkeys trapped within the stable region experienced lower survival than turkeys in the declining region. This supported Glazener (1967) and Miller (1980) who reported that predation risks were greater for turkeys forced into unfavorable habitat and long-distance travels. Stable region turkeys frequently moved further and more often than turkeys trapped within the declining region (J. Schaap, Texas A&M University, unpublished data). However, seasonal survival in spring 2003 supported the findings of Miller (1993) who indicated an opposite trend; survival was greater among juvenile hens dispersing greater distances than their cohort. Spring 2003 survival estimates supported my null hypothesis, but small sample sizes among study areas during that period (SAA, 6 males and 26 females; SAB, 9 males and 11 females; DAA, 2 males and 18 females; DAB, 6 males and 9 females) resulted in low precision of survivorship probabilities as reflected by 95% CIs (Table 3). Pollock et al. (1989) warn of precision problems when sample size is <20 individuals and recommended a sample size of 40–50 individuals.

Increasing incidents of springtime mortality, primarily from mammalian predation, are well documented for both the Rio Grande (Ransom et al. 1987, Smith-Blair 1993, Miller 1993, Miller et al. 1995) and eastern wild turkeys (*M. g. silvestris*; Palmer et al. 1993, Miller et al. 1998*b*, Hubbard et al. 1999). There were no statistical differences between areas for bobcats or raccoons (Chapter III), the 2 likely predators of adult and juvenile turkeys on the EP (Glazener 1967). In addition, predation was not a limiting factor among Rio Grande turkeys on the EP historically (Walker 1949, 1951). Rather, range management practices, such as rotational grazing, fresh-water supply, and turkey conscious brush control, were reported to be of primary importance for the success of Rio Grande turkeys (Glazener 1967, Merrill 1975, Miller 1980, Quinton et al. 1980, Miller 1993). Thus, habitat parameters on SAA and DAA need further examination to determine if deficiencies in DAA areas exist. Although vegetative differences of study areas have of yet to been addressed, other differences existed between areas including stocking rate, current brush control, and hunting pressure (Chapter V).

CHAPTER III

MAMMALIAN PREDATOR ABUNDANCE ON REGIONS OF STABLE AND DECLINING RIO GRANDE TURKEY POPULATIONS, EDWARDS PLATEAU, TEXAS

Models of eastern turkey population dynamics identified reproduction (Roberts and Porter 1996, Miller et al. 1998*a*), either-sex fall harvest (Norman et al 2001), or both (Rolley et al. 1998) as significant contributing factors to a population's rate of increase. Ambiguity also is evident in Rio Grande turkey simulations; either reproduction (Reagan and Morgan 1980) or survival (Miller 1993) has been reported to most affect the rate of population change. No hens were harvested from my sample of turkeys on the Edwards Plateau (EP). Predation, on the other hand, affected both survival and reproductive success.

Mammals such as gray fox (*Urocyon cinereoargenteus*), opossum (*Didelphis virginiana*), and striped skunk (*Mephitis mephitis*) are documented nest predators (Ransom et al. 1987, Miller and Leopold 1992) while bobcats, coyotes, and raccoons predate both nests and all age classes of turkeys (Glazener 1967, Cook 1972, Miller and Leopold 1992). Abundance estimation of these predators would provide insight into why turkey populations are decreasing in the southern but not the northern EP (Chapter I).

Reports of predator influence on EP turkey numbers were circumstantial (Walker 1949, 1951), and no published abundance estimates existed. Obtaining an estimate of predator abundance would potentially identify a causative factor of differing trend data between regions of stable and declining turkey abundance. I used scent-station transects to test the following hypothesis: there was no difference in mammalian predator relative mean abundance (RMA) between the regions of stable and declining turkey populations on the EP, Texas.

STUDY AREAS AND METHODS

Study Areas

Turkey population trend data from the 1970s was used to classify regions as either stable or in decline (Chapter I); within regions, 2 areas were located to establish scent-station transects. Stable areas A and B, hereafter referred to as SAA and SAB, were located in Kerr and Real counties, respectively. In addition, adjacent to and north of SAB was a working cattle and sheep ranch of 728 ha where radioed turkeys frequently inhabited; scent-station transects were established on this ranch as well.

Two declining areas, hereafter referred to as DAA and DAB, were located on the northwest and southeast corners of Bandera County, respectively. Due to the landowner's preference, no scent-station transects were established at DAA. Rather, 2 working cattle and goat ranches with exotic and native game located due north of DAA, and consisting of 4,295 ha combined, were sampled instead. Turkeys trapped on DAA frequently moved to and from these northerly ranches; hence it was deemed appropriate to sample these areas as a replacement for DAA.

Scent-Station Transects

Since Linhart and Knowlton (1975) standardized methodology, scent-station transects have been used extensively by several state and federal wildlife agencies. Indices derived from scent-station transects were used to determine density, population trends, and relative abundance of furbearing mammals to differing degrees of success (Conner et al. 1983, Minser 1984, Nottingham et al 1989, Diefenbach et al. 1994). I followed the general outline for scent-station methodology (Linhart and Knowlton 1975) with few modifications (Roughton and Sweeny 1982). I constructed scent-stations with a circular area of 0.85-m in diameter covered in enriched, bleached flour. Flour provided a substrate to identify visitation to a scent lure placed in the center of the station. The scent lure, Carman's Distant Canine Call (Russ Carman, Milford, Pennsylvania, USA), was a homogenous, commercially available, and superior attractant for certain mammal species (Stapper et al. 1992).

Scent-station transects were open for 3 consecutive nights and, except on a few instances, were run at least once a month on each study area from July 2002–July 2003. I determined which night to run transects based primarily on precipitation forecasts. Each ranch had multiple scent-station transects, based on size of the respective ranch, established along non-paved, ranch roads (senderos). Transect starting points were established at a random location. Each 4.0-km transect consisted of 10 scent-stations placed approximately 0.4-km apart on opposite sides of a sendero. To prevent mammal familiarity with scent-stations (R. Heilbrun, Texas Parks and Wildlife, personal communication), I chose which transect to run based on the elapsed time from previous sampling. The preferred elapse of time between subsequent runs of a particular transect was 3 months since this was the minimum number of transects on each study area.

After each evening of sampling, stations were checked for visitation; flour and lure were reapplied and refreshed as needed. Readable tracks were recorded by species, while unknown tracks classified as a predator (UKP), non predator (UKNP), or unknown (UK). Classifications were made based on presence of claws for UKPs, hooves for UKNPs, or no determining mark for UKs. Additionally, precipitation and certain non-targeted animals such as livestock, deer, or feral hogs occasionally destroyed a station; these stations were censored in nightly analysis. Additional data recorded included lunar phase, minimum and maximum temperature, and maximum wind velocity.

Relative mean predator abundance was calculated from the proportion of scent-stations visited per night averaged over the number of consecutive nights transects were run:

$$\text{RMA} = \frac{\text{Mammal species visited}}{\text{Number of operable stations}} \times \frac{1}{\text{Nights open}}$$

Since adjacent scent-stations along transects were not independent (Linhart and Knowlton 1975, Sargeant et al. 1998), only 1 visit per animal was recorded for transects on a particular evening.

Data Analysis

Not all mammals detected at scent-station transects were included for statistical analysis. An arbitrarily set inclusion limit of >10 total visitations was required for statistical analysis by species. Mammal tracks recorded but not included in analysis with the number of times detected were domestic cat (*Felis domesticus*; 2), domestic dog (*Canis familiaralis*; 6), porcupine (*Erethizon dorsatum*; 1), ringtail (*Bassariscus astutus*; 3), and long-tailed weasel (*Mustela frenata*; 1). The following mammal tracks were analyzed and comprised the bulk of data: bobcat, coyote, fox-like canid, opossum, raccoon, skunk, and 2 unknown categories (UK and UKP). No attempt was made to differentiate between the 3 fox species found on the study area (kit [*Vulpes velox*], gray, and red fox [*V. vulpes*]). In addition, eastern and western spotted (*Spilogale putorius*, *S. gracilis*, respectively) and striped skunks were found on the study area, but tracks were pooled for analysis because only 1 spotted skunk track was recorded.

Data from each study site were analyzed using Statistical Package for the Social Sciences (SPSS) (Chicago, Illinois, USA) Version 11.0. Data distributions for all mammalian categories, tested for normality with the Shapiro-Wilk statistic, were non-normal. Variance homogeneity was tested with Levene's statistic. Opossum, bobcat, fox, UK, and UKP had similar variances, and RMA for those species was tested with the Kruskal-Wallace test statistic. Coyote, raccoon, and skunk data distributions were not homogeneous. When pooled across study areas, raccoon data distribution was homogenous and tested with a Mann-Whitney U test statistic. Coyote and skunk data variance were not homogenous across regions and were not tested for differences.

RESULTS

There were a total of 1,330 operable scent-station nights. Flour was an effective tracking substrate initially, but was later destroyed more frequently by feral hogs (14% during July 2002–March 2003 and 73% during April–July 2003). Relative mean abundance was highest for bobcats, opossum, skunk, and UKP on SAB ($\bar{x}$ = 0.0117, $\bar{x}$ = 0.0495, $\bar{x}$ = 0.0151, $\bar{x}$ = 0.0141, respectively); for fox and raccoon on SAA ($\bar{x}$ = 0.0330, $\bar{x}$ = 0.1344, respectively), for UK on DAA ($\bar{x}$ = 0.0788); and for coyotes on DAB ($\bar{x}$ = 0.0434) (Table 4). A Kruskal-Wallace test statistic detected differing (H = 19.653, $P \leq 0.000$; Table 5) opossum abundance among study areas. When re-analyzed without SAB, no difference (H = 0.620, P = 0.734) in opossum abundance was detected among the remaining study areas. Raccoon RMA, when pooled, did not differ (T = 0.654, P = 0.602) between regions.

Data distributions of coyote and skunk RMA preclude straightforward statistical analysis. Skunk RMA was greater on stable areas (SAA $\bar{x}$ = 0.0148, SAB $\bar{x}$ = 0.0151, DAA $\bar{x}$ = 0.0042, DAB $\bar{x}$ = 0.0065), and the 95% CIs were wide enough to include the means from the other study areas (Fig. 2). Coyote RMA was higher and 95% CIs wider on DAA ($\bar{x}$ = 0.0234) and DAB ($\bar{x}$ = 0.0434) than stable areas (SAA $\bar{x}$ = 0.0067, SAB $\bar{x}$ = 0.0022) (Fig. 3). When data were pooled between regions, skunk RMA was higher on the stable ($\bar{x}$ = 0.015, SE = 0.014) than the declining region ($\bar{x}$ = 0.005, SE = 0.003). Neither the stable nor decline region's 95% CI included the mean of the other region (Fig. 4). For coyotes, RMA was higher on study areas within the declining region ($\bar{x}$ = 0.032, SE = 0.010) than within the stable region ($\bar{x}$ = 0.005, SE = 0.002) and 95% CIs for neither region coincided (Fig. 5).

Table 4. Predator of Rio Grande turkeys relative mean abundance on study areas within stable and declining regions of turkey abundance, Edwards Plateau, Texas, July 2002–July 2003.

Species	Study site		$\bar{x}$	95% CI
Raccoon	Stable	A	0.1344	0.0617-0.2072
		B	0.0962	0.0689-0.1235
	Declining	A	0.0919	0.0600-0.1238
		B	0.0818	0.0379-0.1256
Opossum	Stable	A	0.0135	0.0008-0.0261
		B	0.0495	0.0334-0.0656
	Declining	A	0.0168	0.0037-0.0299
		B	0.0195	-0.0093-0.4839
Coyote	Stable	A	0.0067	0.0002-0.0132
		B	0.0022	-0.0025-0.0070
	Declining	A	0.0234	-0.0014-0.0482
		B	0.0434	0.0091-0.0778
Bobcat	Stable	A	0.0075	-0.0035-0.0186
		B	0.0117	-0.0001-0.0235
	Declining	A	0.0041	-0.0018-0.0099
		B	0.0096	-0.0066-0.0258
Skunk[a]	Stable	A	0.0148	0.0042-0.0255
		B	0.0151	0.0023-0.0279
	Declining	A	0.0042	-0.0045-0.0130
		B	0.0065	-0.0031-0.0161
Fox[b]	Stable	A	0.0330	-0.0119-0.0778
		B	0.0122	0.0022-0.0222
	Declining	A	0.0130	-0.0043-0.0304
		B	0.0067	-0.0076-0.0210
Unknown predator	Stable	A	0.0104	-0.0001-0.0208
		B	0.0141	-0.0026-0.0308
	Declining	A	0.0095	0.0002-0.0188
		B	0.0111	-0.0127-0.0349
Unknown	Stable	A	0.0603	0.0332-0.0874
		B	0.0438	0.0117-0.0760
	Declining	A	0.0788	0.0404-0.1173
		B	0.0406	0.0146-0.0666

[a]Skunk category includes eastern (*Spilogale putorius*) and western spotted (*S. gracilis*) and eastern striped (*Mephitis mephitis*) skunks.

[b]Fox category includes kit (*Vulpes velox*), gray (*Urocyon cinereoargenteus*), and red (*V. vulpes*) foxes.

Table 5. Predator of Rio Grande turkeys relative mean abundance test results on 4 study areas within stable and declining regions of turkey abundance, Edwards Plateau, Texas, July 2002–July 2003.

Classification	Study site		*n*	Mean rank	*H*	*P*
Opossum*	Stable	A	23	32.74		
		B	15	56.93	19.653	0.000
	Declining	A	22	35.25		
		B	15	31.17		
Opossum[a]	Stable	A	23	30.22		
	Declining	A	22	32.00	0.620	0.734
		B	15	28.73		
Bobcat	Stable	A	23	36.52		
		B	15	42.57	2.536	0.469
	Declining	A	22	36.39		
		B	15	38.07		
Fox[b]	Stable	A	23	41.59		
		B	15	41.30	4.071	0.254
	Declining	A	22	35.50		
		B	15	32.87		
Unknown	Stable	A	23	39.61		
		B	15	33.73	1.539	0.673
	Declining	A	22	42.45		
		B	15	33.27		
Unknown predator	Stable	A	23	38.20		
		B	15	40.83	2.473	0.480
	Declining	A	22	38.32		
		B	15	34.40		

* Significance at $\alpha = 0.05$.

[a]Opossum relative abundance excluding SSB.

[b]Fox category includes kit (*Vulpes velox*), gray (*Urocyon cinereoargenteus*), and red (*V. vulpes*) foxes.

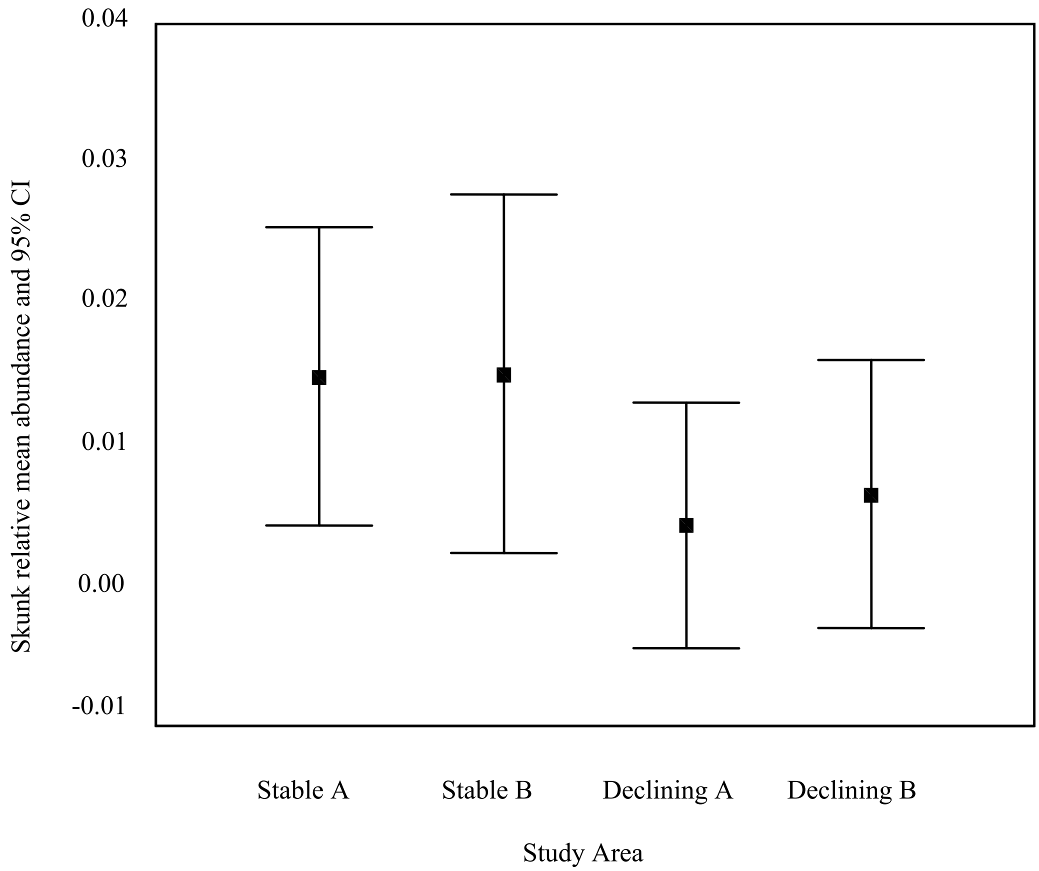

Fig. 2. Skunk relative mean abundance at 4 Rio Grande turkey study areas within stable and declining regions of turkey abundance, Edwards Plateau, Texas, July 2002–July 2003.

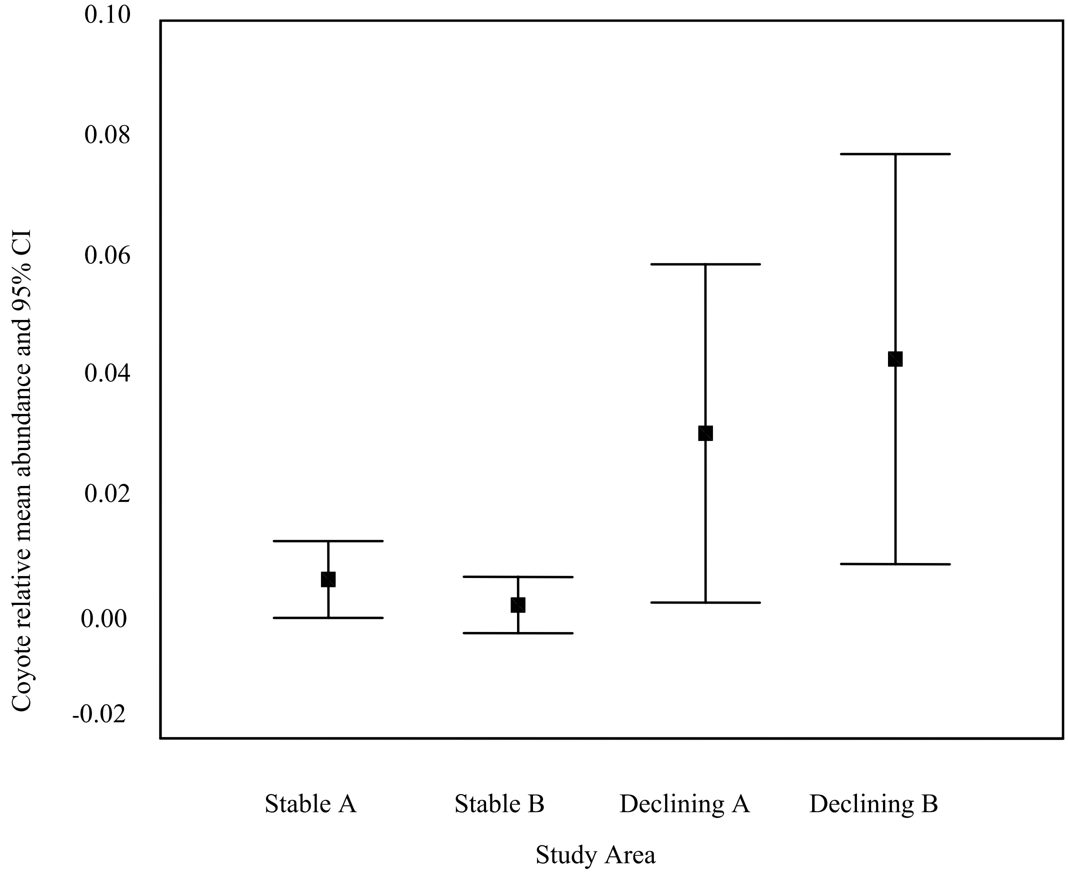

Fig. 3. Coyote relative mean abundance at 4 Rio Grande turkey study areas within stable and declining regions of turkey abundance, Edwards Plateau, Texas, July 2002–July 2003.

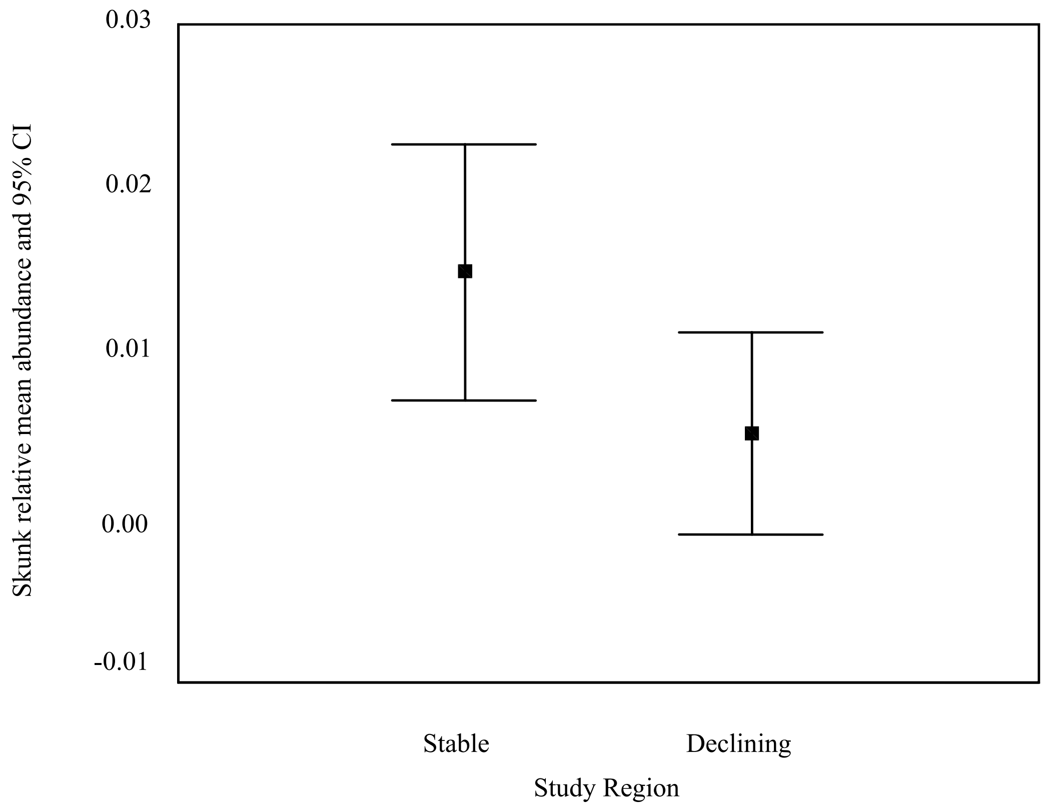

Fig. 4. Skunk relative mean abundance within stable and declining regions of Rio Grande turkey abundance, Edwards Plateau, Texas, July 2002–July 2003.

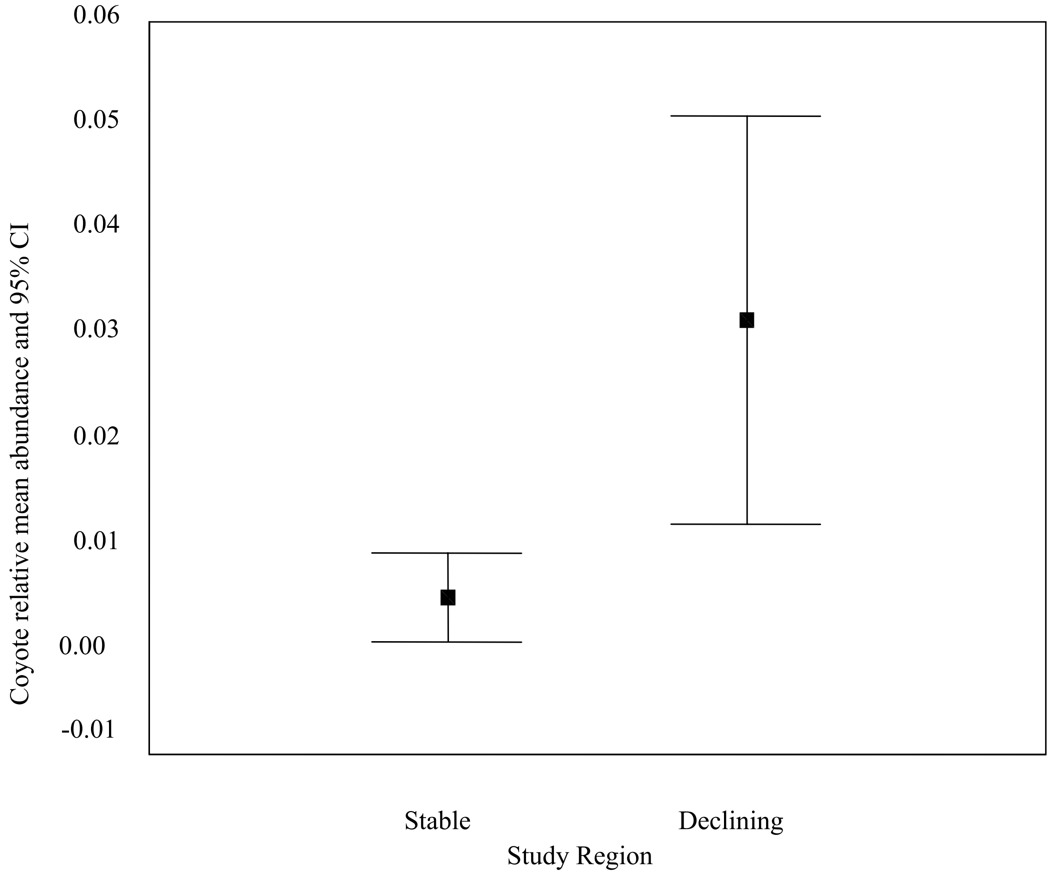

Fig. 5. Coyote relative mean abundance within stable and declining regions of Rio Grande turkey abundance, Edwards Plateau, Texas, July 2002–July 2003.

DISCUSSION

Three predators of Rio Grande turkeys across their range are bobcats, coyotes, and raccoons (Glazener 1967). Bobcat RMA did not differ statistically between study areas on the EP; changes in abundance have been detected in South Carolina (Diefenbach et al. 1994). Raccoon RMA among areas could not be tested due to non-normality and heterogeneity of variances, but a test between regions detected no statistical difference. Statistical testing of coyote abundance also was problematic; however, RMA was greater on the declining region suggesting a potential causative factor for the declining turkey trend. Since, however, coyotes are opportunistic feeders a direct cause and effect can not be inferred (Knowlton 1964).

Knowlton (1964) found a higher volume of turkey remains in coyote stomachs during fall and winter in South Texas. He hypothesized that social instability and high turkey concentrations within large flocks increased turkey predation by coyotes. Although few remains were found in stomachs, Knowlton (1964) pointed out that spring breeding behavior also increased mortality. No turkey remains were found in coyote stomachs during summer, but poult remains may not have been identifiable. High poult mortality would decrease reproductive recruitment regardless if coyote-attributed mortality to adults was small.

In addition to coyote, foxes, opossums, raccoons, and skunks are turkey nest predators. Differences found in opossum RMA and implied in skunk RMA, which were both higher on stable areas, intuitively conflicted with the historic turkey trend data. There was no difference in nest success between regions (C.J. Randel, Texas A&M University, unpublished data). Therefore, higher RMA of certain nest predators on the stable region conflicted with expectations, and additional or different furbearer abundance indices, such as radio telemetry, indirect-sampling indices (Foran et al. 1997*a*), and numerous mark–recapture techniques [radioisotope tagging (Nellis et al. 1967, Kohn et al. 1998), remote cameras (Heilbrun 2002), and hair snares (Foran et al. 1997*b*)], were desired.

It is doubtful whether scent-station transects were useful in detecting differences in RMA among areas. Rather, scent-station indices should be used in conjunction with empirical data to detect broad trends among years (Linhart and Knowlton 1975, Sargeant et al. 1998). Few studies reported a direct relationship between scent-station indices and absolute predator density (Conner et al. 1983, Minser 1984); most suggest scent stations not be used unless empirical data substantiated results (Nottingham et al. 1989, Smith et al. 1994). Although I minimized bias as well as possible, scent station indices were biased when (1) sampling effort was not stratified by habitat, season, or human activity (Griffith et al. 1980, Nottingham et al. 1989, Smith et al. 1994), (2) when target species exhibited density dependent behavior (Conner et al. 1983, Smith et al. 1994), and (3) when independence between stations and nights are not addressed (Linhart and Knowlton 1975, Morrison et al. 1981, Roughton and Sweeny 1982).

The majority of scent-stations transects were located in similar vegetative structure, plant communities, and topographical relief. Most were open on the same evenings, as well. As a result, differences associated with environmental conditions and seasonal movement patterns were minimized (Nottingham et al. 1989).

Bobcats, coyotes (Griffith et al. 1980), fox-like canids (Conner et al. 1983), and raccoons (Smith et al. 1994) all exhibit density dependent, if not individual (Harris and Knowlton 2001), behavior. It is unclear if scent-station indices would produce the same results if densities were similar among areas because predators react differently given similar habitat and densities (Beasom 1974).

Due to the proximity of adjacent scent stations along transects and consecutive nights of sampling, Linhart and Knowlton (1975) suggested each scent station and evening be considered a separate datum. I did not follow these guidelines. Instead, I considered each night of sampling as independent given the limited number of transects on each study site and the broad range of species of interest.

MANAGEMENT IMPLICATIONS

I would not recommend continuing scent-station surveys on the study areas. My reasons are 2-fold; first, most study areas were working livestock ranches with supplementary fed wildlife, which became more familiar with flour-based scent-stations as food. Destruction of scent-stations by feral hogs - which destroyed 25% of operable scent-stations – became more prominent over time (14% during July 2002 – March 2003 and 73% during April – July 2003). Despite trapping of hogs, each study area had a great number of the animals destroying stations and leaving them inoperable. Use of agricultural lime ($CaCo_3$), another acceptable tracking substrate (Morrison et al. 1981), may have alleviated the problem. Second, the lack of empirical data to validate scent-stations indices and reliably detect changes in predator population size precludes the use of scent-stations.

CHAPTER IV
MAMMALIAN VISITATION TO SCENT-STATION TRANSECTS DURING LUNAR PHASES

Scent-station transects are widely used by federal and several state wildlife agencies in charge of monitoring mammalian furbearer abundance and population trends (Johnson and Pelton 1981). Although relatively inexpensive, large amounts of time and effort were placed in establishing, monitoring, and maintaining transects. Simple changes in methodology, if yielding an increase in mammal visitation, would be welcome and may further account for visitation variance.

The mammalian predators of interest were either crepuscular, nocturnal, or both, therefore, an increase in lunar illumination would provide greater visual contact with scent stations. Scent-station transects provide both a visual and olfactory stimulus; the visual stimulus is equally if not more an attractant than olfactory for bobcats (Morrison et al. 1981, Miller et al. 1983) and coyotes (Griffith et al. 1980, Roughton and Sweeny 1982). Few published scent-station index studies (Griffith 1977, Diefenbach et al. 1994) report lunar phase as a methodological consideration. I was, therefore, interested if lunar phase affected scent-station visitation rates, and tested the following null hypothesis: There was no difference in mammalian scent-station visitation between maximum and minimum lunar illumination (i.e., the full and new moon, respectively).

STUDY AREAS AND METHODS

Study Areas

Within regions where turkey population trend data from the 1970s on the Edwards Plateau (EP), Texas, showed stable and declining populations (Chapter I), 2 study areas within each region were located. On each study area scent station transects were established to estimate mammalian furbearer RMA (Chapter III). Stable Areas (SAA and SAB) were, respectively, located in Kerr and Real counties. In addition, adjacent to and north of SAB was a working livestock (cattle and sheep) ranch of 728 ha where radioed turkeys frequently inhabited; scent-station transects were established on this ranch, as well.

Decline Areas (DAA and DAB) were located on the northwest and southeast corners of Bandera County, respectably. Due to land owner preference, no scent-station transects were established at DAA. Rather, 2 working livestock (cattle and goat) ranches with exotic and native game located due north of DAA, and consisting of 4,295 ha, were sampled instead. Certain turkeys trapped on DAA frequently moved to and from these northerly ranches, hence, it was deemed appropriate to sample these areas as a replacement for DAA.

Scent-station Transects

Scent-station transects were run twice a month from May–July 2003 during the full- and new-moon cycles, when lunar illumination would be at its highest and lowest, respectively. Scent-station transects were open for 3 consecutive nights. I determined which night to run transects based primarily on lunar phase and precipitation forecasts. Transects established to determine mammalian predator abundance among areas (Chapter III) were used during this phase of research. Scent-station transect methods were identical to those outlined in Chapter III, except the turnover rate between subsequent transect runs were decreased to 1.5 months.

Data Analysis

Not all mammals detected during scent-station transects were included in statistical analysis. An arbitrarily set inclusion limit of >10 visitations was required for statistical analysis by species. Mammal tracks recorded but not included in the analysis, with the number of times detected in parentheses, were: coyote (1), bobcat (1), striped skunk (2), fox (3), and UKP (5). Raccoon, opossum, and UK categories were analyzed.

Data from each study site were analyzed using SPSS Version 11.0. Data distributions for all mammal categories, tested for normality with the Shapiro-Wilk statistic, were non-normal. Variance homogeneity was tested with Levene's statistic. Raccoon data distribution between lunar phases was homogeneous, and therefore tested with the Mann-Whitney U test statistic. Variance associated with opossum and UK distributions were not homogenous and were not tested statistically.

RESULTS

There were a total of 380 operable scent-station nights. No difference was detected in raccoon visitation (T = 100.0, P = 0.822) between full- and new-lunar cycles. Mean and 95% CI of opossum (new, $\bar{x}$ = 0.0111, SE = 0.0061; full, $\bar{x}$ = 0.0324, SE = 0.0138), and UK (new, $\bar{x}$ = 0.0649, SE = 0.0224; full, $\bar{x}$ = 0.0375, SE = 0135) visitation between lunar phases did not appear to differ (Figs. 6 and 7, respectively).

DISCUSSION

Scent stations provide both olfactory and visual stimulus – the visual stimulus potentially eliciting a greater response than the olfactory (Griffith et al. 1980, Morrison et al. 1981, Roughton and Sweeny 1982, Miller et al. 1983, Nottingham et al. 1989). However, Griffith (1977), Diefenbach et al. (1994), nor this research suggest the lunar phase was a covariate in scent-station use. Given the superior nocturnal vision of mammalian predators, low illumination from a new moon would not affect behavior. Unfortunately, low sample size and short duration of sampling render this research inconclusive.

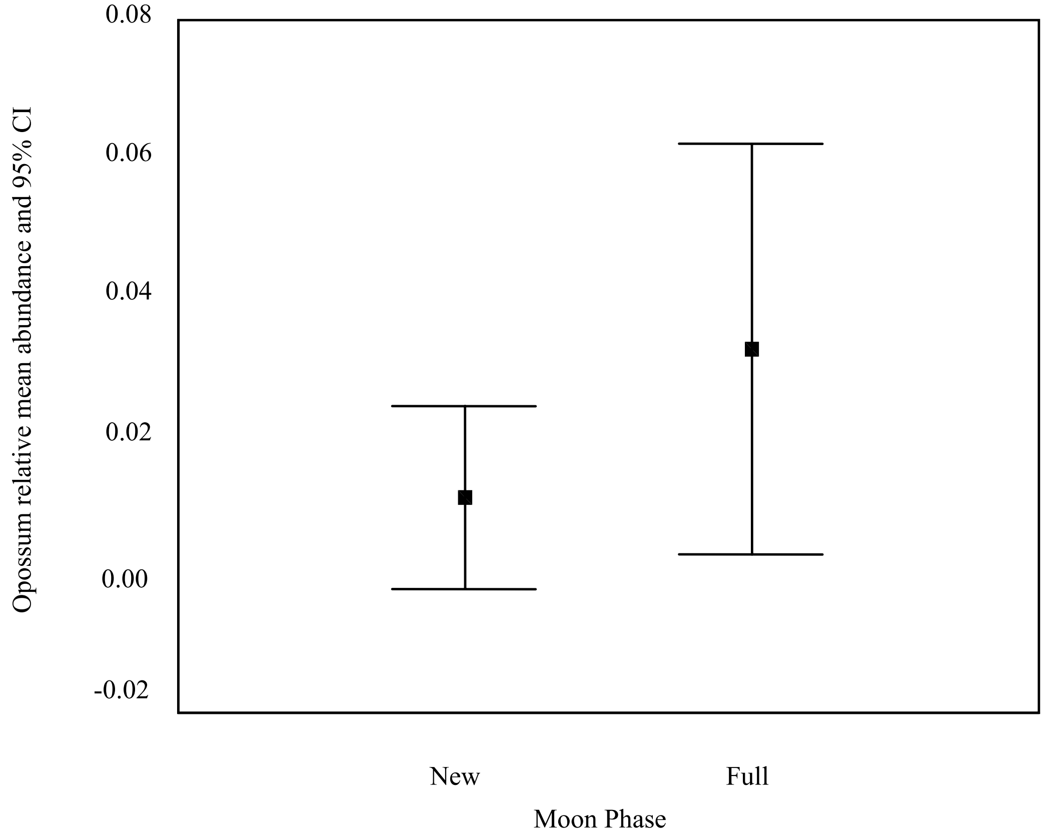

Fig. 6. Mean opossum scent-station visitation on the Edwards Plateau, Texas, during the new and full lunar phase from May 2003–July 2003.

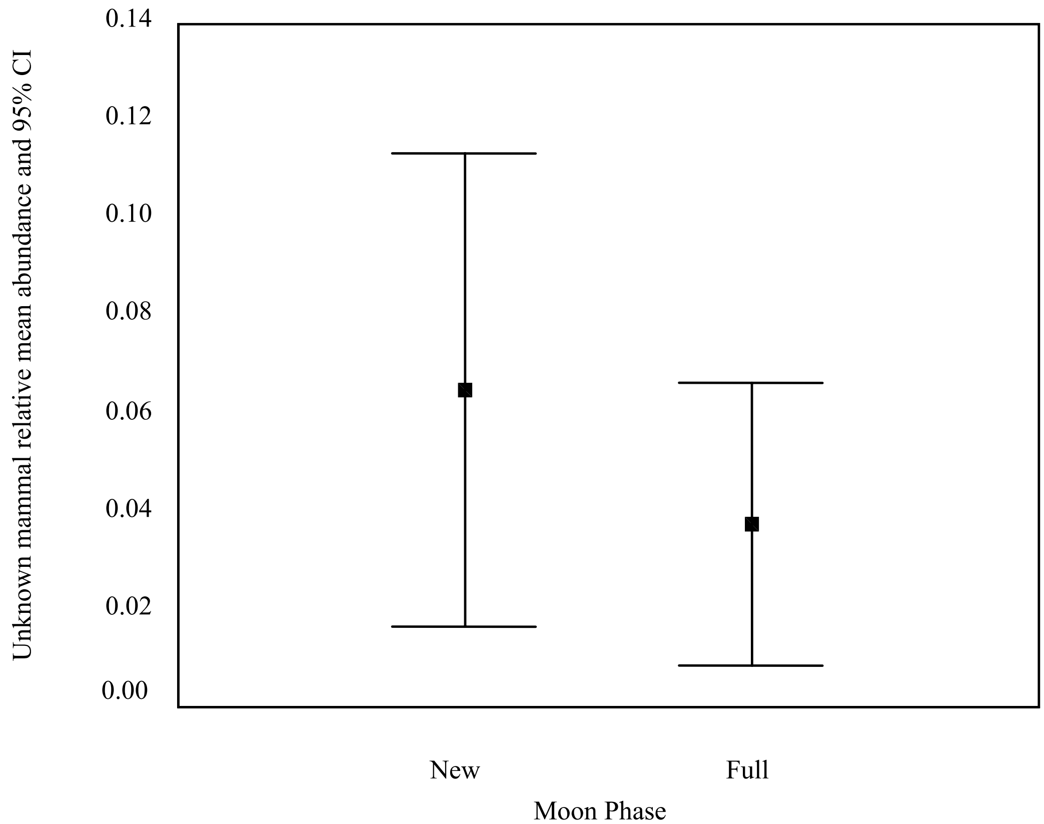

Fig. 7. Mean unknown scent-station visitation on the Edwards Plateau, Texas, during the new and full lunar phase from May 2003–July 2003.

CHAPTER V
CONCLUSIONS

My first objective was to find whether differences in variables existed between study areas in stable and declining regions of the Edwards Plateau (EP), Texas. Although annual survival rates did not deviate from rates reported elsewhere within historic range, estimates between the study areas (SAA, SAB, DAA, and DAB) were statistically different. Counter intuitively, annual survival rates during 2002 were greater on DAA than on SAA. Seasonal analysis among sites during spring 2003 showed greater survival on SAB than both SAA and DAA. Higher survival on stable areas was expected, yet SAA did not statistically differ from DAA during the same period.

Known turkey mortality was caused by predation, legal hunting, and highway collisions; unfortunately, most causes were unknown. Of the 3 known predators of Rio Grande turkeys across their range, coyotes appeared to be the only species with greater abundance on study areas within the declining region. Thus, greater coyote abundance has the potential to account for the declining trend. In addition, 2 documented nest predators, opossums and skunks, differed among the study regions; the stable study region had higher relative mean abundance (RMA) estimates of both nest predators. Lunar illumination was not associated with mammal visitation to scent stations.

DISCUSSION

Given higher annual survival with a greater abundance of coyotes on the declining area suggested turkey demography was largely determined by recruitment. The reproductive potential of turkeys is adequate to offset losses from predators (Markley 1967), and may account for 58% variation between years in eastern turkey population projections (Roberts and Porter 1996). Neither nest success or poult survival was addressed in my study. Nest success among study areas did not vary substantially; however, poult survival was greater on the stable areas (C. J. Randel, Texas A&M University, unpublished data). Whereas Rio Grande turkey hens will initiate nesting 3 times in the breeding season, hens will only hatch 1 nest per year making poult survival the paramount fercundity variable.

Turkey productivity has been linked to favorable vegetative conditions through proper range management (Merrill 1975, Quinton 1980, Miller 1980, Miller 1993) and greater amounts of rainfall and soil moisture (Thomas and Green 1957, Beasom and Pattee 1980). Certain vegetative structure characteristics at nest sites were different between areas, but it is unclear how to manage for those characteristics (C. Randel, Texas A&M University, unpublished data). However, range management is of primary importance for the success of turkeys (Glazener 1967, Merrill 1975, Quinton et al. 1980, Miller 1980, Miller 1993). Features such as fresh water, adequate roost trees, low intensities of block or strip brush control, and rotational and light grazing have all been linked to increases in turkey density. Rainfall amounts during the fall months were important as well (Beasom and Pattee 1980).

Management practices, such as stocking rate, brush control, and hunting pressure, differed among the study areas as did anthropomorphic disturbance and number of turkeys seen while in the study areas. All study areas were used by livestock during my study period, however, the number of animals was markedly different. Compared to the other study areas, SAA had a moderate stocking rate, but the vegetation appeared as healthy as SAB and DAA. Although sheep and cattle were grazed in the near vicinity of SAB, livestock infrequently grazed on SAB as in May–July 2003 when the foreman on SAB allowed a few head to graze as a favor. The vegetation appeared as healthy and vigorous as SAA and DAA. Cattle production on DAA appeared to be a more leisurely pursuit than an economic necessity; a few head of cattle were grazed during the study period. The heaviest stocked study area was DAB where the vegetation was shorter and less vigorous than the other study areas.

Located near Bandera, Texas, a popular tourist locale, a state natural area, Hill Country State Natural Area, and multiple guest ranches, many of which offered horseback trail rides and hiking, DAB received more anthropomorphic disturbances than did the rest of the study areas. Turkeys were rarely seen on or near the study area during the study period, and trapping on DAB was much less than on the other study areas (Table 1). Trapping was not satisfactory and fewer turkeys were seen on DAA as well. Only 1 substantial winter flock was known to exist on the study area where human activity was the least of all other study areas. Turkeys were most readily seen and trapping most productive (Table 1) on SAA and SAB. Human activity, such as brush control and hunting, on both stable areas was moderate compared to the declining areas.

Current invasive-brush control was ongoing on various parts of SAA and extensively on SAB during the study period; little to no brush management was conducted on either DAA or DAB during the same period. Brush cutting on the stable area was conducive to turkey management as cut brush was allowed to lie without removal or burning (D. Rollins, Texas Agriculture Extension Service, personal communication). Cleared patch size differed among the stable areas though; small patches were cut on SAA while large areas were cut on SAB. Miller (1980) and Quinton et al. (1980) both suggest only small patches be cut to provide nearby escape cover for resident turkeys. The combination of frequent human disturbance and change in local habitat may have been the impetus for more frequent turkey movement on the stable study areas (J. Schaap, unpublished data).

Hunting pressure was greatest on SAA and DAB where private land was leased to hunters; 4 males were killed on SAA during 2002 and 1 male on DAB during 2003. However, big game hunts keep a steady stream of hunters on both areas and on SAB during fall hunting seasons; this also possibly causes turkeys to move more frequently. Landowners of DAA hunted big game but the land was not leased and hunting traffic was minimal.

Similarities among study areas include stock tanks and supplementary feeding at automatic feeders, which may contribute to predation, disease, and intraspecific aggression by concentrating turkeys spatially and temporally (Glazener 1967, Miller 1980). Topography among the study areas was not greatly different. A more gently rolling topography was evident on SAA, DAA, and DAB. Stable area B, on the other hand, was more mountainous with greater relief. In my opinion, this contributed to a higher incidence of missing turkeys on SAB (2 and 38 turkeys disappeared < 4 month post trapping in 2002 and 2003, respectively) because signal reception was interfered with by the mountainous terrain.

MANAGEMENT IMPLICATIONS

Survival analysis is a crucial aspect of population demography and should continue to be monitored. Also, further examination of egress from the study areas would be insightful in examining turkey population fluctuations on the EP. Further resources directed towards this investigation should be aimed at collecting additional data on survival, recruitment, nest success and poult survival, as well as differences in current and past habitat structure. If, however, predator abundance is of primary concern, I suggest other methods than scent-station transects be used.

LITERATURE CITED

Baker, B. W., S. L. Beasom, and N. J. Silvy. 1980. Turkey productivity and habitat use on south Texas rangelands. Proceedings of the National Wild Turkey Symposium 3:145-158.

Beasom, S. L. 1974. Intensive short-term predator removal as a game management tool. Transactions of the North American Wildlife and Natural Resource Conference 39:230-240.

_____, and O. H. Pattee. 1980. The effect of selected climatic variables on wild turkey productivity. Proceedings of the National Wild Turkey Symposium 3:127-135.

Conner, M. C., R. F. Labisky, and D. R. Progulske, Jr. 1983. Scent-station indices as measures of population abundance for bobcats, raccoons, gray foxes, and opossums. Wildlife Society Bulletin 11:146-152.

Cook, R. L. 1972. A study of nesting turkeys in the Edwards Plateau of Texas. Proceedings of the Annual Conference Southeastern Association of Fish and Game Commission 26:236-244.

Cox, D. R., and D. Oates. 1984. Analysis of survival data. Chapman and Hall, New York, New York, USA.

Davis, B. D. 1994. A funnel trap for Rio Grande turkey. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 48:109-116.

Diefenbach, D. R., M. J. Conroy, R. J. Warren, W. E. James, L. A. Baker, and T. Hon. 1994. A test of the scent-station survey technique for bobcats. Journal of Wildlife Management 58:10-17.

Foran, D. R, K. R. Crooks, and S. C. Minta. 1997*a*. Species identification from scat: an unambiguous genetic method. Wildlife Society Bulletin 25:835-839.

_____, S. C. Minta, and K. S. Heinemeyer. 1997*b*. DNA-based analysis of hair to identify species and individuals for population research and monitoring. Wildlife Society Bulletin 25:840-847.

Glazener, W. C. 1967. Management of the Rio Grande turkey. Pages 453-492 *in* O. H. Hewitt, editor. The wild turkey and its management. The Wildlife Society, Washington, D.C., USA.

_____, D. Ransom, Jr. J. R. Cary, and O. J. Rongstad. 1990. Demographic analysis of a Rio Grande turkey population. Southwestern Naturalist 35:23-27.

Gould, F. W. 1975. Texas plants – A checklist and ecological summary. Texas Agriculture Experiment Station, College Station, Texas, USA.

Griffith, D. B. 1977. Seasonal properties of the coyote scent station index. Thesis, Oregon State University, Corvallis, Oregon, USA.

_____, H. M. Wight, W. S. Overton, and E. C. Meslow. 1980. Seasonal properties of the coyote scent station index. Pages 197-220 *in* L. A. Miller, A. Gun, and S. R. Hieb, editors, Symposium on census methods for population and habitats. Forest, Wildlife, and Range Experiment Station, Moscow, Idaho, USA.

Harris, C. E., and F. F. Knowlton. 2001. Differential responses of coyotes to novel stimuli in familiar and unfamiliar settings. Canadian Journal of Zoology 79:2005-2013.

Heilbrun, R. D. 2002. Using automatically-triggered cameras to monitor and estimate bobcat abundance. Thesis, Texas A&M University, College Station, Texas, USA.

Hubbard, M. W., D. L. Garner, and E. E. Klaas. 1999. Wild turkey poult survival in southcentral Iowa. Journal of Wildlife Management 63:199-203.

Johnson, K. G., and M. R. Pelton. 1981. A survey of procedures to determine relative abundance of furbearers in the southeastern United States. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 35:261-272.

Knowlton, F. F. 1964. Aspects of coyote predation in south Texas, with special reference to white-tailed deer. Dissertation, Purdue University, West Lafayette, Indiana, USA.

Kohn, M. H., E. C. York, D. A. Kamradt, G. Haught, R. M. Sauvajot, and R. K. Wayne. 1998. Estimating population size by genotyping faeces. Proceedings of the Royal Society of London, Series B 266:657-663.

Linhart, S. B., and F. F. Knowlton. 1975. Determining the relative abundance of coyotes by scent station lines. Wildlife Society Bulletin 3:119-124.

Logan, T. H. 1973. Seasonal behavior of Rio Grande wild turkeys in western Oklahoma. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 27:74-91.

Markley, M. H. 1967. Limiting factors. Pages 199-243 *in* O. H. Hewitt editor. The wild turkey and its management. The Wildlife Society, Washington D.C., USA.

Merrill, L. B. 1975. Effect of grazing management practices on wild turkey habitat. Proceedings of the National Wild Turkey Symposium 3:108-112.

Miller, E. B. 1980. Rio Grande turkey populations and habitat analysis in connection with land use practices in Mills County, Texas. Thesis, Abilene Christian University, Abilene, Texas, USA.

Miller, M. S. 1993. Rio Grande wild turkey hen survival and habitat selection in south central Kansas. Thesis, Texas Tech University, Lubbock, Texas, USA.

Miller, J. E., D. J. Buford, and R. S. Lutz. 1995. Survival of female Rio Grande turkeys during the reproductive season. Journal of Wildlife Management 59:766-771.

Miller, D. A., L. W. Burger, B. D. Leopold, and J. A. Hurst. 1998*b*. Survival and cause-specific mortality of wild turkey hens in central Mississippi. Journal of Wildlife Management 62:306-313.

Miller, S. D., E. P. Hill, and M. S. O'Brien. 1983. Bobcat. Pages 195–200 *in* E. F. Deems, Jr., and D. Pursley, editors. North American furbearers: a contemporary reference. International Association of Fish and Wildlife Agencies, Bethesda, Maryland, USA.

Miller, D. A., B. D. Leopold, and J. A. Hurst. 1998*a*. Reproductive characteristics of a wild turkey population in central Mississippi. Journal of Wildlife Management 62:903-910.

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

Minser, W. G., III. 1984. Comments on scent-station method for monitoring furbearers. Wildlife Society Bulletin 12:328.

Morrison, D. W., R. M. Edmunds, G. Linscombe, and J. W. Goertz. 1981. Evaluation of specific scent station variables in northcentral Louisiana. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 35:281-291.

Nellis, D. W., J. H. Jenkins, and A. D. Marshall. 1967. Radioactive zinc as a feces tag in rabbits, foxes, and bobcats. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 21:205-207.

Nenno, E. S., and W. M. Healy. 1979. Effects of radio packages on behavior of wild turkey hens. Journal of Wildlife Management 43:760-765.

Norman, G. W., J. C. Pack, C. I. Taylor, D. E. Steffen, and K. H. Pollock. 2001. Reproduction of eastern wild turkey in Virginia and West Virginia. Journal of Wildlife Management 65:1-9.

Nottingham, B. G., Jr., K. G. Johnson, and M. R. Pelton. 1989. Evaluation of scent-station surveys to monitor raccoon density. Wildlife Society Bulletin 171:29-35.

Palmer, W. E., G. A. Hurst, J. E. Stys, D. R. Smith, and J. D. Burk. 1993. Survival rates of wild turkey hens in loblolly pine plantations in Mississippi. Journal of Wildlife Management 57:783-789.

Peterson, M. N., R. Aguirre, T. A. Lawyer, D. A. Jones, J. N. Schaap, M. J. Peterson, and N. J. Silvy. 2003. Animal welfare-based modification of the Rio Grande wild turkey funnel trap. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 57:In Press.

Petrides, G. A. 1945. First-winter plumages in the Galliformes. Auk 62:223-227.

Pollock, K. H., S. R. Winterstein, C. M. Bunck, and P. D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. Journal of Wildlife Management 53:7-15.

Quinton, D. A., A. K. Mantel, J. T. Flinders. 1980. Brush control and Rio Grande turkey in north-central Texas. Journal of Range Management 332:95-99.

Ransom, D., Jr., O. J. Rongstad, and D. H. Rusch. 1987. Nesting ecology of Rio Grande turkeys. Journal of Wildlife Management 51:435-439.

Reagan, J. M., and K. D. Morgan. 1980. Reproductive potential of Rio Grande turkey hens in the Edwards Plateau of Texas. Proceedings of the National Wild Turkey Symposium 3:136-144.

Riskind, D. H., and D. D. Diamond. 1988. An introduction to environments and vegetation. Pages 1-16 *in* B. B. Amos, and F. R. Gehlbach, editors. Edwards Plateau vegetation. Baylor University Press, Waco, Texas, USA.

Roberts, S. D., and W. F. Porter. 1996. Importance of demographic parameters to annual changes in wild turkey abundance. Proceedings of the National Wild Turkey Symposium 7:15-20.

Rolley, R. E., J. F. Kubisiak, R. N. Paisley, and R. G. Wright. 1998. Wild turkey population dynamics in southwestern Wisconsin. Journal of Wildlife Management 62:917-924.

Roughton, R. D., and M. W. Sweeney. 1982. Refinements in scent-station methodology for assessing trends in carnivore populations. Journal of Wildlife Management 46:217-229.

Sargeant, G. A., D. H. Johnson, and W. E. Berg. 1998. Interpreting carnivore scent-station surveys. Journal of Wildlife Management 62:1235-1245.

Smith, W. P., D. L. Borden, and K. M. Enders. 1994. Scent-station visits as an index to abundance of raccoons: an experimental manipulation. Journal of Mammalogy 75:637-647.

Smith-Blair, A. E. 1993. Rio Grande wild turkey hen habitat and edge use, survival, and reproductive characteristics in the Texas Rolling Plains. Thesis, Texas Tech University, Lubbock, Texas, USA.

Stapper, R. J., D. L. Rakestraw, and N. J. Silvy. 1992. Evaluation of two lures for furbearer scent station surveys. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 46:75-78.

Thomas, J. W., and H. Green. 1957. Something to gobble about. Texas Game and Fish 15:9-11,24.

Tsai, K., K. H. Pollock, and C. Brownie. 1999. Effects of violation of assumptions for survival analysis methods in radiotelemetry studies. Journal of Wildlife Management 63:1369-1375.

Walker, E. A. 1949. A study of factors influencuencing wild turkey populations in the central mineral region of Texas. Texas Game, Fish, and Oyster Commission, Austin, Texas, USA.

_____. 1951. A study of factors influencing wild turkey populatins in the live oak–shin oak divide area of the Edwards Plateau, Texas. Texas Game, Fish, and Oyster Commission, Austin, Texas, USA.

White, G. C., and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, California, USA.

VITA

NAME Beau Judson Willsey

ADDRESS 110 Walnut Drive
Swansboro, NC 28584

EDUCATION B.S., Wildlife Sciences, North Carolina State University, December 1998.
M.S., Wildlife and Fisheries Sciences, Texas A&M University, December 2003.

WORK EXPERIENCE

Texas Agriculture Experiment Station

Research Assistant August 2001 – Present

I trapped, handled, and tracked Rio Grande turkeys on the Edwards Plateau, Texas, as well as performed predator censuses within the region.

College of William and Mary

Field Technician May 2001 – August 2001

I trapped, handled, and tracked Whip-poor-wills (*Caprimulgus vociferus*) on a managed pine plantation in North Carolina.

Society of *Tympanuchus cupido pinnatus*, Ltd. December 1999 – April 2001

Research Fellow

I trapped, handled, and collected a variety of data (locations and various habitat parameters) on Greater Prairie Chickens (*Tympanuchus cupido pinnatus*) in Wisconsin, Minnesota, and North Dakota. In addition, I trapped, handled, and tracked American Bitterns (*Botaurus lentiginosus*) in both their summer (Minnesota) and winter (Florida) ranges.

Delaware Department of Natural Resources

Field Technician April 1999 – August 1999

I monitored the state's breeding piping plover (*Charadrius melodus*) population and conducted public outreach to inform the public of current plover events.

Louisiana State University

Research Assistant December 1998 – March 1999

I assisted a graduate student (Jeb Linscombe) in observing nesting bald eagle (*Haliaeetus leucocephalus*) behavior to human disturbances in southern Louisiana.