LESSER PRAIRIE-CHICKEN HABITAT SELECTION ACROSS VARYING LAND USE PRACTICES IN EASTERN NEW MEXICO AND WEST TEXAS

by

Philip K. Borsdorf, B.S.

A Thesis

In

WILDLIFE, AQUATIC, AND WILDLANDS SCIENCE AND MANAGEMENT

Submitted to the Graduate Faculty
of Texas Tech University in
Partial Fulfillment of
the Requirements for
the Degree of

MASTER OF SCIENCE

Dr. Clint W. Boal
Committee Chair

Dr. David A. Haukos

Dr. Mark C. Wallace

Ms. Kathy Boydston

Dr. Dominick Casadonte
Interim Dean of the Graduate School

August, 2013

Copyright 2013, Philip K. Borsdorf

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my graduate advisor Dr. Clint Boal for his patience and guidance. I extend my gratitude to my committee members Dr. David Haukos, Dr. Mark Wallace, and Ms. Kathy Boydston for their scientific, logistical, and financial support. I thank the private landowners who made this research possible. To Mr. Bob Perkins, who provided a home and central-station for me and my fellow field researchers—thank you. Mr. Jim Weaver, Mr. Willard Heck, and Mr. Charles Dixon thoughtfully provided data. Also, thank you to Apple Wood and the other technicians who collected data in New Mexico.

I appreciate the generosity that the Grishams extended to me. Blake, you were an outstanding mentor and I am grateful for your support and unwavering belief in me. To all the technicians from 2008 through 2012: Clinton Kveton, Chris Frey, Nick Pirius, Dan Fuhs, Austin Teague, Lucas Schilder, Preston Stewart, Lee Rindlisbacher, Shay Hlavaty, Trevor Gicklhorn, Ryan Vaughan, and Luke Haen—your consistency and effort was tremendous.

Thank you to my friends; especially Luke Haen—your dependability as a field-crew leader and friend is deeply appreciated. I offer sincere thanks to The Houston Safari Club for their generous financial support. My time spent afield on the west Texas landscape was a truly rewarding experience that I will fondly remember and miss. Last, and most importantly, I would like to thank my parents, Fred and Lynda Borsdorf, for their endless love, faith, and support—you instilled in me a conservation ethic and inspired my interest in wildlife.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS ..... **ii**

ABSTRACT ..... **viii**

LIST OF TABLES AND FIGURES ..... **ix**

I. INTRODUCTION **1**

LITERATURE REVIEW **1**

Population and Range Decline 1

Habitats and Habitat Requirements 3

Sand-Shinnery Oak Control 6

Home Ranges 9

Roost Site Selection 9

THESIS FORMATTING **10**

LITERATURE CITED **11**

II. HOME RANGE SIZE AND HABITAT SELECTION OF LESSER PRAIRIE-CHICKENS ON THE SOUTHERN HIGH PLAINS OF TEXAS **15**

ABSTRACT **15**

INTRODUCTION **15**

STUDY AREA **18**

METHODS **19**

Capture 19

Cover-typing 20

Radio-telemetry 21

Space Use Estimation 21

Habitat Selection 24

RESULTS 27

Space Use 27

Habitat Selection 29

DISCUSSION 31

Home Range Estimators 31

Space Use 35

Habitat Selection 37

Implication of Results 38

LITERATURE CITED 41

III. HABITAT SELECTION OF LESSER PRAIRIE-CHICKENS ON EXPERIMENTALLY HERBICIDE TREATED AND GRAZED LANDS IN EASTERN NEW MEXICO 52

ABSTRACT 52

INTRODUCTION 52

STUDY AREA 55

METHODS 56

Capture 56

Radio-telemetry 57

Habitat Selection 57

RESULTS 58

DISCUSSION 59

LITERATURE CITED 63

IV. LESSER PRAIRIE-CHICKEN NOCTURNAL ROOSTING SITE SELECTION ON THE SOUTHERN HIGH PLAINS OF TEXAS 68

ABSTRACT 68

INTRODUCTION 68

STUDY AREA 70

METHODS 71

Capture 71

Radio-telemetry 71

Microhabitat 73

Microclimate 74

RESULTS 75

Microhabitat 75

Microclimate 76

DISCUSSION 77

LITERATURE CITED 80

ABSTRACT

Currently, lesser prairie-chickens occur in two primary geographic areas on the southern Great Plains. The northern geographic area includes portions of eastern Colorado, Kansas, western Oklahoma, and the northwestern Panhandle of Texas (hereafter; northeastern region). The southern geographic area is located on the Southern High Plains of eastern New Mexico and west Texas (hereafter; southwestern region). Habitat loss and fragmentation are implicit causes for range-wide declines of lesser prairie-chicken populations. Furthermore, the degradation of the native rangelands where lesser prairie-chickens occur may negatively affect the species' persistence.

In the southwestern region, lesser prairie-chickens are primarily relegated to sand-shinnery oak grassland communities. Sand-shinnery oak grassland communities are comprised of some combination of sand-shinnery oak, native perennial prairie-grasses, sand sagebrush, and various different forbs. Livestock production is a common land use within sand-shinnery oak grassland communities of the southwestern region. Unmanaged grazing systems in this region frequently result in near monoculture stands of sand-shinnery oak that are practically devoid of a grass component. Also common within this region, is the use of herbicides (e.g., tebuthiuron) to eradicate shrubs from the plant community to increase grass forage for livestock. There is interest in using moderate intensity, rotational grazing systems, and reduced-rate tebuthiuron applications as a tool to restore sand-shinnery oak grassland communities to supposed historical standards. The primary goal of reduced-rate tebuthiuron applications is to reduce the competitive sand-shinnery oak component present in monocultures to restore a dominating or co-

dominating grass component. However, the effects of reduced-rate tebuthiuron applications on lesser prairie-chicken populations is unknown.

The primary focus of this thesis was to assess gender-specific lesser prairie-chicken breeding season habitat selection in relation to the previously mentioned land use practices. Data were collected on two different study areas occurring in sand-shinnery oak grassland communities within the southwestern region. From 2008-2012, on a study area occurring in west Texas, male lesser prairie-chickens demonstrated selection for vegetative cover-types comprised of sand-shinnery oak, but dominated by native prairie-grasses, while females used the cover-types in proportion to availability. On experimentally tebuthiuron treated (0.6 kg/ha) and rotationally grazed plots in eastern New Mexico, results suggested selection by male lesser prairie-chickens for areas not treated with tebuthiuron in comparison to tebuthiuron treated areas. Female lesser prairie-chickens, in New Mexico, used the not-treated and not-grazed areas in greater proportion to availability, the treated and not-grazed, and not-treated and grazed areas in proportion to availability, and the treated and grazed areas less than were proportionally available.

Gender-specific home range size was assessed for lesser prairie-chickens from 2008-2012 on the west Texas study area. Three different home range estimators were used; 95% fixed kernel density estimates using two different bandwidths (LSCV and Plug-in) and a 100% Minimum Convex Polygon were implemented to estimate home range sizes. I chose to use three different estimators to compare and contrast the size differences among home range estimates, and to facilitate comparison of results with other studies. For male lesser prairie-chickens, both 95% fixed kernel density estimates (LSCV and Plug-in) were significantly larger than 100% MCP home ranges. For female

lesser prairie-chickens, only the 95% fixed kernel density (LSCV) estimates were significantly larger than 100% MCP home ranges. Despite the home range estimator, all female home ranges were approximately twice the size of male home ranges.

Nocturnal roosting site selection was assessed in relation to microhabitat and microclimate in west Texas during the breeding seasons of 2011 and 2012. There were no differences in visual obstruction readings between roost and paired random sites. Lesser prairie-chickens roosted directly on bareground with no overhead vegetative coverage. In 2011, there was significantly more bareground and less humidity (% relative humidity) at roosting site point center compared to paired random sites. In 2012, roost and random sites were equally humid, but there was more litter coverage surrounding roosting sites compared to paired random sites. Temperature did not appear to differ between roost and random sites in either 2011 or 2012.

My results suggest that male lesser prairie-chicken habitat selection is inadequate for assessing the species' general breeding season habitat requirements due to male breeding behavior, and lekking site fidelity, as confounded by uneven trapping effort across cover-types/experimental plots for both study areas. Female lesser prairie-chickens used cover-types in proportion to availability in Texas, and nearly so in New Mexico, which suggested that reduced-rate tebuthiuron applications and moderate, rotational grazing does not appear to influence the preference or avoidance of available vegetative communities, as measured by general breeding season habitat use. Because tebuthiuron applications do not appear positively or negatively affect lesser prairie-chicken habitat selection, I caution the widespread tebuthiuron treatment of sand-shinnery oak grassland communities.

LIST OF TABLES AND FIGURES

2.1. Land cover-types used for determining breeding season habitat selection by lesser prairie-chickens on the Southern High Plains of Texas (2008-2012). Adapted from Pirius (2011). 45

2.2. Summary of the use, availability, and reconsolidation of the cover-types (Table 2.1) into the habitat categories used for both 2nd and 3rd order compositional analysis for breeding season males (n = 37) on the Southern High Plains of Texas (2008-2012). 46

2.3. Summary of the use, availability, and reconsolidation of the cover-types (Table 2.1) into the habitat categories used for both 2nd and 3rd order compositional analysis for breeding season females (n = 38) on the Southern High Plains of Texas (2008-2012). 47

2.4. Average male fixed kernel home range estimates (ha) on the Southern High Plains of Texas (2008-2012).....48

2.5. Average female fixed kernel home range estimates (ha) on the Southern High Plains of Texas (2008-2012).....48

2.6. Average male and female 100% minimum convex polygon (MCP) home ranges (ha) on the Southern High Plains of Texas (2008-2012).....48

2.7. Male (n=37) 2nd order compositional analysis results: Ranking Matrix. Data collected on the Southern High Plains of Texas (2008-2012).....49

2.8. Male (n=37) 2nd order compositional analysis results: Ranking Matrix (Mean difference between used and available log-ratios). Data collected on the Southern High Plains of Texas (2008-2012).....49

2.9. Female (n=38) 2nd order compositional analysis results: Ranking Matrix. Data collected on the Southern High Plains of Texas (2008-2012).....49

2.10. Female (n=38) 2nd order compositional analysis results: Ranking Matrix (Mean difference between used and available log-ratios). Data collected on the Southern High Plains of Texas (2008-2012).....49

2.11. Male (n=37) 3rd order compositional analysis results: Ranking Matrix. Data collected on the Southern High Plains of Texas (2008-2012).....50

2.12. Male (n=37) 3rd order compositional analysis results: Ranking Matrix (Mean difference between used and available log-ratios). Data collected on the Southern High Plains of Texas (2008-2012).....50

2.13. Female (n=38) 3rd order compositional analysis results: Ranking Matrix. Data collected on the Southern High Plains of Texas (2008-2012).....50

2.14. Female (n=38) 3rd order compositional analysis results: Ranking Matrix (Mean difference between used and available log-ratios). Data collected on the Southern High Plains of Texas (2008-2012).....50

2.1. Distance from lek of capture (km) for all male and female telemetry-based relocations on the Southern High Plains of Texas (2008-2012).....51

3.1. Vegetative composition of treatment types used for determining breeding season habitat selection by lesser prairie-chickens. Categories include: sand-shinnery oak (*Quercus havardii*); other shrubs: mostly sand sagebrush (*Artemisia filifolia*); and grass (mostly native prairie-grasses). Summarized from measurements collected in Roosevelt County, NM from 2002-2010 as shown in Zaveleta (2012).....65

3.2. Male lesser prairie-chicken habitat selection in Roosevelt County, NM (2006-2010).....66

3.3. Female lesser prairie-chicken habitat selection in Roosevelt County, NM (2006-2010). 67

4.1. Mean VORs (dm) (±SD) at lesser prairie-chicken roosting sites and paired random sites on the Southern High Plains of Texas (2011 and 2012). 82

4.2. Roosting site canopy coverage proportions at point center and 1 meter in each cardinal direction for 2011. Occurrence pooled across 30 sites and then proportion calculated. Data collected on the Southern High Plains of Texas (2011). 82

4.3. Random site canopy coverage proportions at point center and 1 meter in each cardinal direction for 2011. Occurrence pooled across 30 sites and then proportion calculated. Data collected on the Southern High Plains of Texas (2011). 82

4.4. Roosting site canopy coverage proportions at point center and 1 meter in each cardinal direction for 2012. Occurrence pooled across 30 sites and then proportion calculated. Data collected on the Southern High Plains of Texas (2011). 82

4.5. Roosting site canopy coverage proportions at point center and 1 meter in each cardinal direction for 2012. Occurrence pooled across 30 sites and then proportion calculated. Data collected on the Southern High Plains of Texas (2012). 83

4.6. Welch's adjusted *t*-test results between roost and random sites for point center canopy coverage categories in 2011. Proportions per canopy coverage category shown for visualization. Arcsine-square root transformations (not shown) were the values tested. Data collected on the Southern High Plains of Texas (2011).....83

4.7. Welch's adjusted *t*-test results between roost and random sites for point center canopy coverage categories in 2012. Proportions per canopy coverage category shown for visualization. Arcsine-square root transformations (not shown) were the values tested. Data collected on the Southern High Plains of Texas (2012).....83

4.8. Mean temperature °C (±SD) and relative humidity % RH (±SD) at lesser prairie-chicken roosting sites and paired random sites on the Southern High Plains of Texas (2011 and 2012).....83

CHAPTER I

INTRODUCTION

LITERATURE REVIEW

Population and Range Decline

The lesser prairie-chicken (*Tympanuchus pallidicinctus*), a prairie grouse species of the central and southern Great Plains, has experienced an estimated 90% reduction in both range and population since the 1800's (Taylor and Guthery 1980a, Hagen et al. 2004). Due to range wide reductions in population and distribution, the lesser prairie-chicken was first petitioned for listing as threatened under the Endangered Species Act (ESA) in 1995 (Davis et al 2008). The U.S. Fish and Wildlife Service determined that listing of the species under the ESA was "warranted but precluded" (USFWS 2009). Currently, the species is again under review (Federal Register 2013).

The occupied range of lesser prairie-chickens in Texas has decreased by an estimated 78.3% (1,070,426 ha) since 1940 with much of the loss occurring in the southwestern part of the Panhandle (Sullivan et al. 2000). Litton is cited in Davis et al. (2008) as speculating that the Texas lesser prairie-chicken population could have been as high as 2 million birds before the 1900s. Davis et al. (2008) suggested that Litton's speculated Texas lesser prairie-chicken population estimate was high due to the corresponding density estimate of 20 birds/mi². In 1963, Jackson and DeArment estimated the population of lesser prairie-chickens in Texas at about 3,000 birds, based on springtime lek counts. Recently, it was estimated that less than 6,000 lesser prairie-chickens exist in 14 Panhandle counties, and between 30,000-50,000 birds range wide

(Davis et al. 2008). It is estimated that up to 56% of the historical range in New Mexico no longer supports lesser prairie-chickens (Bailey and Williams (2000) cited in Davis et al. 2008).

Long term declines of lesser prairie-chickens occurring on the Texas Southern High Plains can be mainly attributed to the conversion of native rangeland to crop production (Crawford and Bolen 1976), habitat degradation due to overgrazing and excessive shrub control, and oil and gas development (Sullivan et al. 2000). Crawford and Bolen (1976) found that areas of limited cultivation harbored the greatest number of leks while intensely cultivated areas held the lowest number of leks. Furthermore, Crawford and Bolen (1976) suggested that areas consisting of <63% grassland were not suitable for stable lesser prairie-chicken populations.

Positive correlations have been detected between declining lesser prairie-chicken numbers and percent of total area changed from one cover-type to another, total loss of shrubland, and rate of landscape change (cited in Jamison et al. 2002). Jamison et al. (2002) suggests that the most important management practice for lesser prairie-chicken preservation is to maintain large tracts of sand-shinnery oak (*Quercus havardii*) and sand sagebrush (*Artimisia filifolia*) grasslands. Furthermore, Davis et al. (2008) recommends establishing native prairie plants on CRP land and restoring existing lesser prairie-chicken habitat that has been degraded.

Habitats and Habitat Requirements

Across the lesser prairie-chicken's range the species occurs in mid and mixed prairies and grasslands containing sand-shinnery oak and sand sagebrush (NRCS 1999). Throughout the southwestern region (Southern High Plains of west Texas and eastern New Mexico), lesser prairie-chickens are closely associated with sand-shinnery oak grassland communities. Sand-shinnery oak also occurs in portions of the northerneastern region where lesser prairie-chickens occur (northeastern Texas Panhandle and in western Oklahoma). Sand-shinnery oak is estimated to occur on 5-7 million ha (Peterson and Boyd 1998), or on 2-3 million ha (Harrell et al. 2001) in west central Oklahoma, southeastern New Mexico and in the Texas Panhandle. There are more than 1.4 million ha of sand-shinnery oak growing on the sandy soils in the northern and southwestern portions of the Texas Panhandle/Southern High Plains (Pettit 1979). Within the last 100 years, more than 500,000 ha of sand-shinnery oak grassland communities across the southern Great Plains have been converted to either cropland or grassland (Peterson and Boyd 1998).

Throughout the southwestern region, lesser prairie-chicken hens are known to nest in sand-shinnery oak grassland communities with a significant sand-shinnery oak component. Haukos and Smith (1989) and Johnson et al. (2004) observed lesser prairie-chicken hens selecting sand-shinnery oak dominated grassland communities not treated with herbicide, for nest sites, significantly more than herbicide treated vegetative communities. Johnson et al. (2004) observed higher compositions of shrubs within a 3 m radius surrounding lesser prairie-chicken nest sites. In New Mexico, Bell et al. (2010)

most often located lesser prairie-chicken broods in dense sand-shinnery oak areas within sand-shinnery oak dominated habitats. Olawsky and Smith (1991) did not detect a difference in summer season lesser prairie-chicken density between sand-shinnery oak dominated areas and herbicide treated areas dominated by grass in Texas. Cannon and Knopf (1981) found greater densities of displaying male lesser prairie-chickens in sand sagebrush and grass dominated rangelands in Oklahoma. Lesser prairie-chicken hens nest in dense sand-shinnery oak habitats under residual grasses or shrubs with abundant side and overhead obstruction (Sell 1979, Haukos and Smith 1989, Giesen 1994). Copelin (1963) and Riley (1978) suggest that lesser prairie-chicken nesting habitat is dominated by perennial grasses.

Patten et al. (2005) found lesser prairie-chicken adult survival to be higher in habitats consisting of greater shrub densities. While they did not identify a specific upper limit of shrub density that promoted lesser prairie-chicken survival they deduced that it is less than 50%. Lesser prairie-chicken survival was highest in habitats with shrub density ≥20% (Patten et al. 2005). Survival was also positively correlated with grass density. Therefore Patten et al. (2005) recommended that managers maintain shrub densities of ≥20% and to avoid prolonged intensive livestock grazing in order to conserve lesser prairie-chicken populations.

Loss and fragmentation of sand-shinnery oak grassland communities is not the only threat to lesser prairie-chicken habitat. Degredation of remaining sand-shinnery oak grassland communities from overgrazing, native shrub removal, and enchroachment of woody vegetation are serious concerns. It is hypothesized that wildfire suppression and changes in grazing regimes since European settlement has resulted in an increase in sand-

shinnery oak density where the plant occurs (Harrell et al. 2001). This hypothesis, paired with declines in lesser prairie-chicken populations, has incited a common desire to identify pre-settlement sand-shinnery oak grassland community structure and composition. Habitat structure and composition may be important to lesser prairie-chicken conservation as is providing a sufficient amount of useable space for the species. If so, the goal to identify historic sand-shinnery oak grassland community characteristics and the processes that facilitate these habitat conditions may be helpful in conserving lesser prairie-chicken populations.

There has been limited critical assessment of the effects that livestock grazing has on lesser prairie-chicken habitat use. Copelin (1963) observed lesser prairie-chickens in Oklahoma using moderately grazed pastures more than heavily grazed pastures. Crawford and Bolen (1976) assessed grazing intensity and reported it for each of their 8 study plots on a scale of 1 to 4 (1=heavily grazed, 2=moderate, 3=light, 4=ungrazed). They did not detect a correlation between lek population size and grazing intensity with the multiple regression tests they used. Grazing can reduce residual grass cover thought necessary to obscure nesting lesser prairie-chickens from predators (Davis et al. 1979, Riley et al. 1992, Giesen 1994). Drought can amplify the effects of heavy grazing by inhibiting new grass growth (Giesen 2000 cited in Davis et al 2008). Periods of drought from 1934-39 and 1952-56, described by Jackson and DeArment (1963) had a significant negative impact on lesser prairie-chicken populations in Texas. Sullivan et al. (2000) also cites Texas Pandhandle lesser prairie-chicken population declines attributed to extended droughts in the 1930’s, 1950’s, and early 1990’s.

Sand-Shinnery Oak Control

Sand-shinnery oak is a low growing shrub that spreads via its rhizomes and rarely, if ever, by seed (acorn) germination in natural settings (Peterson and Boyd 1998). Twenty years of research in New Mexico, beginning in 1977, revealed that local acorn crops occurred every year in sand-shinnery oak stands, but crops only occurred 2 out of 5 years in a specific location (Peterson and Boyd 1998). Sand-shinnery oak is very effective in obtaining and storing water, and at preventing wind-induced soil erosion (Peterson and Boyd 1998).

Sand-shinnery oak is eliminated from native rangelands to increase forage (grass and forbs) for livestock. During the spring season, if more palatable forage is not present, livestock that browse on sand-shinnery oak can become malnourished and ill from sand-shinnery oak ingestion (Pettit 1979, Peterson and Boyd 1998). Reducing sand-shinnery oak dominance may be necessary to restore sand-shinnery oak to its supposed historical densities in order to benefit lesser prairie-chickens. Sand-shinnery oak removal is most commonly achieved through the application of herbicides. Early sand-shinnery oak control attempts were temporarily achieved with phenoxy herbicides including 2, 4-D and 2, 4, 5-T and Silvex (2-(2,4,5-T) propionic acid), benzoic acids, including dicamba, and a picolenic acid, picloram (Tordon) (Peterson and Boyd 1998). These herbicides usually only resulted in temporary top kill of sand-shinnery oak (Pettit 1979). Tebuthiuron (N-[5-(1,-dimehylethyl)-1,3,4-thiadiazol-2-yl]-N,N'-dimehylurea) is a granular herbicide that attacks the root systems of woody vegetation such as sand-shinnery oak and sand sagebrush and causes plant death (Peterson and Boyd 1998).

Pettit (1979) applied picloram and tebuthiuron herbicides to 20 m² plots at rates of 1,3, 5, and 7 kg/ha. These pastures contained >10% sand-shinnery oak canopy cover. Tebuthiuron rates ≥3 kg/ha removed forbs and injured perennial grasses in addition to killing all of the sand-shinnery oak. This resulted in colonization by annual false buffalograss (*Bouteloua dactyloides*) into these plots. Plots treated with ≥3 kg/ha of picloram killed all sand-shinnery oak, injured grasses, but did not kill all forbs. The picloram treated plots had less abundance of false buffalograss.

Picloram and tebuthiuron can be applied in winter or spring at doses of >3 kg/ha and 1kg/ha, respectively, to achieve total sand-shinnery oak kill (Pettit 1979). An application rate of 0.6 kg/ha is considered on the lower end of a lethal application rate, but it can be applied at lower rates to reduce sand-shinnery oak density (Pettit 1979). Overgrazing by livestock can have lasting effects on sand-shinnery oak/bluestem habitats. Once grasses and forbs are significantly reduced, the sand-shinnery oak can outcompete grasses and forbs. In these circumstances, it may be beneficial to treat and reduce the sand-shinnery oak to restore grasses and forbs critical for nesting and brood rearing (Copelin 1963, Donaldson 1969). Lower rates of herbicide application in areas of excessive sand-shinnery oak dominance that achieve partial and temporary top kill of sand shinnery oak may satisfactorily mimic the results of a natural fire disturbance in areas where fire is less frequent.

Bell et al. (2010) found that applications of tebuthiuron to sand-shinnery oak pastures increased basal and canopy cover contacts for grasses and decreased canopy cover and stem density for sand-shinnery oak on 10 m transects. Jackson and DeArment (1963) noted the prevention of sand-shinnery oak acorn production for two years

following herbicide treatments. Sand-shinnery oak acorns are a commonly consumed winter food source for lesser prairie-chickens (Peterson and Boyd 1998). The immediate effects of herbicide treatment can eliminate a valuable winter food source and negatively impact lesser prairie-chicken survival.

Bell et al. (2010) recommended prescribed fire and prescriptive grazing as good alternatives to herbicide treatments in temporarily reducing sand-shinnery oak. The effects of fire on vegetative structure and composition in sand-shinnery oak grassland communities are relatively short-term (≤3 growing seasons) (Boyd and Bidwell 2001, Harrell et al. 2001). Boyd and Bidwell (2001) measured vegetation and insect production during the 1st and 2nd year growing seasons following fall, winter, and spring prescribed fires on sand-shinnery oak grassland communities in Oklahoma. They discovered that nesting habitat was significantly reduced for 2-3 years following a fire. At one year post burn, sand-shinnery oak catkin, leaf bud, and mast production was inhibited. At two years post burn, only a spring-season burn reduced catkin density. For all burn seasons, warm and cool season forbs and sedges increased by more than 100%. Grasshopper abundance significantly increased in most instances at 1 and 2 years post-burn. Boyd and Bidwell (2001) caution that the results from their study may not be repeatable in the more arid ranges of sand-shinnery oak grassland community occurrence.

Home Ranges

Home range size may be reduced by the availability of quality habitat and accumulation of ≥ average amount of seasonal rainfall (Sell 1979). Lesser prairie-chickens may travel greater distances during years experiencing drought conditions than in years of approximately average precipitation (Copelin 1963). Winter home range analysis by Taylor and Guthery (1980a) found male lesser prairie-chicken home range sizes of 50 to 1,945 ha when using monthly minimum convex polygon method.

Roost Site Selection

Copelin (1963) noted that lesser prairie-chickens in Oklahoma roosted on ridges, in draws and ravines, and in areas with less than 1 meter of overhead cover. Jones (1963) discussed the use of pockets of shorter vegetation by roosting lesser prairie-chickens in Oklahoma. During the fall/winter, lesser prairie-chicken foraging areas, and associated nocturnal roosting sites consisted of a greater component of grass than shrubs, in eastern New Mexico (Davis et al. 1979; Riley et al. 1993). Kukal (2010) did not detect a difference between daytime and nighttime telemetry-based relocation distances to known leks during the fall/winter in the northeast Texas Panhandle. Bell et al. (2010) evaluated daytime brooding site selection in relation to microclimate and suggested that broods seeking heat avoidance sites may be selecting sites on a very small scale (a few meters) due to the homogeneity of the landscape on his study site. Furthermore, Bell found that the temperatures along a 10 m line could vary substantially (Bell et al. 2010).

THESIS FORMATTING

Each chapter is formatted as an independent manuscript, and meant to facilitate future publication of results. Chapters contain redundancies in introduction and study area because they are meant to be complete, stand-alone documents. These chapters are formatted to meet the guidelines for The Wildlife Society Bulletin (WSB 2012) while also adhering to Texas Tech University Graduate School formatting guidelines. All methods were approved under Texas Tech University Animal Care and Use protocol #1052-08.

LITERATURE CITED

Bell, L.A., S.D. Fuhlendorf, M.A. Patten, D.H. Wolfe, and S. K. Sherrod. 2010. Lesser prairie-chicken hen and brood habitat use on sand shinnery oak. Rangeland Ecology and Management 63:478-486.

Chamberlain, E., R.D. Drobney, and T.V. Dailey. 2002. Winter macro- and microhabitat use in central Missouri. Pages Symposium. Texas Parks and Wildlife Department, Austin, TX.

Copelin, F. F. 1963. The lesser prairie chicken in Oklahoma. Oklahoma Wildlife Conservation Department, Oklahoma City, Oklahoma, USA.

Crawford, J.A. and E.G. Bolen. 1976b. Effects of land use on lesser prairie chickens in Texas. Journal of Wildlife Management 40:96-104.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43–64.

Davis, D.M. 2009. Nesting ecology and reproductive success of lesser prairie-chickens in shinnery oak-dominated rangelands. The Wilson Journal of Ornithology 121:322-327.

Davis, D.M., R.E. Horton, E.A. Odell, R.D. Rodgers and, H.A. Whitlaw. 2008. Lesser Prairie-Chicken Conservation Initiative. Lesser Prairie Chicken Interstate Working Group. Unpublished Report. Colorado Division of Wildlife, Fort Collins, CO. USA.

Donaldson, D.D. 1964. Effect on lesser prairie-chickens of brush control in western Oklahoma. Ph.D. Dissertation. Oklahoma State University, Stillwater, Oklahoma, USA.

Federal Register. May 6, 2013. Proposed Rules Vol. 78, No. 87, pg. 1.

Fuhlendorf, S.D., A.J. Woodward, D.M. Leslie Jr., and J.S. Shackford. 2002. Multiscale effects of habitat loss and fragmentation on lesser prairie-chicken populations. Landscape Ecology 17:601-615.

Geisen, K.M. 1994. Movements and nesting habitat of lesser prairie-chicken hens in Colorado. The Southwestern Naturalist 39:96-98.

Jackson, A.S. and R. DeArment. 1963. The lesser prairie chicken in the texas panhandle. Journal of Wildlife Management 27:733-737.

Jamison, B.E., J.A. Dechant, D.H. Johnson, L.D. Igl, C.M. Goldade, and B.R. Euliss. 2002. Effects of management practices on grassland birds: lesser prairie-chicken. Northern Prairie Research Center, Jamestown, ND. 29 pages.

Johnson, K., B.H. Smith, G. Sadoti, T.B. Neville, and P. Neville. 2004. Habitat use and nest site selection by lesser prairie-chickens in southeastern New Mexico. The Southwestern Naturalist 49:334-343.

Jones, R.E. 1964. The specific distinctness of the greater and lesser prairie chickens. The Auk 81:65-73.

Hagen, C.A., B.E. Jamison, K.M. Giesen, and T.Z. Riley. 2004. Guidelines for managing lesser prairie-chicken populations and their habitats. Wildlife Society Bulletin 32(1): 69-82.

Harrell, W.C., S.D. Fuhlendorf, and T.G. Bidwell. 2001. Effects of prescribed fire on sand shinnery oak communities. Journal of Range Management 54:685-690.

Haukos, D.A. and L.M. Smith. 1989. Lesser prairie-chicken nest site selection and vegetation characteristics in Tebuthiuron-treated and untreated sand shinnery oak in Texas. The Great Basin Naturalist 49:624-626.

Haukos, D.A., L.M. Smith, and G.S. Broda. 1989. Spring trapping of lesser prairie-chickens. Journal of Field Ornithology 61:20-25.

Howell, D.C. 1995. Fundamental statistics for the behavioral sciences. 3rd edition. Belmont, CA. Wadsworth Publishing Company.

Litton, G.W. 1978. The lesser prairie-chicken and its management in Texas. Texas Parks and Wildlife Booklet 7000-7025.

Manly, B.F., L.L. McDonald, D.L. Thomas, T.L. McDonald, and W.P. Erickson. 2002. Resource selection by animals statistical design and analysis for field studies. 2nd Edition. Dordrecht, The Netherlands. Kluwer Academeic Publishers.

Morrison, M.L., B.G. Marcot, and R.W. Mannan. 2006. Wildlife-Habitat Relationships concepts and applications. Washington, D.C.: Island Press.

Newman, A.L. 1964. Soil Survey of Cochran County, Texas. Washington, DC: U. S. Department of Agriculture, Soil Conservation Service. 80 pp. + maps.

NRCS. 1999. Lesser prairie-chicken *(Tympanuchus pallidicinctus*). Fish and Wildlife Habitat Management Leaflet.

Patten, M.A., D.H. Wolfe, E. Shochat, and S.K. Sherrod. 2005. Effects of microhabitat and microclimate selection on adult survivorship of the lesser prairie chicken. Journal of Wildlife Management 69(3):1270-1278.

Peterson, R.S. and C.S. Boyd. 1998. Ecology and management for sand shinnery oak communities: a literature review. USDA Forest Service General Technical Report RMRS-GTR-16, 44 p. Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Pettit, R.D. 1979. Effects of picloram and tebuthiuron pellets on sand shinnery oak communities. Journal of Range and Management 32:196-200.

Pitman, J.C., C.A. Hagen, R. J., Robel, T.M., Loughin and R.D. Applegate. 2005. Location and success of lesser prairie-chicken nests in relation to vegetation and human disturbance. Journal of Wildlife Management 69:1259-1269.

Robel, R.J., J N. Briggs, A.D. Dayton, and L.C. Hulbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management 23:295-297.

Seaman, D.E., J.J. Millspaugh, B. J. Kernohan, G.C. Brundige, K. J. Raedeke and R. A. Gitzen. 1999. Effects of sample size on kernel home range estimates. The Journal of Wildlife Management 63:739-747.

Silvy, N.J., M. J. Peterson and R. R. Lopez. 2004. The cause of the decline of pinnate grouse: the Texas example. Wildlife Society Bulletin 32:16-21.

Smythe, L.A., and D.A. Haukos. 2009. Nesting success of grassland birds in shinnery oak communities treated with tebuthiuron and grazing in eastern New Mexico. The Southwestern Naturalist 54:136-145.

Sullivan, R.M., J. P. Hughes, and J.E. Lionberger. 2000. Review of the historical and present status of the lesser prairie-chicken (*Tympanuchus pallidicinctus*) in Texas. The Prairie Naturalist 32:177-188.

Taylor, M.A., and F.S. Guthery. 1980a. Fall-winter movements, ranges, and habitat use of lesser Prairie Chickens. Journal of Wildlife Management 44:521-524.

Taylor, M.A., and F.S. Guthery. 1980b. Status, ecology, and management of the lesser prairie chicken. USDA Forest Service General Technical Report RM-77, 15 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

USFWS. 2008. Candidate and listing priority assignment form: lesser prairie chicken. United States Fish and Wildlife Service, Tulsa, OK, USA.

USFWS. 2009. U.S. Fish and Wildlife Service species assessment and listing priority assignment form. United States Fish and Wildlife Service.

Wildlife Society Bulletin (WSB) Manuscript Guidelines. 2012. <http://onlinelibrary.wiley.com/journal/10.1002/%28ISSN%291938-5463a/homepage/ForAuthors.html>. Accessed 5 Jul 2013.

CHAPTER II

HOME RANGE SIZE AND HABITAT SELECTION OF LESSER PRAIRIE-CHICKENS ON THE SOUTHERN HIGH PLAINS OF TEXAS

ABSTRACT

The lesser prairie-chicken is currently under review for listing as "threatened" under the Endangered Species Act. In addition to substantial range wide losses of habitat, lesser prairie-chickens are subjected to the degradation of the plant communities in which they exist. I assessed gender-specific lesser prairie-chicken breeding season home range size and habitat selection on a study area occurring on the Southern High Plains of west Texas. Varying grazing systems and shrub removal practices on the study area have resulted in alterations to the native sand-shinnery oak grassland community present on the study area. Male lesser prairie-chickens demonstrated selection for vegetative cover-types comprised of sand-shinnery oak, but dominated by native prairie-grasses, while females used the cover-types in proportion to availability. Female lesser prairie-chicken home ranges were approximately twice the size of male home ranges. Overall, my results suggest that sand-shinnery oak removed via herbicide treatment, resulting in native prairie-grass dominance, did not influence lesser prairie-chicken habitat selection across the available plant communities on my study area.

INTRODUCTION

The lesser prairie-chicken (*Tympanuchus pallidicinctus*), a prairie grouse species of the central and southern Great Plains, has experienced an estimated 90% reduction in both range and population since the 1800's (Taylor and Guthery 1980a, Hagen et al. 2004). Today, lesser prairie-chickens exist as two geographically separate populations.

Lesser prairie-chickens of the southwestern region (southeastern New Mexico and west Texas) are primarily relegated sand-shinnery oak (*Quercus havardii*) grassland communities, and lesser prairie-chickens of the northeastern region (Kansas, Colorado, Oklahoma, and northeast Texas Panhandle) occur mostly in native mixed grassland and/or sand sagebrush (*Artimisia filifolia*) communities. In both regions, the conversion of native plant communities to cropland is a major cause of decline (Davis et al. 2008, Hagen et al. 2004, Silvy et al. 2004). Habitat fragmentation, in a variety of forms, is also cited as a major human-induced cause of decline (Davis et al. 2008).

The direct reduction in useable space, and fragmentation of habitat connectivity, are implicit causes of range-wide population declines. However, a less obvious cause of decline may be the degradation and modification of the remaining native plant communities for both populations (Sullivan et al. 2000). As previously stated, lesser prairie-chickens existing in the southwestern region occur mostly in sand-shinnery oak grassland communities (Bell et al. 2010). Sand-shinnery oak grassland communities are comprised of some combination of the shrubs sand-shinnery oak and sand sagebrush, prairie grasses such as sand bluestem (*Andropogon hallii*), little bluestem (*Schizachyrium scoparium*), sand dropseed (*Sporobolis cryptandrus*), and purple three-awn (*Artistida purpurea*), and various forbs (Crawford and Bolen 1976, Peterson and Boyd 1998). The historical relationship between lesser prairie-chickens and sand-shinnery oak grassland communities in the southwestern region is not fully understood. In the literature, there is discussion regarding the typical pre-settlement vegetative composition of sand-shinnery oak grassland communities (Bell et al. 2010, Haukos 2011, and Zavaleta 2012).

It is common for the remaining sand-shinnery oak grassland communities in the southwestern region to be subjected to heavy and/or continuous grazing. Although sand-shinnery oak density does not reportedly increase as grasses decrease, it is an effective water gatherer, and, for this reason, it can be difficult for grasses to be competitive after being continuously removed by grazing cattle (Zavaleta 2012). Commonly, the result can be near monocultures of sand-shinnery oak (Smythe and Haukos 2009, Pirius 2011). It would seem obvious that this type of community modification is much different than the impact that intermittently migrating bison (*Bison bison*) had on sand-shinnery oak grassland communities prior to European-American settlement (Haukos 2011).

Herbicides (e.g., tebuthiuron) are frequently used by livestock producers to eradicate sand-shinnery oak from rangeland as a means to increase grass production for livestock forage. Currently, reduced-rate application of tebuthiuron is considered a potential tool for restoring over-grazed sand-shinnery oak grassland communities to supposed historical vegetative compositions (Zavaleta 2012). Reduced-rate application of tebuthiuron to increase the grass component in unmanaged, grazed sand-shinnery oak grassland communities seems a constructive goal. However, at the cost of losing some portion of a sand-shinnery oak component, the effects of this habitat management activity on lesser prairie-chickens is not fully understood.

The complexity and confusion over the historical habitat requirements, lack of scientific research (until relatively recent times), the species' range-wide ecological differences (Grisham 2012), and conflicting scientific evidence has hampered development of management guidelines and their implementation for the population of lesser prairie-chickens in the southwestern region. Currently, the lesser prairie-chicken is

being reviewed for listing as threatened under the Endangered Species Act of 1973 (Federal Register 2013). The purpose of this chapter was to assess the space use and habitat selection characteristics of lesser prairie-chickens on the Southern High Plains of Texas. More specifically, I investigated breeding season home range size and habitat selection for 37 male and 38 female lesser prairie-chickens occurring in a sand-shinnery oak grassland community.

STUDY AREA

This study was conducted on privately owned lands in Cochran, Hockley, Terry, and Yoakum counties of Texas, USA. The study area occurred on the Llano Estacado or Southern High Plains of Texas. Brownfield-Tivoli fine sand soils made up the substrate of a topography that was predominantly flat, with low-lying sand dunes, and dune complexes scattered throughout (Newman 1964). Temperatures ranged from -33 to 44° C and the average annual precipitation is 45.9 cm (Neuman 1964).

The core study area was an isolated mosaic of sand-shinnery oak grassland communities and sand sagebrush dominated areas. On the fringes of this core area was honey mesquite (*Prosopis glandulosa*) and U.S. Department of Agriculuture, Conservation Reserve Program (CRP) enrollments consisting primarily of introduced lovegrass (*Eragrostis* spp.) and old-world bluestem (*Bothriochloa* spp.). The main land use of the core area was beef cattle production; there was also some oil mining infrastructure present. The surrounding area included dense center pivot fields (cotton) and oil mining infrastructures (pump jacks and associated roads).

Herbicide application by cattle ranchers occurred on my study area at various different times during the past 50 years. Differing herbicide application rates, date of application, application timing, and post application grazing regimes and land uses have resulted in a variety of different shrub and grass compositions. Unfortunately, documentation of herbicide treatment history is non-existent or insufficient for rigorous assessments. Data were collected from 2008 through 2012, and between the dates of 1 March through 18 August of each year.

METHODS

Capture

I used drift fences and walk-in-funnel traps (Haukos et al. 1989, Schroder and Braun 1991), and magnetized drop nets (Wildlife Capture Services LLC, P.O. Box 334, Flagstaff, AZ 86002) to capture male and female lesser prairie-chickens on leks from 1 March through 15 May each year. After capture, gender of lesser prairie-chickens was determined by pinnae length (millimeters) and the presence of eye combs (Copelin 1963). Age was determined by presence or absence of spotting within 2.5 centimeters (cm) from the tips of the 9th and 10th primary feathers (Copelin 1963). Both male and female adult lesser prairie-chickens lack these spots. Tarsus length (mm), un-flattened wing cord (mm), and mass (grams) were measured for each captured individual. Finally, each lesser prairie-chicken was banded with a uniquely numbered aluminum butt-end band and radio-collared. Lesser prairie-chickens were fitted with a 9 g necklace style radio-transmitter from 2008-2011 and a 12 g radio-transmitter of the same style and manufacturer in 2012 (American Wildlife Enterprises, Florida, USA).

Cover-typing

Cover-typing of the study area was performed in the spring of 2011 by Pirius (2011). Pirius (2011) developed ten pre-determined cover-types (Table 2.1) to accurately describe the vegetative communities of the study area and for comparison with the results of Fuhlendorf et al. (2002) and Kukal (2010). Additional cover-type delineation outside of the original map was performed by myself and followed the same methodology as Pirius (2011). To cover-type new areas, I imported National Aerial Imagery Program (NAIP) aerial imagery at 1-m resolution (2010 imagery) into ArcMap 10 (ArcInfo, Environmental Research Institute, Redlands, CA). A few modifications were made to the original cover-type designations established by Pirius (2011). One new cover-type category (Burn Scar; BNSR) was added while delineating new areas due to two prairie fires that occurred on the study area. The original CRP Grassland cover-type (CRPG) (see Table 2.1) was changed to Grassland, Other (GROT) and expanded to include CRP grasslands, grasslands resulting from tebuthiuron treatment, and a few unusual grassland areas—some heavily tebuthiuron treated and grazed pastures resulted in grasslands co-dominated with yucca (*Yucca glauca*). Lastly, the cover-type Agriculture (AGRI) was changed to describe areas planted in cotton (*Gossypium* spp.), rather than sunflower (*Helianthus* spp.) or winter wheat (*Triticum aestivum*).

Cover-type delineations were confirmed via ocular estimation of the study area at 309 systematically placed points. Percent sand-shinnery oak, grass, shrubs (typically sand sagebrush), and bareground were estimated in 5% increments in each of the four inter-cardinal directions (NW, NE, SW, and SE). All pastures within the study area were

estimated from 7-8 points in March of 2011 and 2013 when the sand-shinnery oak and sand sagebrush were beginning to bud (Vermeire and Wester 2001).

Radio-telemetry

After release, triangulation (Cochran and Lord 1963) was used to located lesser prairie-chickens 4-7 times per week throughout the breeding season. To collect location data, I used a hand-held 3 element Yagi antenna, an Advanced Telemetry Systems R-2000 receiver (Advanced Telemetry Systems, Ashanti, Minnesota, USA), and a hand-held Garmin Etrex Vista (Garmin International Inc., Olathe, KS, USA) global positioning systems unit. I attempted to collect relocations across four time periods evenly: AM (0601-1000); mid-morning (1001-1400); mid-day (1401-1800); and evening (1801-2200). Additionally, I collected approximately five locations for each lesser prairie-chicken during the nocturnal roosting (2201-0600) time period. A 20 minute time limit per triangulation was implemented to reduce error from lesser prairie-chicken movement. I used the computer program LOAS 4.0 (Location of a Signal, Ecological Software Solutions, Florida, USA) to obtain the Universal Transverse Mercator (UTM) coordinates and the associated error polygon for each estimated location. The maximum acceptable error polygon was no greater than 2 ha (20,000 m^2). Each lesser prairie-chicken's set of relocations were plotted as separate point layers in ArcMap10.

Space Use Estimation

Point layers were imported into Geospatial Modeling Environment (GME) version 0.7.2 software (GME, Spatial Ecology LLC., Hawthorne L. Beyer 2009-2012) to estimate home range area for male and female lesser prairie-chickens. Each year of this

study, we regularly collected locations of radio-collared males on leks during spring trapping activities. Additionally, during the nesting season, we purposefully relocated females when they were most likely to be on their nests to track nest fate. For males that had repeated lek site locations, and females with repeated nest site locations, all but one of either type of location was omitted from these individuals' sample of relocations. I did this because these locations were not collected at random, and because they could influence the output of the probabilistic home range estimators (i.e., fixed kernel density estimates). Areas of lekking and nesting use were known for each individual and did not need to be further identified by kernels. I considered the resulting influence on home range size/shape not useful when evaluating overall breeding season space and habitat use (see below).

I used three different estimators to assess lesser prairie-chicken home ranges. For all three methods, the same sample of lesser prairie-chickens with the same set of associated relocations was used. A minimum of 30 relocations per individual is recommended to estimate individual home range size (Otis and White 1999). The three home range estimators were: 1) 95% fixed kernel density estimate (bandwidth = least squares cross-validation) (hereafter; 95% LSCV), 2) 95% fixed kernel density estimate (bandwidth = Plug-in) (hereafter; 95% Plug-in), and 3) 100% minimum convex polygon (hereafter; 100% MCP). For both fixed kernel density estimators, a kernel density raster was produced, and then isopleths were calculated to delineate the boundaries of each individual's home range and core range. The home range isopleths contained 95% of the output raster volume and the core range isopleths contained 50% of the raster volume. I selected these three home range estimators/bandwidths based on their past and present

popularity in the literature, and because I was curious how the resulting outputs would compare and contrast. It is debatable whether or not estimating home range size using three different estimators has direct biological relevance to this thesis chapter. However, I feel that this decision is reasonable due to the comparability and versatility of my results.

I used Program R version 3.0.0 (R Development Core Team 2008) to perform statistical analyses on home range data. The same statistical procedures were implemented to make comparisons between and within the three different home range estimation methods. I used a one-way analysis of means, not assuming equal variances (R script: "oneway.test"), to test for differences in home range sizes among years for both genders. Welch's-adjusted two-sample *t*-tests were used to assess gender-specific differences in home range size. To compare the outputs from the different home range estimation methods, I performed one-way analysis of means, not assuming equal variances. Welch's-adjusted pairwise *t*-tests were used to assess which home range methods produced significantly different estimates from one another.

Two other minor space use assessments were conducted for this chapter. I assessed the distance from lek of capture for all breeding season male and female lesser prairie-chicken telemetry-based relocations collected throughout the duration of this study. All lek locations for males were removed, and all but one nest site location was removed for each nesting female. Male and female relocations were pooled separately and plotted as point layers in ArcMap10. Spider diagrams were used to ascertain the linear distances (km) of lesser prairie-chicken relocations from the associated lek of capture within five zones of proximity: <0.8 km, 1.7-3.2 km, 3.2-4.8 km, and ≥4.8 km. This assessment was previously performed by Pirius (2011) during the non-breeding

seasons (1 September-28 February) for many of the same radio-collared lesser prairie-chickens on the same study area. I did this analysis to facilitate seasonal comparisons between my breeding season results to the non-breeding season results of Pirius (2011).

Lastly, I attempted to assess the combined and shared space use for 5 male lesser prairie-chickens captured at the same lek in 2010. I elected to use the males' 95% Plug-in home ranges and 50% Plug-in core ranges because these estimates fell in the middle of the other two estimator outputs. I used the Merge, Dissolve, and Intersect tools in ArcMap10 to calculate the combined (total area covered by all 5 home or core ranges) and shared (area of home or core range overlap) space use of these males. This assessment was only performed for one lek as it was the only robust sample I had in my dataset (5 of 7 males typically attending this lek were used to produced home range estimates).

Habitat Selection

I used compositional analysis to assess gender-specific habitat selection at Johnson's 2nd and 3rd order scales (Johnson 1980), across all five years of the study, for the same sample of lesser prairie-chickens used in the home range analyses. The adehabitatHS package (Calenge 2011) in Program R was used to perform all compositional analyses. For both habitat selection assessments, zeros in the use category were replaced by 0.01, and zeros in the availability category were replaced with weighted mean lambdas, as suggested by Aebischer et al. (1993). All compositional analyses were randomized 1000 times to determine the correct level of significance.

To perform a logical and useful assessment of habitat selection by lesser prairie-chickens, I attempted to meet the requirements and assumptions of compositional analysis as best as possible. Rather than omitting cover-types, I re-grouped the original 11 cover-types into four new habitat categories based on vegetative composition, degree of use, and availability (Table 2.2 and 2.3). The resulting habitat categories were: 1) Sand-shinnery oak dominated, with grassland (hereafter; SSOG), 2) Grassland dominated, with sand-shinnery oak (hereafter; GSSO), 3) Sand sage-brush dominated (hereafter; SAGE), and 4) Other (hereafter; OTHER).

The study area was large and lesser prairie-chickens were trapped at three main spatially separated clusters of leks (hereafter; lek complexes). These lek complexes occurred in an east/west orientation with the central lek complex being approximately 14 km equidistant between the east and west lek complexes. A north/south Farm to Market Road separated the east lek complex from the central, and another Farm to Market Road separated the central from the west lek complex. Crossover from one lek complex to another by lesser prairie-chickens was not observed during the course of the study. Illustration of the spatial configuration of the study area was necessary to validate the methods I used to perform my 2nd order habitat selection analysis.

A 2nd order habitat selection analysis considers availability at the population level, and is typically defined by the area the population occupies (i.e., study area) (Johnson 1980). But, based on my preliminary observations, and the distances between lek complexes, I determined that it was inappropriate to include areas in between lek complexes that were not observed to be traversed by members of my sample. Therefore, I viewed the three lek complexes as if they were separate study areas. However, I did not

consider the individuals of the different lek complexes as belonging to different populations, and, therefore, did not assess habitat selection separately for each lek complex due to sample size limitations. As a compromise, for my 2nd order habitat selection analysis, I adjusted the availability for each individual based on the lek complex to which it belonged. In this way, my 2nd order analysis consisted of a fusion of Johnson's 2nd and 3rd order habitat selection analyses, and seemed a fitting compromise.

To conduct the 2nd order habitat selection analysis, the Minimum Bounding Geometry tool, in ArcMap10, was used to draw a minimum convex polygon around the 95% LSCV home ranges at each lek complex across all five years. The available habitat category proportions were calculated separately for each of the three lek complexes, and use was defined as the proportion of categories within each individual's 95% LSCV home range.

The 3rd order habitat selection analysis considered the habitat category proportions within each 95% LSCV home range as availability, and the proportion of relocations within the corresponding habitat categories as use. All four habitat categories were available to the entire sample of lesser prairie-chickens at the 2nd order scale regardless of lek complex. Lastly, the same four habitat categories were used for both 2nd order and 3rd order habitat selection analyses to ensure proper comparability between the different scales of selection.

RESULTS

In five breeding seasons (2008-2012), 241 unique lesser prairie-chickens were captured. I obtained 5,971 telemetry-based relocations for 164 radio-tracked lesser prairie-chickens. However, forty-three individuals were recaptures, or re-found in consecutive years. Therefore, only 121 total lesser prairie-chickens were unique radio-collared captures. Eighty-nine lesser prairie-chickens were censored from the home range and habitat selection analyses due to radio-collar failure, dropped collars, immigration, death, or an insufficient number of telemetry-based relocations. Of the 89 lesser prairie-chickens censored, 59 (66%) were censored as a result of suspected radio-collar failure or disappearance from the study area and surrounding landscape. The same sample of 75 lesser prairie-chickens (37 males and 38 females) was used for both home range and habitat selection assessments. Results will be presented for each of the three home range estimation methods: 1) 95% LSCV, 2) 95% Plug-in, and 3) 100% MCP in the same order each time (Tables 2.4 through 2.6).

Space Use

For males, there was not a significant difference in home range size among years except for the MCPs: 95% LSCV: (F = 3.41, df = 4, P = 0.06), 95% Plug-in: (F = 2.07, df = 4, P = 0.20), 100% MCP: (F = 9.56, df = 4, P < 0.01). For females, there was not a difference among years for all three methods: 95% LSCV: (F = 0.73, df = 4, P = 0.59), 95% Plug-in: (F = 0.68, df = 4, P = 0.62) 100% MCP: (F = 2.04, df = 4, P = 0.14). Although there was a difference among years for male 100% MCPs, I pooled male and female home ranges separately, across years, for gender-specific home range size

comparisons. Male and female home ranges sizes were significantly different for all three home range estimation methods: 95% LSCV: (t = 3.95, df = 46.14, P < 0.01), 95% Plug-in: (t = 3.95, df = 48.87, P < 0.01), and 100% MCP: (t = 4.57, df = 46.95, P < 0.01).

For males, the average (± SD) 95% LSCV, 95% Plug-in, and 100% MCP home range sizes were (306.0 ± 188 ha), (244.7 ± 131 ha), and (173.2 ± 112 ha), respectively. There was a significant difference between the three methods (F = 7.68, df = 2, P < 0.01). Welch's-adjusted pairwise t-tests revealed a significant difference between 95% LSCV and 100% MCP (P < 0.01), and 95% Plug-in and 100% MCP (P = 0.03), but not between 95% LSCV and 95% Plug-in (P = 0.11). For females, the average (± SD) 95% LSCV, 95% Plug-in, and 100% MCP home range sizes were (671.4 ± 538 ha), (471.2 ± 327 ha), and (415.1 ± 306 ha), respectively. There was a significant difference between the three methods (F = 3.23, df = 2, P < 0.05). Welch's adjusted pairwise t-tests were revealed a significant difference only between 95% LSCV and 100% MCP (P = 0.04).

Linear distance from lek of capture was measured for males (n = 2,463 locations) and females (n = 3,081 locations) separately across all five years of the study. For males, 99.6% of locations were within 3.2 km of lek of capture, 0.28% between 3.2 and 4.8 km, and 0.16% farther than 4.8 km from lek of capture (Figure 2.1). For females, 85.4% of locations were within 3.2 km of lek of capture, 10.3% between 3.2 and 4.8 km, and 4.3% farther than 4.8 km from lek of capture (Figure 2.1).

Combined and percent overlapping space use was calculated for 5 male lesser prairie-chickens attending a lek in 2010. The mean (±SD) 95% Plug-in home range and 50% Plug-in core range sizes were 277.1 ha (±76.6) and 73.0 ha (±22.2), respectively. The combined home range space used by these 5 males was 721.0 ha, but 261.0 ha

(36.2%) was overlapping. The combined core range space used by the same 5 males was 245.0 ha, but 73.0 ha (29.8%) was overlapping.

Habitat Selection

Of the original cover-types, those that were not available at all three lek complexes were lumped into the OTHER category. The Sand-shinnery oak (SHIN) cover-type was lumped into the SSOG habitat category due to its compositional similarity. Either the Sand sagebrush dominated, with bareground (SHDB) cover-type or Sand sagebrush dominated, with grassland (SHDG) cover-type were present at all three lek complexes. Therefore, these two cover-types were combined to form the SAGE habitat category (see Tables 2.2 and 2.3).

At the 2nd order scale, compositional analysis showed that habitat use differed from random for male ($\Lambda = 0.57$, $P < 0.01$), but not by female ($\Lambda = 0.89$, $P = 0.26$) lesser prairie-chickens. For male lesser prairie-chickens, cover-type categories were ranked as: SSOG > GSSO > OTHER > SAGE. For female lesser prairie-chickens, cover-types were ranked as: SSOG > GSSO > SAGE > OTHER. For additional ranking information and other detailed 2nd order compositional analysis outputs see Tables 2.7 through 2.10.

At the 3rd order scale, compositional analysis showed that habitat use was significantly different from random by male ($\Lambda = 0.21$, $P < 0.01$), but not by female ($\Lambda = 0.58$, $P = 0.06$) lesser prairie-chickens. For male lesser prairie-chickens, cover-types were ranked as: GSSO > SSOG > OTHER > SAGE. For female lesser prairie-chickens, cover-types were ranked as: SSOG > GSSO > OTHER > SAGE. For additional ranking

information and other detailed 3rd order compositional analysis outputs see Tables 2.11 through 2.14.

Female lesser prairie-chicken habitat use was not significantly different from random at either scale of analysis (i.e., no selection). Twenty-three (60%) females were captured at leks occurring in the GSSO habitat category, and 15 (40%) were captured at leks occurring in the SSOG habitat category. At both scales of analysis, SSOG was ranked higher than GSSO, but not significantly. At the 3rd order scale, both SSOG and GSSO were used significantly more than SAGE. Also, at the 3rd order scale, the higher ranking of OTHER than SAGE may be influenced by the use of the Burn Scar cover-type (included in OTHER) by 4 females in 2011 and 2012. During the breeding season, females typically moved farther away from their lek of capture than males (only 20% of all female locations occurred within 0.8 km of lek of capture), and females had larger home range sizes (mean female 95% LSCV home range = 671 ha). Therefore, unlike males, female habitat use was less affected by the habitat in which their lek of capture occurs. Lastly, 63%, 35%, and 2% of all radio-telemetry detected nests/re-nests (n = 51) occurred in the SSOG, GSSO, and OTHER habitat categories, respectively.

I recorded use of the Burn Scar (BNSR) cover type by 5 individuals (3 females in 2011; and 1 male and 1 female in 2012). I recorded 7%, 24%, and 45% of each of three female's locations, respectively, on the January 2011 burn scar. In 2012, I recorded 29% of telemetry relocations for one female on the July 2010 burn scar, which by that time was much more vegetated than the 2011 burn scar. The females I recorded using the burn scars did not have broods. In 2012, I recorded only one telemetry location for the male on the 2011 burn scar. However, I did observe the presence of lekking males on the burn

scars during the springs following the prairie fires, in areas where no leks were previously known to occur.

The lack of accessibility and other logistical limitations prohibited us from searching for missing lesser prairie-chickens in the CRP areas adjacent to my study area. Therefore, I was unable to effectively evaluate the potential use of CRP grasslands by lesser prairie-chickens. However, I relocated 12 different individuals (4 males and 8 females) in the GROT cover-type. Ten of these individuals were relocated an average of 14 times in a few heavily treated areas that were devoid of sand-shinnery oak. The other two individuals were females that were located in CRP grasslands. One female was relocated 6 times in an area consisting of old-world bluestem (*Bothriochloa* spp.). The other female migrated to the edge of a large lovegrass area after two failed nesting attempts in 2012. This lovegrass area was 5.5 km away from her lek of capture and I collected five of her locations within the lovegrass. One other female was located more than 6 km from her lek of capture in a planted sunflower (*Helianthus* spp.) field near the edge of a lovegrass area. This female was missing for the majority of 2012 and was excluded from analysis due to a lack of telemetry relocations.

DISCUSSION

Home Range Estimators

Hemson et al. (2005) cautioned that the use of different bandwidths can complicate and invalidate the comparison of space use results among research studies. More important than selecting a kernel may be selecting the kernel's bandwidth (Epanechnikov 1969). Bandwidth selection affects the smoothness, shape, spatial

accuracy, and size of a kernel home range estimates (Gitzen and Millspaugh 2003). The least squares cross-validation (LSCV) bandwidth has been suggested as a good default bandwidth in the literature (Seaman and Powell 1996, Worton 1989). However, Seaman et al. (1999) found that simulated sample sizes with ≤50 points produced overly smooth and overly estimated home ranges when using LSCV bandwidths. Gitzen et al. (2006) showed that the LSCV bandwidth is more sensitive to clumps of points and is therefore better at identifying areas of high use. I removed repeated lek and nest site relocations for that reason: 95% LSCV home range size and shape would have been influenced by these points. Additionally, because I knew where each individual lesser prairie-chicken lekked or nested, I decided that the influence these points had on home range shape and size did not provide useful information.

Gitzen et al. (2006) found that Plug-in bandwidths were less prone to error when calculating home range size than LSCV bandwidth. Hawthorne Beyer (Ph.D.) is the developer of the GME software program that I used to calculate all home ranges, and author of the software's accompanying manual. He suggests testing out different bandwidths and selecting one based on biological relevance to the research question, but he also notes, in his experience, the satisfactory performance of the Plug-in bandwidth. Fieberg (2007) notes that the comparative performance between LSCV and Plug-in bandwidth estimators is an important topic in current research literature.

Despite concerns regarding bandwidth, there was not a difference between 95% LSCV and 95% Plug-in mean home range estimates for male or female lesser prairie-chickens in my study. However, though not statistically significant, there was a 200 ha difference between 95% LSCV (671 ha) and 95% Plug-in (471 ha) mean home range

estimates for females. This difference, and therefore the choice of bandwidth in estimating lesser prairie-chicken home range size, may have significant ecological implications in terms of the species general space use requirements, comparison of results among studies, and therefore potential habitat conservation guidelines.

I assessed the effects that the omission of repeated nest site and auto-correlated brooding site (focal run) relocations had on 95% LSCV and 95% Plug-in home range estimates for only one female lesser prairie-chicken tracked in 2010. I collected 27 nest site relocations for this female, and after her nest hatched she kept a brood for 35 days until she slipped her radio-collar. She was the only female of this study for which brooding site focal run relocations were also collected (6 separate focal runs). For each focal run, I triangulated this female with her brood once every hour for several consecutive hours. Each set of these relocations produced tight clumps of relocations that I considered auto-correlated in consideration of the typical sampling rate (4-7 times per week per individual) used in this study. The total number of relocations for this female, including all nest site and brooding site relocations, was n = 81.

Including all relocations (n = 81), her 95% LSCV and 95% Plug-in home range estimates were 786 and 444 ha, respectively. I removed 26 of her 27 nest site relocations (total n = 55 relocations), and her 95% LSCV and 95% Plug-in home range estimates increased to 957 (+22%) and 679 ha (+53%), respectively. Next, in addition to omitting the nest site relocations, I removed all but one location from each focal run set (total n = 42 relocations), and her 95% LSCV and 95% Plug-in home range estimates increased to 1,032 (+31%) and 762 ha (+72%), respectively. I did not perform this assessment for any other lesser prairie-chickens, but the effects of omitting nesting site and brooding site

relocations had noticeable influence on home range size estimates for both kernel estimators. The 100% MCP home range size and shape were unaffected by the omission of any relocations and remained 504 ha due to the spatial distribution of the omitted relocations, as expected.

I would like to note that for this particular female, the omission of point relocations had an obviously lesser effect on 95% LSCV home ranges than on 95% Plug-in home ranges, in terms of size, shape/smoothness, and number of 95% contour areas. Regardless of the inclusion of nest site and brooding site relocations, home ranges calculated with the LSCV bandwidth produced one contiguous 95% contour area. With the inclusion of nest site and brooding site relocations, the Plug-in bandwidth produced 4 isolated 95% contour areas. It produced three 95% contour areas when only omitting nest site relocations, and it produced one contiguous 95% contour area with the omission of both nest site and focal run relocations.

I did observe that 95% LSCV home range estimates were consistently smoother than 95% Plug-in home range estimates across my sample. A few females from my sample displayed dispersal-like behavior, either after being trapped and searching for suitable nesting habitat, or sometimes after the loss of a nest. The LSCV bandwidth may have over-smoothed the home ranges of a few females that displayed this behavior and produced the disparity between the 95% LSCV and 95% Plug-in home range size estimates. Therefore, the Plug-in bandwidth may be more appropriate for species, populations, or individuals that exhibit dispersal or large movements/migrations.

The effects of bandwidth selection, and point relocation omission, on the home range characteristics for this hen are quite interesting. However, because the effects of

point relocation omission on home range characteristics was only assessed for one individual, I caution that the similar responses in home ranges may not occur in the rest of my sample, or other sets of data. Furthermore, different variations of bandwidths exist, and these variations may be used in different ecological software packages used to calculate kernel home range estimates (Gitzen and Millspaugh 2003; Beyer 2009-2012). In short, I recommend that researchers give due consideration to the selection of a bandwidth estimator, and the sample of point relocations they collect and include when conducting space use and resource selection studies.

Space Use

Pirius (2011) assessed non-breeding season (1 September-28 February) space use and habitat selection on the same study area in 2008-2009, 2009-2010, and 2010-2011. His sample (17 males and 6 females) included many of the same individuals used in this study. Pirius (2011) did not find a significant difference in non-breeding season home range size between male (504 ha) and female (489 ha) lesser prairie-chickens. In contrast, I found male and female breeding season home range sizes (95% LSCV) to be 306 and 671 ha, respectively. Smaller male breeding season home range size was associated with breeding behavior (lekking) and remaining in close proximity to the lek. Larger female breeding season home range size was most likely influenced by nesting site selection activities and dispersal behavior sometimes following the loss of a nest. I did not assess the influence of brooding activities on female breeding season home range size as only 8 of the 38 females included in the analysis had broods.

With male and female locations pooled together, I found that 91.7% of all breeding season lesser prairie-chicken locations occurred within 3.2 km of lek of capture, compared to 97.2% of non-breeding season relocations, as reported by Pirius (2011). I recorded 5.8% of all locations between 3.2 and 4.8 km, and only 2.5% of locations beyond 4.8 km from lek of capture. Pirius (2011) found relatively similar results between 3.2 and 4.8 km and beyond 4.8 km. I pooled male and female locations to compare directly to Pirius (2011), but I feel it is important to consider the differences between male and female location sets.

In short, these results to corroborate the management suggestion made by Pirius (2011): habitat within 4.8 km of leks should receive highest conservation priority. Further breakdown of my telemetry data may provide intuitive, but more detailed space use information. Specifically, assessing distance from lek of capture based on breeding season activities defined as lekking (1 March-31 May) and post-lekking (1 June-31 August) for males, and lekking (1 March-31 April), nesting (1 May-31 May), and brood rearing (1 June-31 August) for females, may be worthwhile.

My assessment of combined and overlapping home range areas may not provide information about territoriality or the explicit sharing of space/resources because the proximity of locations from different individuals was not assessed in relation to time. However, the observance of home range overlap may suggest that extrapolating space use requirements based solely on home range estimates may be an inaccurate or inappropriate methodology for groups or populations of lesser prairie-chickens. Lastly, I observed evident overlapping of female home ranges each year of the study. Twenty-eight of the 38 (74%) female home ranges overlapped at least one other female home range within the

years. However, home range overlap by females was not standardized to captures from a single lek and only anecdotal.

Habitat Selection

There were slight differences in habitat selection between 2nd and 3rd order analyses for males. At both scales, compositional analysis showed that males used the habitat categories significantly different from random (i.e., selection). The greater proportional use of GSSO by males at the 3rd order scale may be a result of a few different factors. First, 25 (68%) males were trapped at 4 leks in the GSSO habitat category, and 12 (32%) males were trapped at 6 leks in the SSOG habitat category. My results show that males have relatively small home ranges and remain near their lek of capture during the breeding season (mean male 95% LSCV home range size = 306 ha, and 67% of all male locations occurred within 0.8 km of lek of capture). Furthermore, at the 3rd order scale, the 95% LSCV home ranges were considered available, and the telemetry relocations were considered use. The 95% LSCV home ranges were quite smooth and sometimes contained available areas of cover-types that did not contain any telemetry relocations (use). The perceived over-smoothing of 95% LSCVs and/or the apparent unequal trapping effort may have had an influence on the significantly greater use of GSSO than SSOG by males, but it is unclear. In general, the results from both scales of analysis showed that males selected both GSSO and SSOG over the other habitat categories.

I defined the study area differently than Pirius (2011), and, as a result, the cover-type areas do not match up between our studies. However, Pirius (2011) only assessed the

non-breeding season habitat selection on our study area at the 3rd order scale by implementing the chi-squared goodness-of-fit test and 95% confidence intervals as described in Neu et al. (1974). Due to sample size limitations, Pirius (2011) was unable to perform gender-specific habitat selection analyses but demonstrated that non-breeding season lesser prairie-chickens used sand sagebrush dominated areas in lesser proportion to their availability; my results support the avoidance of these cover-types. My habitat category GSSO is the same as the cover-type GRDS used by Pirius (2011) who also demonstrated that non-breeding season lesser prairie-chickens selected the Grassland dominated, with sand-shinnery oak (GRDS) cover-type in greater proportion to its availability, and the Sand-shinnery oak dominated, with grassland (SHIDG) cover-type in proportion to its availability (see Table 2.1). This may suggest that the areas of shinnery oak dominated by native grasses may provide better thermal refuge or forage during the winter season after sand-shinnery oak has dropped its leaves.

Implication of Results

A summarization of the breeding and non-breeding season habitat selection results indicate that areas consisting of vegetative cover that is dominated by native grasses co-occurring with sand-shinnery oak, and areas dominated with sand-shinnery oak co-occurring with native grasses were mostly used in proportion to their availability. However, some evidence from both studies suggests that areas dominated by native grasses co-occurring with sand-shinnery oak are selected in greater proportion to their availability by lesser prairie-chickens.

Female lesser prairie-chicken habitat use for nesting purposes appears to be slightly disproportionate to availability, favoring sand-shinnery oak dominated, with grass areas. However, occurrence of nesting sites within habitat categories was only briefly noted, and not thoroughly investigated. While all but one lesser prairie-chicken nest/re-nest occurred in either the SSOG or GSSO habitat categories, most occurred under plants other than sand-shinnery oak (Grisham 2012). Within the sand-shinnery oak grassland communities, lesser prairie-chickens selected nest sites based on structural characteristics (i.e., greater visual obstruction readings, % shrub, and % grass than random; Grisham 2012). Survival of lesser prairie-chickens in the study area was reported as among the highest found in the literature (Pirius 2011, Grisham 2012). Additionally, Grisham (2012) found that nest success on the study area was relatively high, except during years of drought. However, brood survival (particularly 0-14 days post hatch) was identified as the predominant limiting factor for population persistence on the study area (Grisham 2012), possibly due to a lack of adequate brood rearing habitat, in terms of sufficient invertebrate abundance (i.e., biomass), as a possible result of a reduced forb component.

Currently, lesser prairie-chicken populations in the state of Texas are low (Timmer 2012). Although lesser prairie-chickens of the southwestern region evolved in an environment subjected to intermittent drought conditions, at current population levels, the apparent effects of drought on nest success may be a threat to local population persistence. In conclusion, lesser prairie-chicken conservation may be enhanced by focusing first on ensuring the preservation of existing sand-shinnery oak grassland communities within at least 4.8 km of known leks. Current evidence shows that the

propagation of some populations of lesser prairie-chickens occurring in the sand-shinnery oak grassland communities of the southwestern region is contingent on management activities that increase brood survival. Urgent attention given to research and adaptive management strategies that seek to increase lesser prairie-chicken brood survival may be warranted. Remediation of the previously listed limiting factors is not necessarily disconnected from, or second to, the benefits of larger scale habitat restoration and/or increased habitat connectivity. Therefore, future research and management consideration given to the recovery of lost habitat and connection of lesser prairie-chicken populations would likely be beneficial.

LITERATURE CITED

Aebischer, N. J., P. A. Robertson, and R. E. Kenward. 1993. Compositional analysis of habitat use from animal radio-tracking data. Ecology 74:1313-1325.

Bell, L. A., S. D. Fuhlendorf, M. A. Patten, D. H Wolfe, and S. K. Sherrod. 2010. Lesser prairie-chicken hen and brood habitat use on sand shinnery oak. Rangeland Ecology and Management 63:478-486.

Beyer, H. L. 2009-2012. Geospatial Modelling Environment. Downloads: > 15000. <http://www.spatialecology.com/gme>.

Calenge, C. 2006. The package adehabitat for the R software: a tool for the analysis of space and habitat use by animals. Ecological Modelling 197:516-519.

Calenge, C. 2011. Exploratory analysis of the habitat selection by the wildlife in R: the adehabitatHS package. Office national de la chasse et de la faune sauvage, Saint Benoist, Auffargis, France.

Cochran, W.W., and R.D. Lord. 1963. A radio-tracking system for wild animals. Journal of Wildlife Management 27:9-24.

Copelin, F. F. 1963. The lesser prairie-chicken in Oklahoma. Oklahoma Department of Wildlife Technical Bulletin 6. Oklahoma City, Oklahoma, USA.

Crawford, J.A. and E.G. Bolen. 1976b. Effects of land use on lesser prairie chickens in Texas. Journal of Wildlife Management 40:96-104.

Davis, D. M., R. E. Horton, E. A. Odell, R. D. Rodgers and, H. A. Whitlaw. 2008. Lesser Prairie-Chicken Conservation Initiative. Lesser Prairie Chicken Interstate Working Group. Unpublished Report. Colorado Division of Wildlife, Fort Collins, CO. USA.

Epanechnikov, V. A. 1969. Nonparametric estimation of a multidimensional probability density. Theory of Probability and its Applications 14(1):156-161

Federal Register. May 6, 2013. Proposed Rules Vol. 78, No. 87, pg. 1.

Fieberg, J. 2007. Kernel density estimators of home range: smoothing and the autocorrelation red herring. Ecology 88(4):1059-1066

Fuhlendorf, S.D., A. J. Woodward, D. M. Leslie Jr., and J. S. Shackford. 2002. Multiscale effects of habitat loss and fragmentation on lesser prairie-chicken populations. Landscape Ecology 17:601-615.

Gitzen, R. A., and J. J. Millspaugh. 2003. Comparison of least squares cross-validation bandwidth options for kernel home-range estimation. Wildlife Society Bulletin 31:823-831.

Gitzen, R. A., J. J. Millspaugh, and B. J. Kernohan. 2006. Bandwidth selection for fixed-kernel analysis of animal utilization distributions. Journal of Wildlife Management 70(5):1334-1344.

Grisham, B. A. 2012. The ecology of lesser prairie-chickens in shinnery oak-grassland communities in New Mexico and Texas with implications toward habitat management and future climate change. Ph.D. Dissertation, Texas Tech University, Lubbock, USA.

Hagen, C.A., B.E. Jamison, K.M. Giesen, and T.Z. Riley. 2004. Guidelines for managing lesser prairie-chicken populations and their habitats. Wildlife Society Bulletin 32(1):69-82.

Haukos, D. A. 2011. Use of tebuthiuron to restore sand shinnery oak grasslands of the Southern High Plains. M. N. A El-Ghany Hasanee (Ed.) In Herbicides: Mechanisms and mode of action (103-124). Rijeka, Croatia.

Haukos, D. A., L. M. Smith, and G. S. Broda. 1989. Spring trapping of lesser prairie-chickens. Journal of Field Ornithology 61:20-25.

Hemson, G., P. Johnson, A. South, R. Kenward, R. Ripley, and D. MacDonald 2005. Are kernels the mustard? Data from global positioning system (GPS) collars suggests problems for kernel home-range analyses with least-squares cross-validation. Journal of Animal Ecology 74:455-463.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65-71.

Kukal, C. A. 2010. The over-winter ecology of Lesser Prairie-Chickens (*Tympanuchus pallidicinctus*) in the northeast Texas panhandle. M.S. thesis. Texas Tech University. Lubbock, TX, U.S.A.

Neu, C., B. Randall, and J. Peek. 1974. A Technique for analysis of utilization-availability data. Journal of Wildlife Management 38(3):541-545.

Newman, A. L. 1964. Soil Survey of Cochran County, Texas. Washington, DC: U. S. Department of Agriculture, Soil Conservation Service. 80 pp. + maps.

Otis, D. L., and G. C. White. 1999. Autocorrelation of location estimates and the analysis of radiotracking data. Journal of Wildlife Management 63:1039-1044.

Peterson, R. S., and C. S. Boyd. 1998. Ecology and management for sand shinnery oak communities: a literature review. USDA Forest Service General Technical Report RMRS-GTR-16, 44 p. Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Pirius, N. 2011. The non-breeding season ecology of lesser prairie-chickens (*Tympanuchus pallidicinctus*) on the Southern High Plains of Texas. M.S. Thesis. Texas Tech University. Lubbock, Texas, USA.

Schroeder, M.A., and C.E. Braun. 1991. Walk-in traps for capturing greater prairie-chickens on leks. Journal of Field Ornithology 62:378-385.

Seaman, D. E., and R. Powell. 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. Ecology 77:2075-2085.

Seaman, D. E., J. J Millspaugh, B. J. Kernohan, G. C. Brundige, K. J. Raedeke, and R. A. Gitzen. 1999. Effects of sample size on kernel home range estimates. The Journal of Wildlife Management 63:739-747.

Silvy, N. J., M. J. Peterson, and R. R. Lopez. 2004. The cause of the decline of pinnate grouse: the Texas example. Wildlife Society Bulletin 32:16-21.

Smythe, L. A., and D. A. Haukos. 2009. Nesting success of grassland birds in shinnery oak communities treated with tebuthiuron and grazing in eastern New Mexico. The Southwestern Naturalist 54:136-145.

Sullivan, R. M., J. P. Hughes, and J. E. Lionberger. 2000. Review of the historical and present status of the lesser prairie-chicken (*Tympanuchus pallidicinctus*) in Texas. The Prairie Naturalist 32:177-188.

Taylor, M. A., and F. S. Guthery. 1980a. Fall-winter movements, ranges, and habitat use of lesser Prairie Chickens. Journal of Wildlife Management 44:521-524.

Timmer, J. M. 2012. Relationship of lesser-prairie chicken density to landscape characteristics in Texas. M.S. Thesis, Texas Tech University, Lubbock, TX, USA.

Vermeire, L. T., and D. B. Wester. 2001. Shinnery oak poisoning of rangeland cattle: causes, effects and solutions. Rangelands 23:19-21.

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168.

Zavaleta, J. C. 2012. Community response to use of prescribed grazing and herbicide for restoration of sand shinnery oak grasslands. M.S. Thesis, Texas Tech University, Lubbock, TX, USA.

Table 2.1. Land cover-types used for determining breeding season habitat selection by lesser prairie-chickens on the Southern High Plains of Texas (2008-2012). Adapted from Pirius (2011).

Cover -type	**Classification**	**Description**
1	Agriculture (AGRI)	Cultivated field. Typically cotton (*Gossypium* spp.).
2	Burn Scar (BNSR)	Areas burned by prairie-fires (0 to 2 years post burn).
3	Grassland dominated, with mesquite (GRDM)	≥70% Native grasslands (e.g., *Andropogon halli*, *Schizachyrium scoparium*, *Sporobolis cryptandrus*) with ≤30% honey mesquite (*Prosopis glandulosa*) intermixed within.
4	Grassland dominated, with sand-shinnery oak (GRDS)	≥70% Native grasslands with ≤30% sand-shinnery oak (*Quercus havardii*) intermixed within.
5	Grassland, other (GROT)	CRP (introduced love grass (*Eragrostis* spp.), old world bluestem (*Bothriochloa* spp.)), or other heavily treated (herbicide) and unusual grassland.
6	Mesquite savannah (MESA)	≥70% honey mesquite (*Prosopis glandulosa*) and ≤30% native grasslands and or shrubs [e.g., sand-shinnery oak, sand-sage brush (*Artemesia filifolia*)] in understory.
7	Reverted Agriculture (REAG)	Formerly plowed or tilled landscape that has returned to shrub land (≥50 sand-shinnery oak, 20-30% native grassland, and 20-30% sand-sage brush).
8	Sand-shinnery oak (SHIN)	Areas dominated by sand-shinnery oak (≥70%), with 20-30% sand-sage brush, and <10% native grasslands.
9	Sand-shinnery oak dominated, with grassland (SHIDG)	≥70% Sand-shinnery oak with ≤30% native grassland and sand-sage brush intermixed within.
10	Sand sagebrush dominated, with bareground (SHRDB)	≥70% Sand-sage brush with ≤30% bareground.
11	Sand sagebrush dominated, with grassland (SHRDG)	≥70% Sand-sage brush with ≤30% native grassland and sand-shinnery oak intermixed within.

Table 2.2. Summary of the use, availability, and reconsolidation of the cover-types (Table 2.1) into the habitat categories used for both 2nd and 3rd order compositional analysis for breeding season males (*n* = 37) on the Southern High Plains of Texas (2008-2012).

Sand-shinnery oak dominated, with grass (SSOG)	SHIDG	467 (28.7%)	3714 (32.2%)	1375 (24.1%)*	2515 (46.9%)*	1549 (32.9%)
	SHIN	252 (15.5%)	1538 (13.3%)	0 (0.0%)	973 (18.1%)	11 (0.2%)
Grassland dominated, with sand-shinnery oak (GSSO)	GRDS	792 (48.6.5%)	4978 (43.2%)	2502 (43.9%)	412 (7.7%)*	1682 (35.8%)
Sand sagebrush dominated (SAGE)	SHRDB	1 (0.1%)	52 (0.5%)	12 (0.2%)	63 (1.2%)	252 (5.4%)
	SHRDG	25 (1.5%)	248 (2.1%)	247 (4.3%)	489 (9.1%)	136 (2.9%)
Other (OTHER)	AGRI	2 (0.1%)	26 (0.2%)	54 (0.9%)	23 (0.4%)	258 (5.5%)
		1 (0.1%)	53 (0.5%)	154 (2.7%)*	815 (15.2%)*	0 (0.0%)
	GRDM	0 (0.0%)	0 (0.0%)	58 (1.0%)	0 (0.0%)	11 (0.2%)
	GROT	52 (3.2%)	519 (4.5%)	941 (16.5%)	0 (0.0%)	447 (9.5%)
	MESA	3 (0.2%)	33 (0.3%)	361 (6.3%)	56 (1.0%)	127 (2.7%)
	REAG	35 (2.1%)	374 (3.2%)	0 (0.0%)	17 (0.3%)	231 (4.9%)
Total		1630 (100%)	11536 (100%)	5704 (100%)	5363 (100%)	4704 (100%)

Regrouped habitat categories used in both 2nd and 3rd order compositional analyses.
Cover-types as classified in Table 2.1. Shows the consolidation of cover-types into the habitat categories.
Total male telemetry locations (with percentage) per cover-type.
Total area in hectares (with percentage) of each cover-type within all male 95% LSCV home ranges.
Cover-type availability in hectares (with percentage) at the East Complex (2nd order availability).
Cover-type availability in hectares (with percentage) at the Central Complex (2nd order availability).
Cover-type availability in hectares (with percentage) at the West Complex (2nd order availability).
BNSR (Burn Scar) was only available during 2011 and 2012. *Denotes which cover-type areas were adjusted post-burn.

Table 2.3. Summary of the use, availability, and reconsolidation of the cover-types (Table 2.1) into the habitat categories used for both 2nd and 3rd order compositional analysis for breeding season females (*n* = 38) on the Southern High Plains of Texas (2008-2012).

Sand-shinnery oak dominated, with grass (SSOG)	SHIDG	663 (33.7%)	9965 (39.3%)	1375 (24.1%)*	2515 (46.9%)*	1549 (32.9%)
	SHIN	259 (13.2%)	2408 (9.5%)	0 (0.0%)	973 (18.1%)	11 (0.2%)
Grassland dominated, with sand-shinnery oak (GSSO)	GRDS	694 (35.3%)	7103 (28.0%)	2502 (43.9%)	412 (7.7%)*	1682 (35.8%)
Sand sagebrush dominated (SAGE)	SHRDB	23 (1.2%)	476 (1.9%)	12 (0.2%)	63 (1.2%)	252 (5.4%)
	SHRDG	97 (4.9%)	1094 (4.3%)	247 (4.3%)	489 (9.1%)	136 (2.9%)
Other (OTHER)	AGRI	7 (0.4%)	455 (1.8%)	54 (0.9%)	23 (0.4%)	258 (5.5%)
		53 (2.7%)	662 (2.6%)	154 (2.7%)*	815 (15.2%)*	0 (0.0%)
	GRDM	21 (1.1%)	138 (0.5%)	58 (1.0%)	0 (0.0%)	11 (0.2%)
	GROT	100 (5.1%)	1895 (7.5%)	941 (16.5%)	0 (0.0%)	447 (9.5%)
	MESA	22 (1.1%)	653 (2.6%)	361 (6.3%)	56 (1.0%)	127 (2.7%)
	REAG	27 (1.4%)	533 (2.1%)	0 (0.0%)	17 (0.3%)	231 (4.9%)
Total		1966 (100%)	25382 (100%)	5704 (100%)	5363 (100%)	4704 (100%)

Regrouped habitat categories used in both 2nd and 3rd order compositional analyses.
Cover-types as classified in Table 2.1. Shows the consolidation of cover-types into the habitat categories.
Total female telemetry locations (with percentage) per cover-type.
Total area in hectares (with percentage) of each cover-type within all female 95% LSCV home ranges.
Cover-type availability in hectares (with percentage) at the East Complex (2nd order availability).
Cover-type availability in hectares (with percentage) at the Central Complex (2nd order availability).
Cover-type availability in hectares (with percentage) at the West Complex (2nd order availability).
BNSR (Burn Scar) was only available during 2011 and 2012. *Denotes which cover-type areas were adjusted post-burn.

Table 2.4. Average male fixed kernel home range estimates (ha) on the Southern High Plains of Texas (2008-2012).

Year	**n**	**LSCV 95% (sd)**	**Plug-in 95% (sd)**	**LSCV 50% (sd)**	**Plug-in 50% (sd)**	**Avg. Relocations**
2008	2	468 (53)	378 (88)	113 (31)	93 (39)	31
2009	7	294 (225)	224 (139)	69 (57)	50 (30)	35
2010	16	259 (162)	209 (105)	66 (41)	51 (26)	48
2011	4	245 (199)	178 (103)	47 (29)	34 (13)	48
2012	8	401 (201)	335 (151)	95 (49)	80 (42)	46
All	37	306 (188)	245(131)	73 (46)	58 (33)	44

Table 2.5. Average female fixed kernel home range estimates (ha) on the Southern High Plains of Texas (2008-2012).

Year	**n**	**LSCV 95% (sd)**	**Plug-in 95% (sd)**	**LSCV 50% (sd)**	**Plug-in 50% (sd)**	**Avg. Relocations**
2008	7	711 (765)	494 (467)	160 (176)	102 (94)	48
2009	9	570 (433)	382 (172)	112 (60)	78 (32)	48
2010	8	496 (293)	394 (222)	127 (79)	94 (53)	52
2011	7	653 (416)	450 (286)	144 (113)	90 (67)	56
2012	7	981 (713)	672 (442)	237 (177)	155 (98)	58
All	38	671 (538)	471 (327)	153 (153)	102 (72)	52

Table 2.6. Average male and female 100% minimum convex polygon (MCP) home ranges (ha) on the Southern High Plains of Texas (2008-2012).

Males				***Females***			
Year	**n**	**100% MCP (sd)**	**Avg. Relocations**	**Year**	**n**	**100% MCP (sd)**	**Avg. Relocations**
2008	2	247 (7)	31	2008	7	428 (352)	48
2009	7	153 (96)	35	2009	9	367 (364)	48
2010	16	138 (68)	48	2010	8	263 (140)	52
2011	4	160 (128)	48	2011	7	437 (139)	56
2012	8	249 (169)	46	2012	7	616 (391)	58
All	37	173 (112)	44	All	38	415 (306)	52

Table 2.7. Male (n=37) 2nd order compositional analysis results: Ranking Matrix. Data collected on the Southern High Plains of Texas (2008-2012).

	SSOG	**GSSO**	**SAGE**	**OTHER**
SSOG	0	+	+++	+++
GSSO	-	0	+++	+
SAGE	---	---	0	---
OTHER	---	-	+++	0

Table 2.8. Male (n=37) 2nd order compositional analysis results: Ranking Matrix (Mean difference between used and available log-ratios). Data collected on the Southern High Plains of Texas (2008-2012).

	SSOG	**GSSO**	**SAGE**	**OTHER**
SSOG	0.000	0.463	2.709	1.696
GSSO	-0.463	0.000	2.246	1.233
SAGE	-2.709	-2.246	0.000	-1.013
OTHER	-1.696	-1.233	1.013	0.000

Table 2.9. Female (n=38) 2nd order compositional analysis results: Ranking Matrix. Data collected on the Southern High Plains of Texas (2008-2012).

	SSOG	**GSSO**	**SAGE**	**OTHER**
SSOG	0	+	+	+
GSSO	-	0	+	+
SAGE	-	-	0	+
OTHER	-	-	-	0

Table 2.10. Female (n=38) 2nd order compositional analysis results: Ranking Matrix (Mean difference between used and available log-ratios). Data collected on the Southern High Plains of Texas (2008-2012).

	SSOG	**GSSO**	**SAGE**	**OTHER**
SSOG	0.000	0.447	0.604	1.138
GSSO	-0.447	0.000	0.157	0.691
SAGE	-0.604	-0.157	0.000	0.534
OTHER	-1.138	-0.691	-0.534	0.000

Table 2.11. Male (n=37) 3rd order compositional analysis results: Ranking Matrix. Data collected on the Southern High Plains of Texas (2008-2012).

	SSOG	**GSSO**	**SAGE**	**OTHER**
SSOG	0	---	+++	+
GSSO	+++	0	+++	+++
SAGE	---	---	0	-
OTHER	-	---	+	0

Table 2.12. Male (n=37) 3rd order compositional analysis results: Ranking Matrix (Mean difference between used and available log-ratios). Data collected on the Southern High Plains of Texas (2008-2012).

	SSOG	**GSSO**	**SAGE**	**OTHER**
SSOG	0.000	-1.934	1.380	0.885
GSSO	1.934	0.000	2.476	2.348
SAGE	-1.380	-2.476	0.000	-0.485
OTHER	-0.885	-2.348	0.485	0.000

Table 2.13. Female (n=38) 3rd order compositional analysis results: Ranking Matrix. Data collected on the Southern High Plains of Texas (2008-2012).

	SSOG	**GSSO**	**SAGE**	**OTHER**
SSOG	0	+	+++	+
GSSO	-	0	+++	+
SAGE	---	---	0	-
OTHER	-	-	+	0

Table 2.14. Female (n=38) 3rd order compositional analysis results: Ranking Matrix (Mean difference between used and available log-ratios). Data collected on the Southern High Plains of Texas (2008-2012).

	SSOG	**GSSO**	**SAGE**	**OTHER**
SSOG	0.000	0.360	1.972	0.436
GSSO	-0.360	0.000	1.623	0.210
SAGE	-1.972	-1.623	0.000	-1.023
OTHER	-0.436	-0.210	1.023	0.000

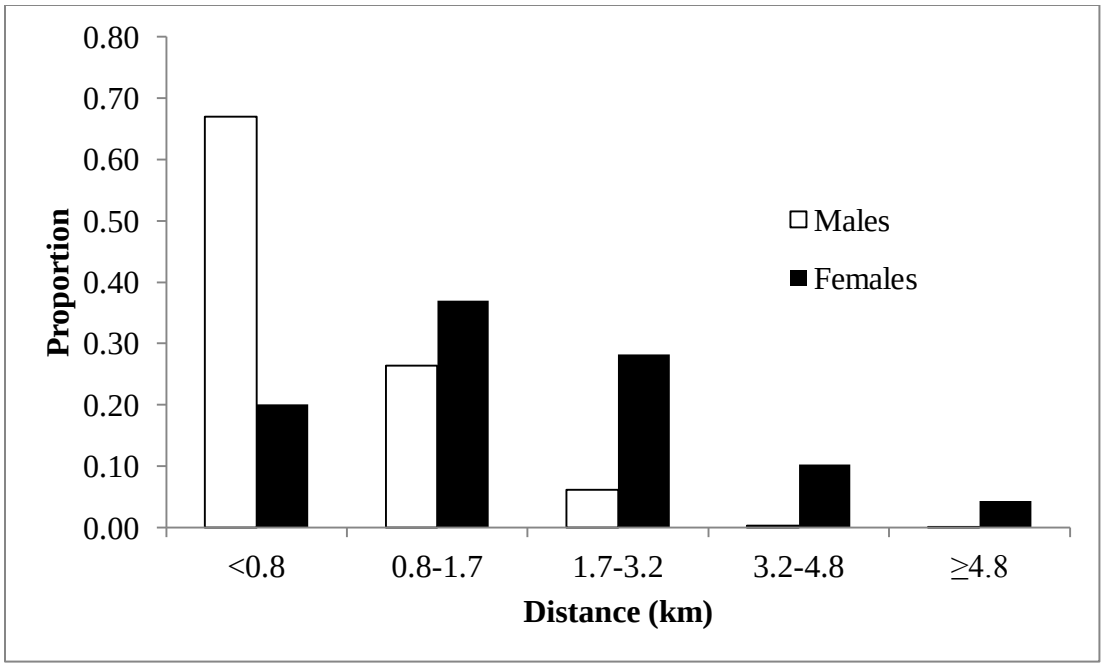

Figure 2.1. Distance from lek of capture (km) for all male and female telemetry-based relocations on the Southern High Plains of Texas (2008-2012).

CHAPTER III

HABITAT SELECTION OF LESSER PRAIRIE-CHICKENS ON EXPERIMENTALLY HERBICIDE TREATED AND GRAZED LANDS IN EASTERN NEW MEXICO

ABSTRACT

The lesser prairie-chicken is currently under review for listing as "threatened" under the Endangered Species Act. In addition to substantial range wide losses of habitat, lesser prairie-chickens are subjected to the degradation of the plant communities in which they exist. Gender-specific lesser prairie-chicken breeding season habitat selection was assessed on a study area occurring on the Southern High Plains of eastern New Mexico. Reduced rate (0.6 kg/ha) tebuthiuron herbicide and moderate, rotational grazing were applied to plots rendering four treatment combinations. Results suggested selection by male lesser prairie-chickens for areas not treated with tebuthiuron in comparison to tebuthiuron treated areas. Female lesser prairie-chickens used the not-treated and not-grazed areas in greater proportion to availability, the treated and not-grazed, and not-treated and grazed areas in proportion to availability, and the treated and grazed areas less than were proportionally available. My results suggest that male and female lesser prairie-chickens may display some preference for areas of sand-shinnery oak not treated with tebuthiuron herbicide.

INTRODUCTION

The lesser prairie-chicken (*Tympanuchus pallidicinctus*), a prairie grouse species of the central and southern Great Plains, has experienced an estimated 90% reduction in both range and population since the 1800's (Taylor and Guthery 1980a, Hagen et al.

2004). Today, lesser prairie-chickens exist as two geographically separate populations. Lesser prairie-chickens of the southwestern region (southeastern New Mexico and west Texas) are primarily relegated sand-shinnery oak (*Quercus havardii*) grassland communities, and lesser prairie-chickens of the northeastern region (Kansas, Colorado, Oklahoma, and northeast Texas Panhandle) occur mostly in native mixed grassland and/or sand sagebrush (*Artimisia filifolia*) communities. In both regions, the conversion of native plant communities to cropland is a major cause of decline (Davis et al. 2008, Hagen et al. 2004, Silvy et al. 2004). Habitat fragmentation, in a variety of forms, is also cited as a major human-induced cause of decline (Davis et al. 2008).

The direct reduction in useable space, and fragmentation of habitat connectivity, are implicit causes of range-wide population declines. However, a less obvious cause of decline may be the degradation and modification of the remaining native plant communities for both populations (Sullivan et al. 2000). As previously stated, lesser prairie-chickens existing in the southwestern region occur mostly in sand-shinnery oak grassland communities (Bell et al. 2010). Sand-shinnery oak grassland communities are comprised of some combination of the shrubs sand-shinnery oak and sand sagebrush, prairie grasses such as sand bluestem (*Andropogon hallii*), little bluestem (*Schizachyrium scoparium*), sand dropseed (*Sporobolis cryptandrus*), and purple three-awn (*Artistida purpurea*), and various forbs (Crawford and Bolen 1976, Peterson and Boyd 1998). The historical relationship between lesser prairie-chickens and sand-shinnery oak grassland communities in the southwestern region is not fully understood. In the literature, there is discussion regarding the typical pre-settlement vegetative composition of sand-shinnery oak grassland communities (Bell et al. 2010, Haukos 2011, and Zavaleta 2012).

It is common for the remaining sand-shinnery oak grassland communities in the southwestern region to be subjected to heavy and/or continuous grazing. Although sand-shinnery oak density does not reportedly increase as grasses decrease, it is an effective water gatherer, and, for this reason, it can be difficult for grasses to be competitive after being continuously removed by grazing cattle (Zavaleta 2012). Commonly, the result can be near monocultures of sand-shinnery oak (Smythe and Haukos 2009, Pirius 2011). It would seem obvious that this type of community modification is much different than the impact that intermittently migrating bison (*Bison bison*) had on sand-shinnery oak grassland communities prior to European-American settlement (Haukos 2011).

Herbicides (e.g., tebuthiuron) are frequently used by livestock producers to eradicate sand-shinnery oak from rangeland as a means to increase grass production for livestock forage. Currently, reduced-rate application of tebuthiuron is considered a potential tool for restoring over-grazed sand-shinnery oak grassland communities to supposed historical vegetative compositions (Zavaleta 2012). Reduced-rate application of tebuthiuron to increase the grass component in unmanaged, grazed sand-shinnery oak grassland communities seems a constructive goal. However, at the cost of losing some portion of a sand-shinnery oak component, the effects of this habitat management activity on lesser prairie-chickens is not fully understood.

The complexity and confusion over the historical habitat requirements, lack of scientific research (until relatively recent times), the species' range-wide ecological differences (Grisham 2012), and conflicting scientific evidence has hampered development of management guidelines and their implementation for the population of lesser prairie-chickens in the southwestern region. Currently, the lesser prairie-chicken is

being reviewed for listing as threatened under the Endangered Species Act of 1973 (Federal Register 2013).The purpose of this chapter is to assess the effects of reduced-rate tebuthiuron application and moderate rotational grazing on lesser prairie-chicken habitat selection in a sand-shinnery oak grassland community.

STUDY AREA

The New Mexico study area covered portions of the New Mexico Game and Fish North Bluitt Prairie-Chicken Area, and neighboring private lands. The study area occurred on the Llano Estacado or Southern High Plains, within which Brownfield-Tivoli fine sand soils made up the substrate of a topography that was predominantly flat, with low-lying sand dunes, and dune complexes scattered throughout. Temperatures ranged from -33 to 44° C (Neuman 1964) and the average annual precipitation was 31.5 cm (Smythe and Haukos 2009). Sixteen experimental plots, 65 ha each (except one was 80 ha), were designated as being part of a sand-shinnery oak grassland community, and selected to receive treatment combinations of tebuthiuron herbicide and livestock grazing. In 2000, tebuthiuron herbicide (N-[5-(1,-dimehylethyl)-1,3,4-thiadiazol-2-yl]-N,N'-dimehylurea) was applied to eight plots (532 ha) at 0.6 kg/ha. The other eight plots (518 ha) did not receive applications of tebuthiuron.

After deferring grazing from the plots for two years post treatment, cattle (*Bos taurus*) were stocked in four of the tebuthiuron treated, and four of the non-treated plots. Each year, cattle were grazed on designated plots once during the growing season and once during the dormant season. Stocking rates were determined each year and applied to remove 50% of available herbaceous material for that year. There were four different treatment and grazing combinations: Treated and Grazed (T-G), Treated and Not Grazed

(T-NG), Not Treated and Grazed (NT-G), and Not Treated and Not Grazed (NT-NG). The remaining area on the public land to the west of the untreated experimental plots was designated as Not Treated-Grazed (NT-G). The remaining land on the private property to the east of the treated experimental plots was designated as Treated-Grazed (T-G) as assigned by Grisham (2012). The radio telemetry data were provided by the Grasslans Charitable Foundation. See Table 3.1 for a list of vegetative characteristics for all four experimental combinations. Data were collected year-round, but mostly during the breeding seasons (1 March-18 August) of each year from 2006 through 2010 in Roosevelt County, New Mexico.

METHODS

Capture

Lesser prairie-chickens were captured on leks using walk-in-funnel traps (Haukos et al. 1989, Schroder and Braun 1991), rocket nets, and drop nets (Charles Dixon, PhD, Wildlife Plus, P. O. Box 416, Alto, NM). The drop nets used a car/boat battery to magnetize, and hold them at ready, until disconnected and dropped to ensnare lesser prairie-chickens. Upon capture, gender of lesser prairie-chickens was determined by pinnae length (mm) and the presence of eye combs (Copelin 1963). Age was determined by presence or absence of spotting within 2.5 centimeters (cm) from the tips of the 9th and 10th primary feathers (Copelin 1963). Both male and female adult lesser prairie-chickens lack these spots. Tarsus length (mm), un-flattened wing cord (mm), and mass (g) were measured for each captured individual. A 13 g bib-style radio-transmitter was looped around the necks of male and female lesser prairie-chickens (Advanced Telemetry

Systems, Ashanti, Minnesota, USA; Telemetry Solutions, California, USA). Following capture, all lesser prairie-chickens were released on site.

Radio-telemetry

Radio-tracking was conducted as frequently as possible and all lesser prairie-chickens were radio-tracked with handheld 3-element Yagi antennas and Advanced Telemetry Systems R-4000 receivers (Advanced Telemetry Systems, Ashanti, Minnesota, USA). To obtain lesser prairie-chicken location estimates, observers used homing to get in close proximity and then estimated the distance to the radio-collared individual. Care was given to avoid flushing each target individual, and Universal Transverse Mercator (UTM) coordinates were estimated using a handheld global positioning system unit and compass.

Habitat Selection

Lesser prairie-chickens were captured at leks located all across the New Mexico study area, but only six leks were within the experimental plots. Because the focus of this study was to assess the effects of herbicide and grazing on lesser prairie-chicken habitat selection I focused on the experimental plots. In ArcMap10 (ArcInfo, Environmental Research Institute, Redlands, CA), I used the Buffer, Merge, Clip, and Join tools to define Johnson's (1980) 2nd order scale of availability. I constructed a 1.9 km buffer around the six leks, as I perceived this to achieve the most non-biased habitat selection assessment possible, given the nature the dataset and the configuration of the study area. This resulted in a 2,571 ha area (hereafter; study area) that included all of the experimental plots and some outside areas. Most leks not within the study area were considered far enough away that unless lesser prairie-chickens were dispersing to the

experimental plots their locations would not be included within the buffer area. All experimental plot combinations were easily accessible to males captured at these five leks.

Because of logistical limitations and the original intent for this research project (focus on nesting ecology), most radio-collared individuals (from 2006-2010) were relocated too few times to assess habitat selection within the home ranges of individuals. Therefore, I pooled male and female relocations that occurred within the study area into gender groupings. White and Garrott (1990) stated that pooling the radio-relocations from different individuals is an adequate approach with limited data. Each lek observation was omitted from the relocations dataset. All repeated nesting site relocations were omitted so as to only include one nest site location per nesting female.

I considered use as the proportional number of radio-relocations occurring within the different treatment combinations and additional area within the study area. I used chi-square goodness-of-fit tests to test for a significant difference between use and availability for males and females, separately, and Bonferoni-corrected 95% confidence intervals to assess whether or not lesser prairie-chickens used each treatment type in proportion to its availability (Neu et al. 1974).

RESULTS

Within the study area there were 498 male relocations and 618 female relocations obtained from 2006-2010. Five of the six buffered leks occurred in the untreated plots, but were in relatively close proximity to the available treated plots (average linear distance (±SD) of these leks to treated plot centers was 2.2 km (±0.7)). Chi-square

goodness-of-fit tests revealed that cover-types were used disproportionately to what was available for both males (= 47.70, *df* = 3, *P* < 0.05) and females (= 77.12, *df* = 3, *P* < 0.05). Male lesser prairie-chickens used the Not Treated and Grazed (NT-G) areas in greater proportion to its availability, the Not Treated and Not Grazed (NT-NG) area in proportion to its availability, and both the Treated and Grazed (T-G), and Treated and Not Grazed (T-NG) areas less than was proportionally available (Table 3.2). Female lesser prairie-chickens used the Not Treated and Not Grazed (NT-NG) areas in greater proportion to its availability, the Treated and Not Grazed (T-NG), and Not Treated and Grazed (NT-G) areas in proportion to availability, and the Treated and Grazed (T-G) areas less than was proportionately available (Table 3.3).

DISCUSSION

The male lesser prairie-chicken habitat selection results were based on data collected during the breeding season. Males were shown to remain in close proximity to their lek of capture in Texas (see Chapter 1). Results suggest selection by male lesser prairie-chickens for sand-shinnery oak. Female habitat use may be less influenced by lek of capture, and, therefore results for females are more robust than the results for males.

Overall, the methodology implemented in Chapter 1 for assessing the general breeding season habitat selection by lesser prairie-chickens is more robust than the analysis that was conducted with the New Mexico data. Although tebuthiuron treated areas were present on the Texas study area, lesser prairie-chickens nested in habitat categories that were not only untreated, but were comprised of at least 30% sand-shinnery oak (Chapter 1). The nest site selection results from New Mexico showed that nests occurred in the experimental plots in proportion to what was expected; Grisham (2012)

found that 37 (55%) nests occurred in untreated areas which were characterized by 15-35% sand-shinnery oak, 15-30% other shrubs, and 10-25% grass. He also found that 30 (45%) nests occurred in treated areas that consisted of 0-20% sand-shinnery oak, 5-15% other shrubs, and 25-35% grass. These results may suggest that both treated areas (0.6 kg/ha, 6-10 years post treatment) and untreated areas can potentially provide adequate vegetative structure/cover for nesting lesser prairie-chickens (see Grisham 2012).

Bell et al. (2010) assessed brooding site habitat selection on the New Mexico study area from 2002-2003 (1-3 years post tebuthiuron treatment) and found that hens with broods selected areas categorized as untreated (i.e., comprised of sand-shinnery oak). While Bell et al. (2010) did locate broods within the treated areas they noted the use of untreated sand-shinnery oak dunes within these areas. Further, they described that in only three years post tebuthiuron treatment, a 70% reduction in sand-shinnery oak canopy coverage occurred between brood and random sites within the recently tebuthiuron treated area.

Grisham (2012) assessed brood site selection from 2006-2010 on this study area (6-10 years post treatment), and detected use as expected for the treated and untreated areas. At ten years post treatment, Zavaleta (2012) reported a 91% decrease in sand-shinnery oak composition within treated plots. Like Bell et al. (2010), Grisham (2012) did observe broods using untreated strips of sand-shinnery oak adjacent to a recently treated area (treated in 2008). Considering the results of Bell et al. (2010), and the results within his own dissertation, Grisham (2012) hypothesized that tebuthiuron application may negatively impact broods until grass can rebound and provide adequate thermal cover.

Grisham (2012) identified brood survival as a limiting factor for lesser prairie-chicken recruitment on the Southern High Plains of Texas. Furthermore, he hypothesized that lacking forb/insect abundance was the source for low brood survival in west Texas. Forb density was overall greater on the New Mexico study area then the Texas study area (Grisham 2012). On the New Mexico study area, forb composition was also shown to be higher in treated than untreated areas (Zavaleta 2012). Despite greater forb and invert abundance in treated areas, Grisham (2012) detected proportional use of the treated and untreated areas by lesser prairie-chicken broods. Forb and invert abundance was not shown to differ between brood site and random sites (Grisham 2012). This may suggest that while tebuthiuron treatments can increase forbs and inverts, treatment may not be necessary to increase forbs/inverts for lesser prairie-chicken broods where adequate forb cover already exists. Furthermore, while prescribed fire has been shown to only temporarily top-kill sand-shinnery oak and not increase grass composition, it has been shown to increase forb growth (Boyd and Bidwell 2001, Harrell et al. 2001). Prescribed fire may be difficult to effectively apply in some parts of the southwestern region, but additional research on prescribed fire as a means to increase forb growth may be warranted.

Considering what is known about the physiology and autoecology of sand-shinnery oak, I consider any permanent removal of this plant to be potentially harmful to the greater community in which it belongs. Even reduced rates (0.6 kg/ha) of tebuthiuron kills and removes the sand-shinnery oak from the entire area of application. Because tebuthiuron removal of sand-shinnery oak can be irreversible, the supposition that the resulting vegetative composition equates to supposed historical standards is debatable,

and the measurable benefit to lesser prairie-chickens is lacking, the current method for use of tebuthiuron treatment of sand-shinnery oak for lesser prairie-chicken habitat improvement seems questionable.

While the negative impacts of sand-shinnery oak treatment on lesser prairie-chicken breeding ecology is not apparent, the potential benefits are also not apparent. Regardless, tebuthiuron treatment of sand-shinnery oak seems to be promoted as a compromise between livestock production and lesser prairie-chicken conservation. My overall interpretation of the information leads me to believe that consideration should be given to prescribed fire, ultra-light application rates of tebuthiuron herbicide, or herbicide use that results in the temporary top-kill of sand-shinnery oak while promoting forb growth, as adaptive lesser prairie-chicken habitat management tools.

LITERATURE CITED

Bell, L. A., S. D. Fuhlendorf, M. A. Patten, D. H Wolfe, and S. K. Sherrod. 2010. Lesser prairie-chicken hen and brood habitat use on sand shinnery oak. Rangeland Ecology and Management 63:478-486.

Boyd, C. S. and T. G. Bidwell. 2001. Influence of prescribed fire on lesser prairie-chicken habitat in shinnery oak communities in western Oklahoma. Wildlife Society Bulletin 29:938-947.

Copelin, F. F. 1963. The lesser prairie-chicken in Oklahoma. Oklahoma Department of Wildlife Technical Bulletin 6. Oklahoma City, Oklahoma, USA.

Crawford, J.A. and E.G. Bolen. 1976b. Effects of land use on lesser prairie chickens in Texas. Journal of Wildlife Management 40:96-104.

Davis, D. M., R. E. Horton, E. A. Odell, R. D. Rodgers and, H. A. Whitlaw. 2008. Lesser Prairie-Chicken Conservation Initiative. Lesser Prairie Chicken Interstate Working Group. Unpublished Report. Colorado Division of Wildlife, Fort Collins, CO. USA.

Federal Register. May 6, 2013. Proposed Rules Vol. 78, No. 87, pg. 1.

Grisham, B. A. 2012. The ecology of lesser prairie-chickens in shinnery oak-grassland communities in New Mexico and Texas with implications toward habitat management and future climate change. Ph.D. Dissertation, Texas Tech University, Lubbock, USA.

Hagen, C.A., B.E. Jamison, K.M. Giesen, and T.Z. Riley. 2004. Guidelines for managing lesser prairie-chicken populations and their habitats. Wildlife Society Bulletin 32(1):69-82.

Harrell, W.C., S.D. Fuhlendorf, and T.G. Bidwell. 2001. Effects of prescribed fire on sand shinnery oak communities. Journal of Range Management 54:685-690.

Haukos, D. A. 2011. Use of tebuthiuron to restore sand shinnery oak grasslands of the Southern High Plains. M. N. A El-Ghany Hasanee (Ed.) In Herbicides: Mechanisms and mode of action (103-124). Rijeka, Croatia.

Haukos, D. A., L. M. Smith, and G. S. Broda. 1989. Spring trapping of lesser prairie-chickens. Journal of Field Ornithology 61:20-25.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65-71.

Neu, C., B. Randall, and J. Peek. 1974. A Technique for analysis of utilization-availability data. Journal of Wildlife Management 38(3):541-545.

Newman, A. L. 1964. Soil Survey of Cochran County, Texas. Washington, DC: U. S. Department of Agriculture, Soil Conservation Service. 80 pp. + maps.

Peterson, R. S., and C. S. Boyd. 1998. Ecology and management for sand shinnery oak communities: a literature review. USDA Forest Service General Technical Report RMRS-GTR-16, 44 p. Rocky Mountain Research Station, Fort Collins, Colorado, USA.

Pirius, N. 2011. The non-breeding season ecology of lesser prairie-chickens (*Tympanuchus pallidicinctus*) on the Southern High Plains of Texas. M.S. Thesis. Texas Tech University. Lubbock, Texas, USA.

Schroeder, M.A., and C.E. Braun. 1991. Walk-in traps for capturing greater prairie-chickens on leks. Journal of Field Ornithology 62:378-385.

Silvy, N. J., M. J. Peterson, and R. R. Lopez. 2004. The cause of the decline of pinnate grouse: the Texas example. Wildlife Society Bulletin 32:16-21.

Smythe, L. A., and D. A. Haukos. 2009. Nesting success of grassland birds in shinnery oak communities treated with tebuthiuron and grazing in eastern New Mexico. The Southwestern Naturalist 54:136-145.

Sullivan, R. M., J. P. Hughes, and J. E. Lionberger. 2000. Review of the historical and present status of the lesser prairie-chicken (*Tympanuchus pallidicinctus*) in Texas. The Prairie Naturalist 32:177-188.

Taylor, M. A., and F. S. Guthery. 1980a. Fall-winter movements, ranges, and habitat use of lesser Prairie Chickens. Journal of Wildlife Management 44:521-524.

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

Zavaleta, J. C. 2012. Community response to use of prescribed grazing and herbicide for restoration of sand shinnery oak grasslands. M.S. Thesis, Texas Tech University, Lubbock, TX, USA.

Table 3.1. Vegetative composition of treatment types used for determining breeding season habitat selection by lesser prairie-chickens. Categories include: sand-shinnery oak (*Quercus havardii*); other shrubs: mostly sand sagebrush (*Artemisia filifolia*); and grass (mostly native prairie-grasses). Summarized from measurements collected in Roosevelt County, NM from 2002-2010 as shown in Zaveleta (2012).

Treament Type	**Classification**	**Description (structural composition ranges per treatment type)**
T-G	Treated-Grazed	0-20% Sand-shinnery oak, 5-15% other shrubs, 25-35% grass.
T-NG	Treated-Not Grazed	0-20% Sand-shinnery oak, 5-15% other shrubs, 25-35% grass.
NT-G	Not Treated-Grazed	15-35% Sand-shinnery oak, 15-30% other shrubs, 10-25% grass.
NT-NG	Not Treated-Not Grazed	15-35% Sand-shinnery oak, 15-30% other shrubs, 10-25% grass.

Table 3.2. Male lesser prairie-chicken habitat selection in Roosevelt County, NM (2006-2010).

Treatment Type	**Available Area (ha)**	**Total Locations**	**Lower (95% CI)**	**Upper (95% CI)**	**Expected Proportion**	**Use vs. Availability**
T-G	875 (34%)	127 (26%)	0.217	0.293	0.340	Less
T-NG	264 (10%)	21 (4%)	0.025	0.060	0.103	Less
NT-G	1177 (46%)	291 (58%)	0.541	0.628	0.458	More
NT-NG	255 (10%)	59 (12%)	0.090	0.147	0.099	No difference
Total	2571	498				

Table 3.3. Female lesser prairie-chicken habitat selection in Roosevelt County, NM (2006-2010).

Treatment Type	**Available Area (ha)**	**Total Locations**	**Lower (95% CI)**	**Upper (95% CI)**	**Expected Proportion**	**Use vs. Availability**
T-G	875 (34%)	135 (22%)	0.186	0.251	0.340	Less
T-NG	264 (10%)	65 (11%)	0.081	0.129	0.103	No difference
NT-G	1177 (46%)	302 (49%)	0.449	0.528	0.458	No difference
NT-NG	255 (10%)	116 (19%)	0.157	0.218	0.099	More
Total	2571	618				

CHAPTER IV

LESSER PRAIRIE-CHICKEN NOCTURNAL ROOSTING SITE SELECTION ON THE SOUTHERN HIGH PLAINS OF TEXAS

ABSTRACT

Nocturnal roosting site selection was assessed in relation to microhabitat and microclimate variables in west Texas during the breeding seasons of 2011 and 2012. There were no differences in visual obstruction readings between roost and paired random sites. Lesser prairie-chickens roosted directly on bareground with no overhead vegetative coverage. In 2011, there was significantly more bareground and less humidity (% RH) at roosting site point center compared to paired random sites. In 2012, roost and random sites were equally humid, but there was more litter coverage surrounding roosting sites compared to paired random sites. Temperature did not appear to differ between roost and random sites in either 2011 or 2012. Results may show evidence for the selection of nocturnal roosting sites based on tradeoffs between visual and/or scent concealment from nocturnal predators as related to the available microclimate and microhabitat variables during the course of this study.

INTRODUCTION

The lesser prairie-chicken (*Tympanuchus pallidicinctus*), a prairie grouse species of the central and southern Great Plains, has experienced an estimated 90% reduction in both range and population since the 1800's (Taylor and Guthery 1980a, Hagen et al. 2004). These population level declines have resulted in the lesser prairie-chicken being reviewed for listing as threatened under the Endangered Species Act of 1973 (Federal Register 2013). Consequentially, substantial conservation effort and research has been

focused on the species, with most research focused on survival, nesting ecology, and habitat associations (Pirius 2011, Grisham 2012).

Recent advances in technology have allowed for the fine scale measurement of climate at sites of animal occupancy (i.e., microclimate). Other variables can be measured (e.g., microhabitat) and thorough investigations of site characterization/selection can be performed. Furthermore, relationships can be drawn between microclimate and parameters such as survival and physiological response to environmental conditions. Patten et al. (2005) found that lesser prairie-chicken survival was greater at sites that were cooler and more humid. Bell et al. (2010) found evidence for the temporal selection of lesser prairie-chicken brooding sites based on microclimate (temperature and % relative humidity). Grisham (2012) found evidence of a temperature threshold at which lesser prairie-chickens no longer successfully hatched nests, and, as a result, identified a potential limiting factor for lesser prairie-chicken persistence under drought conditions.

One aspect of lesser prairie-chicken ecology for which there is little information is the characterization and selection of nocturnal roosting sites. A literature review of the subject reveals that most of the existing data are anecdotal. Copelin (1963) noted that lesser prairie-chickens in Oklahoma roosted on ridges, in draws and ravines, and in areas with less than 1 meter (m) of overhead cover. Jones (1963) discussed the use of pockets of shorter vegetation by roosting lesser prairie-chickens in Oklahoma. During the fall/winter, lesser prairie-chicken foraging areas, and associated nocturnal roosting sites consisted of a greater component of grass than shrubs, in eastern New Mexico (Davis et al. 1979; Riley et al. 1993). Kukal (2010) did not detect a difference between daytime and nighttime telemetry-based relocation distances to known leks during the fall/winter in

northeast Texas Panhandle. To address the lack of quantitative data on this aspect of lesser prairie-chicken ecology, I attempted to more rigorously assess nocturnal roost site characteristics of the species in context of measureable microhabitat and microclimate components available on the Southern High Plains of Texas.

STUDY AREA

This study was conducted on privately owned lands in Cochran, Hockley, Yoakum, and Terry counties of Texas, USA. The study area occurred on the Llano Estacado or Southern High Plains of Texas. Brownfield-Tivoli fine sand soils made up the substrate of a topography that was predominantly flat, with low-lying sand dunes, and dune complexes scattered throughout. Temperatures ranged from -33 to 44° C and the average annual precipitation was 45.9 cm (Neuman 1964).

The core study area was an isolated mosaic of sand-shinnery oak (*Quercus havardii*) grassland communities and sand sagebrush (*Artimisia filifolia*) dominated areas. On the fringes of this core area was honey mesquite (*Prosopis glandulosa*) and Conservation Reserve Program (CRP) enrollments consisting primarily of introduced lovegrass (*Eragrostis* spp.) and old-world bluestems (*Bothriochloa* spp.). The main land use of the core area was beef cattle production; with some oil mining infrastructure present. The surrounding area was made up of dense center pivot fields (cotton) and oil mining infrastructures (pump jacks and associated roads).

METHODS

Capture

I captured male and female lesser prairie-chickens on leks using drift fences and walk-in-funnel traps (Haukos et al. 1989, Schroder and Braun 1991), and magnetized drop nets (Wildlife Capture Services LLC, P.O. Box 334, Flagstaff, AZ 86002) from 1 March through 15 May of 2011 and 2012. After capture, gender of lesser prairie-chickens was determined by pinnae length (mm) and the presence of eye combs (Copelin 1963). Age was determined by presence or absence of spotting within 2.5 centimeters (cm) from the tips of the 9th and 10th primary feathers (Copelin 1963). Both male and female adult lesser prairie-chickens lack these spots. Tarsus length (mm), un-flattened wing cord (mm), and mass (g) were measured for each captured individual. Finally, each lesser prairie-chicken was banded and radio-collared with a 9 g necklace style radio-transmitter in 2011 and a 12 g radio-transmitter of the same style and manufacturer in 2012 (American Wildlife Enterprises, Florida, USA).

Radio-telemetry

I used a hand-held 3 element Yagi antenna, an Advanced Telemetry Systems R-2000 receiver (Advanced Telemetry Systems, Ashanti, Minnesota, USA), and a hand-held Garmin Etrex Vista (Garmin International Inc., Olathe, KS, USA) global positioning systems unit to record locations of lesser prairie-chickens during the nocturnal roosting period (2200 and 0600). I used two different methods to determine the exact nocturnal roosting locations. In 2011, triangulations (Cochran and Lord 1963) at close distances (≤25 meters) were obtained on roosting lesser prairie-chickens. The following day,

observers returned to the area where the triangulation took place and identified the points from which triangulation bearings were obtained. Once the triangle was visualized, line transects (1.5 meters apart) were walked across the triangle to locate lesser prairie-chicken droppings deposited the night before. Only droppings that were visibly fresh were designated as the radio-collared individual's nocturnal roosting location.

In 2012, radio-telemetry was used to find lesser prairie-chickens, and homing was used to get in close proximity (10-20 m) of roosting lesser prairie-chickens. With sufficient experience, I developed a strong sense of distance from radio-collared individuals with the radio-telemetry equipment mentioned above. Once I was positioned in close proximity to a roosting lesser prairie-chicken, and aware of the directional location of the target individual, an L3 Thermal-Eye X200XP thermal imaging scope (L-3 Communications Infrared Products, Garland, TX 75041) was used to visually locate the roosting lesser prairie-chicken. Vegetation typically obscured the heat signal and dictated that I get within close proximity to roosting individuals. In some instances, vegetative obstruction required careful circling of roosting individuals until a break in obstruction allowed for a heat signal to be detected. Upon detection of a heat signal, I recorded UTM coordinates, compass bearing, estimated distance to the roosting individual, and marked the vegetation directly in front of myself with orange surveyor's flagging. I was careful not to flush roosting lesser prairie-chickens. The following day, I relocated the flagging, and retraced the bearing to locate the roosting individual's droppings.

Microhabitat

The point center was considered to be right on top of the roosting lesser prairie-chicken's droppings. At point center, I measured visual obstruction readings (VOR) to the nearest half decimeter (dm), from a distance of 4 m and a height of 1 m, in all four cardinal directions using a Robel Pole (Robel et al. 1970). To assess canopy coverage, I took digital photographs of a 20 x 50 centimeter (cm) Daubenmire frame (Daubenmire 1959) from a height of 1.5 m, at point center and at 4 points 1 m from point center in each cardinal direction. A list of random distances (50-360 m) and bearings (0-359°) was generated and used to select paired random sites for each roost location. All VOR and canopy coverage measurements taken at roost sites were replicated at the paired random sites.

Percent canopy coverage of shrubs, grass, forbs, litter, and bareground was estimated by importing the digital photographs into Microsoft Powerpoint 2007. In Powerpoint, 20 points were placed within the Daubenmire frame's perimeter, and at each point one of the five canopy coverage categories was assigned. An arcsine-squareroot transformation was applied to the proportions of the canopy coverage categories (Howell 1995). For each year, I used a one-way analysis of means, not assuming equal variances (R script: "oneway.test"), to test for differences between canopy coverage categories. Welch's-adjusted two samples *t*-tests were used to test for differences between each canopy coverage category between roost and random sites. Also, Welch's-adjusted two samples *t*-tests were used to test for differences between 0% and 100% visual obstruction readings between roost and random sites. Data from 2011 and 2012 were analyzed

separately due to differences in both VOR and canopy coverage measurements between years.

Microclimate

Bell et al. (2010) evaluated daytime microclimate characteristics within sand-shinnery oak grasslands in eastern New Mexico and found that temperatures along a 10 m line could vary substantially (Bell et al. 2010). Based on this information, and because I did not want to flush roosting lesser prairie-chickens, I determined it would be inappropriate to place a data logger near to but not directly at a lesser prairie-chicken's roosting site. Instead, I opted to investigate the hypothesis that sites selected by lesser prairie-chickens for roosting had different microclimate characteristics compared to random sites consistently across time. I placed a Maxim Integrated Semiconductor weather data logger (Maxim Integrated Products, Sunnyville, CA, USA) at the roost site and paired random site at the time when vegetation measurements were taken (the day following roost location). Data loggers were programmed to record temperature in degrees Celcius (°C) and relative humidity (% RH) every hour, and left at the roost and paired random sites for 14 consecutive days. Data recorded by the data loggers that did not fall in between the nocturnal roosting hours (2200-0600) was omitted from analysis. Roost and random site measurements (temperature and % RH) were pooled separately, and a Welch's adjusted two-samples *t*-test was used to test for differences in microclimate variables between roost and random sites for 2011 and 2012.

RESULTS

Microhabitat

Each year, VOR and canopy coverage was measured at 30 pairs of roost and random sites. For the VOR analysis, the readings from all four cardinal directions for 100% and 0% readings were included in the within year analyses. This rendered 120 VOR readings for each sample comparison per year (Table 4.1). In 2011, average 100% VORs (±SD) were 0.35 dm (0.58) at roost and 0.34 dm (0.44) at random sites, respectively. In 2011, 0% VORs were 5.01 dm (2.40) at roost and 4.89 dm (2.48) at random sites, respectively. In 2012, average 100% visual obstruction readings (±SD) were 0.25 dm (0.43) at roost and 0.23 dm (0.41) at random sites, respectively. And, in 2012, 0% VORs were 3.46 dm (1.68) at roost and 3.24 dm (1.80) at random sites, respectively.

Welch's-adjusted two-samples *t*-tests showed there was not a significant difference between years for roosting site 100% VORs ($t = 1.52$, $df = 221.26$, $P = 0.13$). However, there was a significant difference between years for 0% roosting site VORs ($t = 5.81$, $df = 212.99$, $P < 0.01$). Therefore, roost and random site VORs were not pooled across years. In 2011, there was not a significant difference in 100% ($t = -0.19$, $df = 221.82$, $P = 0.85$) or 0% ($t = -0.40$, $df = 237.69$, $P = 0.69$) VORs between roost and random sites. In 2012, there was not a significant difference in 100% ($t = -0.38$, $df = 237.47$, $P = 0.70$) or 0% ($t = -1.00$, $df = 236.73$, $P = 0.32$) VORs between roost and random sites.

In 2011 and 2012, canopy coverage categories (i.e., shrubs, grass, forbs, litter, and bareground) were averaged separately for both roost and random sites across all 30 paired samples. Total proportional coverage for roost and random sites was calculated and summarized (Tables 4.2 through 4.5). To test for differences between roost and random point center canopy coverage, canopy coverage proportions were calculated for each site's point center, arcsine-squareroot transformed, pooled across all 30 samples, and then tested with Welch's-adjusted two samples *t*-tests.

One-way analysis of means, not assuming equal variances, showed significant differences between canopy coverage categories for roost ($F = 123.81$, $df = 4.00$, $P < 0.01$) and random sites ($F = 29.95$, $df = 4.00$, $P < 0.01$), respectively, in 2011. Welch's-adjusted pairwise *t*-tests showed differences between roost and random point centers for bareground ($t = 3.82$, $df = 51.97$, $P < 0.01$) and grass ($t = -3.33$, $df = 42.72$, $P < 0.01$), but not forb, litter, or shrubs (Table 4.6). Similarly, there were differences between canopy coverage categories for roost ($F = 107.28$, $df = 4.00$, $P < 0.01$) and random sites ($F = 42.32$, $df = 4.00$, $P < 0.01$), respectively, in 2012. However, in contrast to 2011 results, the only differences between roost and random point centers in 2012 was for shrubs ($t = -2.18$, $df = 55.36$, $P = 0.03$; Table 4.7).

Microclimate

In 2011, 883 measurements of temperature and relative humidity were recorded at 11 pairs of roost and random sites (Table 4.8). The average temperature (±SD) for roost and random sites in 2011 was 24.2° C (2.9) and 23.8° C (2.9), respectively. The average relative humidity at roost and random sites in 2011 was 49.7% (15.8) and 54.4% (16.4),

respectively. In 2012, 1,268 measurements of temperature and relative humidity were recorded by 14 pairs of data loggers (Table 4.8). The average temperature (±SD) for roost and random sites in 2012 was 21.7° C (3.0) and 21.6° C (3.1), respectively. The average relative humidity at roost and random sites in 2012 was 66.3% (20.9) and 65.4% (20.1) at, respectively.

A Welch's-adjusted two samples *t*-test showed a difference in temperature between roost and random for 2011 (t = -2.92, df = 1759.77, P < 0.01), but not for 2012 (t = -0.90, df = 2530.84, P = 0.37). Similarly, a Welch's-adjusted two samples *t*-test showed a significant difference in % RH between roost and random for 2011 (t = 6.10, df = 1757.87, P < 0.01), but not in 2012 (t = -1.15, df = 2528.95, P = 0.25).

DISCUSSION

Initially, I was surprised to find that there was not a difference in 0% visual obstruction readings (i.e., vegetative height) between roost and random sites. I had originally hypothesized that lesser prairie-chickens would select nocturnal roosting sites with shorter surrounding vegetation that would facilitate easier flight escape from predators during the night. While the vegetative obstruction at 4 m around roosting lesser prairie-chickens did not differ from random sites, this may not capture the influential aspects of vegetation on roost site selection. During 2011 and 2012, all roost and random site 0% VORs ranged from approximately 3.5 to 5 dm (35-50 cm), which is low. Potentially influential, however, is that there was typically no overhead coverage at any nocturnal roosting sites, and all lesser prairie-chickens roosted directly on bareground. The results from the canopy coverage measurements were quite interesting. At point center, there was more bareground at roosting sites than random sites in 2011, but not in

2012. And in 2012, there was more litter coverage immediately surrounding lesser prairie-chicken roosting sites than random sites. In 2011, there did not appear to be a difference in the surrounding litter coverage between roosting and random sites.

Roosting sites were on average 4.7% less humid than paired random sites in 2011, whereas both roosting and random sights were more humid, and equally so, in 2012. Humidity can increase scent production in the feathers of birds (Conover 2007). Therefore, conditions that increase humidity also increases the olfactory capabilities of predators to detect prey (Gutzwiller 1990). Nocturnal/olfactory predators such as coyotes (*Canis latrans*), American badgers (*Taxidea taxus*), and striped skunks (*Mephitis mephitis*) occurred on my study area. Therefore, the selection of less humid nocturnal roosting sights by lesser prairie-chickens may be adaptive in reducing the risk of detection by olfactory based predators. However, under some conditions, such as periods of precipitation, greater humidity may not be avoidable. In 2012, when humidity was higher at both roosting and random sites, there was greater litter coverage at roosting site point center, and the area immediately surrounding the roost, than the random sites. Explanations for this are elusive, but speculatively, there are at least three possible explanations for this. This could suggest that lesser prairie-chickens select sites of greater vegetative concealment (i.e., camouflage) to decrease visual detectability by predators when sites with lower humidity are either not available or not perceived to be necessary. Alternatively, humidity, and therefore moisture, may possibly increase odors from litter that may serve to mask the scent of lesser prairie-chickens. Finally, increased litter may result in greater difficulty in maintaining silence by stalking predators, thereby increasing a lesser prairie-chickens ability to detect predators and flush.

Previous research on lesser prairie-chicken roosting site selection lacked rigor and mostly provided baseline information about the vegetative characteristics of roosting sights. This study assessed selection as related to vegetation, and was the first to investigate weather-related features that influence the selection of nocturnal roosting sights. Thus, this study adds to a rather new and growing body of prairie grouse research that is attempting to relate behavior, physiological response, and resource selection to climatic features present in these birds' environments. Further research relating vegetation and microclimate may provide insightful information about the preferences and habitat requirements beneficial for the conservation of lesser prairie-chickens.

LITERATURE CITED

Bell, L. A., Fuhlendorf, S. D., Patten, M. A., Wolfe, D. H., and S. K. Sherrod. 2010. Lesser prairie-chicken hen and brood habitat use on sand shinnery oak. Rangeland Ecology and Management 63:478-486.

Cochran, W.W., and R.D. Lord. 1963. A radio-tracking system for wild animals. Journal of Wildlife Management 27:9-24.

Copelin, F. F. 1963. The lesser prairie-chicken in Oklahoma. Oklahoma Department of Wildlife Technical Bulletin 6. Oklahoma City, Oklahoma, USA.

Conover, M. R. 2007. Predator-prey dynamics: the use of olfaction. Taylor and Francis, Boca Raton, FL.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43–64.

Davis, C. A., T. Z. Riley, H. R. Suminski, and M. J. Wisdom. 1979. Habitat evaluation of lesser prairie chickens in eastern Chaves County, New Mexico. Final Report to Bureau of Land Management, Rosewell, Contract YA-512-CT6-61. Department of Fishery and Wildlife Sciences, New Mexico State University, Las Cruces.

Grisham, B. A. 2012. The ecology of lesser prairie-chickens in shinnery oak-grassland communities in New Mexico and Texas with implications toward habitat management and future climate change. Ph.D. Dissertation, Texas Tech University, Lubbock, USA.

Gutzwiller, K. J. 1990. Minimizing dog-induced biases in game bird research. Wildlife Society Bulletin 18:351–356

Howell, D. C. 1995. Fundamental statistics for the behavioral sciences. 3rd edition. Belmont, CA. Wadsworth Publishing Company.

Jones, R. E. 1963. Identification and analysis of lesser and greater prairie chicken habitat. Journal of Wildlife Management 27:757-778.

Kukal, C. A. 2010. The over-winter ecology of Lesser Prairie-Chickens (*Tympanuchus pallidicinctus*) in the northeast Texas panhandle. M.S. thesis. Texas Tech University. Lubbock, TX, U.S.A.

Patten, M.A., D.H. Wolfe, E. Shochat, and S.K. Sherrod. 2005. Effects of microhabitat and microclimate selection on adult survivorship of the lesser prairie chicken. Journal of Wildlife Management 69(3):1270-1278.

Pirius, N. 2011. The non-breeding season ecology of lesser prairie-chickens (*Tympanuchus pallidicinctus*) on the Southern High Plains of Texas. M.S. Thesis. Texas Tech University. Lubbock, Texas, USA.

Riley, T. Z., C. A. Davis, and R. A. Smith. 1993. Autumn-winter habitat use of the lesser prairie-chicken (Tympanuchus pallidicinctus) (Galliformes: tetraonidae). Great Basin Naturalist 53:409-411.

Robel, R. J., Briggs, J. N., Dayton, A. D., and L. C. Hulbert. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management 23:295-297.

Table 4.1. Mean VORs (dm) (±SD) at lesser prairie-chicken roosting sites and paired random sites on the Southern High Plains of Texas (2011 and 2012).

Year	**Site**	**100% VOR**	**0% VOR**	***n***
2011	Roost	0.35 (0.58)	5.01 (2.40)	30 sites x 4 VORs = 120
2011	Random	0.34 (0.44)	4.89 (2.48)	30 sites x 4 VORs = 120
2012	Roost	0.25 (0.43)	3.46 (1.68)	30 sites x 4 VORs = 120
2012	Random	0.23 (0.41)	3.73 (5.91)	30 sites x 4 VORs = 120

Table 4.2. Roosting site canopy coverage proportions at point center and 1 meter in each cardinal direction for 2011. Occurrence pooled across 30 sites and then proportion calculated. Data collected on the Southern High Plains of Texas (2011).

Year	**PC**	**East**	**West**	**North**	**South**
Bareground	63.5%	27.0%	23.2%	30.5%	20.2%
Forb	0.2%	0.3%	0.7%	0.0%	0.0%
Grass	1.8%	9.3%	15.2%	12.3%	11.2%
Litter	29.3%	45.8%	45.5%	40.2%	42.7%
Shrubs	5.2%	17.5%	15.5%	17.0%	26.0%

Table 4.3. Random site canopy coverage proportions at point center and 1 meter in each cardinal direction for 2011. Occurrence pooled across 30 sites and then proportion calculated. Data collected on the Southern High Plains of Texas (2011).

Year	**PC**	**East**	**West**	**North**	**South**
Bareground	37.0%	30.0%	23.2%	30.8%	25.2%
Forb	0.5%	0.3%	1.0%	1.0%	0.5%
Grass	10.0%	11.5%	10.5%	13.2%	8.8%
Litter	42.3%	42.8%	48.2%	38.2%	44.7%
Shrubs	10.2%	15.3%	17.2%	16.8%	20.8%

Table 4.4. Roosting site canopy coverage proportions at point center and 1 meter in each cardinal direction for 2012. Occurrence pooled across 30 sites and then proportion calculated. Data collected on the Southern High Plains of Texas (2011).

Year	**PC**	**East**	**West**	**North**	**South**
Bareground	58.2%	26.8%	20.5%	27.2%	33.3%
Forb	1.8%	3.2%	2.7%	3.2%	2.2%
Grass	6.2%	5.2%	7.2%	9.5%	7.2%
Litter	30.2%	44.8%	53.8%	46.5%	39.2%
Shrubs	3.7%	20.0%	15.8%	13.7%	18.2%

Table 4.5. Roosting site canopy coverage proportions at point center and 1 meter in each cardinal direction for 2012. Occurrence pooled across 30 sites and then proportion calculated. Data collected on the Southern High Plains of Texas (2012).

Year	**PC**	**East**	**West**	**North**	**South**
Bareground	50.3%	39.7%	37.5%	39.7%	47.5%
Forb	3.2%	2.5%	3.3%	3.3%	1.7%
Grass	4.7%	11.8%	10.5%	8.2%	6.2%
Litter	34.0%	31.8%	35.7%	35.8%	31.3%
Shrubs	7.8%	14.2%	13.0%	13.0%	13.3%

Table 4.6. Welch's adjusted *t*-test results between roost and random sites for point center canopy coverage categories in 2011. Proportions per canopy coverage category shown for visualization. Arcsine-square root transformations (not shown) were the values tested. Data collected on the Southern High Plains of Texas (2011).

Year	**Roost PC**	**Random PC**	***t***	***df***	***P***
Bareground	63.5%	37.0%	3.817	51.973	<0.001
Forb	0.2%	0.5%	-0.719	46.722	0.476
Grass	1.8%	10.0%	-3.327	42.721	0.002
Litter	29.3%	42.3%	-1.746	54.405	0.086
Shrubs	5.2%	10.2%	-1.731	54.000	0.089

Table 4.7. Welch's adjusted *t*-test results between roost and random sites for point center canopy coverage categories in 2012. Proportions per canopy coverage category shown for visualization. Arcsine-square root transformations (not shown) were the values tested. Data collected on the Southern High Plains of Texas (2012).

Year	**Roost PC**	**Random PC**	***t***	***df***	***P***
Bareground	58.2%	50.3%	1.089	51.059	0.281
Forb	1.8%	3.2%	-1.146	55.636	0.257
Grass	6.2%	4.7%	0.096	54.686	0.924
Litter	30.2%	34.0%	-0.304	45.002	0.762
Shrubs	3.7%	7.8%	-2.181	55.357	0.033

Table 4.8. Mean temperature °C (±SD) and relative humidity % RH (±SD) at lesser prairie-chicken roosting sites and paired random sites on the Southern High Plains of Texas (2011 and 2012).

Year	**Site**	**°C**	**% RH**	***n***
2011	Roost	24.2 (2.9)	49.7 (15.8)	883
2011	Random	23.8 (2.9)	54.4 (16.4)	883
2012	Roost	21.7 (3.0)	66.3 (20.9)	1268
2012	Random	21.6 (3.1)	65.4 (20.1)	1268