ESTIMATING DISTRIBUTION AND ABUNDANCE OF RIO GRANDE WILD TURKEYS IN SOUTH TEXAS

A Thesis

by

ROBERT JOHN CAVENY

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 2009

Major Subject: Wildlife and Fisheries Sciences

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Approved by:

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Bret A. Collier
Committee Members, X. Ben Wu
William P. Kuvlesky
Head of Department, Thomas Lacher

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ABSTRACT

Estimating Distribution and Abundance of Rio Grande Wild Turkeys in South Texas.

(August 2009)

Robert John Caveny, B.S., Eastern Illinois University

Co-Chairs of Advisory Committee: Dr. Markus J. Peterson
Dr. Bret A. Collier

Sustainable management of wildlife populations relies on accurate estimates of population size as harvest recommendations are dependent on estimates of sustainable surplus. Techniques for surveying wild turkey populations in Texas are constrained by land access issues, requiring that new methods be developed for population monitoring. I evaluated a combined approach using patch-occupancy modeling at broad spatial scales and intensive double observer roost surveys at local scales to estimate Rio Grande wild turkey (*Meleagris gallapavo intermedia*) distribution and abundance.

I flew replicated aerial surveys during 2007 and 2008 to evaluate distribution of Rio Grande wild turkeys in the south Texas Coastal Sand Plains. I used a double observer approach to estimate local scale abundance. I used a single observer approach to estimate temporal variation in roost use. Detection probabilities from aerial surveys ranged between 0.24 (SE = 0.031) and 0.30 (SE = 0.083). Spatial parameters that influenced distribution of wild turkeys included size of suitable roosting habitat patches and distance to the nearest suitable roosting habitat.

I conducted 100 inter-patch double observer roost counts, with counts ranging between 0 to 183 individuals. Average detection probabilities for observers were ~0.90. Roost level occupancy was ~0.84 with detection probabilities between 0.69 (SE = 0.107) and 0.79 (SE = 0.091). Based on my results, aerial surveys combined with local abundance estimation may be one viable alternative to monitor turkey populations over large spatial scales, by reducing overall survey effort without loss of estimated precision.

ACKNOWLEDGMENTS

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Last, but not least, I would like to thank my family and friends for all their support. To my parents and brothers, thank you for always keeping my hopes up and pushing me along during this time in my life. To my friends, thanks for listening and encouraging me to excel.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

Sustainable management of wildlife populations relies on accurate estimates of population size as harvest recommendations are dependent on estimates of sustainable surplus. Thus, managers implementing monitoring programs estimate abundance (or some index of population size) and associated detection probabilities for species of interest (Pollock et al. 2002, Thompson 2002) either during the breeding season (Reinecke et al. 1992, Lougheed et al. 1999) or before harvest occurs (Steinert et al. 1994, Collier et al. 2007a). Successful monitoring programs, which often rely on counts of animals seen, heard, or captured (Thompson et al. 1998, Nichols et al. 2000, Williams et al. 2002), must provide reliable estimates of population change for them to be useful to managers (Thomas 1996).

Wildlife population monitoring is essential to management and conservation of all species. Biologists and managers need accurate estimates of abundance over broad spatial scales, but are often limited by resources or logistical constraints. The sampling designs for monitoring approaches need to be designed to encompass not only public lands but also private lands since the majority of wildlife exists on private lands.

Before settlement of the western United States, between 1.8 and 2.0 million Rio Grande wild turkeys (*Meleagris gallapavo intermedia*) were thought to inhabit Kansas, New Mexico, Oklahoma, Texas, and Mexico (Glazner 1967). Unregulated hunting

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

during the 1800s and habitat conversion and degradation reduced numbers to ~96,000 in Texas by 1928, with populations occurring primarily in the Edwards Plateau and South Texas Plains regions of Texas (Texas Game, Fish and Oyster Commission 1929:91, 1945:15–33, Gore 1969). The Texas Game, Fish and Oyster Commission began restoration efforts to other areas in the 1930s, primarily with translocated birds from populations trapped in these physiographic regions.

STUDY SITE

My study area was a private ranch approximately 30-km south of Falfurrias and east of Highway 281 in Brooks and Kenedy counties Texas (Figure 1.1). The study site encompassed approximately 42,000 ha of Coastal Sand Plains in south Texas (Diamond et al. 1987). Major habitat types included live oak (*Quercus fusiformis*) woodlands, mesquite (*Prosopis pubescens*) savannah, and mesquite and mixed brush shrubland (Scifres 1980). Grass species included big bluestem (*Adropogon gerardii*), little bluestem (*Schizachyrium scoparium* var. *littoralis*), yellow indiangrass (*Sorghastrum nutans*), eastern gammagrass (*Tripsacum dactyloides*), bufflegrass (*Pennisetum cilare*), and King Ranch bluestem (*Bothriochloa ischaemum*) (Gould 1975).

The study site is managed for native and exotic wildlife hunting as well as rotational cattle grazing on the entire area (Phillips 2008). Hunting leases use a 4–year fire rotation system for range management depending on annual rainfall in the area (R. Howard, San Tomas Hunting Camp). Mechanical and chemical brush treatments are also used for range management.

Average high temperatures obtained at the Weather Services International Intellicast (WSII) regional climate data for Falfurrias, Texas, during winter months ranged from 20.5 ^{o}C in January to 26.1 ^{o}C in March. Average low temperatures ranged from 6.7 ^{o}C in January to 12.2 ^{o}C in March. Average annual precipitation for Falfurrias was 64.6 cm per year with all winter averages being >2.2 cm for January to March.

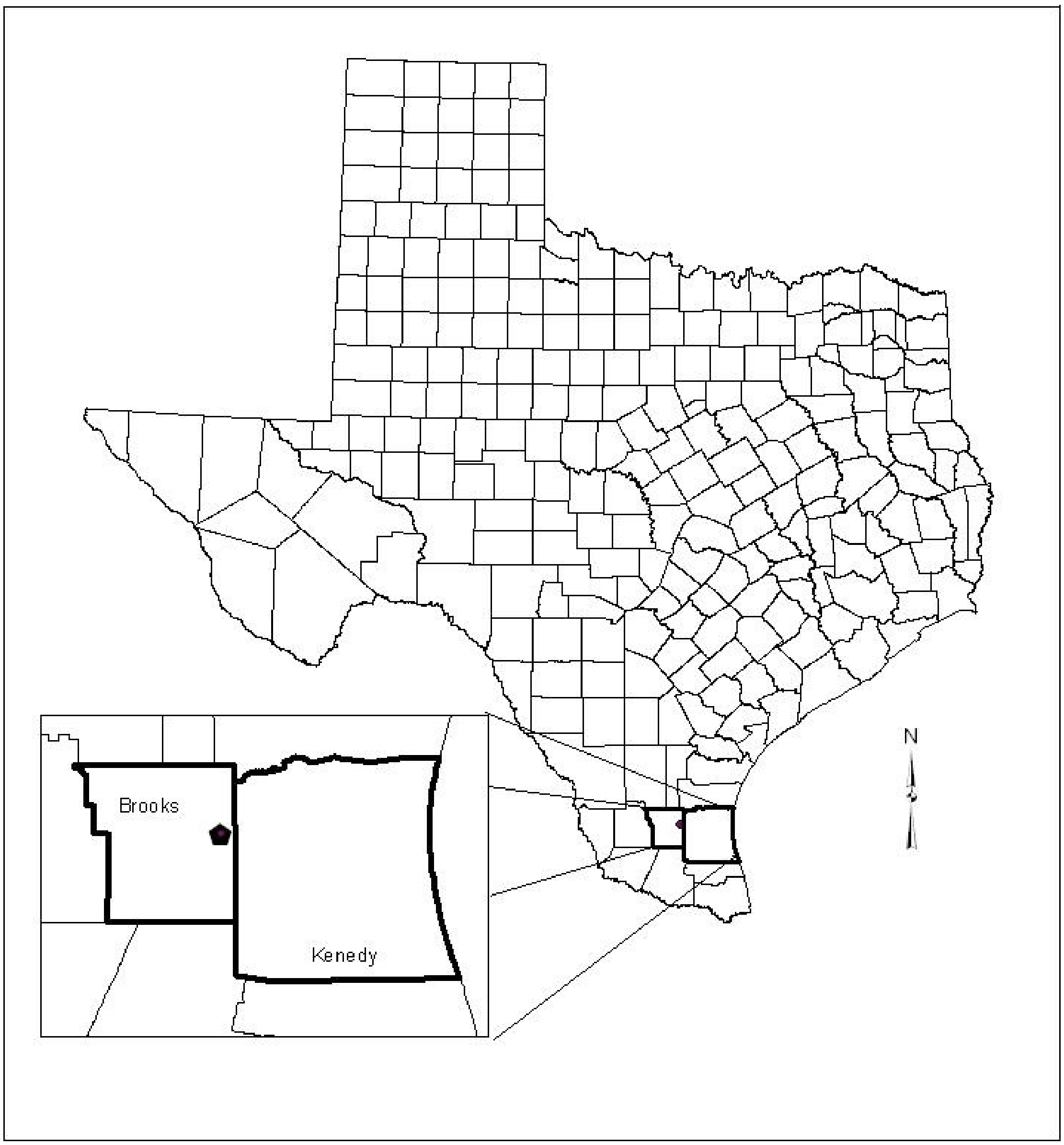

Figure 1.1: Location of the study site in Brooks and Kenedy counties, Texas, USA.

CHAPTER II

PREDICTING DISTRIBUTION OF RIO GRANDE WILD TURKEYS IN SOUTH TEXAS

Knowing where species occur is essential to management of any wildlife population (Thompson et al. 1998, MacKenzie et al. 2006). Spatial distribution and the ability to observe changes in distribution are essential to long term monitoring programs for any species (Buckland and Elston 1993). A common constraint when surveying wildlife populations is limited access to private lands. Generally, biologists are limited to surveying public lands and rights of ways, which comprise only a small portion of many states (e.g., ~5% in Texas; Dinkens et al. 2000). Because the majority of wildlife habitat, and thence wildlife, exists on private property in such states, surveys on private property must be included in large scale monitoring programs. Moreover, biologists need the capability to survey large areas accurately while addressing logistical and economical feasibility. Aerial surveys have been used to determine distribution and can alleviate land access issues because all land can potentially be surveyed and they also allow coverage of large spatial areas (Caughley 1977, Reinecke et al. 1992, Butler et al. 1995).

Methods for monitoring Rio Grande wild turkey (*Meleagris gallapavo intermedia*) populations in Texas have included roadside gobble and visual surveys, roost counts, harvest surveys, thermal imaging, and distance sampling (Butler et al. 2005, Butler et al. 2006, Locke et al. 2006, Erxleben 2008). The most viable technique for small-scale surveys is visual confirmation, including morning and evening roost counts (Butler et al. 2006). However, the aforementioned techniques are not suitable for rangewide sampling because of logistical constraints as well as land access issues.

Researchers have evaluated detection probabilities for aerial surveys using decoys in the Texas Rolling Plains (Butler et al. 2007) and the south Texas Coastal Sand Plains (Dong 2008). Detection rates and distribution of wild turkeys for large spatial scales were evaluated using helicopters, however economic feasibility for range wide surveys was not attained (Butler et al. 2008). Estimates of detection rate distribution and factors influencing regional distribution have yet to be evaluated using fixed-wing aerial surveys for live birds.

My objective was to develop and test a survey technique that will provide an accurate estimate of Rio Grande wild turkey distribution in the south Texas Coastal Sand Plains physiographic region. This technique uses aerial surveys conducted with fixed–wing aircraft to determine distribution of Rio Grande wild turkeys. It utilizes patch occupancy modeling to estimate distribution for later combination with local-scale estimates of Rio Grande wild turkey population abundance to estimate turkey population size across broad spatial scales.

METHODS

I developed sampling protocols for my study by combining methods used for previous aerial surveys (Cook and Jacobson 1979, Butler et al. 2007). I conducted 3 surveys during winter of 2007 (13–19 Feb, 28 Feb–7 Mar, and 8–14 Mar) and 3 additional surveys during the winter of 2008 (13–15 Feb, 18–23 Feb, and 25–29 Feb). Surveys during 2007 consisted of 6 flights each, whereas surveys during 2008 consisted of 3 flights each. Surveys began at 0830 hours and lasted until approximately 1100. I conducted flights during the morning under the expectation that turkeys would be concentrated in large roost flocks close to roosting sites.

Survey Design

For 2007 surveys, I used a simple random sampling design to survey my study area as well as 3 km outside of the study area to ensure coverage of flocks roosting on the property boundary. My sampling design used fixed-width transects 1 km apart on a north/south axis and were created using ArcGIS v. 9.3 software (Environmental Systems Research Institute (ESRI), Redlands, CA) using 2004 National Agricultural Imagery Program (NAIP) photographs and a shapefile of the boundary of the study site (Eric Redeker, Texas A&M University – Kingsville). Each sampling cell was 3 km by 1 km, encompassing 300 ha. For each survey, a random selection of approximately 20% of the ranch was selected for surveying and new survey cells were selected between each survey (Figure 2.1, Figure 2.2, and Figure 2.3).

Based on the locations of Rio Grande wild turkeys observed during the 2007 survey, the sampling design was altered to focus on locations more likely to have turkeys. Many winter flocks center their ranges on communal roost sites (Thomas et al. 1966, Beasom 1970). In the south Texas Coastal Sand Plains, live oak mottes are the primary roosting habitat because these trees tend to be the largest throughout this ecoregion. I identified and delineated each potential roosting area manually from 2004 NAIP imagery and created a new shapefile using ArcMap v. 9.3. I used a stratified random sampling design based on potential roosting areas with a 2 km buffer using ArcMap v. 9.3 and 2004 NAIP Imagery (Figure 2.4). I stratified each

Figure 2.1: Sampling units for survey 1 during the winter of 2007 sampled for estimating distribution of Rio Grande wild turkeys in south Texas.

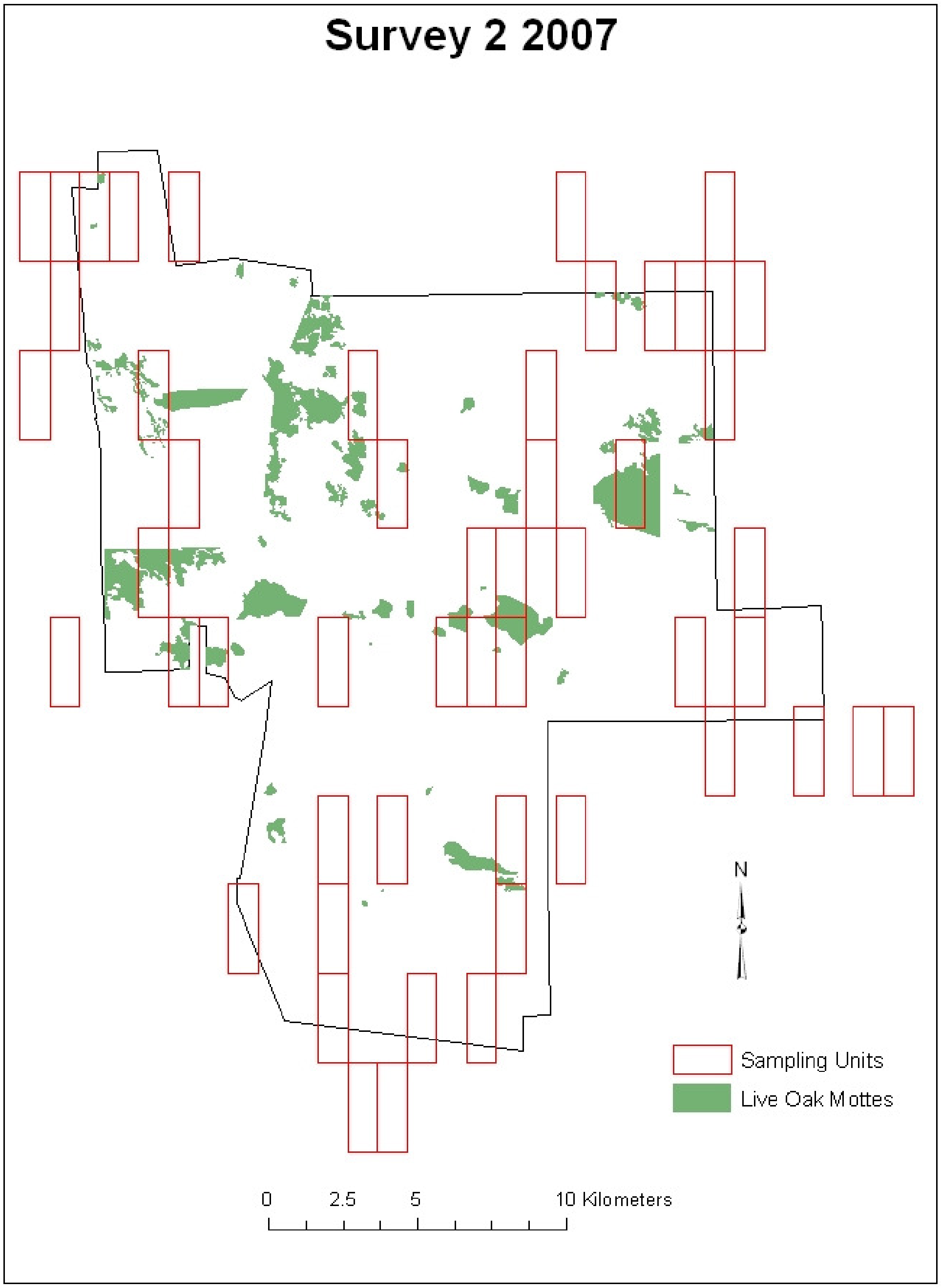

Figure 2.2: Sampling units for survey 2 during the winter of 2007 sampled for estimating distribution of Rio Grande wild turkeys in south Texas.

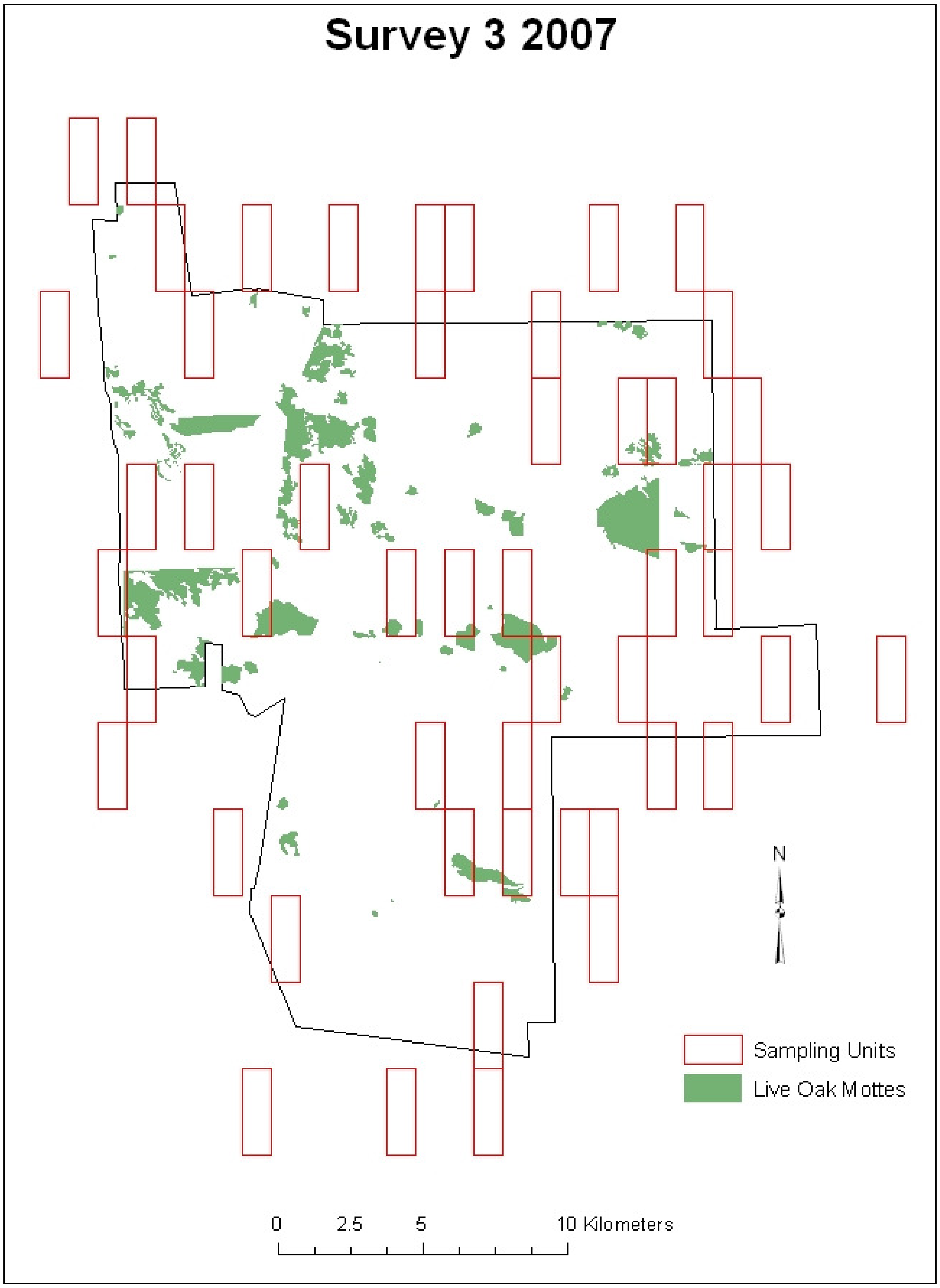

Figure 2.3: Sampling units for survey 3 during the winter of 2007 sampled for estimating distribution of Rio Grande wild turkeys in south Texas.

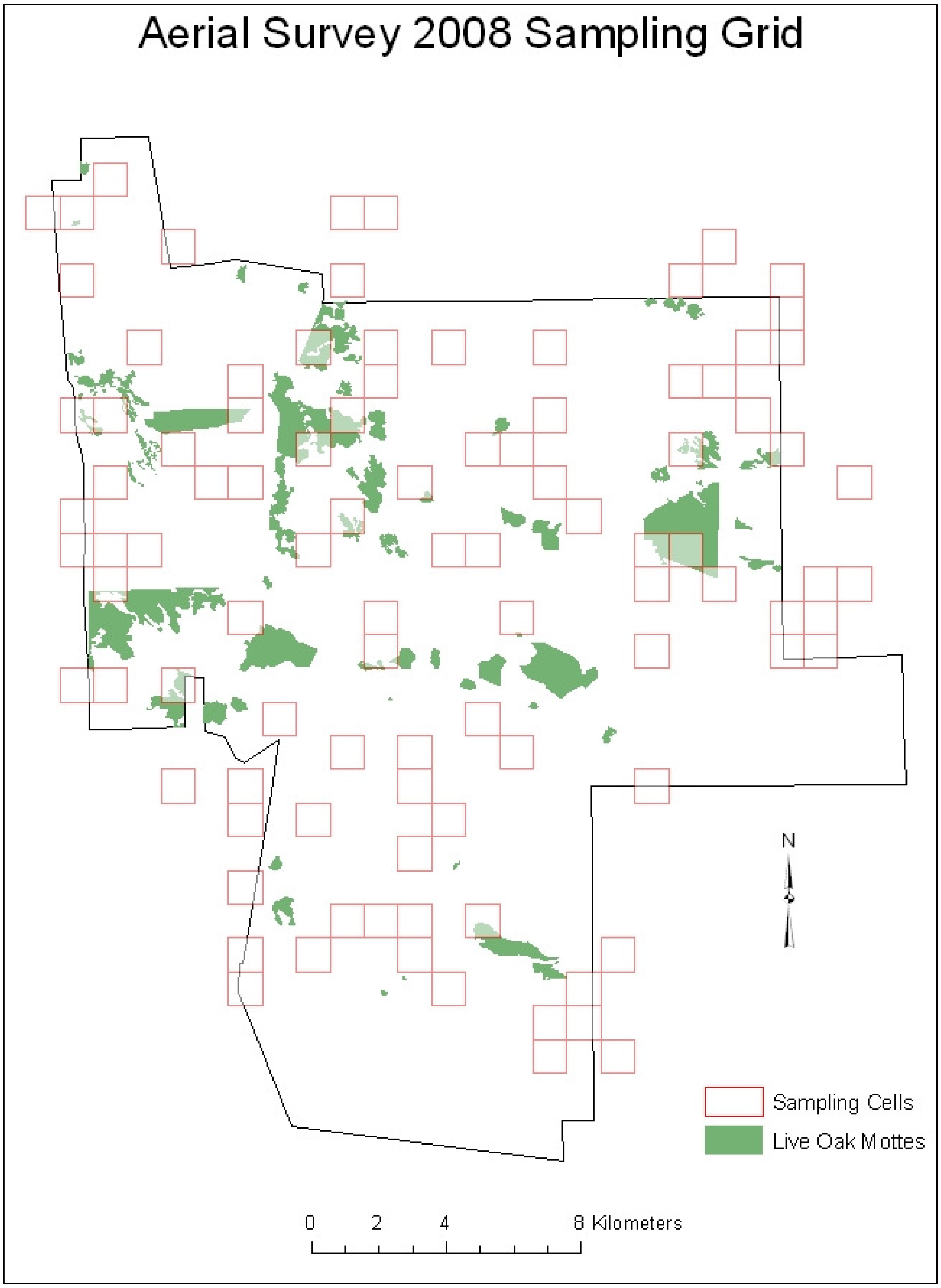

Figure 2.4: Aerial survey grids sampled for estimating distribution of Rio Grande wild turkeys in south Texas during the winter of 2008.

sampling unit to be within the 2 km buffer around the potential roosting habitat, and reduced each unit to 1 km x 1 km (100 ha). Sampling units were randomly chosen within each stratum selected for surveying, and encompassed 100 ha.

All flights took place in a fixed-wing aircraft (Cessna 172, Cessna Aircraft Co., Wichita, KS; Anse Windham, USA Flight, Kingsville, TX) at an altitude of 100 m. The pilot navigated transects using Garmin Etrex (Garmin International, Olathe, KS) Global Positioning System (GPS) receiver while paired observers sat in the front right seat and the rear left seat. The pilot flew in the center of a 1 km transect, whereas each observers' primary objective was to identify wild turkey flocks within 0.5 km of the transect, which is the approximate range where a turkey flock could be identified from that altitude (Robert Caveny, Texas A&M University, unpubl. data). Each observer recorded the number of flocks seen, approximate number of birds in each flock, time of the encounter, location of the encounter (generally sampling cell or Universal Transverse Mercator coordinates), and where possible, the sex ratio of each flock.

Data Analysis

I estimated distribution of Rio Grande wild turkey flocks for each survey. I estimated detection probabilities and associated occupancy estimates using Program MARK (White and Burnham 1999, MacKenzie et al. 2002). I chose several spatial covariates that I concluded were biologically significant to the distribution of wild turkeys, including size of live oak mottes, distance to the nearest live oak motte, and oak motte density in each sampling unit (Haucke 1975, Beasom and Wilson 1992). I measured each spatial covariate using ArcMap v. 9.3 and 2008 NAIP imagery.

I ran a Normalized Difference Vegetation Index (ESRI) to determine woody cover across the study area, and then removed all areas <0.1 ha from the analysis because these areas may be too small for suitable roosting habitat (Beasom and Haucke 1975, Haucke 1975, Beasom and Wilson 1992). I manually corrected the output to ensure that only live oak mottes were represented in the sample. I then ran zonal statistics (ESRI) to determine oak motte density in each sampling unit for both survey designs. I started at the centroid of each sampling cell to determine the distance to the nearest oak motte, and then determined the size of that motte.

I developed 8 predictive models for occupancy using the spatial parameters and time and used Akaike's Information Criterion (AIC) to determine the best fitting models (Table 2.1; Burnham and Anderson 2002). Models ranged from constant time with each spatial parameter to time dependant using each spatial parameter. I also used models that did not incorporate any of the spatial parameters into estimation of the occupancy or detection probability. Detection probabilities and occupancy rates were derived from the best models from the occupancy estimation.

RESULTS

Observers made 355 observations of turkey flocks from the air on the study area during both years of the study. Estimated detection probabilities from aerial surveys ranged between 0.24 and 0.30 (Table 2.2) for both years. Aerial survey 1 from 2008 was dropped from further analysis because there were too few positive observations for reliable estimation of turkey distribution. Estimates of Rio Grande wild turkey occupancy ranged widely between surveys. Two spatial parameters, size of oak mottes and distance to oak mottes, were important to estimating distribution of

Table 2.1: Models used for occupancy estimation of Rio Grande wild turkeys in south Texas during the winters of 2007 and 2008.

Model	Description
psi(.)p(.)	Occupancy estimates based on constant time between flights.
psi(t)p(t)	Occupancy estimates based on time variance between flights.
psi(size)p(.)	Occupancy estimates based on size of oak mottes while time remains constant.
psi(size)p(t)	Occupancy estimates based on size of oak mottes while time varies for each flight.
psi(dist)p(.)	Occupancy estimates based on distance to oak mottes while time remains constant.
psi(dist)p(t)	Occupancy estimates based on distance to oak mottes while time varies for each flight.
psi(den)p(.)	Occupancy estimates based on density of oak mottes while time remains constant.
psi(den)p(t)	Occupancy estimates based on density of oak mottes while time varies for each flight.

Table 2.2: Detection probabilities from aerial surveys for Rio Grande wild turkeys in south Texas during the winters of 2007 and 2008.

	Detection Probability	SE	Lower 95% CI	Upper 95% CI
Survey 1 2007	0.28	0.058	0.183	0.409
Survey 2 2007	0.27	0.036	0.206	0.344
Survey 3 2007	0.24	0.031	0.184	0.304
Survey 1 2008	-	-	-	-
Survey 2 2008	0.30	0.072	0.178	0.454
Survey 3 2008	0.30	0.083	0.163	0.481

turkeys across south Texas. The most parsimonious model across all surveys was where size of live oak mottes best predicted occupancy. As oak motte size increases, the probability of occupancy tends toward 1 (Figure 2.5). Turkeys tend to utilize oak mottes; therefore, when there is a landscape with oak mottes that has a known turkey population, it is highly probable that there will be a group of turkeys in any given large oak motte (Table 2.3). Models incorporating distance to oak mottes were also considered plausible with low ΔAIC values for 2007 but less evidence for 2008 (Appendix 1).

DISCUSSION

Based on my results, aerial surveys can provide a viable approach for evaluating turkey population distribution over large spatial scales. Mean detection probability for aerial surveys was 0.27, meaning approximately 25% of flocks are detected during the survey period. If detection probability is not taken into account during occupancy surveys, the estimated distribution based on occupancy estimates would be biased low (MacKenzie 2005).

Size of oak mottes and distance to the nearest oak mottes were the primary spatial parameters that determined distribution of Rio Grande wild turkeys across my study area. Concentrating survey effort on live oak mottes reduced overall survey effort. On my study area, surveying within 1 km of potential roosting habitat reduced overall survey area by approximately 50% (Figure 2.6). Surveys should be flown shortly after sunrise before birds have time to move > 1 km away from roosts. Surveying within 2 km of potential roosting habitat reduced overall survey area by approximately 22% across the study area (Figure 2.6).

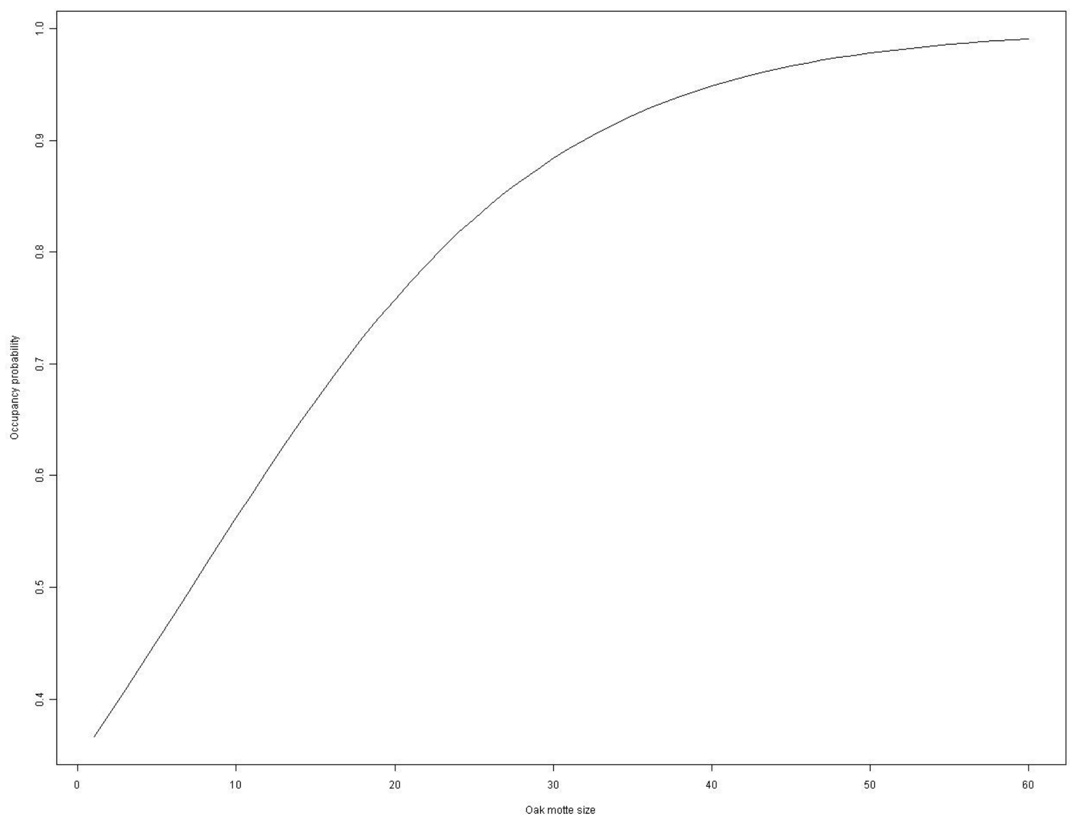

Figure 2.5: Probability of occupancy as oak-motte size increases for Rio Grande wild turkeys in south Texas during the winters of 2007 and 2008.

Table 2.3: Probability of occupancy based on live oak motte size (ha) for Rio Grande wild turkeys in south Texas during the winters of 2007 and 2008 (Beta estimates in Appendix 2).

	Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
Survey 1 2007	0.248 (0.104)	0.248 (0.125)	0.250 (0.223	0.284 (2.488)	0.254 (0.425)	0.993 (59.680)
Survey 2 2007	0.554 (0.103)	0.572 (0.124)	0.606 (0.164)	0.703 (3.670)	0.833 (0.510)	1.000 (112.000)
Survey 3 2007	0.350 (0.101)	0.600 (0.139)	0.937 (0.226)	0.795 (2.239)	1.000 (1.297)	1.000 (59.680)
Survey 1 2008	-	-	-	-	-	-
Survey 2 2008	0.172 (0.100)	0.173 (0.152)	0.179 (0.421)	0.256 (11.410)	0.203 (1.465)	1.000 (343.900)
Survey 3 2008	0.168 (0.100)	0.169 (0.152)	0.172 (0.421)	0.228 (11.410)	0.183 (1.465)	1.000 (343.900)

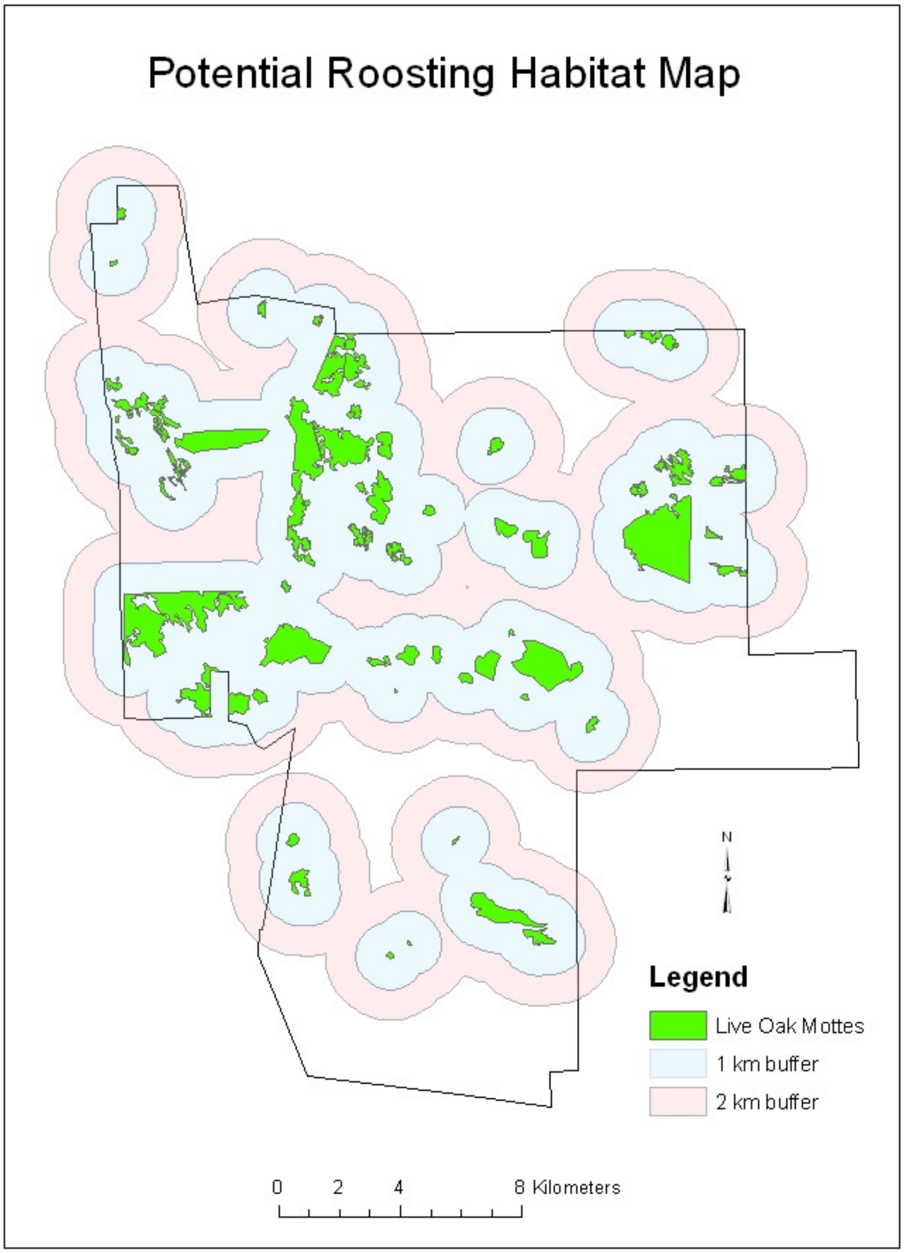

Figure 2.6: Potential roosting cover on the study area for Rio Grande wild turkeys during winters of 2007 and 2008.

During winter, Rio Grande wild turkeys center their daily activities on roosting areas (Watts 1969, Thomas et al. 1973, Beasom and Wilson 1992). Concentrating surveys in these areas allows us to evaluate population distribution efficiently based on distribution of the primary habitat requirement for Rio Grande wild turkeys. In portions of the south Texas Coastal Sand Plains, many live oak mottes have not yet reached suitable height for turkey roosting. Hence, while mottes have high density across the south Texas Coastal Sand Plains, motte height likely limits the number of potential roost sites, which can influence roost site fidelity (Thomas et al. 1966, Haucke 1975, Phillips 2008). Determining potential roost sites on a landscape or ecoregion scale is one area that will require standardization of potential roosting habitat before implementation of wide ranging use of fixed-wing aerial surveys for wild turkeys.

Roost site fidelity has been identified as a major issue in the Edwards Plateau (Thomas et al. 1966, Locke et al. 2006) and Rolling Plains (Butler et al. 2006, Swearingen 2007) of Texas, where few suitable roosting areas may be available. Since turkeys are generally limited by the amount of potential roosting habitat, concentrating on these areas may work for large scale monitoring of wildlife populations in other ecoregions (Butler et al. 2006, 2007, and 2008). Erxleben (2008) stated that 90% of telemetry locations in the Texas Rolling Plains and Edwards Plateau occurred within 1 km of riparian areas. Riparian areas are also known to have the majority of roosting habitat for wild turkeys since they generally contain the largest trees.

In conclusion, concentrating aerial survey efforts on potential roosting habitat may simplify large scale monitoring in multiple ecoregions of Texas. Protection and creation of suitable roosting habitat should be a priority if the management of wild turkey populations is the goal (Phillips 2008). Aerial surveys relieve many of the logistical problems associated with currently used techniques for monitoring large scale distribution of wildlife species. Depending on the a priori precision preferred, more surveys should be flown if a higher degree of precision is desired. Further investigation of factors affecting distribution or detectability of Rio Grande wild turkey flocks needs to be completed. These include canopy cover and connectivity of roosting habitat. Large scale distribution surveys flown by state biologists will assess ecoregion scale distribution of Rio Grande wild turkeys. This will allow for long term data collection over large areas with reduced effort put forth by biologists.

CHAPTER III

LOCAL ABUNDANCE ESTIMATION FOR RIO GRANDE WILD TURKEYS USING INDEPENDENT DOUBLE–OBSERVER ROOST COUNTS

Several techniques have been used to estimate abundance or trends in wildlife populations (Thompson et al. 1998, Morrison et al. 2008). Estimates of abundance of wildlife populations are essential in management decisions (Thompson et al. 1998, Nichols et al. 2000, Williams et al. 2002). However, most techniques currently used provide index values without a measure of associated detection probability (Anderson 2001, Butler et al. 2007).

Biologists commonly attempt to estimate turkey abundance using roadside gobble surveys, roost counts, harvest surveys, thermal imaging (Butler et al. 2005, 2006; Locke et al. 2006), and distance sampling (Erxleben 2008). The most viable technique for roost counts is visual confirmation, including morning and evening roost counts (Butler et al. 2006). Rio Grande wild turkeys (*Meleagris gallapavo intermedia*) typically use suitable winter roosting habitats daily and generally return to the same roost annually (Beason and Wilson 1992). Counting turkeys at winter roosts is a technique commonly used to monitor abundance because of flock congregations during fall and winter (Thomas et al 1966, Watts and Stokes 1971). However, turkeys may not always be present at a roost. To estimate average local turkey population size, biologists need to conduct repeated surveys on a roost to allow for an accurate count of individuals and to determine the frequency of roost use.

A common constraint when surveying wildlife populations is that biologists have limited access to the private lands. Instead, they typically are limited to public rights of way or public lands, which comprise a small portion of many states (e.g. ~5% in Texas; Dinkens et al 2000). Since considerable available habitat exists on private property in such states, these areas need to be included in large scale monitoring programs. To accomplish this goal, biologists need to help landowners form cooperatives for the purpose of local population estimation. Incentives may be needed to enter landowners into cooperatives, but the benefits would be crucial for sustainable harvest management. Biologists can train landowners to conduct roost surveys following a set sampling frame to ensure the quality of data. Landowners then would have an accurate way to assess the number of individual animals on their property, and biologists would receive long term monitoring data over large areas.

My objective was to develop and pilot a survey methodology for estimating local and regional population size of Rio Grande wild turkeys in the south Texas Coastal Sand Plain. I conducted independent double observer roost counts to determine roost-specific abundance and turkey detection probability. I also evaluated roost-specific occupancy to determine how frequently roosts were used.

METHODS

Roost Level Detection Rate and Plot Level Abundance

I estimated Rio Grande wild turkey roost abundance and associated detection probabilities using double observer roost counts (Cook and Jacobson 1979, Nichols et al. 2000) on known turkey roosts across the study site (Figure 3.1). Because Rio Grande wild turkey roosts on the division are primarily located in live oak mottes, I

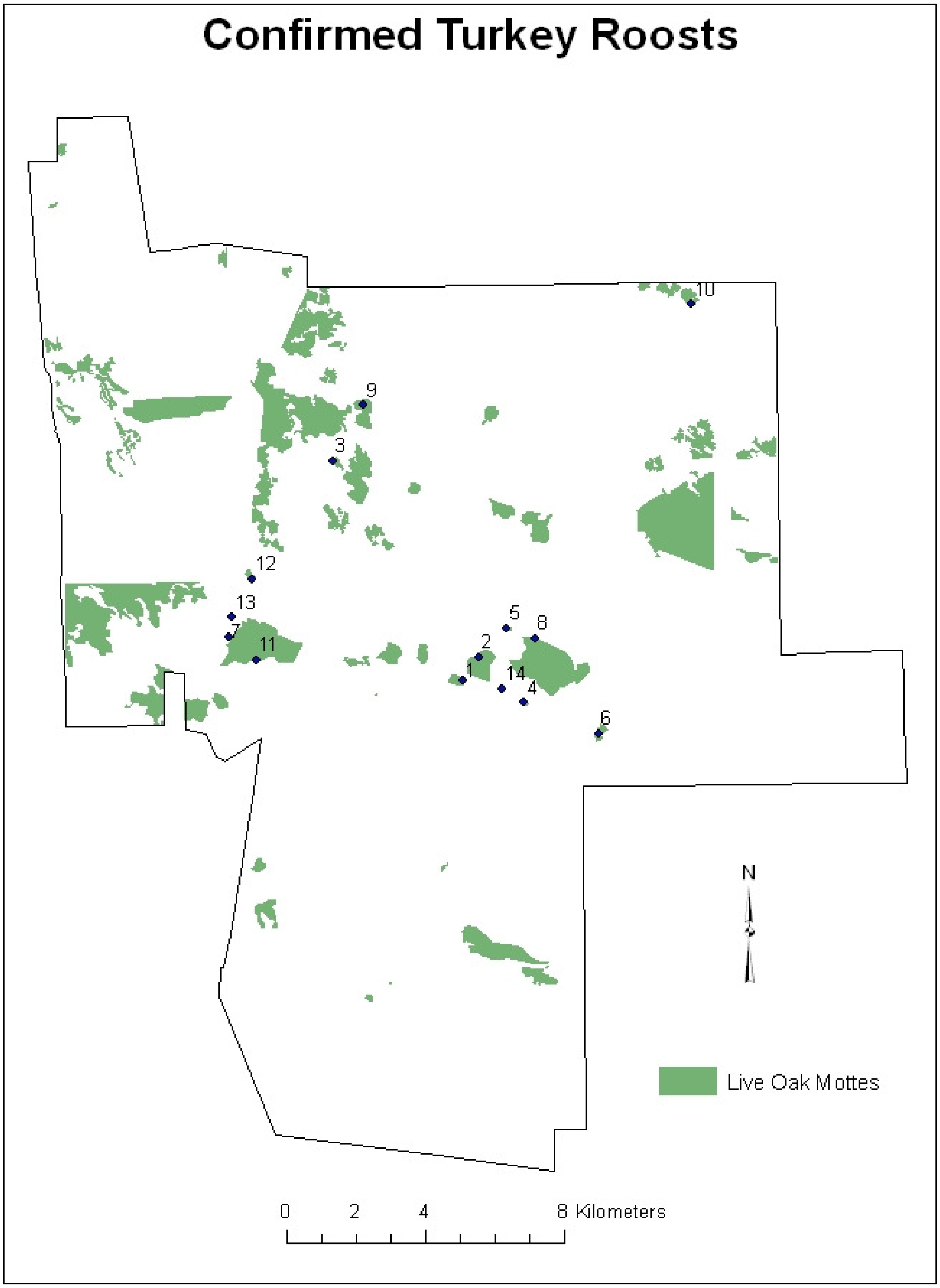

Figure 3.1: Location of confirmed Rio Grande wild turkey roosts on the study area during the winters of 2007 and 2008.

targeted these areas for surveying via roost conformation using both radio telemetry and visual sightings.

Turkeys were captured November–January 2007–2008 and November–December 2008 during a concordant study on the study site (Phillips 2008). We captured birds using walk-in traps (Davis 1994) on the study site. We attached backpack style radio transmitters (69.0–95.0 g: Advanced Telemetry Systems, Isanti, MN, USA) to each captured individual. Birds were located several times at night on the roost before we considered that roost a confirmed roost site.

To ensure precision, the sampling occasions must take place during the same time of year annually. The different sampling occasions are typically close together in time (e.g., winter months) to assure that the same group of birds was exposed to sampling efforts at each occasion (Nichols et al. 2008). Following Nichols et al. (2000), for each survey 2 observers were camouflaged and concealed in vegetation near a roost (> 75 m), with observers approximately 10m apart. Morning surveys began approximately at sunrise and evening counts began about a half hour before sunset until dark.

For each survey, observers independently counted the number of Rio Grande wild turkeys at the roost, with counts beginning immediately after the birds begin to fly on or off the roost. Generally, only a few birds went on or off at first, so we considered that our first count. After our initial count, all birds were counted going up to the roost twice thereafter in 10 minute intervals and we kept a running total (total number of individual birds counted), which was used for analysis.

Roost Level Occupancy

I evaluated roost level occupancy by conducting 3 repeated surveys of 6 randomly selected roost sites. Different roosts were randomly selected between each survey. Counts were conducted 4 times weekly during the winter roosting period. Because roosts were often located contiguous to each other within live oak mottes, I was able to survey several roosts each night. Morning surveys were not conducted after evening surveys on the same roost due to known state of the roost (e.g., presence and absence would be known from previous night), but morning surveys (when the birds fly down) followed by evening surveys (birds flying up) on the same roost on the same day were allowed.

Data Analysis

I estimated roost level abundance and variation in observer detection probabilities using program DOBSERV (Nichols et al. 2000, Hines 2000). I used Akaike's Information Criterion (AIC) to determine the best fitting models from a set of candidate models. DOBSERV uses a set of pre-defined models which differentiate detection probabilities between location, between observers, and between species. Data was entered in different configurations to determine differences between each individual roost and between each observer used. For each roost, count data was entered for all counts on each roost individually. For observers, count data was entered for each observer when acting as the primary observer to determine detection probabilities for each individual.

I estimated Rio Grande wild turkeys roost occupancy for each survey using program MARK (White and Burnham 1999, MacKenzie et al. 2002). I used a single species, single season approach to analyze the data (MacKenzie et al. 2006). Occupancy estimates were derived using a constant model.

RESULTS

We conducted 100 roost-specific double-observer roost surveys with counts ranging between 0 to 183 individuals. Fourteen Rio Grande wild turkey roosts were confirmed in live oak mottes across the study area (Phillips 2008). Several roosts were counted for both study years (2007, 2008), while others were located and hence surveyed only during 2008.

The area of roost mottes ranged from 0.15 to 34.17 ha. Smaller mottes tended to be more even aged compared to larger mottes based on estimates of tree heights (Phillips 2008). Oak motte size was determined using ArcGIS v. 9.3 software (Environmental Systems Research Institute, Redlands, CA). The mottes were concentrated on the north and central parts of the ranch.

I used 7 independent observers during my study. Three observers were used in the first year, with 4 additional observers added during the second year. Two of the same observers were used for both years. Plot level detection probabilities varied little between roosts and between observers. Detection probabilities for roost surveys were high (>95%), both between roosts and years (Table 3.1). When acting as primary observer, roost count detection probabilities were $\geq$ 0.80 (Table 3.2). The observers used during both years had similar detection probabilities (0.90 and 0.87, respectively).

Table 3.1: Number of Rio Grande wild turkeys counted and estimation of detection probability and abundance for multiple turkey roosts across south Texas 2007-2008 (Nichols et al. 2000).

		Detection Probability			Abundance					
Roost	Year	X..	P	SE(P)	N (total all counts)	SE(N)	Lower	Upper	Count Num	Ave Birds / Count
1	2007	104	0.938	0.0000	110.91	2.71	107.29	118.51	3	36.97
	2008	172	1.000	–	172.00	–	–	–	4	43.00
2	2007	–	–	–	–	–	–	–	3	
	2008	134	0.991	–	135.25	–	–	–	3	45.08
3	2007	270	0.991	0.0040	272.61	1.97	270.70	279.71	5	54.52
	2008	61	0.987	0.0076	61.83	1.04	61.13	66.54	4	15.46
4	2007	–	–	–	–	–	–	–	3	
	2008	25	1.000	–	25.00	–	–	–	5	5.00
5	2007	–	–	–	–	–	–	–	0	
	2008	29	0.998	0.0018	29.04	0.20	29.00	30.38	3	9.68
6	2007	253	0.991	0.0030	255.32	1.71	253.64	261.44	5	51.06
	2008	426	0.998	0.0007	426.91	1.00	426.16	431.23	6	71.15
7	2007	160	0.994	0.0033	160.99	1.13	160.17	165.93	5	32.20
	2008	125	0.995	0.0026	125.67	0.88	125.09	129.78	5	25.13
8	2007	513	0.998	0.0010	514.16	1.19	513.22	519.09	6	85.69
	2008	12	0.998	0.0010	12.03	0.17	12.00	13.14	3	4.01
9	2007	360	0.579	0.0000	621.09	21.22	582.70	666.11	3	207.03
	2008	300	0.996	0.0014	301.19	1.18	300.24	306.01	3	100.40
10	2007	–	–	–	–	–	–	–	1	
	2008	49	1.000	–	49.00	–	–	–	3	16.33
11	2007	74	0.955	0.0174	77.52	2.39	75.06	85.74	3	25.84
	2008	23	0.999	0.0010	23.01	0.11	23.00	23.74	3	7.67
12	2007	120	0.981	0.0100	122.36	1.99	120.56	129.91	4	30.59
	2008	26	0.980	0.0164	26.53	0.86	26.06	30.90	3	8.84
13	2007	–	–	–	–	–	–	–	0	
	2008	54	1.000	–	54.00	–	–	–	4	13.50
14	2007	–	–	–	–	–	–	–	0	
	2008	66	0.997	0.0024	66.21	0.05	66.01	69.00	3	22.07

Table 3.2: Mean observer detection probability of Rio Grande wild turkeys during independent double-observer surveys in south Texas 2007–2008.

Observer	Number of Counts	Detection Probability	Std. Error
1	28	0.904	0.006
2	14	0.875	0.009
3	8	0.799	0.021
4	9	0.938	0.011
5	2	0.981	0.006
6	7	0.906`	0.013
7	2	0.952	0.047

Roost level occupancy was estimated ~0.84 with detection probabilities between 0.69 (SE= 0.107) and 0.79 (SE=0.091) (Table 3.3). The naïve occupancy probability estimate was 0.72 (72/100), much lower than the average estimate of roost occupancy surveys.

DISCUSSION

The ability of the primary observer to count the number of birds flying on and off the roost was high during both years. Because similar detection probabilities were obtained, and were high, these index values should be a good approximation of abundance (Johnson 2008, Nichols et al. 2008). Of all surveyed roosts, roost 9 had the lowest detection probability, likely due to observer placement (may not have had a clear view due to vegetation, etc.), low number of individual using the roost, and/or a low number surveys conducted on an individual roost.

While all subspecies of wild turkeys demonstrate communal roosting, the Rio Grande subspecies displays a stronger inclination to roost at the same site for consecutive nights and from year to year than other subspecies (Watts 1969, Thomas et al 1973, Beasom and Wilson 1992, Healy 1992, Phillips 2008). Rio Grande wild turkeys may not roost in the same tree every night, but they typically roost in the same part of a live oak motte (Beasom and Wilson 1992). The practice of roosting in tall trees is common among the eastern subspecies (*M. G. silvestris*; Kilpatrick et al. 1988, Chamberlain et al. 2000, Ermer et al. 2005). While there are numerous live oak mottes across south Texas Coastal Sand Plains, there are fewer mottes with trees tall enough (> 9 m) to serve as roosting habitat (Hauke 1975, Beasom and Wilson 1992, Phillips

Table 3.3: Occupancy of Rio Grande wild turkey roost surveys in south Texas during 2008.

Survey	Occupancy	SE	Detection probability	SE
1	0.841	0.154	0.694	0.107
2	0.837	0.153	0.747	0.099
3	0.835	0.152	0.799	0.091

2008). Thus, large oak mottes with tall trees should be preserved during range management practices to provide suitable roosting habitat for wild turkeys (Gore 1969, Haucke 1975, Phillips 2008).

I found that birds did not always return to the same roost each night; instead they used roosts depending on their location at dusk. One possible explanation is that birds might have been cut off by predators or other disturbances and were unable to make it back to their preferred roost (Chamberlain et al. 2000). An alternative explanation is that birds may choose those roosts each evening at random (Chamberlain et al. 2000). Understanding the scale at which birds select habitat can help determine optimal management techniques (Dreibelbis et al. 2008).

I found that independent double-observer roost counts are a viable alternative for estimating Rio Grande wild turkey abundance on local spatial scales. Since my roost counts had fairly high precision, and were unbiased, land owners and managers may inexpensively yet accurately estimate Rio Grande wild turkey abundance on their properties if they know how many potential roosts exist. This approach allows “access” for biologists to collect local population estimates without actually ever setting foot on the property. Using a random sample of different ranches in an ecoregion, a population estimate can be obtained for that ecoregion.

CHAPTER IV

CONCLUSION

Occupancy modeling may be a viable option for estimating Rio Grande wild turkey distribution in south Texas Coastal Sand Plains. Concentrating aerial survey efforts on potential roosting areas and the area around the roosts will allow for efficient estimation of wild turkey population distribution. Aerial surveys using a fixed-wing aircraft may be more economically feasible than ground-based or helicopter approaches for large scale assessment of distribution. Further, documenting the presence and absence of species requires less effort than density estimation (Gaston et al. 2000).

State biologists will have to fly aerial surveys to determine distribution at regional scales. Concentrating aerial survey efforts on potential roosting areas allows for inferences about accurate population distribution for the entire ecoregion. Biologists will then be able to estimate the probability that birds are present in the ecoregion. Conversely, land managers conducting independent double observer roost counts provide local scale abundance estimates. A random sample of counts by land managers across the ecoregion could provide local abundance estimates that then could be combined with ecoregion distribution estimates conducted using aircraft. These two techniques would enable long-term, large-scale monitoring of Rio Grande wild turkeys in south Texas Coastal Sand Plains and elsewhere in semiarid habitats.

If Rio Grande wild turkey management is an objective, patches of tall trees should be preserved during rangeland management practice (Haucke 1975, Beasom and Wilson 1992, Phillips 2008). Rio Grande wild turkeys also prefer open areas close to the roost in order to have a place to display before ascending in the evening, as well as a safe place to descend in the morning (Swearingin 2007). In the south Texas Coastal Sand Plains, live oak mottes should be protected and managed for suitable roosting habitat. Many of these mottes lie in the middle of open pastures and are sometimes cleared for cattle grazing. In the south Texas Coastal Sand Plains, trees in many live oak mottes have not reached a suitable height for roosting turkeys. Hence, while mottes are of fairly high density across the south Texas Coastal Sand Plains, motte age and thus size, likely limits the number of potential roost sites, which could affect roost site fidelity and turkey distribution (Phillips 2008).

In other regions of Texas, the majority of potential roosting habitat occurs within riparian areas (e.g., Rolling Plains, High Plains, Edwards Plateau, and South Texas Plains), so these areas should be protected and managed to allow large trees to grow for roosting habitat. During management activities, large trees and especially groups of large trees should be conserved while some areas of brush contiguous to these stands should be cleared for adequate open areas for turkeys to ascend or descend from the roosts.

The sampling design I propose could be expanded to other ecoregions following the same protocols set forth for the south Texas Coastal Sand Plains. Concentrating survey effort within 1 km of potential roosting habitat in several other ecoregions will delineate mainly riparian areas (e.g., Texas Rolling Plains, Texas High Plains, Edwards Plateau, Trans-Pecos, and South Texas Plains). Seven years of telemetry data from the Texas Rolling Plains and the Edwards Plateau showed that turkeys mainly used areas within 1 km of riparian areas (Collier et al. 2007*b*, Erxleben 2008). Probabilistically defining a sampling scheme within 1 km of these riparian areas and using random sampling units will allow for distribution estimates for other ecoregions.

Delineating sampling units around riparian areas reduces area that will be sampled, hence, reduces amount of effort put forth by biologists. However, this approach may not be applicable where roosting habitat is not readily identifiable (Haucke 1975, Quinton et al. 1980). In these situations, another approach will likely need to be utilized to determine distribution in these areas (Locke et al. 2006, Butler et al. 2007). Techniques for local abundance estimates will work similarly in other ecoregions as well, and have been shown to work under a different sampling design (Butler et al. 2006).

Monitoring wildlife populations is essential in management of these populations. Techniques that are inexpensive and precise are preferred due to monetary constraints not only by state or federal agencies but also by landowners and managers. The use of occupancy modeling to determine estimates of distribution and counts conducted by landowners may be a viable alternative to other forms of population estimation. Concentrating survey efforts on major habitat requirements of the species may contribute to large scale survey efforts for many wildlife populations.

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APPENDIX

A-1: Candidate models used to examine the difference in occupancy estimates for Rio Grande wild turkeys in south Texas during the winters of 2007 and 2008. (* - Seven parameters were estimated for this model, hence it was not used for inference)

	Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance
Survey 1 2007	psi(size)p(.)	154.718	0	0.534	1	3	148.218
	psi(dist)p(.)	156.878	2.161	0.181	0.339	3	150.378
	psi(.)p(.)	157.284	2.567	0.148	0.277	2	153.039
	psi(den)p(.)	159.098	4.381	0.060	0.112	3	152.598
	psi(size)p(t)	159.718	5.001	0.044	0.082	8	140.369
	psi(t)p(t)	161.828	7.111	0.015	0.029	7	145.283
	psi(dist)p(t)	161.965	7.247	0.014	0.027	8	142.616
	psi(den)p(t)	164.191	9.473	0.005	0.009	8	144.842
Survey 2 2007	psi(size)p(.)	288.711	0	0.618	1	2	284.461
	psi(dist)p(.)	289.927	1.216	0.336	0.544	3	283.417
	psi(.)p(.)	294.781	6.070	0.030	0.048	2	290.531
	psi(den)p(.)	296.405	7.694	0.013	0.021	3	289.895
	psi(size)p(t)	300.300	11.589	0.002	0.003	8*	283.696
	psi(den)p(t)	302.089	13.378	0.001	0.001	8	282.659
	psi(t)p(t)	306.379	17.668	0.000	0.001	7	289.775
	psi(den)p(t)	308.567	19.856	0.000	0	8	289.138
Survey 3 2007	psi(size)p(.)	290.120	0	0.714	1	2	285.870
	psi(size)p(t)	293.711	3.591	0.119	0.166	8*	277.107
	psi(dist)p(.)	293.766	3.646	0.115	0.162	3	287.255
	psi(.)p(.)	296.960	6.840	0.023	0.033	2	292.710
	psi(dist)p(t)	297.738	7.618	0.016	0.022	8	278.309
	psi(den)p(.)	299.217	9.097	0.008	0.010	3	292.707
	psi(t)p(t)	300.426	10.306	0.004	0.006	7	283.822
	psi(den)p(t)	303.247	13.127	0.001	0.001	8	283.818
Survey 2 2008	psi(size)p(t)	147.295	0	0.938	1	5	136.643
	psi(size)p(.)	152.894	5.599	0.057	0.061	3	146.639
	psi(den)p(t)	158.930	11.635	0.003	0.003	5	148.278
	psi(t)p(t)	160.428	13.133	0.001	0.001	4	151.998
	psi(dist)p(t)	162.140	14.845	0.001	0.006	5	151.488
	psi(den)p(.)	163.630	16.335	0.001	0.003	3	157.375
	psi(.)p(.)	165.138	17.843	0.001	0.001	2	161.011
	psi(dist)p(.)	166.803	19.508	0.001	0.001	3	160.548
Survey 3 2008	psi(size)p(.)	134.720	0	0.723	1	3	128.465
	psi(size)p(t)	137.284	2.564	0.201	0.277	5	126.632
	psi(.)p(.)	141.336	6.616	0.027	0.037	2	137.210
	psi(dist)p(.)	142.127	7.407	0.018	0.025	3	135.872
	psi(den)p(.)	142.409	7.689	0.015	0.021	3	136.154
	psi(t)p(t)	143.865	9.145	0.007	0.010	4	135.435
	psi(dist)p(t)	144.748	10.028	0.004	0.007	5	134.096
	psi(den)p(t)	145.036	10.316	0.004	0.006	5	134.383

A-2: Beta parameter estimates of size interactions for estimating the distribution of Rio Grande wild turkeys in south Texas during the winters of 2007 and 2008. Note that survey 1 of 2008 was inestimable.

	Psi Slope	SE	Psi Intercept	SE
Survey 1 2007	0.103	0.108	-1.120	0.380
Survey 2 2007	3.479	2.971	-0.141	0.668
Survey 3 2007	26.396	27.699	-3.260	3.606
Survey 1 2008	-	-	-	-
Survey 2 2008	0.150	0.079	-1.589	0.400
Survey 3 2008	0.077	0.044	-1.608	0.434

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