WINTER ROOSTING ECOLOGY OF RIO GRANDE WILD TURKEYS IN THE ROLLING PLAINS OF TEXAS

by

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ABSTRACT

A crucial time for Rio Grande wild turkeys (*Meleagris gallopavo intermedia*) is during the winter when flocks > 200 birds congregate at traditional winter roosts. As wild turkey home ranges are smallest during this time of year, there is a need for appropriate forage and security habitat in close proximity to suitable roosting habitat. In addition, it is believed that eastern cottonwood (*Populus deltoides*), the favored roost tree species in the Rolling Plains, may be declining due to altered river flow regimes, the invasion of exotic species such as Russian olive (*Elaeanus angustifolia*) and saltcedar (*Tamarix chinensis*), and overgrazing. Consequently, a greater understanding of the critical vegetative characteristics of winter roost sites is needed. We conducted fieldwork on 3 study sites located in the Rolling Plains of Texas during September through flock breakup in April from 2004–2006. We gathered roost locations via radiotelemetry to identify movement patterns and to detect active winter roosts. We measured roosting habitat at 32 roost sites and 32 randomly selected non-roost sites. We measured tree height, tree diameter, canopy cover, tree decay, area of the stand in which the roost occurred (stand area), percent litter cover, and percent shrub cover. We linked winter roost use (presence-absence) with habitat variables representing forest and vegetation structure at roost sites by creating explicit habitat models. We developed 44 *a priori* logistic regression models. We used second-order Akaike's information criterion (AIC_c) for model selection. We found tree height, tree diameter, stand area, and percent litter were all important predictors of roost sites. Based on these findings an appropriate management strategy should include the conservation of large, open-understory, riparian stands of trees. Those stands should contain the tallest, largest diameter trees available. We also suggest that young stands of preferred roost tree species be protected to provide future potential roost sites when current roosts become unsuitable to wild turkeys.

Winter flock congregations of Rio Grande wild turkeys are larger than other turkey subspecies. Roosting flocks > 200 birds are not uncommon. However, thorough evaluations of when flocks congregate on winter areas and the potential climatic factors that drive congregation are lacking. We used opportunistic flock counts (n = 3,047) and roost counts (n = 101) to identify timing of winter flock congregation, peak concentrations, and breakup of winter roosts. We also examined possible relationships between roost/flock counts and climatic variables. We found that winter congregation occurred from 15 November through 28 February with peak concentrations occurring from 16 January through 1 March, and flock breakup occurred from 1 March through 15 April. We suggest that if using roost counts for abundance estimation that surveys be conducted from 16 January though 1 March.

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CHAPTER I

INTRODUCTION

There are 5 subspecies of wild turkey in the United States: the eastern (*Meleagris gallopavo silvestris*), Florida (*M. g. osceola*), Gould's (*M. g. mexicana*), Merriam's (*M. g. merriami*), and Rio Grande (*M. g. intermedia*). Wild turkeys appeared to thrive prior to European colonization. Historically, 39 states supported wild turkey populations. Upon European settlement, wild turkey numbers were driven to near extinction due to habitat destruction from land clearing and over-harvest (Kennamer et al. 1992). Wild turkey numbers were lowest near the end of the 19^{th} century (Kennamer et al. 1992). By 1920, the wild turkey was extirpated from 18 states (Moseby and Handley 1943). Fortunately, wild turkey restoration efforts that began after World War II were successful (Kennamer et al. 1992). Now wild turkey populations inhabit every state except for Alaska and have expanded beyond historical distributions both naturally and with the help of restocking efforts (Kennemer et al. 1992).

In Texas, by 1940 the Rio Grande wild turkey population numbered around 100,000 birds, and the subspecies had been extirpated from Kansas and Oklahoma (Shorger 1966). The Rio Grande wild turkey was restored to its native range through protective legislation, the development of protected areas, and by restocking of wild live–trapped birds (Gore 1969, Beasom and Wilson 1992). Currently, the Rio Grande wild turkey is the second most abundant subspecies behind the eastern subspecies (Peterson 1998).

Although wild turkeys have been successfully reestablished in and beyond their native range, there is concern that changes in land use patterns may negatively impact wild turkey populations (Dickson 1992). Habitat degradation is a continuing problem. Reports for the past 30 years indicate that approximately 5% of all forest and rangeland have declined in the United States through conversion to urban and agricultural cropland (Dickson 1992). Much needs to be learned about wild turkey behavior and habitat requirements before we can effectively manage wild turkey populations in this changing environment. Specifically for the Rio Grande wild turkey, the amount of knowledge has not kept pace with that of other subspecies (Peterson 1998).

Recent evidence suggests Rio Grande wild turkey populations have been declining in portions of the High Plains and Rolling Plains of Texas (Brunjes 2005). In the Rolling Plains, wild turkey movements are restricted primarily to areas near river corridors (Brunjes 2005). The availability of suitable roost sites can ultimately limit wild turkey distributions especially in the Southwestern United States where trees are more limited (Boeker and Scott 1969).

There have been relatively few studies on the roosting ecology of Rio Grande wild turkeys, (Haucke and Ables 1972, Crockett 1973, Haucke 1975, Quinton et al. 1980, Holdstock 2003) especially in the Rolling Plains. The studies that have been conducted on Rio Grande wild turkeys are fairly descriptive in nature, narrow in focus, and site-specific (Weinstein et al. 1995). Before effective management can be implemented, a more thorough evaluation of winter roosts is needed to determine habitat components that are critical to suitable roosting sites.

The processes driving the chronology of flocking behavior are also poorly understood. Most studies define seasons based on wild turkey biology such as breeding, nesting, or brood rearing, but are relatively inconsistent among studies. Some of this variation may be explained due to regional differences in chronology, but could also be an artifact of insufficient knowledge of those factors that influence flocking behavior. A better understanding of seasonal shifts to and from wintering areas in the Rolling Plains region could ultimately provide managers with more accurate abundance estimates. By defining a time period with peak roost concentrations one would potentially be able to obtain better population estimates from roost counts.

The objectives of this study were (1) to develop habitat models to predict areas that are most suitable for Rio Grande wild turkey roost sites during the winter period, and (2) to identify the chronology of winter flocking behavior. The subsequent chapters of this thesis represent partial fulfillment of the requirements for the degree of Master of Science in Wildlife Science for the Graduate School at Texas Tech University. The research reported was conducted on 3 study sites located in the Rolling Plains of Texas. The study sites, methods, and results are reported in Chapters II and III. Chapters II and III were written as separate manuscripts for submission to peer-reviewed journals. I followed the scientific writing style of *The Journal of Wildlife Management* (Messmer and Morrison 2006) for all chapters. Chapter II is an evaluation of the importance of structural and vegetative components at winter roost sites utilized by Rio Grande wild turkeys. Chapter III is an examination of the chronology of winter flocking behavior and an evaluation of the environmental factors behind those processes. All of these chapters are original work of myself and my coauthors. Authorship was based on the guidelines set by Dickson and Conner (1978), Ballard (2005), and the CBE Style Manual Committee (1994). Authorship for each chapter is as follows:

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CHAPTER II

WINTER ROOST CHARACTERISTICS OF RIO GRANDE WILD TURKEYS IN THE ROLLING PLAINS OF TEXAS

Abstract

The favored roost tree species for Rio Grande wild turkeys (*Meleagris gallapavo intermedia*) in the Texas Rolling Plains is the eastern cottonwood (*Populus deltoides*). In this region, as well as in much of the semiarid Southwest, cottonwoods are declining due to natural and human altered river flows, invasion of exotic species such as Russian olive (*Elaeanus angustifolia*) and saltcedar (*Tamarix chinensis*), and overgrazing. Consequently, a better understanding of the vegetative characteristics of wild turkey winter roost sites was needed. We conducted fieldwork on 3 study sites in the Rolling Plains of Texas. We collected data during September through April from 2004–2006. We gathered roost locations using radiotelemetry to identify movement patterns and to detect which winter roosts were active. We measured roosting habitat at 32 roost sites and 32 randomly selected non-roost sites. We measured tree height, tree diameter, percent canopy cover, tree decay, area of the stand in which the roost occurred (stand area), percent litter cover, and shrub density. We linked winter roost use (presence-absence) with habitat variables representing forest and vegetation structure at roost sites by creating explicit habitat models. We assessed 44 *a priori* logistic regression models using second-order Akaike's information criterion (AIC_c) for model selection. We found tree height, tree diameter, stand area, and percent litter were all important predictors of

roost sites. Based on these findings an appropriate management strategy should include the conservation of large, open-understory, riparian stands of trees. Those stands should contain the tallest, largest diameter trees available. We also suggest that young stands of preferred roost tree species be protected to provide future potential roost sites when current roosts eventually become unsuitable to wild turkeys.

Introduction

A crucial period for Rio Grande wild turkeys (*Meleagris gallopavo intermedia*) occurs when large winter flocks (often >200) congregate in traditional winter roosts (Watts 1969, Butler et al. 2006). Home ranges are smallest during the winter period (Phillips 2004). Therefore, Rio Grande wild turkeys need appropriate foraging and security habitat in close proximity to suitable roosting habitat. Maintaining suitable winter roosting habitat is an important management activity.

The main species of roost tree used by wild turkeys in the Rolling Plains is the eastern cottonwood (*Populus deltoides*). There is concern that cottonwoods are not regenerating at a sufficient rate to replace old and dying trees (Holdstock 2003, Leschper 2004). There are several suspected causes for the decline in cottonwood recruitment in riparian areas. Drought coupled with low water tables from increased irrigation may be responsible (Leschper 2004). Impacts from intensive grazing in riparian areas can have a negative impact on the recruitment and growth of cottonwoods (Kauffman and Krueger 1984, Green and Kauffman 1995). Also, with the invasion of exotic shrub species such as Russian olive (*Elaeanus angustifolia*) and saltcedar (*Tamarix chinensis*), cottonwood seedlings can succumb to shading and competition for nutrients (Lesica and Miles 2001). Since roost sites are important to sustaining Rio Grande wild turkey populations, low recruitment of roost tree species could have dramatic effects on wild turkeys in the Rolling Plains.

Roost sites are an essential habitat requirement for wild turkeys throughout the year (Kilpatrick 1988, Chamberlain 2000), but roosts are most important in winter when large numbers of wild turkeys concentrate at communal roosts (Logan 1970, Haucke 1975). Traditional roosts have been described as "home base" for wild turkeys during the winter period (Glazener 1967). It is thought that the lack of roosts in otherwise suitable range may limit wild turkey distributions (Boeker and Scott 1969, Bryant and Nish 1975, Phillips 1980, Quinton et al. 1980, Mackey 1984, Kilpatrick 1988, Hengel 1990, Rumble 1992, Wakeling and Rogers 1995a).

Although roost tree species and roosting behavior differ among regions and subspecies, most studies suggest that wild turkeys favor large, mature, flat-topped trees with large diameter at breast height (DBH), and open canopies containing large horizontal branches for roosting. Roosts commonly occur in close proximity to clearings which aid movements into and out of the roost, and roosts often occur near permanent water sources.

Roosting habitat is as important as suitable foraging habitat because selection of roosting sites can strongly influence daily movement patterns (Chamberlain 2000). There exists a considerable body of literature concerning the microhabitat characteristics of roost trees (Appendix 1), but no studies have related stand area and understory openness to roost site occupancy. Before we can adequately manage roosts and potential roost sites, we need to know what characterizes a suitable and desirable natural roost site. Our objective was to create habitat models to predict roost occurrence and ultimately allow for managers to effectively conserve appropriate potential roost habitat for Rio Grande wild turkeys**.**

Study Areas

We conducted our research at 3 study sites located within the Rolling Plains of Texas (Figure 2.1). The topography of this region was characterized by rolling-high plains bisected by intermittent streams flowing east to southeast (Spears et al. 2005). Wild turkey populations received some hunting pressure during spring and autumn hunting seasons on private land or by special draw-only spring hunts on wildlife management areas.

The southern most study area was the Matador site which was centered on the Matador Wildlife Management Area (MWMA). It was located approximately 10 km north of Paducah, Texas in Cottle County. The Matador consisted of 11,410 hectares of public land that ranged in elevation from 518–640 m above sea level. The area was traversed by the confluence of the Middle and South Pease Rivers that flow intermittently, but generally only after significant rainfall (Holdstock 2003). The MWMA was located in the Mesquite Plains sub-region of the Rolling Plains (Holdstock 2003). Primary riparian vegetation consisted of hackberry (*Celtis occidentalis*), western soapberry (*Sapindus drummondi*), skunkbush sumac (*Rhus aromatica*), eastern cottonwoods (*Populus deltoides*), and woolybucket bumelia (*Bumelia lanuginose*). honey mesquite (*Prosopis glandulosa*), sand sagebrush (*Artemisia filifolia*), shinnery oak (*Quercus havardii*), Chickasaw plum (*Prunus angustifolia*), and redberry juniper (*Junipersu pinchotii*) were also common (Holdstock 2003). Meadows of native grasses are dominated by bluestems (*Andropogon gerardii; Schizachyrium scoparium*) and gramas (*Bouteloua* spp.) (Spears et al. 2002).

The second site was located 11 km north of Clarendon and Hedley, Texas in Donley and Collingsworth Counties. This site was split by the Salt Fork of the Red River (SFRR), and was centered on 2 private land holdings just over 20,000 ha. The SFRR flowed nearly year-round and was only dry during periods of drought. Elevation ranged from 747–838 m. Vegetation consisted of eastern cottonwood, honey locust (*Gleditsia triacanthos*), and black locust (*Robinia pseudo-acacia*) trees in riparian areas, with rolling hills and plains dominated by yucca (*Yucca glauca*), grama grasses, bluestems, and snakeweed (*Guitierrezia sarothrae*) in adjacent rangelands (Spears et al. 2002).

The northern most site was centered on the Gene Howe Wildlife Management Area (GHWMA), surrounded by privately owned lands 9 km northeast of Canadian, Texas in Hemphill County. The GHWMA consisted of 2,138 ha of public land situated along the Canadian River which was primarily a continuous flowing river in the Mesquite Plains sub-region of the Rolling plains. Elevation ranged from 700–777 m and was characterized by topography with less relief than MWMA and SFRR. Despite having groves of salt cedar (*Tamarix chinensis*) (Cable et al. 1996) and Russian olive (*Elaeagnus angustifolia*), as well as a higher density of cottonwood trees, riparian vegetation was very similar to that of MWMA. Upland vegetation was dominated by bluestems and sand sagebrush and was similar to other study sites (Holdstock 2003). Additional information on study sites is available in Spears et al. (2005), Butler et al. (2005), and Holdstock et al. (2006).

Methods

Turkey capture

We captured wild turkeys at baited trap sites using drop net (Glazener et al. 1964), rocket net (Bailey et al. 1980), or walk-in traps (Davis 1994). We maintained 75 transmittered wild turkeys on each study site. We determined sex and age of captured wild turkeys from coloration and banding pattern of the ninth and tenth primary feathers (Pelham and Dickson 1992, Petrides 1942). We equipped wild turkeys with a 100-g, backpack-style transmitter (Advanced Telemetry Systems (ATS), Isanti, Minnesota) fastened with 3.2 mm shock cord. All transmitters possessed an 8-hour mortality switch (Holdstock 2003, Hall 2005).

Roost locations

We obtained locations of radio-equipped birds with a dual 4-element Yagi (Hutton Communications, Inc., Dallas, Texas, USA) truck mounted null-peak system, as well as handheld 3-element Yagi antennas (Wildlife Materials, Inc., Murphysboro, Illinois, USA), and an omni truck mounted antenna (Hutton Communications, Inc., Dallas, Texas, USA). We periodically located birds from helicopter or fixed-wing aircraft when aerial surveys for other studies were conducted. We also used aerial surveys to search for lost birds that could not be found by routine ground methods.

We identified winter roosts used by wild turkey through the use of radiotelemetry. Beginning in September and continuing through March we located the roost sites of all radio-equipped birds a minimum of 2 times per week. We obtained roost locations using triangulation with a minimum of 3 compass bearings, night walk-in observations with a handheld antenna, morning fly-down counts, or evening fly-up counts. We also used roost counts to identify which trees were used, roost boundaries, individual birds, and to determine the number of birds using a roost.

We imported telemetry stations and their associated bearings into Location of a Signal (LOAS, Ecological Software Solutions, Sacramento, California) software to generate turkey locations and their related error polygons. We used universal transverse mercator (UTM) coordinates in the North American Datum of 1983 (NAD 83).

Roost habitat measurements

We measured vegetation on micro- and macro-habitat scales associated with each roost to evaluate the structure of winter roosts. Once a radiomarked bird had been located in a specific roost, that roost was monitored approximately once per week using morning or evening counts (Butler et al. 2006). This allowed us to estimate the size of the roost and which trees were being used. Vegetation sampling occurred during winter months when trees were without leaves. We sampled roost vegetation using 3–5 habitat plots placed randomly within the roost area. We placed the first plot systematically at the geometric center of the roost. All remaining plots were placed randomly. The number of plots measured in a given roost varied due to size of roost areas. We identified roost areas as the outer extent of used roost trees. We marked all roost trees to identify the boundary. We also used Arc GIS 9.1 (Environmental Systems Research, Inc., Redlands, California, USA) to estimate the area of stands by digitizing polygons around the stands on aerial photos taken in 2004.

Each habitat plot consisted of a 20 x 10 m quadrant oriented lengthwise from north to south. At the center of the plot, we used a 10-factor wedge prism to determine basal area and identified trees to species. We determined decay class (Maser et al. 1979), DBH, tree height, height to lowest roostable branch (hlb), and whether or not the tree was a roost tree. Diameter at breast height was defined as the diameter of a tree at 1.37 m height. We classified trees as roost trees if we observed wild turkeys roosting in it or by the presence of droppings underneath the tree canopy. We assessed tree decay using the 9 decay classes described by Maser et al. (1979), DBH was measured in centimeters using a DBH tape (Forestry Suppliers, Inc., Jackson, Mississippi, USA), tree height and hlb were measured in meters using a Cross Sight (Forest Applications Training, Inc., Hiram, Georgia, USA). We estimated canopy cover using a spherical densiometer (Forestry Suppliers, Inc., Jackson, Mississippi, USA) in the 4 cardinal directions while standing at the plot center (Lemmon 1956). We converted canopy cover values to percent canopy cover.

We measured height of visual obstruction at each habitat plot using a Robel pole (Robel et al. 1970). A transect along the 20 m line that bisected the plot was oriented from north to south. We recorded 5 visual obstruction readings with Robel poles placed perpendicularly along the transect at 5 m intervals. We classified the understory into 8 categories: crop, grass, shrub, bare, forb, litter, cacti, and other at 40 cm intervals along a 4-meter string between the sighting dowel and Robel pole for a total of 50 readings. We identified every shrub encountered at the 40 cm intervals by species and placed it into height classes of (0.5–1 m, 1–2 m, 2–4 m, 4–6 m, >6 m). We determined coarse woody debris by counting all non-rooted woody material >10 cm diameter.

For each roost we randomly chose a paired random roost area with similar sized trees and species composition where no wild turkeys were roosting. Habitat characteristics were measured as for roost sites. We used ArcView® GIS 3.2 (Environmental Systems Research, Inc., Redlands, California, USA) in conjunction with a random point generator extension to create points for sampling. All mottes of roost trees on our study sites were located within 200 m of a drainage, as a result we generated all random points within a 200 m buffer of these drainages. We then randomly selected a point, navigated to that point using a handheld global positioning system (GPS), and measured the vegetation within that stand if there was no evidence of wild turkeys using the area for roosting. When points did not fall within a motte, we selected the nearest stand that was not a roost.

Models

We believe that wild turkeys in the Rolling Plains selected roost sites based on factors at 3 scales: stand scale, tree scale, and understory scale. We created a series of habitat models for each scale that included a fully parameterized global model and a series of reduced models that represented plausible alternative representations of the data

(Burnham and Anderson 2002). We analyzed data using logistic regression in SPSS® 12.0 (SPSS Inc., Chicago, Illinois, USA).

For each set of candidate models, we assessed the goodness-of-fit of the global model using the Hosmer-Lemeshow test (Hosmer and Lemeshow 2000). We used second-order Akaike's information criteria (AICc) to evaluate *a priori* candidate models (Burnham and Anderson 2002).

We selected candidate models to evaluate alternative hypotheses based on the 3 roost site selection scales. We hypothesized that at the stand scale winter roost sites were located in stands with larger areas than those areas not occupied as roosts. For the tree scale, we hypothesized that roost sites would be located in areas with tall and large diameter trees with minimal decay. We hypothesized trees with advanced canopy decay would have fewer suitable roost limbs and would be less likely to be used. We included the variables tree height (HT), DBH, and tree decay (DECAY) in this model set. We examined 10 alternative parameterizations of these 3 variables and their potential interactions.

We also hypothesized that roost sites would be located in stands with an open understory. We selected percent litter (LIT), number of shrubs per plot (SHR), and percent canopy cover (CC) as surrogates for openness. For example, a site with few shrubs along with a high amount of litter and a dense canopy describes an open understory. A high percentage of litter cover indicated that a low percentage of obstructing vegetation such as shrubs, grasses, or forbs were present. We examined 10 parameterizations for the 3 variables and their interactions in this model set.

We compared models within a set using normalized Akaike weights (w_i; Burnham and Anderson 2002). We then placed the best models in a model set along with all possible combinations of those models for a total of 23 models. We evaluated the models against one another using AIC_c to select the overall best models. This research was approved by the Texas Tech University Animal Care and Use Committee (Protocol #'s 99917 and 01173B)

Results

We captured 393 Rio Grande wild turkeys and equipped 153 with transmitters from January–March 2005. We also continued to monitor the 83 radio equipped wild turkeys from previous traps. We documented use of 39 roost sites on the 3 study areas. We measured habitat characteristics at 32 of the 39 roosts (Table 2.1). We also sampled an equal number of randomly selected non-roost stands. Data were pooled across study sites because we were interested in evaluating roost habitat characteristics at the regional scale rather than individual study sites.

We found that mean tree height at roost sites (17.0 m) was greater than in non-roost sites (12.5 m) (Table 2.2). We also observed higher values in roosts than non-roosts for DBH (49.4 cm vs 43.5 cm), percent litter (56 % vs 40 %), percent canopy cover (68 % vs 50 %), and stand area (5.8 ha vs 2.4 ha). Trees at roost sites were in a lesser state of decay than at non-roost sites (1.5 vs 1.7). The mean number of shrubs per roost plot was less than habitat plots at non-roosts (2.8 vs 4.2) (Table 2.2).

We discovered that eastern cottonwood was the most dominant tree species at winter roost sites making up almost 70 % of all trees in roosts (Table 2.3). Not only were cottonwoods the most abundant, but they were also the tallest (18.6 m) and had the largest mean diameter (54.4 cm) when compared to all other trees measured. We found that hackberry, western soapberry, black locust, and American elm made up 9.7, 7.9, 6.1, and 3.4 % of trees in roosts respectively (Table 2.3). With the exception of elm, these 4 tree species were much shorter in height and smaller in DBH than cottonwoods.

Understory vegetation sampling indicated that redberry juniper, Chickasaw plum, and skunkbush sumac were the most dominant shrubs in roost understories comprising 85 percent of all shrubs measured (Table 2.4). Redberry juniper was the most dominant shrub at roost sites (37 %), whereas Chickasaw plum was the most common at non-roosts (44 %). Non-roosts had a higher percentage of shrubs ≤ 2 meters than roost sites (77.4 % vs. 65.9 %) (Table 2.4).

Habitat models

We generated 44 total models in 4 different subsets (each subset represented a different hypothesis). Models ranged in size from 1 to 7 explanatory variables. The models were developed based on previous literature and our unpublished observations. Our first model set (stand scale) included only 1 model with the predictor variable stand area. We evaluated this model in the final combined subset only.

We developed a model set of 10 *a priori* candidate models including the explanatory variables: tree height, decay, DBH, and the 3 possible 2-way interactions of those variables to predict roost occurrence based on tree characteristics (Table 2.5).

Although we could have included models without any interaction effects, we believed they were possible and that these factors worked in combination rather than independently to influence winter roost occurrence.

Within the above model set we accepted the 2 best models ($\Delta_i < 2$; Burnham and Anderson, 2002) to predict roost habitat based on tree characters. Both models included tree height, but the better of the 2 models also contained tree DBH and the interaction of height and DBH (Table 2.5). These 2 models accounted for 66.2% of the total weight among all models. The Hosemer-Lemshow goodness-of-fit test for the global model (also the best model in this case) ($\chi^2 = 5.083$, df = 8, $P = 0.749$) indicated a good fit with the data. Tree decay occurred in 6 of 10 models but only accounted for 20.8% of the model weights indicating that tree decay was probably not a good predictor of roost occurrence. Tree height had 100% of the weight within the 6 models that it occurred in, suggesting it was of high importance. The DBH variable held 53.5% weight indicating an intermediate level of importance in this model set.

We also developed 10 *a priori* candidate models based on understory scale characteristics. This model set evaluated the explanatory variables: percent litter cover, percent tree canopy cover, number of shrubs per plot, and 3 possible 2-way interactions. Again we included interactions based on the belief that those factors worked in combination rather than independently to influence winter roost occurrence.

We accepted the 3 best models to predict the occurrence of roosts using $\Delta_i < 2$. These top 3 models all included percent litter (Table 2.6). In general there was strongest support for those models containing percent litter and percent canopy cover, whereas there was less support for number of shrubs per plot. Litter, canopy, and shrub cover accounted for 81.2, 72.7, and 28.4% respectively of the support based on Akaike weights. The third best model was one of the most parameterized models and an adequate fit for the data (χ^2 = 8.568, df = 8, *P* = 0.380).

We opted to combine the 6 best models from the 3 model sets to predict roost occurrence based on all of the "good" explanatory models discovered from prior analyses. This allowed us to directly evaluate these models relative to one another. We also decided to include all possible combinations of the 6 best models which increased the total number of models to 23 (Table 2.7).

Unlike the previous models sets, there was greater model selection uncertainty associated with predicted roost occurrence and 8 models had Δ_i values $\leq$2 (Table 2.7). In general there was greater support for models containing tree and stand-scale variables (tree height, DBH, and stand area) and less support for those variables relating to understory openness (percent litter, number of shrubs per plot, and canopy cover). In total, the top 8 models accounted for 82% of the support. Those models that contained tree height accounted for 99.8% of the weight, those in which canopy cover was included, held only 17.8% weight. Goodness-of-fit for the most parameterized model was assessed using the Hosmer-Lemeshow test (χ^2 = 4.296, df = 8, *P* = 0.830), signifying a good fit to the data.

Since the explanatory variables in the combined model set occurred at different rates, the associated Akaike weights were not very meaningful for individual variable comparisons. For example, litter had a total weight of 51.3% and stand area 48.6%.

Judging from this comparison the 2 variables seemed to be of equal importance. Litter occurred in 18 models, whereas stand area in only 12 so it was difficult to compare the importance of these variables. As a result, normalized relative importance values were calculated for each explanatory variable and interaction effect in the model sets (Table 2.8). Normalized importance values were calculated by summing all the weights in which an individual explanatory variable occurred. The summed weights were then divided by the total number of models in which the variable was present. This allowed us to compare variables relative to one another. Using these importance values we were able to rank variables in order of highest to lowest importance: tree height, DBH, stand area, litter cover, canopy cover, and the litter-canopy cover interaction. The interaction of Height*DBH was not included since it was included in all of the same models as DBH.

Discussion

Forty-four models may initially appear to be data dredging described by Burnham and Anderson (2001), especially evaluating all possible combinations such as in the final "best" model subset. However, if we would have evaluated all possible combinations from the 7 explanatory variables there would have been 127 models. Although *a priori* model selection is the best analysis method, there are cases when this kind of exploration may be acceptable. For example, Welsh et al. (2006) noted that it was reasonable to generate and compare larger sets of *a priori* models for scientific questions for which little is known. Since our objectives were somewhat exploratory due to the lack of information for roost sites in the Rolling Plains we believe that 44 models were appropriate for consideration.

By breaking models up into subsets and evaluating them based on several hypotheses it allowed us to examine all *a priori* explanatory variables of interest with less than half the possible models. It has been noted that there may be substantial cost in the use of small model sets, potentially resulting in under-fitting errors and reducing predictive ability (Taper 2004). This is known as the "model selection problem" that calls for a balance between under-fitted models with too few parameters (bias) and over-fitted models with too many parameters which can increase the chance of finding spurious effects (Forster 2000, Burnham and Anderson 2001). We believe our approach was a compromise between these 2 philosophies.

Tree height was our best explanatory variable that influenced winter roost site selection by Rio Grande wild turkeys on our study sites (Table 2.8). Previous research has consistently documented strong relationships between roost occurrence and tree height for Rio Grande wild turkeys (Crockett 1969, Haucke and Ables 1972, Haucke 1975, Perlichek 2005) as well as for the other subspecies (Jonas 1966, Hoffman 1968, Boeker and Scott 1969, Schemnitz and Zeedyk 1982, Goerndt 1983, Mackey 1984, Kilpatrick 1988, Flake et al. 1995). There are a number of possible explanations as to why wild turkeys prefer to roost in tall trees. One reason is that tall trees allow wild turkeys to isolate themselves, while roosting, from ground dwelling predators. Another reason could be that tall trees provide a better vantage point from which wild turkeys can detect predators before they leave the roost in the morning. Lastly, tall trees may provide a greater number of suitable limbs that wild turkeys will feel comfortable roosting on, thus increasing the capacity of a particular tree. Since wild turkeys in the Rolling Plains exhibit high roost concentrations in relatively small roost areas, it is possible that roost capacity could be influential.

Mean tree heights used by wild turkeys at a particular site seem to be a function of tree species present and tree availability. For example, Rumble (1992) reported a mean roost tree height of 27.0 m (Ponderosa pine [*Pinus ponderosa*]) in South Dakota in which 84% of the study site was forested. In Washington, Mackey (1984) found that Douglas firs (*Pseudotsuga menziesii*) were an average of 26.6 m tall in which 74% of the study area was covered by forest. These heights were much greater than the cottonwood dominated roosts of the Rolling Plains (mean = 17.0 m). Our study areas were only about 4% forested (Brunjes 2005), and as a result, tall trees were rare. Compared to other areas where trees were in similar abundance, our value for average tree height was similar. For example, Crockett (1969) reported that cottonwoods used for roosting in Oklahoma averaged 16.8 m in height. Haucke (1975) reported that mature live oaks in South Texas were about 13.2 m in height, and Perlichek (2005) found mean tree heights of 16.9 m for live oak, ponderosa pine, and hackberry combined. Consequently, it appears that wild turkeys will use the tallest trees that are available to them. Although tree height is important to wild turkey roost sites, it is not likely tree height alone defines winter roosts.

The second best predictor of roost occurrence in our model set was tree DBH. Tree DBH was significantly higher in roost sites compared to potential sites. Mean DBH was 49.4 cm, which included mostly eastern cottonwood, but also hackberry, western soapberry, American elm (*Ulmus americana*), and black locust. This value was consistent with values from other studies. Crockett (1965) reported an average DBH of 52.4 cm for most of the same tree species. Perlichek (2005) measured live oak, ponderosa pine, and hackberry, and found an average DBH of 45.7 cm. In other studies where wild turkeys primarily roosted in conifers, DBH was typically greater (Hoffman 1968, Boeker and Scott 1969, Mackey 1984, Wakeling and Rogers 1995*b*). All of these studies found that roost sites had larger tree diameters than random sites, suggesting that wild turkeys used the largest diameter trees in an area.

Tree diameter may be important because large trees typically have more limbs of suitable roosting size. Crockett (1969) found that average perch diameters used by wild turkeys were 4–5 cm and reasoned that this size was optimal due to comfort and the ability of the limb to support the weight of the turkey. It is also possible that larger diameter trees have a higher proportion of horizontal limbs than smaller trees due to the mature, flat-topped nature of bigger trees.

Our models indicate that tree height and diameter were the 2 most important variables evaluated. The cottonwood appears to be the most important roost tree species in the Rolling Plains of Texas. Seventy percent of trees measured in roosts were cottonwoods, and nearly that many at non-roost sites. Cottonwoods had larger mean heights and diameters than all other tree species encountered on our study areas. American elm, box elder (*Acer negundo*), and pecan (*Carga* illinoensis) trees had similar tree heights and diameters as cottonwoods, but only occurred in our samples about 8 percent of the time, of which most (68 %) were in non-roost sites.

Stand area was also an important predictor of roost occurrence. We found that stands with winter roost sites were typically over twice the size of stands that were not used for roosts (roost = 5.8 ha vs non-roost = 2.4 ha). No previous study has examined stand area and only 2 have measured roost area. Haucke (1975) observed that roosts in South Texas had large surface areas ranging in size from 0.2–5.26 ha. In Colorado, Hoffman (1968) noted that summer roost sites ranged in size from 0.2–1.8 ha and were generally smaller than winter roost sites.

Phillips (1980) reported that single trees with all the proper characteristics were of little value as a wild turkey roost tree unless they were associated with other trees. This idea of an association of trees applies directly to the importance of stand size. Large stands generally have higher numbers of trees than small stands, and thus a greater chance of the stand containing the necessary habitat features that wild turkeys prefer for roosting. In addition, large stands also provide a greater capacity for larger numbers of birds. Higher numbers of birds could result in increased vigilance for the group and possibly an overall greater chance of individual survival.

We measured percent litter cover as a surrogate for understory openness. We found that litter accounted for 55.6% and 39.8% of the ground cover in roosts and non-roosts, respectively. This suggests roosts contained less understory vegetation than potential sites. Additionally, there have been many studies that have claimed that understory vegetation in roosts was typically more sparse compared to random sites (Scott and Boeker 1975, Craft et al. 1986, Mollohan et al. 1995, and Perlicheck 2005).

Latham (1956) and Jonas (1966) both mention that roosts with an open understory aid wild turkeys who rely on eyesight for security from predators. In addition to increased detection of predators, increased openness would also reduce the number of sites in which predators could ambush wild turkeys under the roost. Another explanation for why wild turkeys use sites with an open understory is to facilitate movement into and out of the roost. It was not uncommon for wild turkeys to fly into the roost from directly below it when there was little obstructing vegetation. Mackey (1984) found that wild turkeys usually flew up into the roost from underneath rather than from nearby. Scott and Boeker (1975) found that when birds did not access the roost from underneath, clearings within 45 m of roosts were used to access roost trees. Consequently, open areas are needed in or around roost sites.

Percent tree canopy cover proved to be of least importance in the final model set. Although percent canopy cover in roosts (67.9%) was higher than random sites (50.2%), it was not a good predictor of roost occurrence relative to the other variables examined. While canopy cover did not prove to have a heavy influence on roost occurrence, our findings that canopy cover in roost sites was greater than in random sites agrees with the findings of Mackey (1984), Wakeling and Rogers (1995*b*), and Perlichek (2005).

Our models also showed that the number of shrubs per plot was not an important predictor of roost occurrence relative to all variables evaluated. We believe that understory openness is important to wild turkey roosts in the Rolling Plains, however shrub density may not be a good measure of overall openness since grasses and forbs also create obstruction for turkeys. As a result, percent litter appears to be a better measure of understory openness.

We did observe some differences in the shrub composition of roosts and non-roosts. Roost sites were typically dominated by redberry juniper while Chickasaw plums were more prevalent at non-roost sites. We believe that the height classes of these 2 species explain this trend. Redberry juniper made up 37 percent of all shrubs at roost sites while only 43 percent of those shrubs were ≤ 2 m, however Chickasaw plum comprised 44 percent of the shrubs in non-roosts with 97 percent of those plums being ≤ 2 m. While our models suggest that turkeys prefer the most open roost sites available to them, these data suggest that in the absence of open understories turkeys may prefer shrub heights over 2 m to reduce obstruction in their line of sight. Although shrubs appear prevalent in wild turkey roosts, they only comprised 11 percent of roost understories and 15 percent of non-roost understories.

Tree decay also had little influence on roost occurrence in out model sets. Our anecdotal observations seemed to suggest that turkeys utilized live trees more than dead ones. Our data suggested otherwise, indicating a very small difference in tree decay between roosts (1.5) and non-roosts (1.7). Beasom and Wilson (1992) imply that Rio Grande wild turkeys show no preference for live or dead roost trees, as tree height and diameter were more important.

Potential roost sites were limited in our area and it appeared that wild turkeys were simply using the best sites available to them. In ideal habitat, wild turkeys may prefer to roost in sites with tree heights > 25 m, but since trees of this height were often unavailable in the Rolling Plains, they must utilize smaller trees. In the Trans-Pecos where the availability of large trees is even more limited, wild turkeys are able to use smaller trees such as hackberry and soapberry (Perlichek 2005). This suggests that if cottonwoods were not available the Rolling Plains, smaller trees such as hackberry, soapberry, black locust, or American elm might become the dominant roost species. However there may be a threshold where available habitat may no longer support wild turkeys. For example, Scott and Boeker (1975) observed little impact on a wild turkey population when 65% of the mature ponderosa pines were removed from their study site. However, when stands were cut below a basal area of 16.8 m^2/ha the area was abandoned (Scott and Boeker 1975). We measured 537 trees from which we found evidence of winter use, out of the 537 only 1 tree was less than 10 m height. Therefore, the threshold for winter roosting in our area could be around 10 m.

Regardless of the characteristics needed for wild turkeys to roost in an area, winter roost sites are vitally important. Potential values of communal roosting to survival include thermoregulation, protection from predators, and increased foraging efficiency (Eiserer 1984). In addition, winter roosts provide a congregation locality for high numbers of wild turkeys to aggregate and establish their social structure. Watts and Stokes (1971) described the social order of wild turkeys where the winter roost creates an environment that allows juveniles to be integrated into the population and a hierarchy established for the following breeding season.

Management Implications

Since appropriate size classes of key roost vegetative components vary across the wild turkey's range, we suggest optimizing habitat relative to the surrounding area rather than supplying managers with specific, somewhat arbitrary, management goals. We suggest conservation-based rather than manipulative management recommendations. The largest stands with the tallest, largest diameter trees available should be conserved. Those sites with the lowest amount of visual obstruction in the understory should also be given priority. Understory visual obstruction is the most easily manipulated variable that we examined. We suggest if brush control is to be implemented at roost sites that it be conducted during the spring/summer months after most winter residents have dispersed for the breeding season. This will minimize disturbance to winter concentrations.

Protection of areas where cottonwood recruitment has occurred or is most likely should help to insure that optimal roost sites will be available in the future. The eastern cottonwood is an *r*-selected species that relies on flood events to prepare seedbeds for seed germination (Amlin and Rood 2002). As a result, flood prone areas containing bare soils should be monitored for cottonwood recruitment. When young seedlings are found, the area should be excluded from grazing pressure so that young seedlings are protected from herbivory. Riparian brush control may also increase the likelihood of cottonwood regeneration and provide roost trees for the future.

Future Research

The purpose of this research was to identify those vegetative components that are important to roost site selection by Rio Grande wild turkeys. We felt that a manipulative study examining artificial roosts or food sources was not warranted at the initiation of this research due to the lack of basic roost vegetative information for the Rolling Plains. With the knowledge we have gained of those vegetative characteristics important to winter roost, we feel that future research examining impacts of the manipulation of anthropogenic food sources on roost site selection would be beneficial. Cattle feeding and game feeders provide a huge source of anthropogenic food for wildlife over the West Texas landscape. We believe that these food sources greatly impact wild turkey behavior and may influence which stands of trees are used for roosting.

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Table 2.1. Total number of winter roost sites and non-roost sites sampled on Gene Howe Wildlife Management Area (GHWMA), Matador Wildlife Management Area (MWMA), and Salt Fork of the Red River (SFRR), 2004–2006.

Study site	Roosts sampled	Non-roosts sampled	Total by site
GHWMA	9	9	18
MWMA	12	12	24
SFRR	11	11	22
Total	32	32	64

Table 2.2. Mean, standard error (SE), and 95 percent confidence intervals of wild turkey roost habitat measurements in the Rolling Plains of Texas for roost and non-roost sites, 2004–2006.

	Roost					Non-roost				
				95% CI					95% CI	
Variable	*n*	Mean	SE	Lower	Upper	*n*	Mean	SE	Lower	Upper
Decay[a]	32	1.48	0.08	1.31	1.66	32	1.67	0.10	1.47	1.86
BA[b]	32	71.38	5.92	59.30	83.47	32	52.50	6.49	39.26	65.74
DBH[c]	32	49.44	2.61	44.12	54.77	32	43.57	2.69	38.09	49.05
Height[d]	32	16.98	0.64	15.67	18.29	32	12.49	0.58	11.30	13.67
HLB[e]	32	576.9	50.92	473.1	680.8	32	340.2	35.74	267.3	413.1
Low[f]	32	1.84	0.13	1.58	2.10	32	1.66	0.09	1.47	1.86
Total[g]	32	8.96	0.16	8.62	9.29	32	9.11	0.14	8.83	9.39
% crop	32	0.00	0.00	0.00	0.00	32	0.00	0.00	0.00	0.00
% grass	32	0.21	0.03	0.15	0.28	32	0.31	0.04	0.23	0.38

Table 2.2. Continued.

	Roost					Non-Roost				
				95% CI					95% CI	
Variable	*n*	Mean	SE	Lower	Upper	*n*	Mean	SE	Lower	Upper
% shrub	32	0.11	0.02	0.06	0.15	32	0.15	0.02	0.11	0.20
% bare	32	0.10	0.02	0.06	0.14	32	0.09	0.02	0.06	0.12
% forb	32	0.02	0.01	0.00	0.03	32	0.04	0.01	0.02	0.07
% litter	32	0.56	0.03	0.48	0.63	32	0.40	0.03	0.33	0.46
% cacti	32	0.00	0.00	0.00	0.00	32	0.00	0.00	0.00	0.01
% other	32	0.01	0.00	0.00	0.02	32	0.01	0.00	0.00	0.01
CWD[h]	32	6.01	0.91	4.16	7.86	32	4.64	0.94	2.72	6.56
SPP[i]	32	2.77	0.60	1.56	3.99	32	4.16	0.63	2.87	5.45
% CC[j]	32	67.93	3.44	60.91	74.95	32	50.23	4.56	40.93	59.52
SA[k] (Ha)	32	5.77	1.04	3.65	7.90	32	2.36	0.57	1.19	3.53

[a] Decay = Tree decay categorized into 9 decay classes from Maser et al. (1979).
[b] BA = Basal area.

Table 2.2. Continued.

[c] DBH = Tree diameter at breast height.
[d] Height = Tree height.
[e] HLB = Height to lowest roostable sized branch.
[f] Low = Lowest visual obstruction (lowest band visible on a 1 m Robel pole).
[g] Total = Total visual obstruction (total number of bands visible on a 1 m Robel pole).
[h] CWD = Number of coarse woody debris ≥ 10 cm diameter located within a habitat plot.
[i] SPP = Number of shrubs per plot.
[j] % CC = Percent canopy cover.
[k] SA = Stand area.

Table 2.3. Tree occurrence and associated structural measurements for 10 tree species found at roost sites and non-roost sites of Rio Grande wild turkeys in the Rolling Plains of Texas, 2004–2006.

	Roost						Non-roost					
Species	n	%	Decay	DBH (cm)	Height (m)	HLB (cm)	n	%	Decay	DBH (cm)	Height (m)	HLB (cm)
Eastern cottonwood Populus deltoides	658	69.6	1.6	54.4	18.6	646	405	65.1	1.8	42.2	13.8	512
Hackberry *Celtis occidentalis*	92	9.7	1.2	24.7	9.2	348	39	6.3	1.4	32.9	10.3	195
Western soapberry *Sapindus drummondi*	75	7.9	1.2	18.1	9.8	459	49	7.9	1.3	20.2	9.5	335
Black locust *Robinia pseudo-acacia*	58	6.1	1.6	29.9	14.2	413	8	1.3	2.5	24.9	9.8	263
American elm *Ulmus americana*	32	3.4	1.2	48.7	18.3	277	71	11.4	1.2	46.2	14.9	248
Black willow *Salix nigra*	12	1.3	1.6	24.1	9.5	354	20	3.2	2.4	21.2	5.8	237
Woolybucket bumelia *Bumelia lanuginosa*	9	1.0	1.7	26.1	10.4	248	4	0.6	1.8	45.9	9.0	115
Box elder *Acer negundo*	7	0.7	1.3	36.5	18.4	536	0	0.0				
Osage orange *Maclura pomifera*	3	0.3	1.4	29.1	12.7	377	16	2.6	1.3	26.5	10.9	391
Pecan *Carga illinoensis*	0	0.0					10	1.6	1.0	54.0	15.4	318

[a] Roost indicates the area in which turkeys roosted, does not imply that all trees within this area were used for roosting.
[b] For variable descriptions refer to Table 2.2.

Table 2.4. Shrub height and composition of roost and non-roost sites for Rio Grande wild turkeys in the Rolling Plains of Texas, 2004-2006.

	Roost					Non-Roost				
Common name	½–1 m	1–2 m	2–4 m	>4 m	Total	½–1 m	1– 2 m	2– 4 m	>4 m	Total
Redberry juniper *Juniperus pinchotii*	13	42	61	11	127 (37.0%)	3	32	50	3	88 (19.1%)
Chickasaw plum *Prunus angustifolia*	30	70	10	0	110 (32.1%)	83	114	6	0	203 (44.0%)
Skunkbush sumac *Rhus aromatica*	24	24	8	0	56 (16.3%)	20	52	2	0	74 (16.1%)
Salt cedar *Tamarix chinensis*	2	9	17	2	30 (8.7%)	3	15	23	1	42 (9.1%)
Honey mesquite *Prosopis glandulosa*	0	6	6	2	14 (4.1%)	3	11	15	0	29 (6.3%)
Sand sagebrush *Artemisia filifolia*	6	0	0	0	6 (1.7%)	9	12	4	0	25 (5.4%)
Total	75	151	102	15	343	121	236	100	4	461

Table 2.5. Candidate models describing roost habitat characteristics at the tree scale in the Rolling Plains of Texas, 2004–2006. The –2*log-likelihood (–2LL), number of parameters (K), AIC_c, difference in AIC_c compared to the lowest-scoring model (Δ_i), and AIC_c weight (w_i) are reported.

Model structure[a]	-2LL	K	AIC_c	Δ_i	w_i
HT + DBH + HT*DBH	61.52	4	70.19	0.00	0.359
HT	66.33	2	70.53	0.34	0.303
HT + DBH	65.84	3	72.24	2.05	0.129
HT + DC	66.10	3	72.50	2.30	0.113
HT + DC + HT*DC	65.54	4	74.22	4.03	0.048
HT + DC + DBH	65.57	4	74.25	4.06	0.047
DBH	86.25	2	90.44	20.25	0.000
DC	86.68	2	90.87	20.68	0.000
DBH + DC	84.73	3	91.13	20.93	0.000
DBH + DC + DBH*DC	84.51	4	93.18	22.99	0.000

[a] HT = tree height; DBH = diameter at breast height; and DC = decay class.

Table 2.6. Candidate models describing roost habitat characteristics at the understory scale in the Rolling Plains of Texas, 2004–2006. The –2*log-likelihood (–2LL), number of parameters (*K*), AIC_c, difference in AIC_c compared to the lowest-scoring model (Δ_i), and AIC_c weight (w_i) are reported.

Model structure	-2LL	*K*	AIC_c	Δi	*wi*
LIT + CC	74.91	3	81.31	0.00	0.306
LIT	78.19	2	82.39	1.07	0.179
LIT + CC + LIT*CC	74.24	4	82.92	1.60	0.137
LIT + CC + SHR	74.87	4	83.55	2.24	0.100
CC	79.49	2	83.69	2.38	0.093
CC + SHR	78.11	3	84.51	3.20	0.062
LIT + SHR	78.19	3	84.59	3.27	0.060
LIT + SHR + LIT*SHR	77.25	4	85.93	4.61	0.030
CC + SHR + CC*SHR	77.38	4	86.06	4.74	0.029
SHR	86.29	2	90.49	9.17	0.003

[a] LIT = percent litter cover; CC = percent canopy cover; and SHR = # of shrubs per plot.

Table 2.7. Candidate models describing roost habitat characteristics for the best models from each scale in the Rolling Plains of Texas, 2004–2006. The –2 log-likelihood (–2LL), number of parameters (*K*), AIC_c, difference in AIC_c (Δ_i), and AIC_c weight (w_i) are reported.

Model structure[a]	–2LL	*K*	AIC_c	Δi	w_i
HT + DBH + SA + HT*DBH	58.62	5	69.65	0.00	0.153
HT + SA	63.79	3	70.19	0.54	0.117
HT + DBH + HT*DBH	61.52	4	70.19	0.54	0.117
HT + LIT	63.81	3	70.21	0.56	0.116
HT	66.33	2	70.53	0.88	0.100
HT + LIT + SA	62.16	4	70.84	1.19	0.085
HT + DBH + LIT + HT*DBH	60.15	5	71.19	1.54	0.071
HT + DBH + LIT + SA + HT*DBH	58.01	6	71.48	1.83	0.061
HT + LIT + CC	63.12	4	71.80	2.15	0.052
HT + LIT + CC +SA	61.81	5	72.84	3.19	0.031
HT + DBH +LIT + CC + HT*DBH	59.65	6	73.12	3.47	0.027
HT + DBH + LIT + CC +SA + HT*DBH	57.73	7	73.73	4.08	0.020
HT + LIT + CC + LIT*CC	62.70	5	73.74	4.08	0.020
HT + SA + LIT + CC + LIT*CC	61.49	6	74.96	5.31	0.011
HT + DBH + HT*DBH + LIT + CC + LIT*CC	59.12	7	75.12	5.47	0.010
HT + DBH + HT*DBH + LIT + CC + LIT*CC + SA	57.42	8	76.04	6.39	0.006
LIT + SA	73.05	3	79.45	9.80	0.001
LIT + CC + SA	71.26	4	79.94	10.29	0.001
LIT + CC	74.91	3	81.31	11.66	0.000

Table 2.7. Continued

Model structure	–2LL	K	AIC_c	Δi	w_i
LIT	78.19	2	82.39	12.74	0.000
LIT + CC + LIT*CC	74.24	4	82.92	13.27	0.000
SA	79.24	2	83.44	13.79	0.000

[a] SA = stand Area; HT = tree height; DBH = diameter at breast height; DC = decay class; LIT = percent litter cover; and CC = percent canopy cover.

Table 2.8. Calculated relative importance values for all explanatory variables included in the final combined model set. Since not all variables occurred in the same number of models, the models weights were normalized to rank individual explanatory variables. Data collected in the Rolling Plains of Texas, 2004–2006.

Explanatory variable[a]	Total weight (%)[b]	No. models[c]	Relative importance[b]
Tree height	99.8	16	6.24
DBH	46.5	8	5.81
Stand area	48.6	12	4.05
Litter	51.3	18	2.85
Canopy cover	17.8	12	1.48
Litter*canopy cover	4.7	6	0.78

[a] Explanatory variable includes all variables and interactions that occurred in the final model set. The interaction of Height*DBH was not included in the table since it was included in all of the same models as DBH.

[b] Total weight was obtained by summing all model weights from which that explanatory variable occurred.

[c] Number of models in which a particular explanatory variable occurred.

[d] Normalized value for each explanatory variable (total weight/number of models).

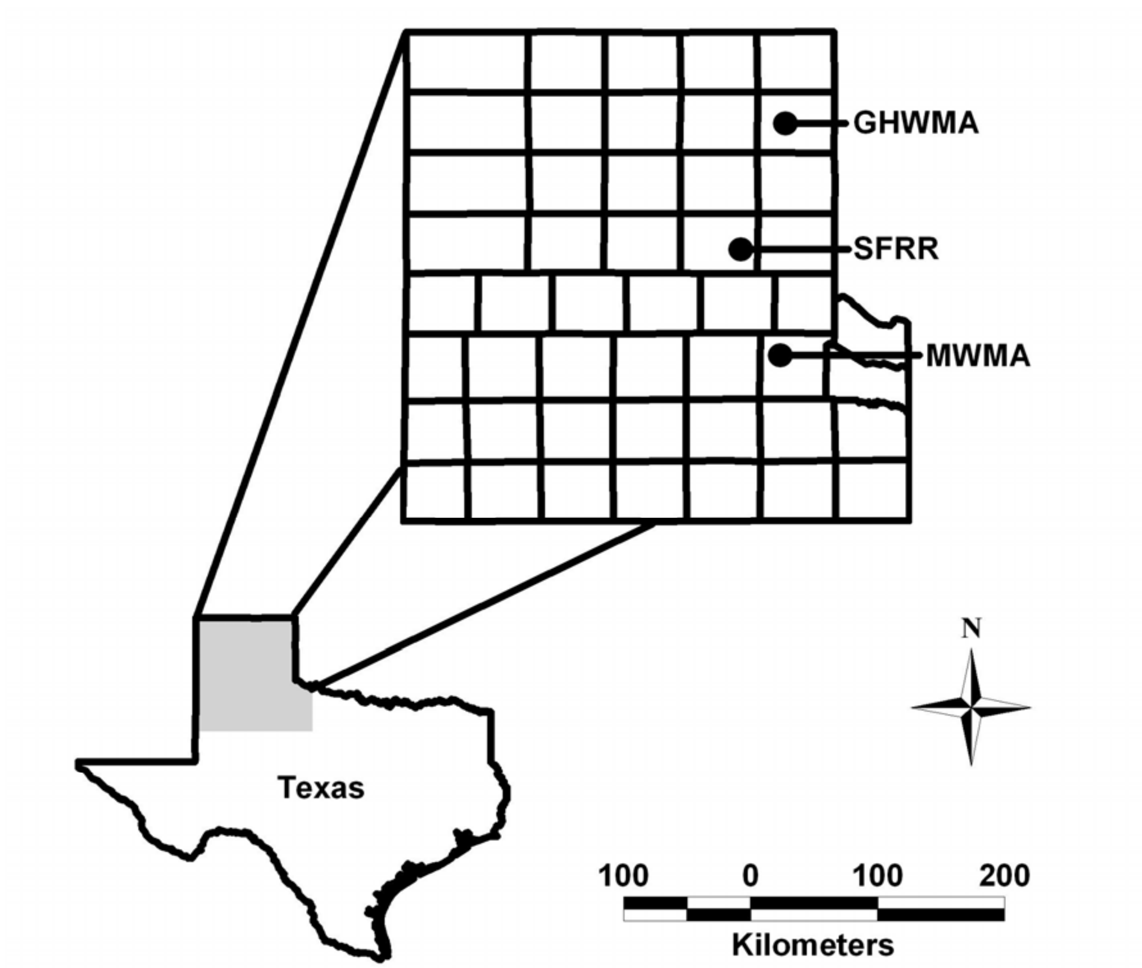

Figure 2.1. Locations of study sites (from north to south: Gene Howe Wildlife Management Area [GHWMA], Salt Fork of the Red River [SFRR], and Matador Wildlife Management Area [MWMA] used for determining winter roost site characteristics for Rio Grande wild turkeys during October through March, 2004–2006.

CHAPTER III

CHRONOLOGY OF RIO GRANDE WILD TURKEY FLOCKING BEHAVIOR IN THE ROLLING PLAINS OF TEXAS

Abstract

Winter flock congregations of Rio Grande wild turkeys (*Meleagris gallapavo intermedia*) are larger than for other turkey subspecies. Roosting flocks > 200 birds are not uncommon. However, evaluations of when winter flocks congregate and potential factors that drive congregation are lacking. We used opportunistic flock counts (*n* = 3,047) and roost counts (*n* = 101) to identify the specific timing of winter flock congregation, peak concentrations, and breakup of winter roosting. We examined possible relationships between roost/flock counts and climatic variables. We found that winter flock congregation occurred from 15 November through 28 February, peak concentrations occurred from 16 January through 1 March, and flock breakup occurred from 1 March through 15 April. We suggest that if winter roost counts are used for abundance estimation that surveys should be conducted during 16 January though 1 March.

Introduction

During autumn, Rio Grande wild turkeys tend to concentrate at traditional wintering areas (Thomas et al. 1966, Logan 1970, Brown 1980, Phillips 2004). Logan (1970) found that most wild turkeys moved to winter ranges in brood flocks of 11–44 birds. Once wild turkeys arrive on winter range, formation of sex and age specific foraging flocks begins (Watts and Stokes 1971). Males normally form several flocks of adults and juveniles, while juvenile and adult hens generally form 1 large flock (Scott and Boeker 1975, Thomas et al.1966). Due to the congregation of age and sex specific foraging flocks, flock sizes peak during winter (Quinton et al. 1980).

Multiple winter foraging flocks that roost together are known as a winter roosting flock. Although winter flocks remain together over night, they generally separate upon leaving the roost (Scott and Boeker 1975). Individual foraging flocks tend to maintain their identity throughout winter (Crockett 1973).

The timing of flock congregation, peak concentration, and flock breakup are poorly understood. Not only is knowledge on flocking and roosting chronology lacking, but the driving forces causing these behaviors are also relatively unknown. Many studies attribute flock congregation and spring breakup to climatic variables based on anecdotal observations. As a result, there is a need for further investigation of the processes of flocking and roosting.

A better understanding of seasonal shifts to and from wintering areas in the Rolling Plains of Texas could provide managers with a clearer understanding of wild turkey populations and management needs. For example, flocking behavioral patterns may help identify periods of increased mortality risk and provide accurate population estimates by identifying peak wild turkey densities in winter roosts. Our objectives were to identify chronology of winter flocking behavior. Our goal was to determine specific timing of winter flock congregation and subsequent breakup as well as the period of peak concentration of wild turkeys on winter roosts. We also examined potential climactic conditions that may be related to congregation at traditional winter roosts. We predicted that daily low temperature and length of photoperiod would explain a significant amount of the variation in foraging and roosting flock sizes throughout the year.

Study Areas

We conducted our research at 3 study sites located within the Rolling Plains of Texas (Figure 3.1). The topography of this region was characterized by rolling-high plains bisected by intermittent streams flowing east to southeast (Spears et al. 2005). Wild turkey populations received some hunting pressure during spring and autumn hunting seasons on private land or by special draw-only spring hunts on wildlife management areas.

The southern most study area was the Matador site which was centered on the Matador Wildlife Management Area (MWMA). It was located approximately 10 km north of Paducah, Texas in Cottle County. The Matador consisted of 11,410 hectares of public land that ranged in elevation from 518–640 m above sea level. The area was traversed by the confluence of the Middle and South Pease Rivers that flow intermittently, but generally only after significant rainfall (Holdstock 2003). The MWMA was located in the Mesquite Plains sub-region of the Rolling Plains (Holdstock 2003). Primary riparian vegetation consisted of hackberry (*Celtis occidentalis*), western soapberry (*Sapindus drummondi*), skunkbush sumac (*Rhus aromatica*), eastern cottonwoods (*Populus deltoides*), and woolybucket bumelia (*Bumelia lanuginose*).

honey mesquite (*Prosopis glandulosa*), sand sagebrush (*Artemisia filifolia*), shinnery oak (*Quercus havardii*), Chickasaw plum (*Prunus angustifolia*), and redberry juniper (*Junipersu pinchotii*) were also common (Holdstock 2003). Meadows of native grasses are dominated by bluestems (*Andropogon gerardii; Schizachyrium scoparium*) and gramas (*Bouteloua* spp.) (Spears et al. 2002).

The second site was located 11 km north of Clarendon and Hedley, Texas in Donley and Collingsworth Counties. This site was split by the Salt Fork of the Red River (SFRR), and was centered on 2 private land holdings just over 20,000 ha. The SFRR flowed nearly year-round and was only dry during periods of drought. Elevation ranged from 747–838 m. Vegetation consisted of eastern cottonwood, honey locust (*Gleditsia triacanthos*), and black locust (*Robinia pseudo-acacia*) trees in riparian areas, with rolling hills and plains dominated by yucca (*Yucca glauca*), grama grasses, bluestems, and snakeweed (*Guitierrezia sarothrae*) in adjacent rangelands (Spears et al. 2002).

The northern most site was centered on the Gene Howe Wildlife Management Area (GHWMA), surrounded by privately owned lands 9 km northeast of Canadian, Texas in Hemphill County. The GHWMA consisted of 2,138 ha of public land situated along the Canadian River which was primarily a continuous flowing river in the Mesquite Plains sub-region of the Rolling plains. Elevation ranged from 700–777 m and was characterized by topography with less relief than MWMA and SFRR. Despite having groves of salt cedar (*Tamarix chinensis*) (Cable et al. 1996) and Russian olive (*Elaeagnus angustifolia*), as well as a higher density of cottonwood trees, riparian vegetation was very similar to that of MWMA. Upland vegetation was dominated by bluestems and sand sagebrush and was similar to other study sites (Holdstock 2003). Additional information on study sites is available in Spears et al. (2005), Butler et al. (2005), and Holdstock et al. (2006).

Methods

Flock counts

We collected flock counts opportunistically throughout the year to assess chronology of flocking behavior. We recorded counts when we visually observed ≥1 wild turkey. We set a goal of 15 counts per week per study area. We did not always obtain 15 counts, especially during the winter when the total number of flocks was much less than during the spring and summer months. We used these data to evaluate changes in flock size over the course of the year.

Roost counts

We began collecting roost counts in October and continued through flock breakup in mid April. We were unable to monitor roost sites during May through September because tree leaves obstructed our view and resulted in poor counts. Since the number of wild turkeys using an individual roost varied through winter, we evaluated each roost independently to derive a maximum number of birds observed in a particular roost. We were then able to plot roost counts as the percentage of the maximum as a function of time for each roost. We then pooled and plotted all primary roosts together. We defined a primary roost as a roost site that was consistently used throughout winter, as well as over consecutive years (Smith 1975).

Climatic and photoperiod data

We obtained weather data from the National Oceanic and Atmospheric Administration (NOAA) website (http://www.ncdc.noaa.gov). The dataset included daily values for maximum temperature, minimum temperature, total snowfall, and total precipitation. We used data from weather stations located nearest each study site (0 to 26.7 km.). When stations had missing values we supplemented the dataset with values from the next closest weather station. We obtained data for the length of photoperiod from the United States Naval Observatory, Astronomical Applications Department (http://aa.usno.navy.mil). Length of photoperiod was the time in minutes from sunrise until sunset.

Correlation analysis

We analyzed data using the Pearson correlation coefficient (SPSS® 12.0, SPSS Inc., Chicago, Illinois, USA) to search for potential correlations between 5 climatic variables and flock size, as well as between the same 5 climatic variables and roost size. We could not use the actual number of birds at roosts in our analysis since roost counts were quite variable among roost sites. For example, if roost 1 peaked at 300 birds while roost 2 peaked at 70, we may not be able to detect a trend due to this variation. As a result, we converted all roost counts to percentage of the maximum for our analyses. This normalized all counts and allowed us to pool across roost sites. We used the actual number of birds observed from flock counts in our analyses since we assumed counts were independent.

Results

Flock counts

We collected 3,047 flock counts from January 2003–April 2006. Flock counts ranged from 1 to 250. Flock size increased from 15 May to late February. We defined the beginning of winter congregation as 15 November when average flock size increased by 25 percent from 15.0 to 20.2 wild turkeys per flock. We determined that this was when winter congregation at traditional winter roosting areas began to occur due to a steady increase in mean flock size from November 15 until peak in late February (Figure 3.2).

When compared to flock congregation, flock breakup was more abrupt and of shorter duration than flock congregation. Flock breakup occurred around 1 March when mean flock size decreased by 33 percent from 34.6 to 23.2 wild turkeys per flock (Figure 3.2). We determined that flock breakup continued until mid-April when mean flock sizes were < 5 wild turkeys per flock (Figure 3.2).

Roost counts

We collected 101 roost counts during winters 2003-2005 (Table 3.1). Roost counts ranged from 3 to 355 wild turkeys. Peak roost concentrations occurred during 16 January – 1 March as evidenced by the stability of roost counts and the relatively tight confidence intervals during this phase (Figure 3.3). A similar peak occurred with flock counts.

<u>Turkey group size</u>

Wild turkey attendance at traditional winter roost sites was not correlated with daily precipitation ($r = 0.139$, $n = 101$, $P = 0.164$), daily snowfall ($r = 0.139$, $n = 101$, $P = 0.164$), length of photoperiod ($r = –0.091$, $n = 101$, $P = 0.368$), or daily maximum temperature ($r = –0.177$, $n = 101$, $P = 0.077$). We did find a significant correlation between roost size and minimum temperature ($r = –0.245$, $n = 101$, $P = 0.014$).

We found no relationship between wild turkey flock sizes and daily precipitation ($r = 0.008$, $n = 3047$, $P = 0.640$) or daily snowfall ($r = 0.028$, $n = 3047$, $P = 0.128$). However, we did find weak negative correlations between wild turkey flock size and maximum daily temperature ($r = –0.290$, $n = 3047$, $P = 0.000$), minimum daily temperature ($r = –0.323$, $n = 3047$, $P = 0.000$), and length of photoperiod ($r = –0.367$, $n = 3047$, $P = 0.000$).

Discussion

Few other studies have examined the timing of peak winter roost concentrations. This may be due to the fact that peak concentrations occur during short time periods. This period may be important for obtaining the best counts because flock stability was greatest and the highest counts occurred. Cook (1973) found that the ability of landowners to estimate the number of wild turkeys on their property was influenced by the stability of individual roost sites. We believe if sampling events were coordinated, roost counts could be an accurate way to estimate abundance, especially if surveys were conducted during peak concentrations.

We believed that minimum temperature would be correlated to group size because Eiserer (1984) reported that birds often roosted communally to reap thermoregulatory benefits. High temperatures would seemingly elicit little response from birds during the winter period since it is likely that coldest temperatures influence behavior at this time.

We suggest that daily precipitation and daily snowfall may have had little effect on wild turkey flocking behavior. Most (70%) rainfall on the study sites occurred between April and August, there were few rain and snowfall events during our period of interest.

Length of photoperiod would seemingly have a strong relationship with roost size since day length is shortest in late December when roost counts were relatively high. Healy (1992) found that breeding behavior was triggered primarily by increasing daylight in spring, but unseasonably warm or cold weather could advance or delay breeding activity. Increased exposure to light causes a rise in the secretion of male sex hormones, which stimulates the development of sexual characteristics and the release of sexual behavior (Schleidt 1970, Lisano and Kennamer 1977).

We found that minimum temperature influences flock size and that minimum temperature, maximum temperature, and length of photoperiod influence roost size. Although these correlations were significant, these variables explained little of the variation in flock and roost size. Even though we observed low correlation coefficients, we believe that these variables may have a greater influence on winter turkey concentrations in combination. There may also be an effect of time lag influencing winter concentrations. Cougill and Marsden (2004) found that by incorporating 1 day time lags into their analysis that they were able to account for additional variability in roost size of Red-tailed Amazon parrots (*Amazona brasiliensis*).

Management Implications

Peak winter concentrations of wild turkeys at winter roosts occurred from January–February. This appears to be the best time to conduct roost counts. Additionally, since cold temperatures impact wild turkey concentrations, roosts should be counted during the coldest portion of the specified peak period for the greatest likelihood of the highest densities of wild turkeys using major roosts.

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Table 3.1. Roost counts at Gene Howe Wildlife Management Area (GHWMA), Matador Wildlife Management Area (MWMA), and Salt Fork of the Red River (SFRR), 2003–2005.

	Study site			
Winter	GHWMA	MWMA	SFRR	Total
2003	3	1	3	5
2004	10	15	8	33
2005	0	38	23	61
Total	13	54	34	101

Table 3.2. Flock counts at Gene Howe Wildlife Management Area (GHWMA), Matador Wildlife Management Area (MWMA), and Salt Fork of the Red River (SFRR), 2003–2006.

	Study Site			
Year	GHWMA	MWMA	SFRR	Total
2003	138	196	198	532
2004	371	193	312	876
2005	379	581	486	1446
2006	57	99	37	193
Total	945	1,069	1,033	3,047

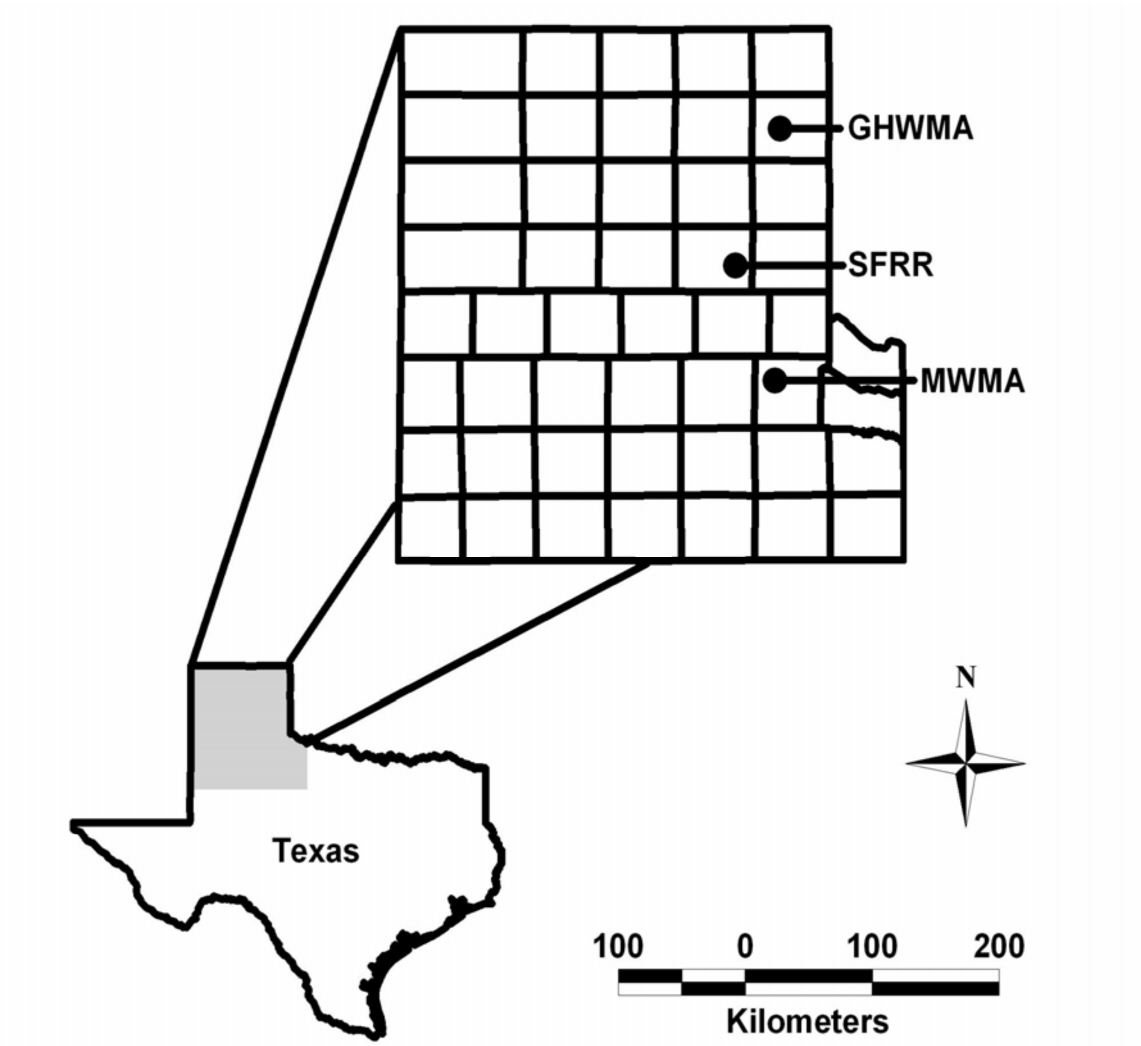

Figure 3.1. Locations of study sites (from north to south: Gene Howe Wildlife Management Area [GHWMA], Salt Fork of the Red River [SFRR], and Matador Wildlife Management Area [MWMA] used for determining the timing of winter flock congregation and subsequent breakup at traditional winter roosting areas for Rio Grande wild turkeys during the winters of 2003–2005.

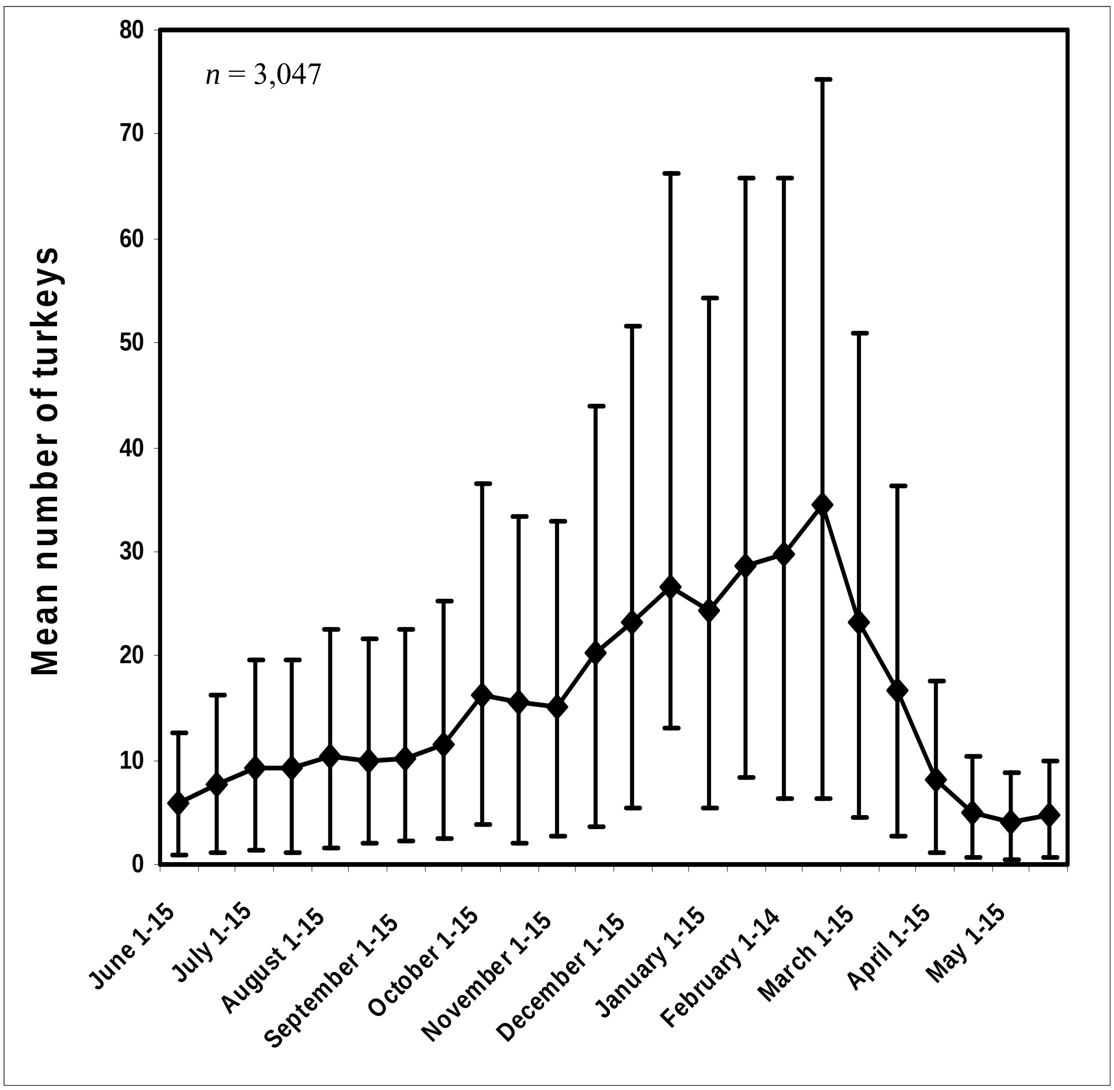

Figure 3.2. Mean number of wild turkeys and associated 95% confidence intervals for flock counts during bimonthly time intervals from the Rolling Plains of Texas, January 2003–April 2006.

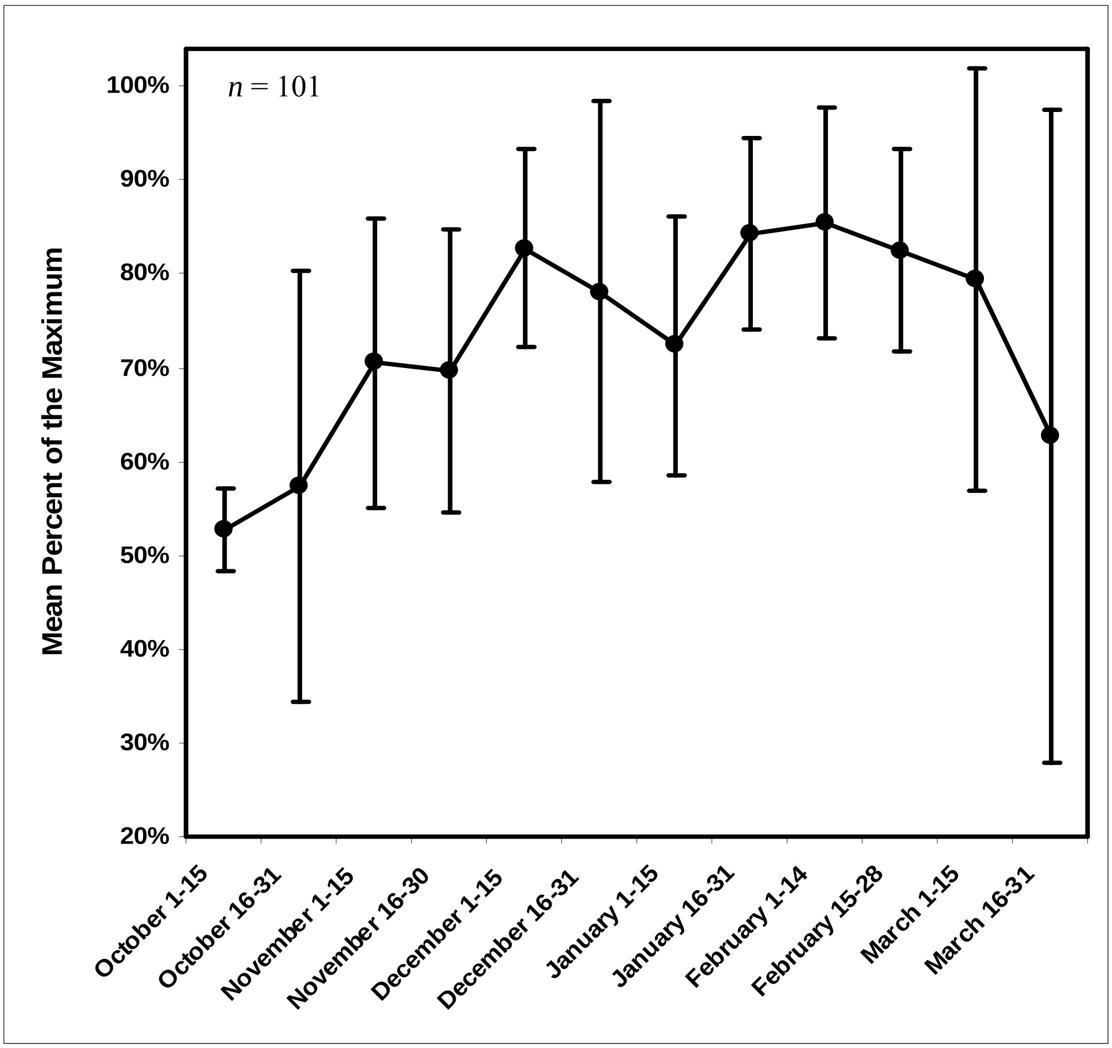

Figure 3.3. Mean percent of maximum turkey roost counts and associated 95% confidence intervals during bimonthly time intervals in Rolling Plains of Texas, winters 2003–2005.

APPENDIX A

SUMMARY OF WILD TURKEY ROOST STUDIES BY VEGETATION CHARACTERISTICS 1966–2007

Table A.1. Summary of wild turkey roost studies in the United States by vegetative characteristics, 1966–2007.

Source	State	Subspecies	Trees species	DBH[a] (cm)	Height (m)	CC[b] (%)	HLB[c] (m)	BA[d] (m^2/ha)
This study (2007)	TX	Rio Grande	Cottonwood	49.4	17.0	67.9	5.8	16.4
Perlichek (2005)	TX	Merriam	Ponderosa pine	45.7	16.9	50.8	6.6	
Perlichek (2005)	TX	Rio Grande	Live oak	57.8	13.6	86.6	3.7	
Perlichek (2005)	TX	Rio Grande	Hackberry	25.8	9.6	43.0	2.3	
Holdstock (2003)	TX	Rio Grande	Cottonwood	49.9	13.6		3.4	
Thompson (2003)	SD	Merriam	Ponderosa pine	34.3		60.7		
Flake et al. (1995)	SD	Merriam	Cottonwood, Elm	70.6			5.3	27.2
Mollohan et al. (1995)	AZ	Merriam	Ponderosa pine	63.2			7.3	20.2
Rumble (1992)	SD	Merriam	Ponderosa pine	35.0	27.0	58.3		22.4
York (1991)	NM	Gould	Chihuahua pine	58.3	16.9	43.0		10.5
Hengel (1990)	WY	Merriam	Ponderosa pine	49.4			4.5	49.2
Kilpatrick et al. (1988)	RI	Eastern	White pine, Oak spp.	48.4	18.9			
Lutz and Crawford (1987)	OR	Merriam	Ponderosa pine	67.8		20.7	9.8	

Table A.1. Continued.

Source	State	Subspecies	Tree species	DBH (cm)	Height (m)	CC (%)	HLB (m)	BA (m²/ha)
Schemnitz et al. (1985)	NM	Merriam	Douglas fir, White fir	44.0	23.0	73.2		40.5
Mackey (1984)	WA	Merriam	Douglas fir	45.2	26.6	73.5	10.8	33.9
Quinton et al. (1980)	TX	Rio Grande	Pecan	68.0	14.7			
Haucke (1975)	TX	Rio Grande	Live oak, Hackberry	62.5	13.2			
Haucke and Ables (1972)	TX	Rio Grande	Hackberry, Mesquite	43.2	9.8			
Tzilkowski (1971)	PN	Eastern	White oak, Maple	44.5	21.0			
Crockett (1969)	OK	Rio Grande	Cottonwood	52.5	16.8			
Boeker and Scott (1969)	AZ	Merriam	Ponderosa pine	64.5	24.4		8.4	
Hoffman (1968)	CO	Merriam	Ponderosa pine	54.6	23.3			
Jonas (1966)	MT	Merriam	Ponderosa pine	45.5	19.5			

[a] DBH = Diameter at breast height.
[b] CC = % Canopy cover
[c] HLB = Height to lowest branch (typically classified as roostable sized branch).
[d] BA = Basal area.

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